



## MEASUREMENT REPORT

### FCC PART 15.407 WLAN 802.11a/n/ac/ax

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**FCC ID:** 2ABLK-GS4227E

**APPLICANT:** Calix Inc.

**Application Type:** Certification

**Product:** GigaSpire, GigaSpire BLAST<sup>u6.1</sup>

**Model No.:** GS4227E, GS4220E

**Brand Name:**  **Calix**

**FCC Classification:** Unlicensed National Information Infrastructure (UNII)

**FCC Rule Part(s):** Part15 Subpart E (Section 15.407)

**Test Procedure(s):** ANSI C63.10-2013, KDB 789033 D02v02r01,  
KDB 662911 D01v02r01

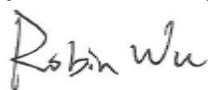
**Test Date:** November 22, 2019 ~ January 06, 2020

**Reviewed By:**



( Kevin Guo )

**Approved By:**



( Robin Wu )



The test results relate only to the samples tested.

This equipment has been shown to be capable of compliance with the applicable technical standards as indicated in the measurement report and was tested in accordance with the measurement procedures specified in KDB 789033 D02v02r01. Test results reported herein relate only to the item(s) tested.

The test report shall not be reproduced except in full without the written approval of MRT Technology (Suzhou) Co., Ltd.

## Revision History

| Report No.    | Version | Description    | Issue Date | Note  |
|---------------|---------|----------------|------------|-------|
| 1911RSU033-U2 | Rev. 01 | Initial report | 02-02-2020 | Valid |
|               |         |                |            |       |

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## §2.1033 General Information

|                                |                                                                                                                                 |
|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| <b>Applicant:</b>              | Calix Inc.                                                                                                                      |
| <b>Applicant Address:</b>      | 1035 N. McDowell Blvd Petaluma, CA94954 U.S.A                                                                                   |
| <b>Manufacturer:</b>           | Calix Inc.                                                                                                                      |
| <b>Manufacturer Address:</b>   | 1035 N. McDowell Blvd Petaluma, CA94954 U.S.A                                                                                   |
| <b>Test Site:</b>              | MRT Technology (Suzhou) Co., Ltd                                                                                                |
| <b>Test Site Address:</b>      | D8 Building, No.2 Tian'edang Rd., Wuzhong Economic Development Zone, Suzhou, China                                              |
| <b>Test Device Serial No.:</b> | N/A <input type="checkbox"/> Production <input checked="" type="checkbox"/> Pre-Production <input type="checkbox"/> Engineering |

### Test Facility / Accreditations

Measurements were performed at MRT Laboratory located in Tian'edang Rd., Suzhou, China.

- MRT facility is a FCC registered (MRT Designation No. CN1166) test facility with the site description report on file and has met all the requirements specified in ANSI C63.4-2014.
- MRT facility is an IC registered (MRT Reg. No. 11384A-1) test laboratory with the site description on file at Industry Canada.
- MRT facility is a VCCI registered (R-4179, G-814, C-4664, T-2206) test laboratory with the site description on file at VCCI Council.
- MRT Lab is accredited to ISO 17025 by the American Association for Laboratory Accreditation (A2LA) under the American Association for Laboratory Accreditation Program (A2LACert. No.3628.01) in EMC, Telecommunications, Radio and SAR testing.



## 1. INTRODUCTION

### 1.1. Scope

Measurement and determination of electromagnetic emissions (EMC) of radio frequency devices including intentional and/or unintentional radiators for compliance with the technical rules and regulations of the Federal Communications Commission and the Innovation, Science and Economic Development Canada and Certification and Engineering Bureau.

### 1.2. MRT Test Location

The map below shows the location of the MRT LABORATORY, its proximity to the Taihu Lake. These measurement tests were conducted at the MRT Technology (Suzhou) Co., Ltd. Facility located at D8 Building, No.2 Tian'edang Rd., Wuzhong Economic Development Zone, Suzhou, China. The measurement facility compliant with the test site requirements specified in ANSI C63.4-2014.



## 2. PRODUCT INFORMATION

### 2.1. Equipment Description

|                      |                                                                                   |
|----------------------|-----------------------------------------------------------------------------------|
| Product Name:        | GigaSpire, GigaSpire BLAST <sup>u6.1</sup>                                        |
| Model No.:           | GS4227E, GS4220E                                                                  |
| Brand Name:          |  |
| Wi-Fi Specification: | 802.11a/b/g/n/ac/ax                                                               |

Note 1: There are the same hardware design, PCB layout between product names and models, except the data rate of the white RJ45 port. For this port, GS4227E supports 2.5Gbps, but GS4220E supports 1Gbps only.

Note 2: The difference addressed as above doesn't affect the RF test result, so we selected GS4227E (product name: GigaSpire) for all RF testing.

### 2.2. Product Specification Subjective to this Report

|                     |                                                                                                                                                                                  |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Frequency Range:    | For 802.11a/n-HT20/ac-VHT20/ax-HE20: 5180~5240MHz, 5745~5825MHz<br>For 802.11n-HT40/ac-VHT40/ax-HE40: 5190~5230MHz, 5755~5795MHz<br>For 802.11ac-VHT80/ax-HE80: 5210MHz, 5775MHz |
| Type of Modulation: | 802.11a/n/ac: OFDM<br>802.11ax: OFDMA                                                                                                                                            |
| Data Rate:          | 802.11a: 6/9/12/18/24/36/48/54Mbps<br>802.11n: up to 600Mbps<br>802.11ac: up to 1733.3Mbps<br>802.11ax: up to 2475Mbps                                                           |

Note: For other features of this EUT, test report will be issued separately.

### 2.3. Working Frequencies for this report

802.11a/n-HT20/ac-VHT20/ax-HE20

| Channel | Frequency | Channel | Frequency | Channel | Frequency |
|---------|-----------|---------|-----------|---------|-----------|
| 36      | 5180 MHz  | 40      | 5200 MHz  | 44      | 5220 MHz  |
| 48      | 5240 MHz  | 149     | 5745 MHz  | 153     | 5765 MHz  |
| 157     | 5785 MHz  | 161     | 5805 MHz  | 165     | 5825 MHz  |

802.11n-HT40/ac-VHT40/ax-HE40

| Channel | Frequency | Channel | Frequency | Channel | Frequency |
|---------|-----------|---------|-----------|---------|-----------|
| 38      | 5190 MHz  | 46      | 5230 MHz  | 151     | 5755 MHz  |
| 159     | 5795 MHz  | --      | --        | --      | --        |

802.11ac-VHT80/ax-HE80

| Channel | Frequency | Channel | Frequency | Channel | Frequency |
|---------|-----------|---------|-----------|---------|-----------|
| 42      | 5210 MHz  | 155     | 5775 MHz  | --      | --        |

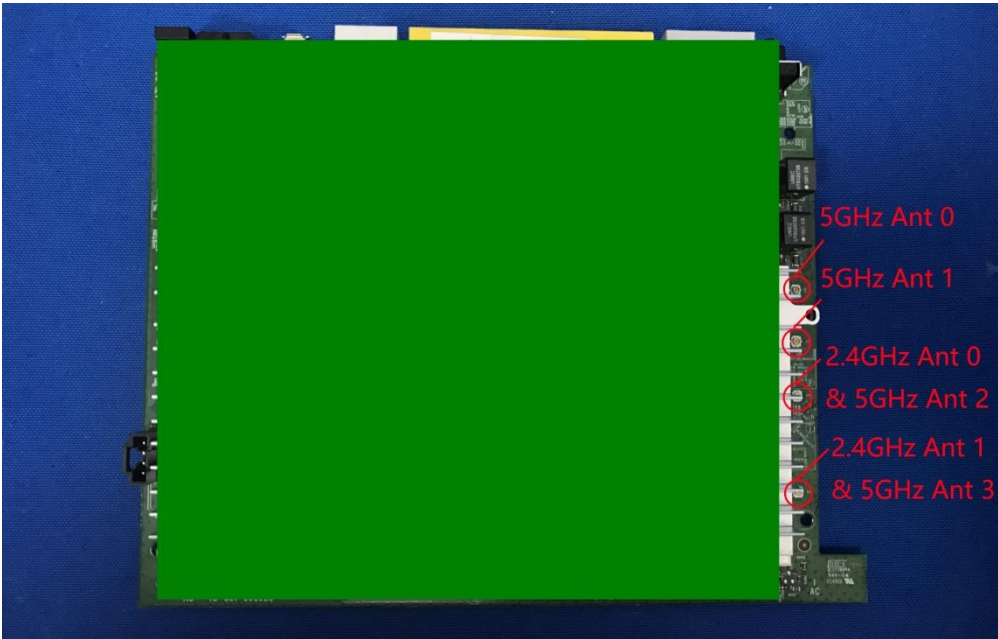
## 2.4. Description of Available Antennas

| Antenna Type | Frequency Band (MHz) | T <sub>x</sub> Paths | Directional Gain (dBi) |                   |
|--------------|----------------------|----------------------|------------------------|-------------------|
|              |                      |                      | Non Beam-Forming Mode  | Beam-Forming Mode |
| PCB Antenna  | 2412 ~ 2462          | 2                    | 2.62                   | 5.52              |
|              | 5150 ~ 5250          | 4                    | 1.89                   | 6.90              |
|              | 5250 ~ 5350          | 4                    | 1.89                   | 6.90              |
|              | 5470 ~ 5725          | 4                    | 2.03                   | 7.44              |
|              | 5725 ~ 5850          | 4                    | 1.20                   | 6.34              |

Note:

1. The EUT supports Beam Forming technology, and the Beam Forming mode support 802.11ac/ax, not include 802.11a/b/g. Its transmit signals are correlated, then  
Directional gain =  $10 \log [(10^{G1/20} + 10^{G2/20} + \dots + 10^{GN/20})^2 / N_{ANT}]$  dBi [Note the “20”s in the denominator of each exponent and the square of the sum of terms; the object is to combine the signal levels coherently.
2. The EUT also support Non Beam-Forming technology, and Non Beam-Forming mode support 802.11a/b/g/n/ac/ax, its transmit signals are uncorrelated, then  
Directional gain =  $10 \log [(10^{G1/10} + 10^{G2/10} + \dots + 10^{GN/10}) / N_{ANT}]$  dBi

## 2.5. Description of Antenna RF Port

| Antenna RF Port                                                                     |                |       |              |       |       |       |
|-------------------------------------------------------------------------------------|----------------|-------|--------------|-------|-------|-------|
| --                                                                                  | 2.4GHz RF Port |       | 5GHz RF Port |       |       |       |
| Software Control Port                                                               | Ant 0          | Ant 1 | Ant 0        | Ant 1 | Ant 2 | Ant 3 |
|  |                |       |              |       |       |       |

## 2.6. Test Mode

|           |                                                                   |
|-----------|-------------------------------------------------------------------|
| Test Mode | Mode 1: Transmit by 802.11a (6Mbps) (Non Beam-Forming Mode)       |
|           | Mode 2: Transmit by 802.11n-HT20 (MCS0) (Non Beam-Forming Mode)   |
|           | Mode 3: Transmit by 802.11n-HT40 (MCS0) (Non Beam-Forming Mode)   |
|           | Mode 4: Transmit by 802.11ac-VHT20 (MCS0) (Non Beam-Forming Mode) |
|           | Mode 5: Transmit by 802.11ac-VHT40 (MCS0) (Non Beam-Forming Mode) |
|           | Mode 6: Transmit by 802.11ac-VHT80 (MCS0) (Non Beam-Forming Mode) |
|           | Mode 7: Transmit by 802.11ax-HE20 (MCS0) (Non Beam-Forming Mode)  |
|           | Mode 8: Transmit by 802.11ax-HE40 (MCS0) (Non Beam-Forming Mode)  |
|           | Mode 9: Transmit by 802.11ax-HE80 (MCS0) (Non Beam-Forming Mode)  |
|           | Mode 10: Transmit by 802.11ac-VHT20 (MCS0) (Beam-Forming Mode)    |
|           | Mode 11: Transmit by 802.11ac-VHT40 (MCS0) (Beam-Forming Mode)    |
|           | Mode 12: Transmit by 802.11ac-VHT80 (MCS0) (Beam-Forming Mode)    |
|           | Mode 13: Transmit by 802.11ax-HE20 (MCS0) (Beam-Forming Mode)     |
|           | Mode 14: Transmit by 802.11 ax-HE40 (MCS0) (Beam-Forming Mode)    |
|           | Mode 15: Transmit by 802.11ax-HE80 (MCS0) (Beam-Forming Mode)     |

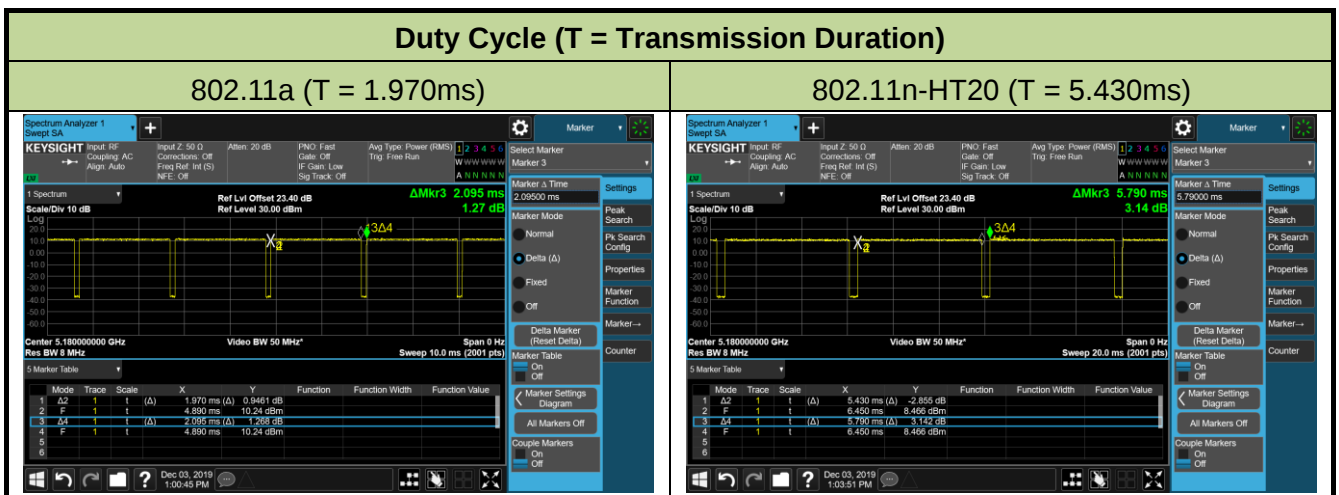
## 2.7. Description of Test Software

The test utility software used during testing was “Qualcomm Radio Control Tool”, and the version was “4.0.00132.0”.

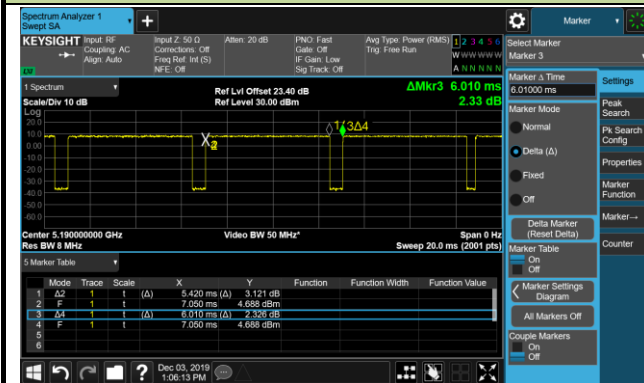
## 2.8. Duty Cycle

5GHz (NII) operation is possible in 20MHz, 40MHz and 80MHz channel bandwidths. The maximum achievable duty cycles for all modes were determined based on measurements performed on a spectrum analyzer in zero-span mode with RBW = 8MHz, VBW = 50MHz per the guidance of Section B)2)b) of KDB 789033 D02v02r01. The RBW and VBW were both greater than 50/T, where T is the minimum transmission duration, and the number of sweep points across T was greater than 100. The duty cycles are as follows:

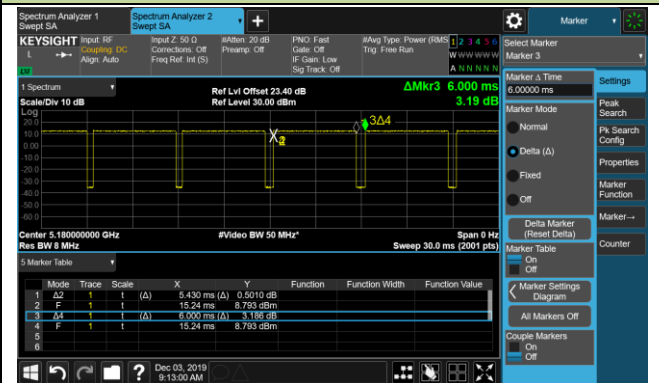
| Test Mode      | Duty Cycle |
|----------------|------------|
| 802.11a        | 94.03%     |
| 802.11n-HT20   | 93.78%     |
| 802.11n-HT40   | 90.18%     |
| 802.11ac-VHT20 | 90.50%     |
| 802.11ac-VHT40 | 90.00%     |
| 802.11ac-VHT80 | 90.25%     |
| 802.11ax-HE20  | 95.03%     |
| 802.11ax-HE40  | 94.28%     |
| 802.11ax-HE80  | 95.61%     |



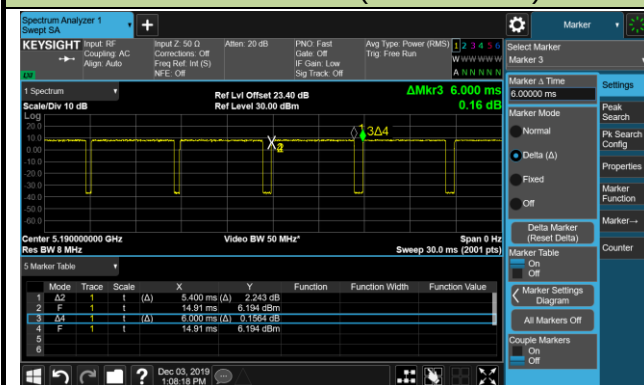
## 802.11n-HT40 (T = 5.420ms)



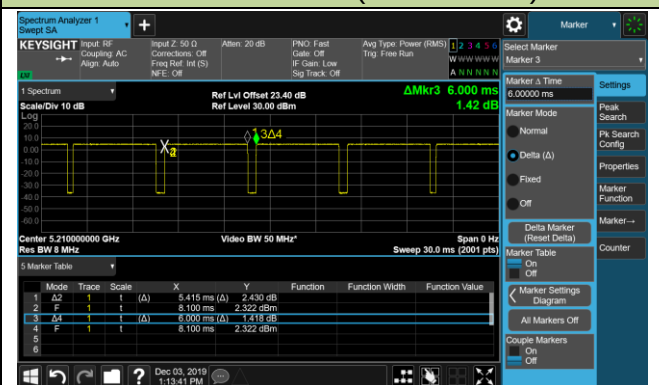
## 802.11ac-VHT20 (T = 5.430ms)



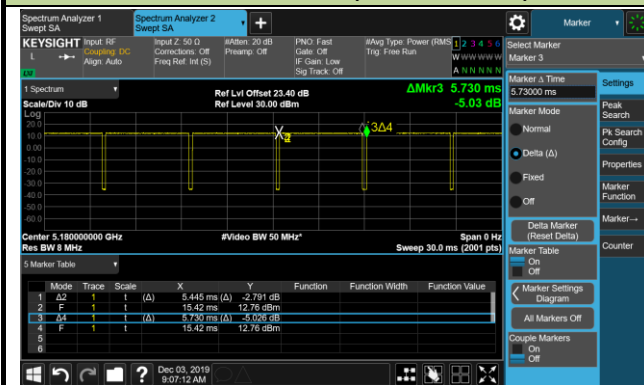
## 802.11ac-VHT40 (T = 5.400ms)



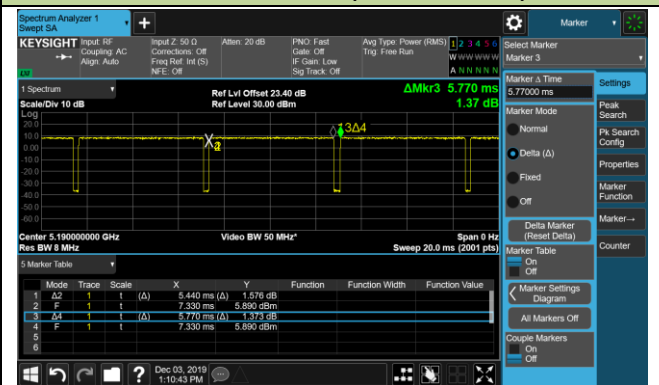
## 802.11ac-VHT80 (T = 5.415ms)



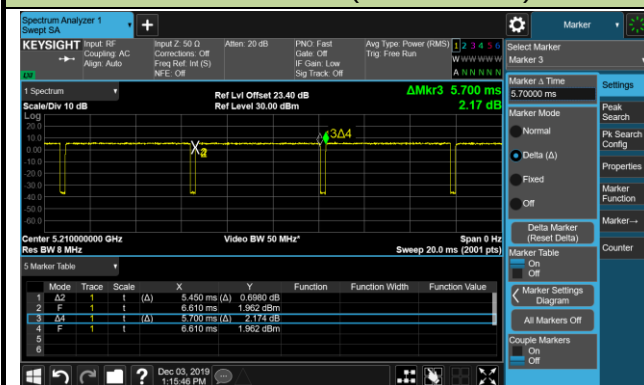
## 802.11ax-HE20 (T = 5.445ms)



## 802.11ax-HE40 (T = 5.440ms)



## 802.11ax-HE80 (T = 5.450ms)



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## **2.9. EMI Suppression Device(s)/Modifications**

No EMI suppression device(s) were added and/or no modifications were made during testing.

## **2.10. Labeling Requirements**

Per 2.1074 & 15.19; Docket 95-19

The label shall be permanently affixed at a conspicuous location on the device; instruction manual or pamphlets supplied to the user and be readily visible to the purchaser at the time of purchase.

However, when the device is so small wherein placement of the label with specified statement is not practical, only the FCC ID must be displayed on the device per Section 15.19(a)(5). Please see attachment for FCC ID label and label location.

### 3. DESCRIPTION OF TEST

#### 3.1. Evaluation Procedure

The measurement procedures described in the American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices (ANSI C63.10-2013), and the guidance provided in KDB 789033 D02v02r01 were used in the measurement of the device.

**Deviation from measurement procedure.....None**

#### 3.2. AC Line Conducted Emissions

The line-conducted facility is located inside an 8'x4'x4' shielded enclosure. A 1m x 2m wooden table 80cm high is placed 40cm away from the vertical wall and 80cm away from the sidewall of the shielded room. Two 10kHz-30MHz, 50Ω/50uH Line-Impedance Stabilization Networks (LISNs) are bonded to the shielded room floor. Power to the LISNs is filtered by external high-current high-insertion loss power line filters. These filters attenuate ambient signal noise from entering the measurement lines. These filters are also bonded to the shielded enclosure.

The EUT is powered from one LISN and the support equipment is powered from the second LISN. All interconnecting cables more than 1 meter were shortened to a 1 meter length by non-inductive bundling (serpentine fashion) and draped over the back edge of the test table. All cables were at least 40cm above the horizontal reference ground-plane. Power cables for support equipment were routed down to the second LISN while ensuring that that cables were not draped over the second LISN.

Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The RF output of the LISN was connected to the receiver and exploratory measurements were made to determine the frequencies producing the maximum emission from the EUT. The receiver was scanned from 150kHz to 30MHz. The detector function was set to peak mode for exploratory measurements while the bandwidth of the analyzer was set to 9kHz. The EUT, support equipment, and interconnecting cables were arranged and manipulated to maximize each emission. Each emission was also maximized by varying: power lines, the mode of operation or data exchange speed, or support equipment whichever determined the worst-case emission. Once the worst case emissions have been identified, the one EUT cable configuration/arrangement and mode of operation that produced these emissions are used for final measurements on the same test site. The analyzer is set to CISPR quasi-peak and average detectors with a 9kHz resolution bandwidth for final measurements.

An extension cord was used to connect to a single LISN which powered by EUT. The extension cord was calibrated with LISN, the impedance and insertion loss are compliance with the requirements as stated in ANSI C63.10-2013.

### 3.3. Radiated Emissions

The radiated test facilities consisted of an indoor 3 meter semi-anechoic chamber used for final measurements and exploratory measurements, when necessary. The measurement area is contained within the semi-anechoic chamber which is shielded from any ambient interference. For measurements above 1GHz absorbers are arranged on the floor between the turn table and the antenna mast in such a way so as to maximize the reduction of reflections. For measurements below 1GHz, the absorbers are removed. A MF Model 210SS turntable is used for radiated measurement. It is a continuously rotatable, remotecontrolled, metallic turntable and 2 meters (6.56 ft.) in diameter. The turn table is flush with the raised floor of the chamber in order to maintain its function as a ground plane. An 80cm high PVC support structure is placed on top of the turntable.

For all measurements, the spectrum was scanned through all EUT azimuths and from 1 to 4 meter receive antenna height using a broadband antenna from 30MHz up to the upper frequency shown in 15.33(b)(1) depending on the highest frequency generated or used in the device or on which the device operates or tunes. For frequencies above 1GHz, linearly polarized double ridge horn antennas were used. For frequencies below 30MHz, a calibrated loop antenna was used. When exploratory measurements were necessary, they were performed at 1 meter test distance inside the semi-anechoic chamber using broadband antennas, broadband amplifiers, and spectrum analyzers to determine the frequencies and modes producing the maximum emissions. Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The test set-up for frequencies below 1GHz was placed on top of the 0.8 meter high, 1 x 1.5 meter table; and test set-up for frequencies 1-40GHz was placed on top of the 1.5 meter high, 1 x 1.5 meter table. The EUT, support equipment, and interconnecting cables were arranged and manipulated to maximize each emission. Appropriate precaution was taken to ensure that all emissions from the EUT were maximized and investigated. The system configuration, clock speed, mode of operation or video resolution, if applicable, turntable azimuth, and receive antenna height was noted for each frequency found.

Final measurements were made in the semi-anechoic chamber using calibrated, linearly polarized broadband and horn antennas. The test setup was configured to the setup that produced the worst case emissions. The spectrum analyzer was set to investigate all frequencies required for testing to compare the highest radiated disturbances with respect to the specified limits. The turntable containing the EUT was rotated through 360 degrees and the height of the receive antenna was varied 1 to 4 meters and stopped at the azimuth and height producing the maximum emission. Each emission was maximized by changing the orientation of the EUT through three orthogonal planes and changing the polarity of the receive antenna, whichever produced the worst-case emissions. According to 3dB Beam-Width of horn antenna, the horn antenna should be always directed to the EUT when rising height.

## 4. ANTENNA REQUIREMENTS

### Excerpt from §15.203 of the FCC Rules/Regulations:

“An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section.”

- The antenna of the device is **permanently attached**.
- There are no provisions for connection to an external antenna.

### Conclusion:

The unit complies with the requirement of §15.203.

## 5. TEST EQUIPMENT CALIBRATION DATE

### Conducted Emissions - SR2

| Instrument         | Manufacturer | Type No.    | Asset No.   | Cali. Interval | Cali. Due Date |
|--------------------|--------------|-------------|-------------|----------------|----------------|
| EMI Test Receiver  | R&S          | ESR3        | MRTSUE06185 | 1 year         | 2020/04/15     |
| Two-Line V-Network | R&S          | ENV 216     | MRTSUE06002 | 1 year         | 2020/06/13     |
| Two-Line V-Network | R&S          | ENV 216     | MRTSUE06003 | 1 year         | 2020/06/13     |
| Thermohygrometer   | Testo        | 608-H1      | MRTSUE06404 | 1 year         | 2020/08/08     |
| Shielding Room     | MIX-BEP      | Chamber-SR2 | MRTSUE06215 | N/A            | N/A            |

### Radiated Emissions - AC1

| Instrument                 | Manufacturer | Type No.    | Asset No.   | Cali. Interval | Cali. Due Date |
|----------------------------|--------------|-------------|-------------|----------------|----------------|
| EMI Test Receiver          | R&S          | ESR7        | MRTSUE06001 | 1 year         | 2020/08/01     |
| PXA Signal Analyzer        | Keysight     | 9030B       | MRTSUE06395 | 1 year         | 2020/09/03     |
| Loop Antenna               | Schwarzbeck  | FMZB 1519   | MRTSUE06025 | 1 year         | 2020/11/13     |
| Bilog Period Antenna       | Schwarzbeck  | VULB 9168   | MRTSUE06172 | 1 year         | 2020/03/31     |
| Broad Band Horn Antenna    | Schwarzbeck  | BBHA 9120D  | MRTSUE06023 | 1 year         | 2020/10/13     |
| Broad Band Horn Antenna    | Schwarzbeck  | BBHA 9170   | MRTSUE06597 | 1 year         | 2020/02/24     |
| Microwave System Amplifier | Agilent      | 83017A      | MRTSUE06076 | 1 year         | 2020/11/15     |
| Preamplifier               | Schwarzbeck  | BBV 9721    | MRTSUE06121 | 1 year         | 2020/06/11     |
| Thermohygrometer           | Testo        | 608-H1      | MRTSUE06403 | 1 year         | 2020/08/08     |
| Anechoic Chamber           | TDK          | Chamber-AC1 | MRTSUE06212 | 1 year         | 2020/04/30     |

### Radiated Emission - AC2

| Instrument                     | Manufacturer | Type No.    | Asset No.   | Cali. Interval | Cali. Due Date |
|--------------------------------|--------------|-------------|-------------|----------------|----------------|
| Spectrum Analyzer              | Keysight     | N9038A      | MRTSUE06125 | 1 year         | 2020/08/01     |
| Loop Antenna                   | Schwarzbeck  | FMZB 1519   | MRTSUE06025 | 1 year         | 2020/11/13     |
| Bilog Period Antenna           | Schwarzbeck  | VULB 9162   | MRTSUE06022 | 1 year         | 2020/10/13     |
| Horn Antenna                   | Schwarzbeck  | BBHA9120D   | MRTSUE06171 | 1 year         | 2020/10/27     |
| Broad Band Horn Antenna        | Schwarzbeck  | BBHA 9170   | MRTSUE06597 | 1 year         | 2020/02/24     |
| Broadband Coaxial Preamplifier | Schwarzbeck  | BBV 9718    | MRTSUE06176 | 1 year         | 2020/11/15     |
| Preamplifier                   | Schwarzbeck  | BBV 9721    | MRTSUE06121 | 1 year         | 2020/06/11     |
| Temperature/Humidity Meter     | Minggao      | ETH529      | MRTSUE06170 | 1 year         | 2020/12/15     |
| Anechoic Chamber               | RIKEN        | Chamber-AC2 | MRTSUE06213 | 1 year         | 2020/04/30     |

## Conducted Test Equipment - TR3

| Instrument                             | Manufacturer | Type No.    | Asset No.   | Cali. Interval | Cali. Due Date |
|----------------------------------------|--------------|-------------|-------------|----------------|----------------|
| EXA Signal Analyzer                    | Agilent      | N9020A      | MRTSUE06106 | 1 year         | 2020/04/15     |
| EXA Signal Analyzer                    | Keysight     | N9010B      | MRTSUE06452 | 1 year         | 2020/07/11     |
| Signal Analyzer                        | R&S          | FSV40       | MRTSUE06218 | 1 year         | 2020/04/15     |
| Power Meter                            | Agilent      | U2021XA     | MRTSUE06030 | 1 year         | 2020/11/18     |
| USB wideband power sensor              | Keysight     | U2021XA     | MRTSUE06446 | 1 year         | 2020/06/30     |
| USB wideband power sensor              | Keysight     | U2021XA     | MRTSUE06447 | 1 year         | 2020/06/30     |
| Bluetooth Test Set                     | Anritsu      | MT8852B-042 | MRTSUE06389 | 1 year         | 2020/06/13     |
| Audio Analyzer                         | Agilent      | U8903B      | MRTSUE06143 | 1 year         | 2020/06/13     |
| Modulation Analyzer                    | HP           | 8901A       | MRTSUE06098 | 1 year         | 2020/10/10     |
| Wideband Radio<br>Communication Tester | R&S          | CMW 500     | MRTSUE06243 | 1 year         | 2020/11/07     |
| DC Power Supply                        | GWINSTEK     | DPS-3303C   | MRTSUE06064 | N/A            | N/A            |
| Temperature & Humidity<br>Chamber      | BAOYT        | BYH-150CL   | MRTSUE06051 | 1 year         | 2020/11/07     |
| Thermohygrometer                       | testo        | 608-H1      | MRTSUE06401 | 1 year         | 2020/08/08     |

| Software     | Version | Function          |
|--------------|---------|-------------------|
| EMI Software | V3      | EMI Test Software |

## 6. MEASUREMENT UNCERTAINTY

Where relevant, the following test uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2. This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of  $k = 2$ .

| Conducted Emission Measurement - SR2                 |                      |
|------------------------------------------------------|----------------------|
| The maximum measurement uncertainty is evaluated as: |                      |
| 9kHz~150kHz: 3.84dB                                  |                      |
| 150kHz~30MHz: 3.46dB                                 |                      |
| Radiated Emission Measurement - AC1                  |                      |
| The maximum measurement uncertainty is evaluated as: |                      |
| Horizontal:                                          | 30MHz~300MHz: 4.07dB |
|                                                      | 300MHz~1GHz: 3.63dB  |
|                                                      | 1GHz~18GHz: 4.16dB   |
| Vertical:                                            | 30MHz~300MHz: 4.18dB |
|                                                      | 300MHz~1GHz: 3.60dB  |
|                                                      | 1GHz~18GHz: 4.76dB   |
| Radiated Emission Measurement - AC2                  |                      |
| The maximum measurement uncertainty is evaluated as: |                      |
| Horizontal:                                          | 30MHz~300MHz: 3.75dB |
|                                                      | 300MHz~1GHz: 3.53dB  |
|                                                      | 1GHz~18GHz: 4.28dB   |
| Vertical:                                            | 30MHz~300MHz: 3.86dB |
|                                                      | 300MHz~1GHz: 3.53dB  |
|                                                      | 1GHz~18GHz: 4.33dB   |

## 7. TEST RESULT

### 7.1. Summary

| FCC Section(s)                           | Test Description                                                            | Test Limit                                                                  | Test Condition | Test Result | Reference         |
|------------------------------------------|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------|----------------|-------------|-------------------|
| 15.407(a)                                | 26dB Bandwidth                                                              | N/A                                                                         | Conducted      | Pass        | Section 7.2       |
| 15.407(e)                                | 6dB Bandwidth                                                               | $\geq 500\text{kHz}$                                                        |                | Pass        | Section 7.3       |
| 15.407(a)(1)(ii), (2), (3)               | Maximum Conducted Output Power                                              | Refer to section 7.4                                                        |                | Pass        | Section 7.4       |
| 15.407(h)(1)                             | Transmit Power Control                                                      | $\leq 24\text{ dBm}$                                                        |                | N/A         | Section 7.5       |
| 15.407(a)(1)(ii), (2), (3), (5)          | Peak Power Spectral Density                                                 | Refer to section 7.6                                                        |                | Pass        | Section 7.6       |
| 15.407(g)                                | Frequency Stability                                                         | $\pm 20\text{ ppm}$                                                         |                | Pass        | Section 7.7       |
| 15.407(b)(1), (4)(i)                     | Undesirable Emissions                                                       | Refer to Section 7.8                                                        | Radiated       | Pass        | Section 7.8 & 7.9 |
| 15.205, 15.209<br>15.407(b)(5), (6), (7) | General Field Strength Limits(Restricted Bands andRadiated Emission Limits) | Emissions in restrictedbands must meet theradiated limits detailed in15.209 |                | Pass        |                   |
| 15.207                                   | AC Conducted Emissions<br>150kHz - 30MHz                                    | < FCC 15.207 limits                                                         | Line Conducted | Pass        | Section 7.10      |

Notes:

- 1) The analyzer plots shown in this section were all taken with a correction table loaded into the analyzer. The correction table was used to account for the losses of the cables and attenuators used as part of the system to connect the EUT to the analyzer at all frequencies of interest.
- 2) Test Items “26dB Bandwidth”, “99% Bandwidth”, “6dB Bandwidth” & “Operation Frequency Range of 26dB BW” have been assessed single and MIMO transmission, and showed the worst test data in this report.
- 3) “N/A” means that this item is not applicable, and the detail information refers to relevant section.

## 7.2. 26dB Bandwidth Measurement

### 7.2.1. Test Limit

N/A

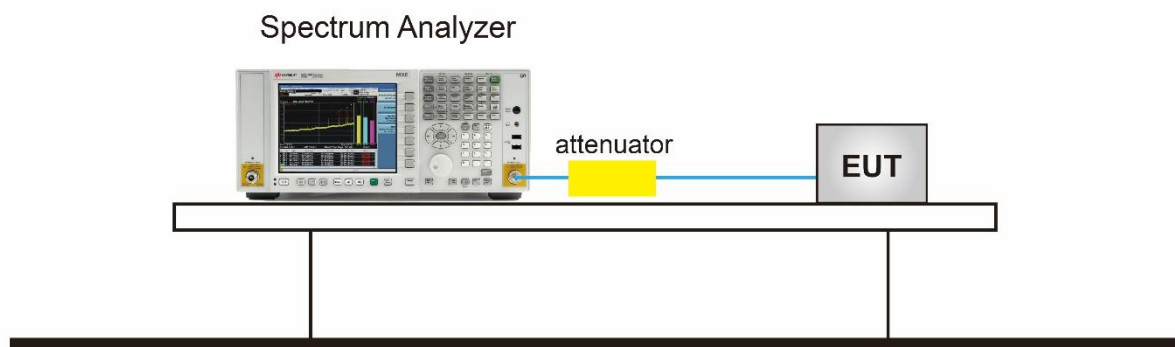
### 7.2.2. Test Procedure used

KDB 789033 D02v02r01 - Section C.1

### 7.2.3. Test Setting

1. The analyzers' automatic bandwidth measurement capability was used to perform the 26dB bandwidth measurement. The "X" dB bandwidth parameter was set to  $X = 26$ . The automatic bandwidth measurement function also has the capability of simultaneously measuring the 99% occupied bandwidth. The bandwidth measurement was not influenced by any intermediated power nulls in the fundamental emission.
2. RBW = approximately 1% of the emission bandwidth.
3. VBW  $\geq 3 \times$  RBW.
4. Detector = Peak.
5. Trace mode = max hold.

### 7.2.4. Test Setup



### 7.2.5.Test Result

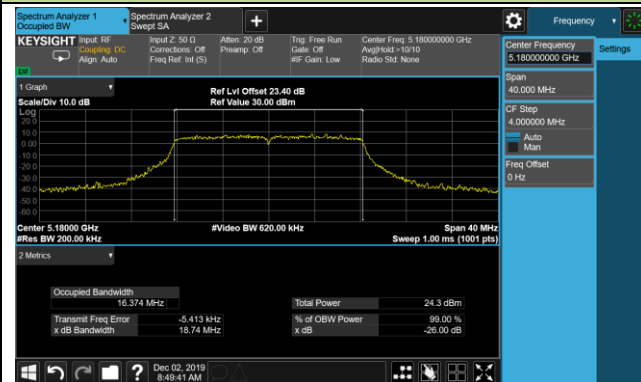
|               |           |                   |                         |
|---------------|-----------|-------------------|-------------------------|
| Product       | GigaSpire | Temperature       | 22 ~ 25°C               |
| Test Engineer | David Lv  | Relative Humidity | 46 ~ 59%                |
| Test Site     | TR3       | Test Date         | 2019/12/02 ~ 2019/12/07 |

| Test Mode                 | Data Rate/<br>MCS | Channel No. | Frequency<br>(MHz) | 26dB Bandwidth<br>(MHz) | 99% Bandwidth<br>(MHz) |
|---------------------------|-------------------|-------------|--------------------|-------------------------|------------------------|
| Ant 0 / Ant 0 + 1 + 2 + 3 |                   |             |                    |                         |                        |
| 802.11a                   | 6Mbps             | 36          | 5180               | 18.74                   | 16.37                  |
| 802.11a                   | 6Mbps             | 44          | 5220               | 19.99                   | 16.40                  |
| 802.11a                   | 6Mbps             | 48          | 5240               | 19.62                   | 16.41                  |
| 802.11a                   | 6Mbps             | 149         | 5745               | 31.48                   | 16.87                  |
| 802.11a                   | 6Mbps             | 157         | 5785               | 22.86                   | 16.55                  |
| 802.11a                   | 6Mbps             | 165         | 5825               | 33.30                   | 17.15                  |
| 802.11n-HT20              | MCS0              | 36          | 5180               | 20.12                   | 17.58                  |
| 802.11n-HT20              | MCS0              | 44          | 5220               | 20.54                   | 17.61                  |
| 802.11n-HT20              | MCS0              | 48          | 5240               | 21.48                   | 17.62                  |
| 802.11n-HT20              | MCS0              | 149         | 5745               | 20.51                   | 17.62                  |
| 802.11n-HT20              | MCS0              | 157         | 5785               | 28.48                   | 17.92                  |
| 802.11n-HT20              | MCS0              | 165         | 5825               | 22.38                   | 17.72                  |
| 802.11n-HT40              | MCS0              | 38          | 5190               | 39.31                   | 36.10                  |
| 802.11n-HT40              | MCS0              | 46          | 5230               | 40.20                   | 36.12                  |
| 802.11n-HT40              | MCS0              | 151         | 5755               | 42.93                   | 36.23                  |
| 802.11n-HT40              | MCS0              | 159         | 5795               | 52.43                   | 36.43                  |
| 802.11ac-VHT20            | MCS0              | 36          | 5180               | 20.03                   | 17.59                  |
| 802.11ac-VHT20            | MCS0              | 44          | 5220               | 21.42                   | 17.65                  |
| 802.11ac-VHT20            | MCS0              | 48          | 5240               | 20.40                   | 17.60                  |
| 802.11ac-VHT20            | MCS0              | 149         | 5745               | 22.37                   | 17.70                  |
| 802.11ac-VHT20            | MCS0              | 157         | 5785               | 27.89                   | 17.83                  |
| 802.11ac-VHT20            | MCS0              | 165         | 5825               | 28.43                   | 17.89                  |

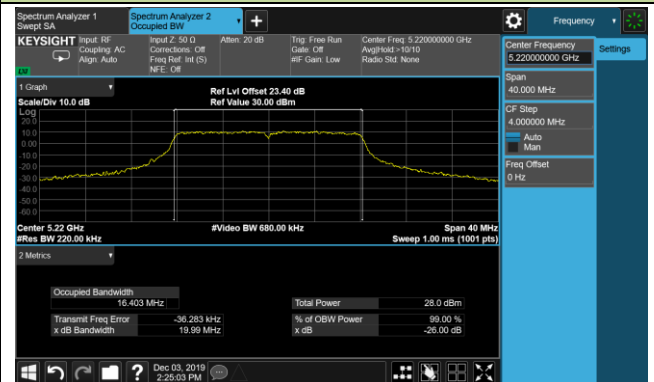
| Test Mode                 | Data Rate/<br>MCS | Channel No. | Frequency<br>(MHz) | 26dB Bandwidth<br>(MHz) | 99% Bandwidth<br>(MHz) |
|---------------------------|-------------------|-------------|--------------------|-------------------------|------------------------|
| Ant 0 / Ant 0 + 1 + 2 + 3 |                   |             |                    |                         |                        |
| 802.11ac-VHT40            | MCS0              | 38          | 5190               | 39.55                   | 36.08                  |
| 802.11ac-VHT40            | MCS0              | 46          | 5230               | 39.98                   | 36.05                  |
| 802.11ac-VHT40            | MCS0              | 151         | 5755               | 40.06                   | 36.07                  |
| 802.11ac-VHT40            | MCS0              | 159         | 5795               | 41.65                   | 36.25                  |
| 802.11ac-VHT80            | MCS0              | 42          | 5210               | 81.25                   | 75.34                  |
| 802.11ac-VHT80            | MCS0              | 155         | 5775               | 81.67                   | 75.36                  |
| 802.11ax-HE20             | MCS0              | 36          | 5180               | 20.87                   | 18.94                  |
| 802.11ax-HE20             | MCS0              | 44          | 5220               | 20.87                   | 18.92                  |
| 802.11ax-HE20             | MCS0              | 48          | 5240               | 21.15                   | 18.95                  |
| 802.11ax-HE20             | MCS0              | 149         | 5745               | 21.32                   | 18.96                  |
| 802.11ax-HE20             | MCS0              | 157         | 5785               | 21.36                   | 19.00                  |
| 802.11ax-HE20             | MCS0              | 165         | 5825               | 21.45                   | 18.98                  |
| 802.11ax-HE40             | MCS0              | 38          | 5190               | 40.43                   | 37.76                  |
| 802.11ax-HE40             | MCS0              | 46          | 5230               | 40.32                   | 37.71                  |
| 802.11ax-HE40             | MCS0              | 151         | 5755               | 41.39                   | 37.81                  |
| 802.11ax-HE40             | MCS0              | 159         | 5795               | 41.31                   | 37.94                  |
| 802.11ax-HE80             | MCS0              | 42          | 5210               | 81.93                   | 77.10                  |
| 802.11ax-HE80             | MCS0              | 155         | 5775               | 82.07                   | 77.07                  |

## 802.11a 26dB Bandwidth & 99% Bandwidth - Ant 0 / Ant 0 + 1 + 2 + 3

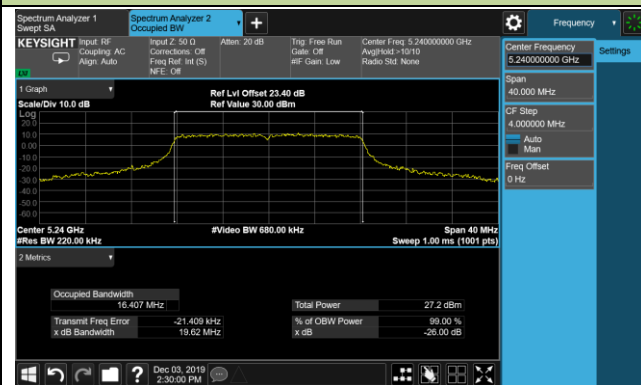
### Channel 36 (5180MHz)



### Channel 44 (5220MHz)



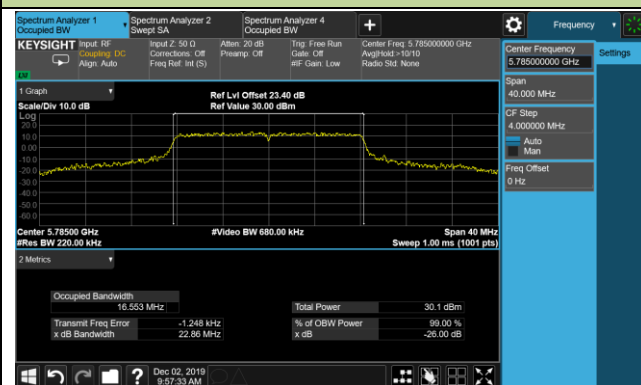
### Channel 48 (5240MHz)



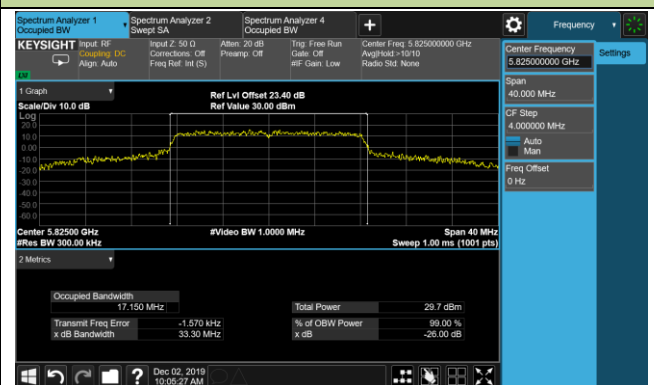
### Channel 149 (5745MHz)



### Channel 157 (5785MHz)

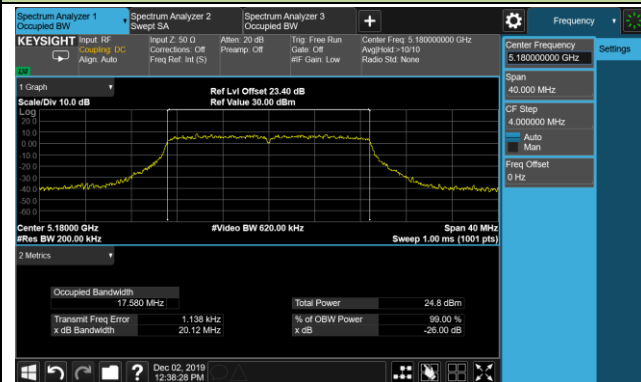


### Channel 165 (5825MHz)

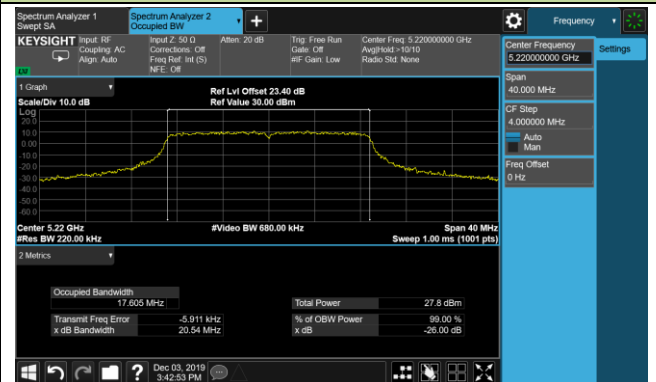


## 802.11n-HT20 26dB Bandwidth & 99% Bandwidth - Ant 0 / Ant 0 + 1 + 2 + 3

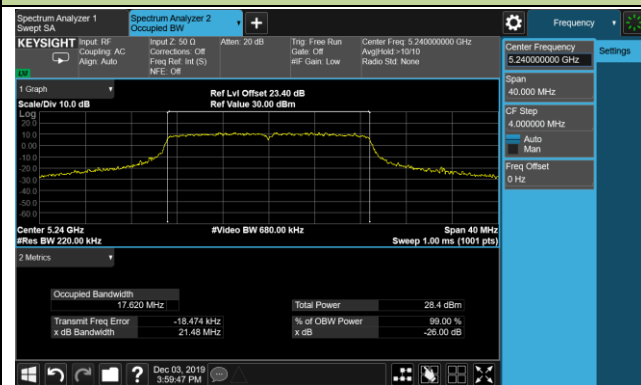
### Channel 36 (5180MHz)



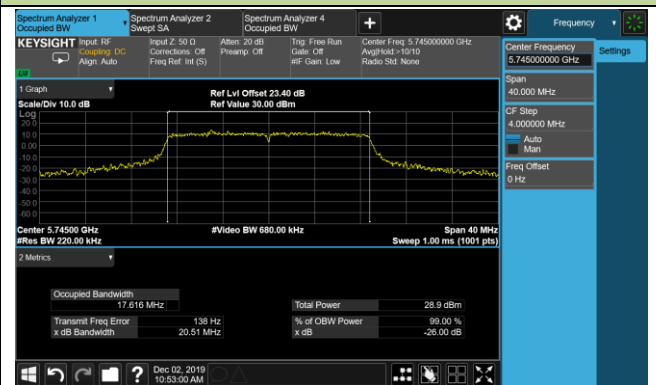
### Channel 44 (5220MHz)



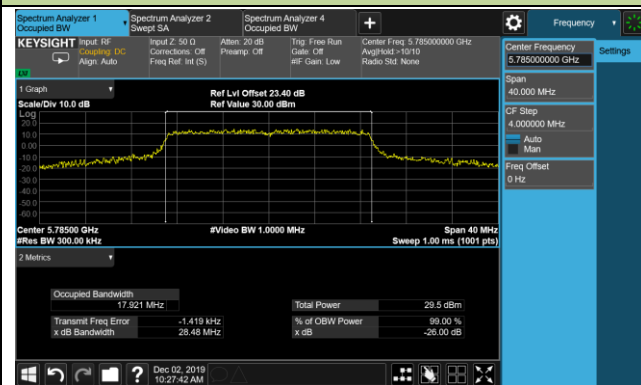
### Channel 48 (5240MHz)



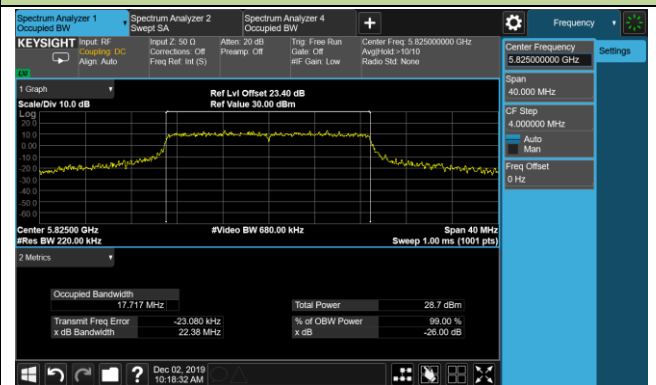
### Channel 149 (5745MHz)



### Channel 157 (5785MHz)

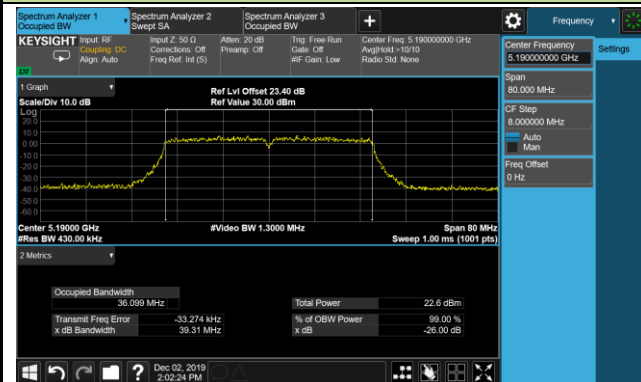


### Channel 165 (5825MHz)

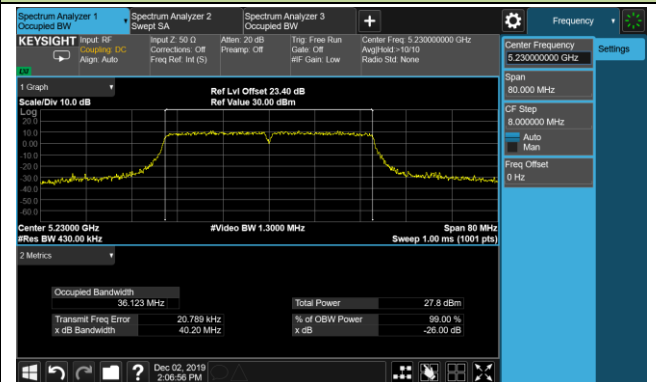


## 802.11n-HT40 26dB Bandwidth & 99% Bandwidth - Ant 0 / Ant 0 + 1 + 2 + 3

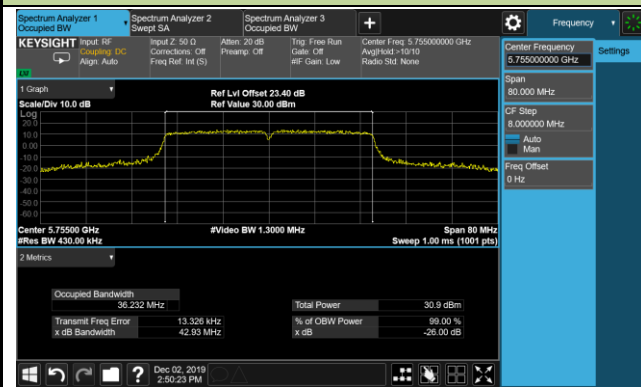
### Channel 38 (5190MHz)



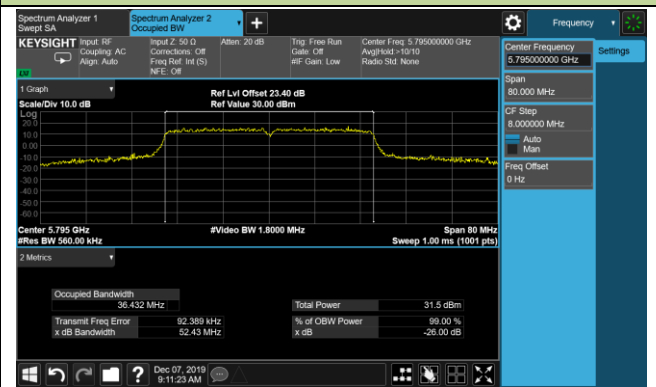
### Channel 46 (5230MHz)



### Channel 151 (5755MHz)



### Channel 159 (5795MHz)

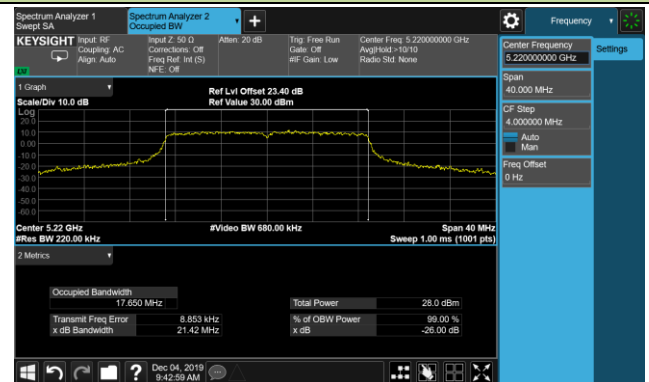


## 802.11ac-VHT20 26dB Bandwidth & 99% Bandwidth - Ant 0 / Ant 0 + 1 + 2 + 3

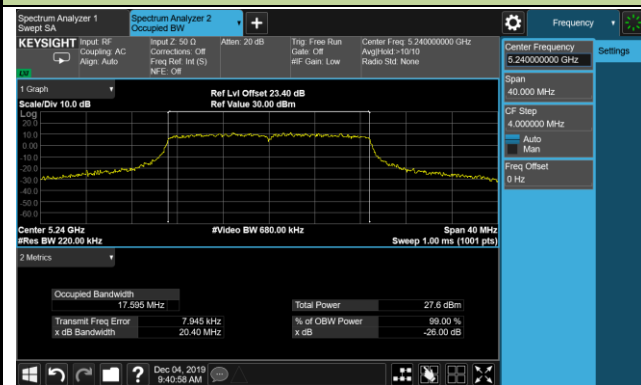
### Channel 36 (5180MHz)



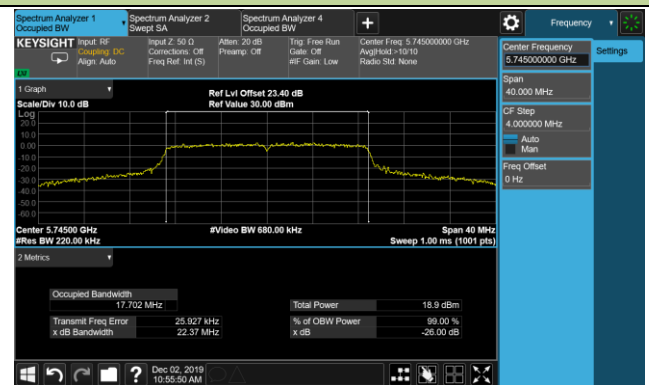
### Channel 44 (5220MHz)



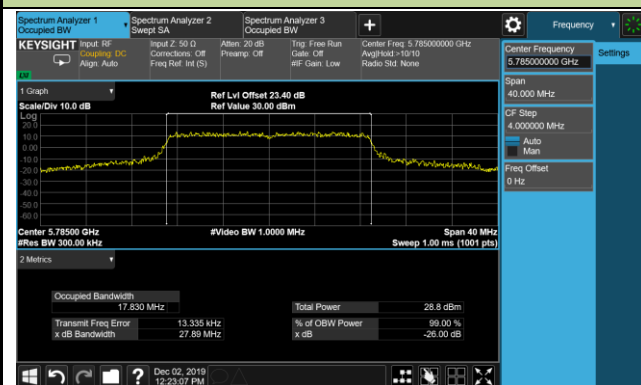
### Channel 48 (5240MHz)



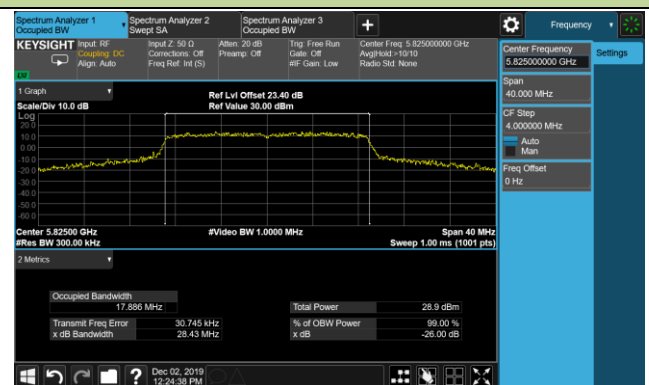
### Channel 149 (5745MHz)



### Channel 157 (5785MHz)

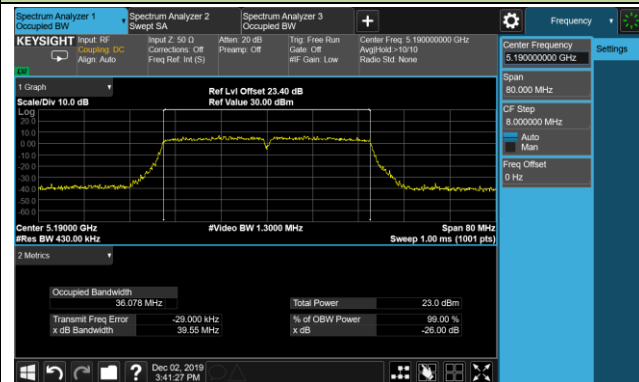


### Channel 165 (5825MHz)

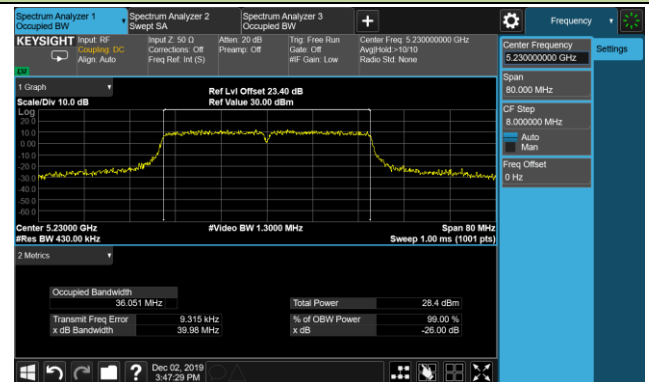


## 802.11ac-VHT40 26dB Bandwidth & 99% Bandwidth - Ant 0 / Ant 0 + 1 + 2 + 3

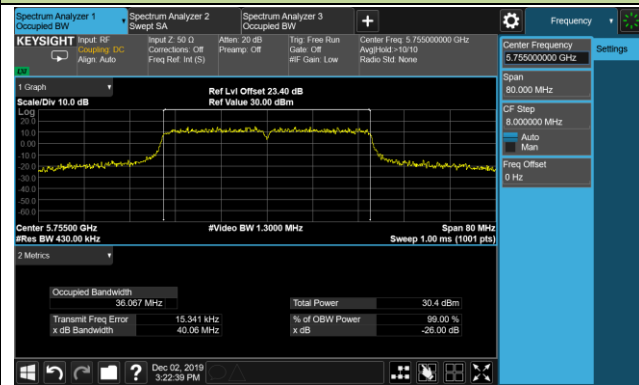
### Channel 38 (5190MHz)



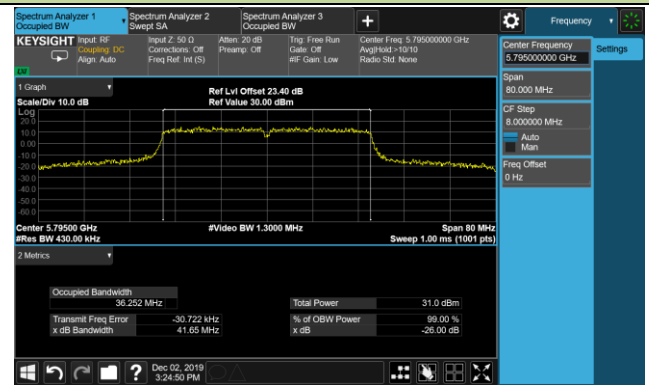
### Channel 46 (5230MHz)



### Channel 151 (5755MHz)

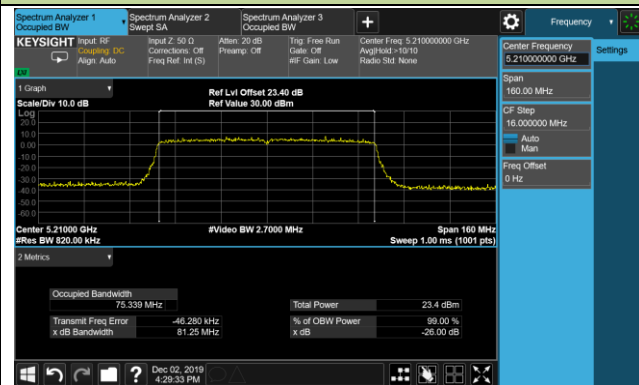


### Channel 159 (5795MHz)

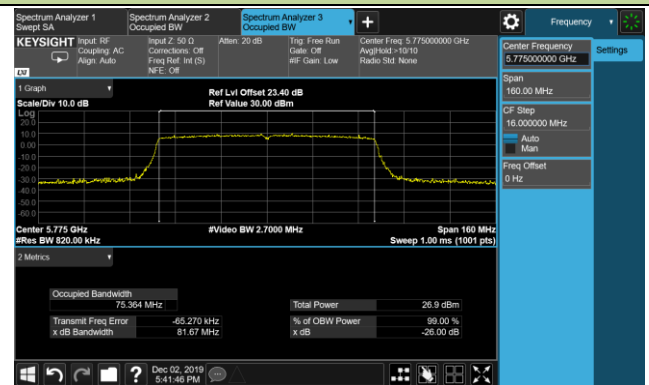


## 802.11ac-VHT80 26dB Bandwidth & 99% Bandwidth - Ant 0 / Ant 0 + 1 + 2 + 3

### Channel 42 (5210MHz)

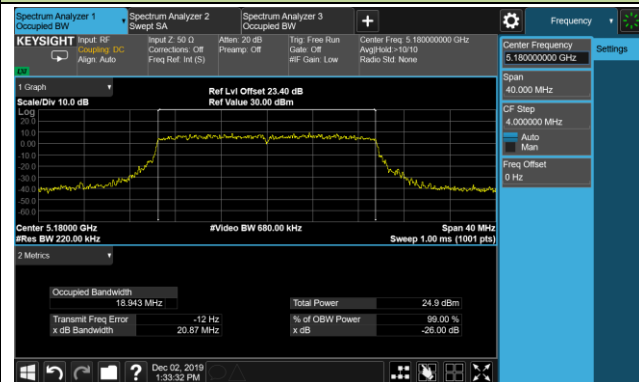


### Channel 155 (5775MHz)

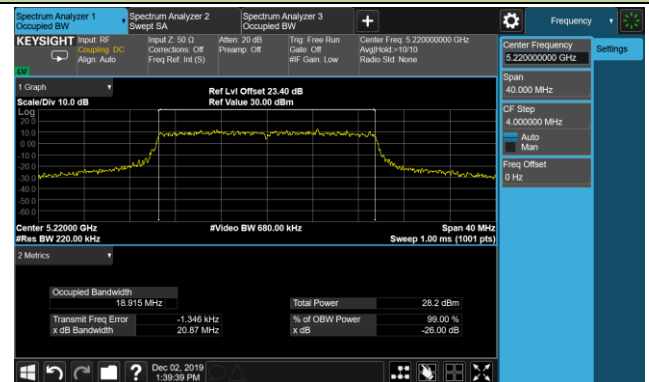


## 802.11ax-HE20 26dB Bandwidth & 99% Bandwidth - Ant 0 / Ant 0 + 1 + 2 + 3

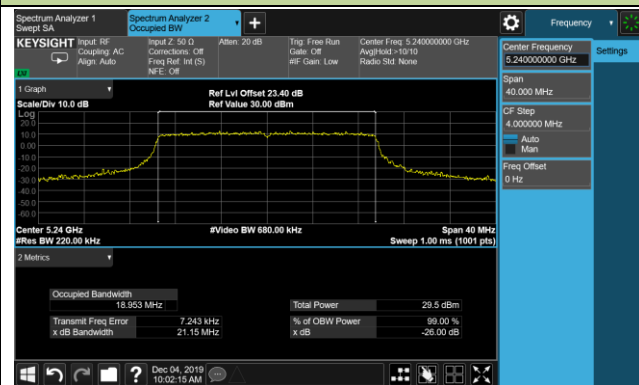
### Channel 36 (5180MHz)



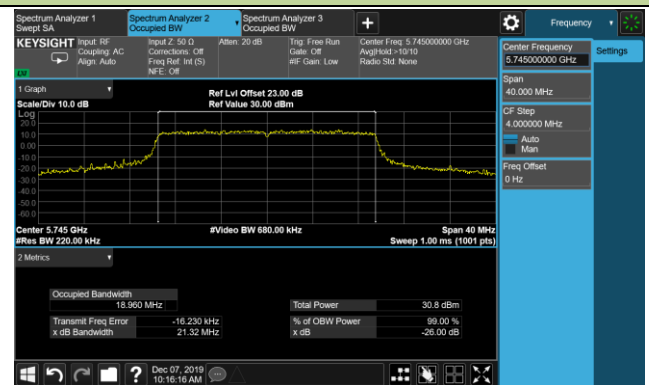
### Channel 44 (5220MHz)



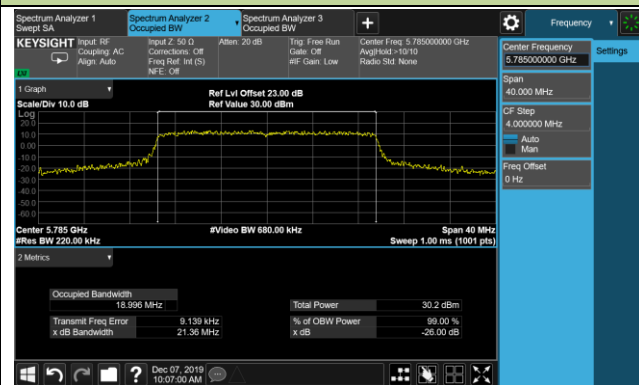
### Channel 48 (5240MHz)



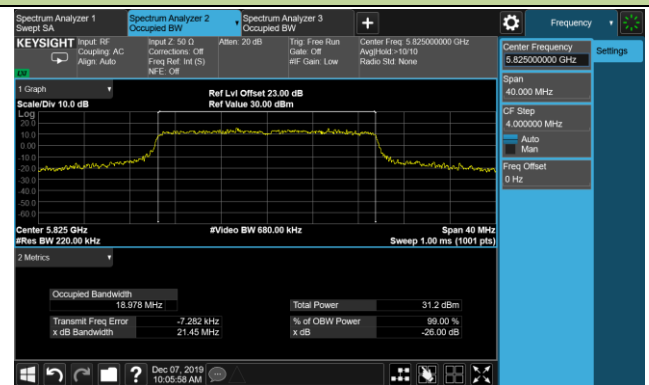
### Channel 149 (5745MHz)



### Channel 157 (5785MHz)

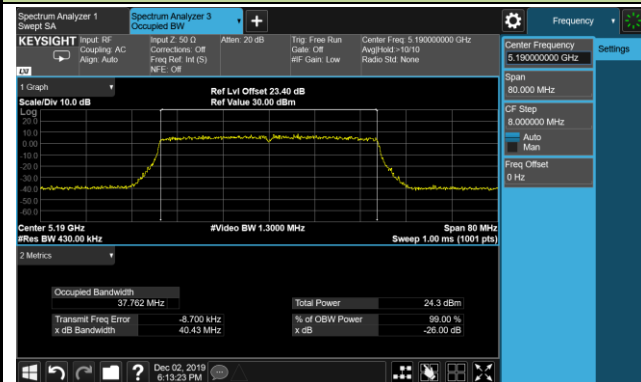


### Channel 165 (5825MHz)

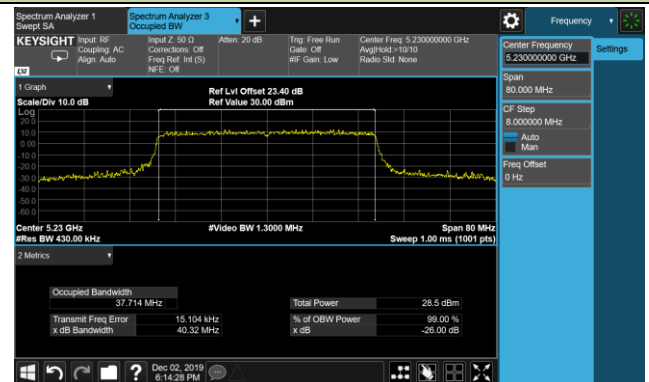


## 802.11ax-HE40 26dB Bandwidth & 99% Bandwidth - Ant 0 / Ant 0 + 1 + 2 + 3

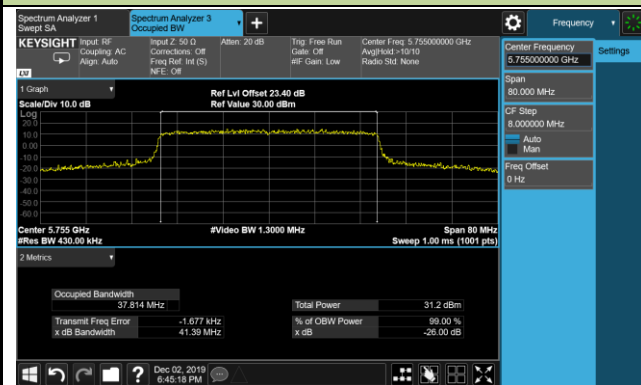
### Channel 38 (5190MHz)



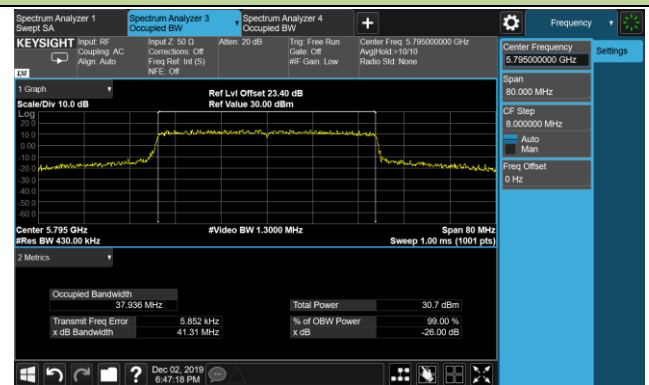
### Channel 46 (5230MHz)



### Channel 151 (5755MHz)

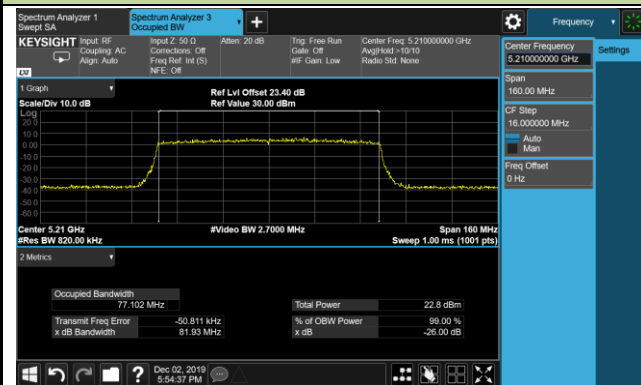


### Channel 159 (5795MHz)

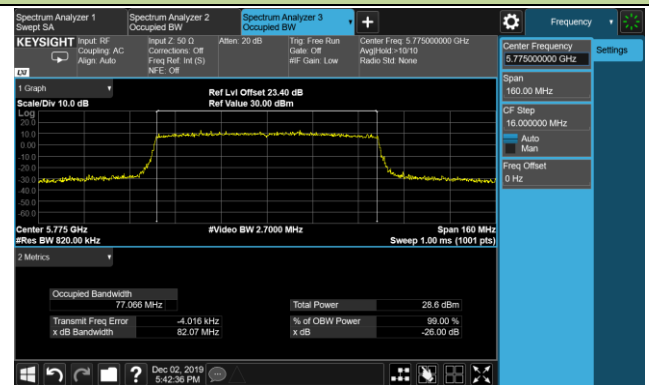


## 802.11ax-HE80 26dB Bandwidth & 99% Bandwidth - Ant 0 / Ant 0 + 1 + 2 + 3

### Channel 42 (5210MHz)



### Channel 155 (5775MHz)



### 7.3. 6dB Bandwidth Measurement

#### 7.3.1. Test Limit

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

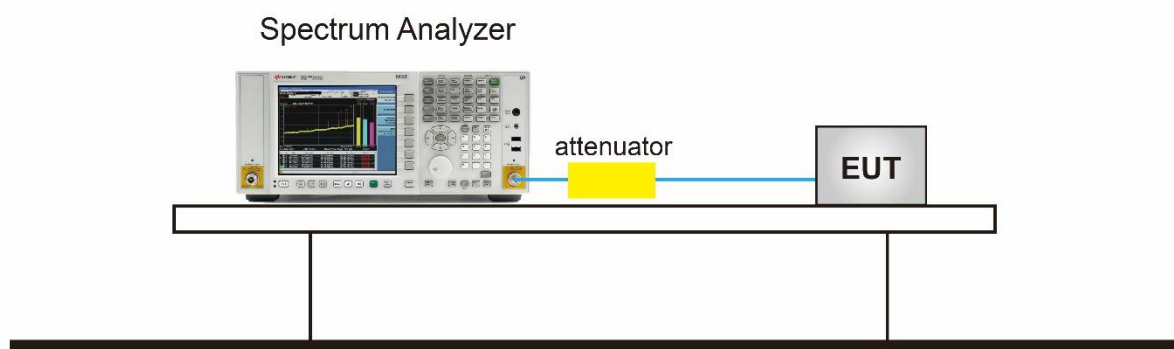
#### 7.3.2. Test Procedure used

KDB 789033 D02v02r01 - Section C.2

#### 7.3.3. Test Setting

1. Set center frequency to the nominal EUT channel center frequency.
2. RBW = 100 kHz.
3. VBW  $\geq 3 \times$  RBW.
4. Detector = Peak.
5. Trace mode = max hold.
6. Sweep = auto couple.
7. Allow the trace to stabilize.
8. Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

#### 7.3.4. Test Setup



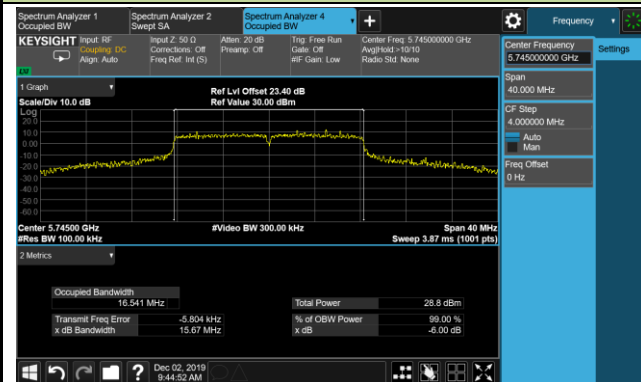
### 7.3.5. Test Result

|               |           |                   |                         |
|---------------|-----------|-------------------|-------------------------|
| Product       | GigaSpire | Temperature       | 22 ~ 25°C               |
| Test Engineer | David Lv  | Relative Humidity | 46 ~ 59%                |
| Test Site     | TR3       | Test Date         | 2019/12/02 ~ 2019/12/07 |

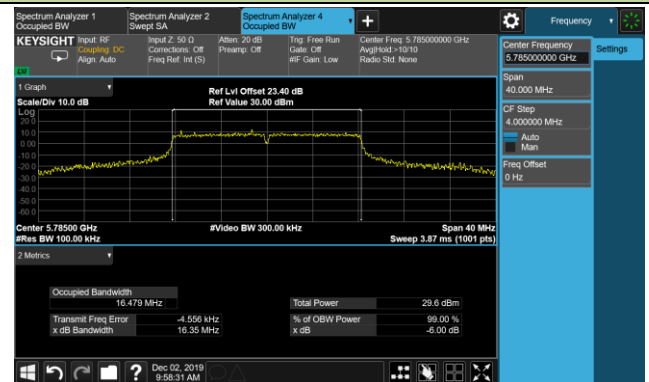
| Test Mode                 | Data Rate/<br>MCS | Channel No. | Frequency<br>(MHz) | 6dB Bandwidth<br>(MHz) | Limit<br>(MHz) | Result |
|---------------------------|-------------------|-------------|--------------------|------------------------|----------------|--------|
| Ant 0 / Ant 0 + 1 + 2 + 3 |                   |             |                    |                        |                |        |
| 802.11a                   | 6Mbps             | 149         | 5745               | 15.67                  | ≥ 0.5          | Pass   |
| 802.11a                   | 6Mbps             | 157         | 5785               | 16.35                  | ≥ 0.5          | Pass   |
| 802.11a                   | 6Mbps             | 165         | 5825               | 16.06                  | ≥ 0.5          | Pass   |
| 802.11n-HT20              | MCS0              | 149         | 5745               | 17.66                  | ≥ 0.5          | Pass   |
| 802.11n-HT20              | MCS0              | 157         | 5785               | 17.59                  | ≥ 0.5          | Pass   |
| 802.11n-HT20              | MCS0              | 165         | 5825               | 17.19                  | ≥ 0.5          | Pass   |
| 802.11n-HT40              | MCS0              | 151         | 5755               | 36.32                  | ≥ 0.5          | Pass   |
| 802.11n-HT40              | MCS0              | 159         | 5795               | 36.39                  | ≥ 0.5          | Pass   |
| 802.11ac-VHT20            | MCS0              | 149         | 5745               | 17.63                  | ≥ 0.5          | Pass   |
| 802.11ac-VHT20            | MCS0              | 157         | 5785               | 17.66                  | ≥ 0.5          | Pass   |
| 802.11ac-VHT20            | MCS0              | 165         | 5825               | 17.66                  | ≥ 0.5          | Pass   |
| 802.11ac-VHT40            | MCS0              | 151         | 5755               | 36.38                  | ≥ 0.5          | Pass   |
| 802.11ac-VHT40            | MCS0              | 159         | 5795               | 35.17                  | ≥ 0.5          | Pass   |
| 802.11ac-VHT80            | MCS0              | 155         | 5775               | 72.75                  | ≥ 0.5          | Pass   |
| 802.11ax-HE20             | MCS0              | 149         | 5745               | 19.03                  | ≥ 0.5          | Pass   |
| 802.11ax-HE20             | MCS0              | 157         | 5785               | 18.88                  | ≥ 0.5          | Pass   |
| 802.11ax-HE20             | MCS0              | 165         | 5825               | 18.95                  | ≥ 0.5          | Pass   |
| 802.11ax-HE40             | MCS0              | 151         | 5755               | 37.89                  | ≥ 0.5          | Pass   |
| 802.11ax-HE40             | MCS0              | 159         | 5795               | 37.49                  | ≥ 0.5          | Pass   |
| 802.11ax-HE80             | MCS0              | 155         | 5775               | 77.51                  | ≥ 0.5          | Pass   |

## 802.11a 6dB Bandwidth - Ant 0 / Ant 0 + 1 + 2 + 3

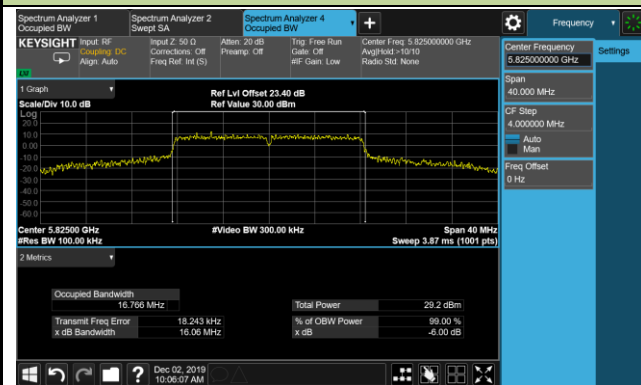
### Channel 149 (5745MHz)



### Channel 157 (5785MHz)

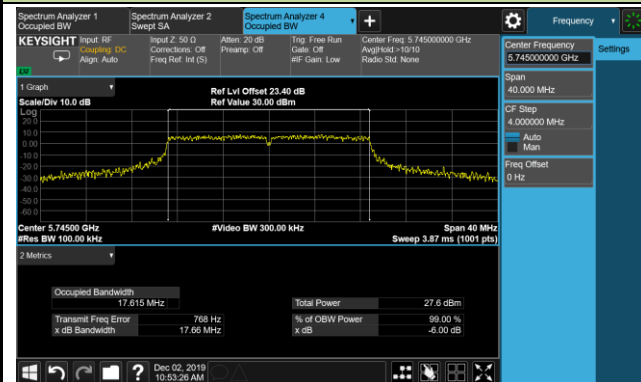


### Channel 165 (5825MHz)

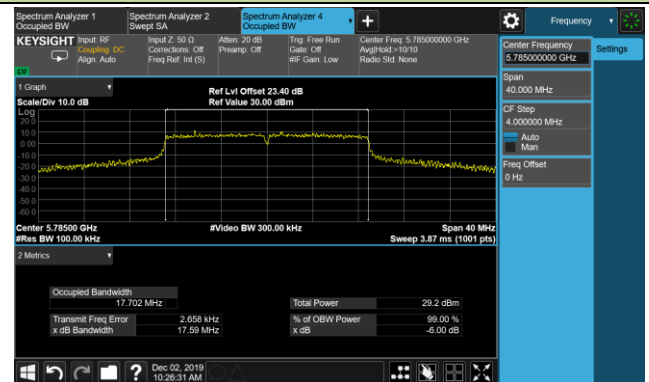


## 802.11n-HT20 6dB Bandwidth - Ant 0 / Ant 0 + 1 + 2 + 3

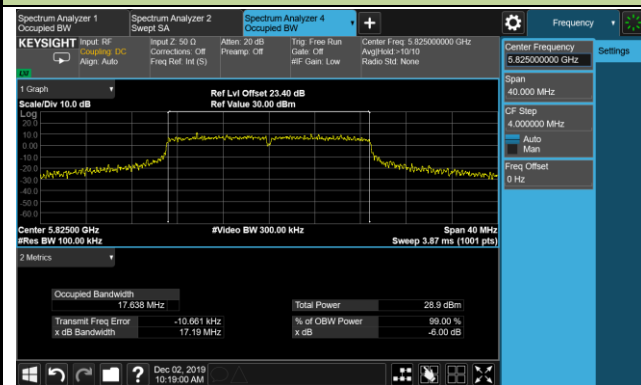
### Channel 149 (5745MHz)



### Channel 157 (5785MHz)

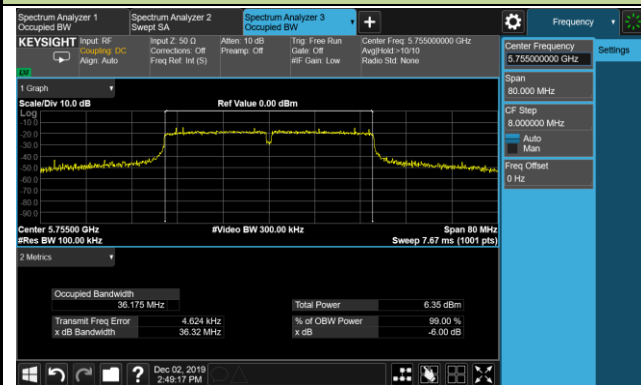


### Channel 165 (5825MHz)

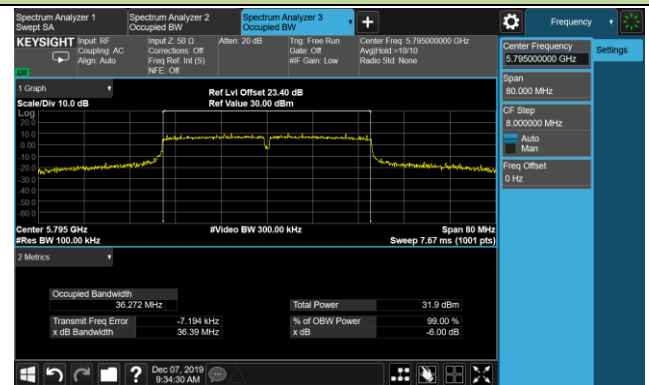


## 802.11n-HT40 6dB Bandwidth - Ant 0 / Ant 0 + 1 + 2 + 3

### Channel 151 (5755MHz)

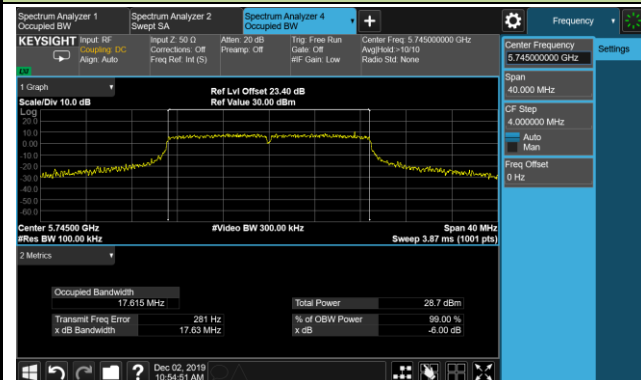


### Channel 159 (5795MHz)

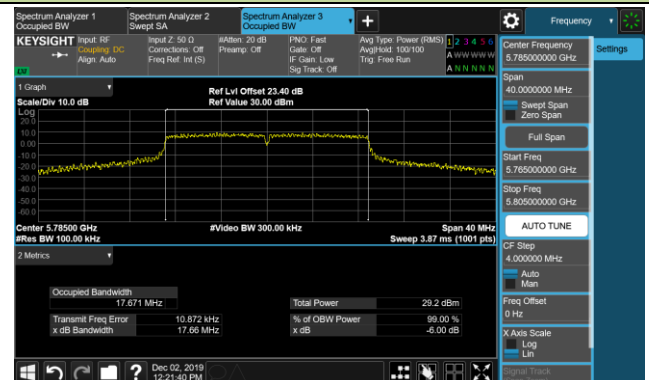


## 802.11ac-VHT20 6dB Bandwidth - Ant 0 / Ant 0 + 1 + 2 + 3

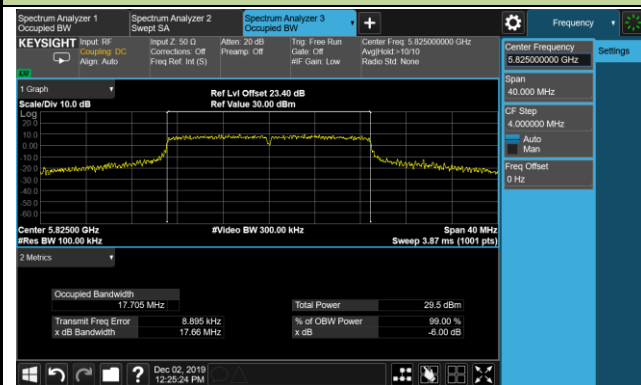
## Channel 149 (5745MHz)



## Channel 157 (5785MHz)

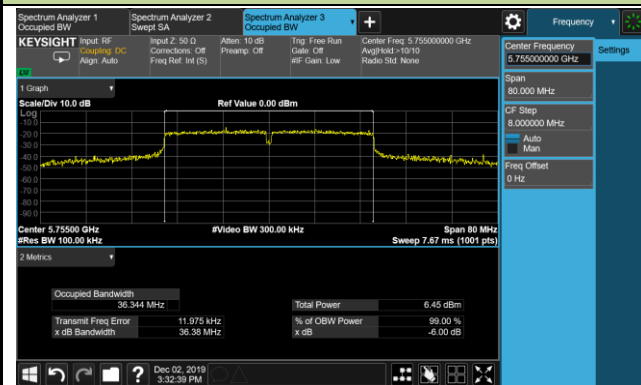


## Channel 165 (5825MHz)

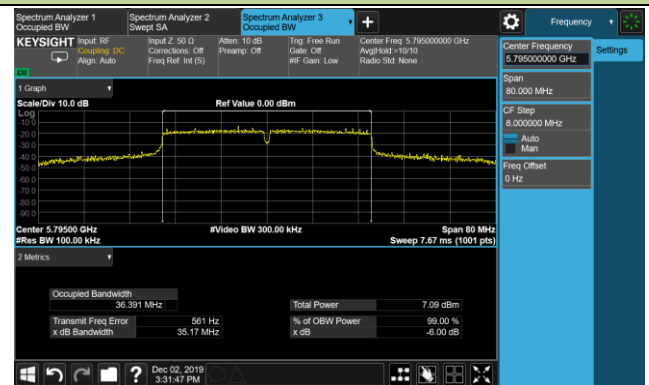


## 802.11ac-VHT40 6dB Bandwidth - Ant 0 / Ant 0 + 1 + 2 + 3

## Channel 151 (5755MHz)



## Channel 159 (5795MHz)



# 802.11ac-VHT80 6dB Bandwidth - Ant 0 / Ant 0 + 1 + 2 + 3

## Channel 155 (5775MHz)

