MEASUREMENT REPORT

FCC PART 15.407 / RSS-247 WLAN 802.11a/n

FCC ID:	2ACS5-YUNFBD
IC:	11554B-YUNFBD
APPLICANT:	Yuneec Technology Co., Limited

Application Type:	Certification
Product:	Firebird FPV
Model No.:	YUNFBD
Brand Name:	YUNEEC
FCC Classification:	Unlicensed National Information Infrastructure (NII)
FCC Rule Part(s):	Part 15.407
IC Rule(s):	RSS-247 Issue 2, RSS-GEN Issue 4
Test Procedure(s):	ANSI C63.10-2013, KDB 789033 D02v02r01
Test Date:	October 21, 2017 ~ January 31, 2018

Reviewed By : Paddy Chen
(Paddy Chen)

Approved By : Chenz Ker
(Chenz Ker)

Testing Laboratory
3261

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 (Taiwan) Co., Ltd.

Revision History

Report No.	Version	Description	Issue Date	Note
1711TW0109-U2	Rev. 01	Initial Report	01-31-2018	Valid

CONTENTS

Description Page

§2.1033 General Information 5

1. INTRODUCTION 6

1.1. Scope 6
1.2. MRT Test Location 6

2. PRODUCT INFORMATION 7

2.1. Equipment Description 7
2.2. Product Specification Subjective to this Report 7
2.3. Working Frequencies for this report 7
2.4. Description of Available Antennas 7
2.5. Description of Antenna RF Port 8
2.6. Test Mode 8
2.7. Description of Test Software 9
2.8. Device Capabilities 10
2.9. Test Configuration 10
2.10. EMI Suppression Device(s)/Modifications 10
2.11. Labeling Requirements 11

3. DESCRIPTION OF TEST 12

3.1. Evaluation Procedure 12
3.2. AC Line Conducted Emissions 12
3.3. Radiated Emissions 13

4. ANTENNA REQUIREMENTS 14

5. TEST EQUIPMENT CALIBRATION DATE 15

6. MEASUREMENT UNCERTAINTY 16

7. TEST RESULT 17

7.1. Summary 17
7.2. 26dB Bandwidth Measurement 19
7.2.1. Test Limit 19
7.2.2. Test Procedure used 19
7.2.3. Test Setting 19
7.2.4. Test Setup 19
7.2.5. Test Result 20
7.3. 6dB Bandwidth Measurement 24
7.3.1. Test Limit 24

7.3.2. Test Procedure used 24
7.3.3. Test Setting 24
7.3.4. Test Setup 24
7.3.5. Test Result 25
7.4. Output Power Measurement 29
7.4.1. Test Limit 29
7.4.2. Test Procedure Used 29
7.4.3. Test Setting 29
7.4.4. Test Setup 30
7.4.5. Test Result 30
7.5. Power Spectral Density Measurement 32
7.5.1. Test Limit 32
7.5.2. Test Procedure Used 32
7.5.3. Test Setting 32
7.5.4. Test Setup 33
7.5.5. Test Result 34
7.6. Frequency Stability Measurement 40
7.6.1. Test Limit 40
7.6.2. Test Procedure Used 40
7.6.3. Test Setup 41
7.6.4. Test Result 42
7.7. Radiated Spurious Emission Measurement 43
7.7.1. Test Limit 43
7.7.2. Test Procedure Used 43
7.7.3. Test Setting 44
7.7.4. Test Setup 45
7.7.5. Test Result 47
7.8. Radiated Restricted Band Edge Measurement 67
7.8.1. Test Limit 67
7.8.2. Test Result 71
7.9. AC Conducted Emissions Measurement 95
7.9.1. Test Limit 95
7.9.2. Test Setup 95
7.9.3. Test Result 95

8. CONCLUSION 96

§2.1033 General Information

Applicant:	Yuneec Technology Co., Limited
Applicant Address:	2/F Man Shung Industrial Building, 7 Lai Yip Street, Kwun Tong, Hong Kong
Manufacturer:	Yuneec International (China) Co., Ltd.
Manufacturer Address:	No.388 East Zhengwei Road, Jinxi Town, Kunshan, Jiangsu 215324, China
Test Site:	MRT Technology (Taiwan) Co., Ltd
Test Site Address:	No. 38, Fuxing Second Rd., Guishan Dist., Taoyuan City 333, Taiwan (R.O.C)
FCC Registration No.:	153292
IC Registration No.:	21723
Test Device Serial No.:	N/A ☐ Production ☒ Pre-Production ☐ Engineering

Test Facility / Accreditations

Measurements were performed at MRT Laboratory located in Fuxing Rd., Taoyuan, Taiwan (R.O.C)

- **MRT facility is a FCC registered (Reg. No. 153292) test facility with the site description report on file and is designated by the FCC as an Accredited Test Film.**
- **MRT facility is an IC registered (MRT Reg. No. 21723-1) test laboratory with the site description on file at Industry Canada.**
- **MRT Lab is accredited to ISO 17025 by the American Association for Laboratory Accreditation (TAF) under the American Association for Laboratory Accreditation Program (TAF Cert. No. 3261) in EMC, Telecommunications and Radio testing for FCC, Industry Taiwan, EU and TELEC Rules.**

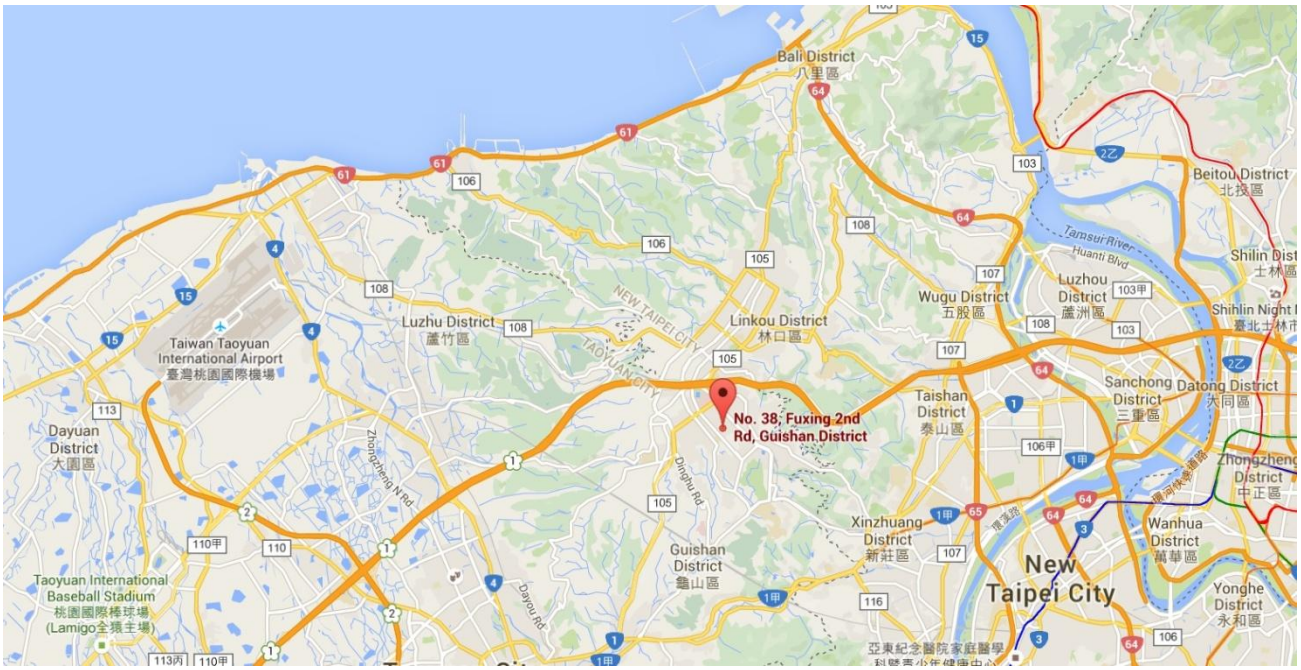
1. INTRODUCTION

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 Industry Canada Certification and Engineering Bureau.

1.2. MRT Test Location

The map below shows the location of the MRT LABORATORY, its proximity to the Taoyuan City. These measurement tests were conducted at the MRT Technology (Taiwan) Co., Ltd. Facility located at No.38, Fuxing 2nd Rd., Guishan Dist., Taoyuan City 33377, Taiwan (R.O.C).



2. PRODUCT INFORMATION

2.1. Equipment Description

Product Name	Firebird FPV
Model No.	YUNFBD
Brand Name	YUNEEC
Wi-Fi Specification	802.11a/n-HT20
ZigBee Specification	802.15.4

2.2. Product Specification Subjective to this Report

Frequency Range	802.11a/n-HT20: 5180~5240MHz, 5745~5825MHz
Type of Modulation	802.11a/n-HT20: OFDM
Data Rate:	802.11a: 6/9/12/18/24/36/48/54Mbps 802.11n-HT20: up to 144.4Mbps

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

2.3. Working Frequencies for this report

802.11a/n-HT20

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

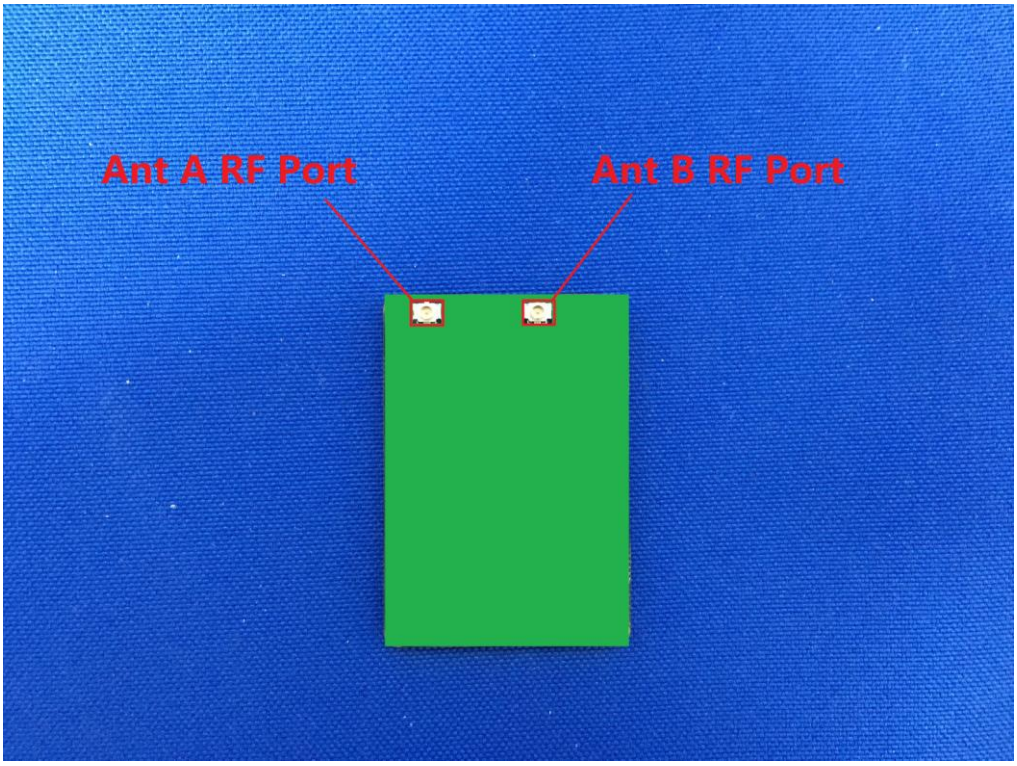
Note: Frequency range 5180 ~ 5240MHz was not used in Canada due to UNII-1 is restricted to indoor use only in Canada.

2.4. Description of Available Antennas

Antenna Type	Manufacturer	Frequency Band (MHz)	Max Peak Gain (dBi)
Omni-directional Antenna	Cortec Technology Inc.	2400 ~ 2483.5	1.5
Omni-directional Antenna	Yuneec International (China) Co., Ltd.	5180 ~ 5240	3.0
		5745 ~ 5825	3.0

2.5. Description of Antenna RF Port

Antenna RF Port		
--	5GHz RF Port	
Software Control Port	Ant A	Ant B



2.6. Test Mode

Test Mode	Mode 1: Transmit by 802.11a
	Mode 2: Transmit by 802.11n-HT20

2.7. Description of Test Software

The test utility software used during testing was engineering directive ordered by applicant.

Mode	Channel No.	Frequency (MHz)	Power Parameter Value		
			SISO Mode	MIMO Mode	
			Ant A	Ant A	Ant B
802.11a	36	5180	47.0	--	--
	44	5220	49.0	--	--
	48	5240	49.0	--	--
	149	5745	40.0	--	--
	157	5785	41.0	--	--
	165	5825	41.0	--	--
802.11n-HT20	36	5180	47.0	47.0	48.0
	44	5220	48.0	54.0	45.0
	48	5240	48.0	55.0	42.0
	149	5745	41.0	47.0	48.0
	157	5785	40.0	45.0	47.0
	165	5825	39.0	46.0	46.0

2.8. Device Capabilities

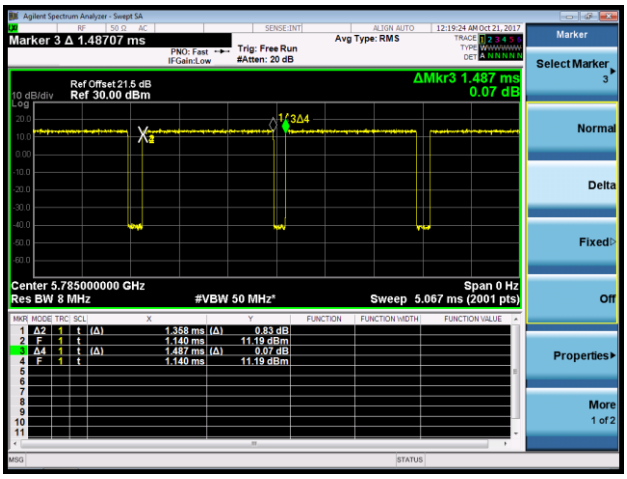
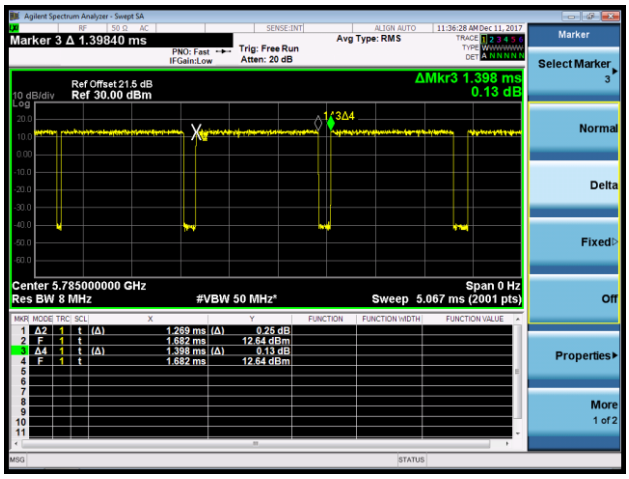
This device contains the following capabilities:

2.4GHz ZigBee (DTS), 5GHz WLAN (NII)

Note: 5GHz (UNII) operation is possible in 20MHz 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.

The duty cycles are as follows:

Test Mode	Duty Cycle
802.11a	91.32 %
802.11n-HT20	90.77 %

802.11a - T = 1.358 ms	802.11n-HT20 - T = 1.269 ms
	

2.9. Test Configuration

The device was tested per the guidance of KDB 789033 D02v02r01. ANSI C63.10-2013 was used to reference the appropriate EUT setup for radiated spurious emissions testing and AC line conducted testing.

2.10. EMI Suppression Device(s)/Modifications

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

2.11. 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 pamphlet 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 for Testing Unlicensed Wireless Devices (ANSI C63.10-2013), and the guidance provided in KDB 789033 D02v02r01 were used in the measurement.

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, remote controlled, 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 **Firebird FPV** 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	MRTTWA00045	1 year	2018/03/17
Two-Line V-Network	R&S	ENV216	MRTTWA00019	1 year	2018/03/23
Two-Line V-Network	R&S	ENV216	MRTTWA00020	1 year	2018/03/23
Temperature/Humidity Meter	TFA	35.1078.10.IT	MRTTWA00033	1 year	2018/06/08

Radiated Emissions - AC1

Instrument	Manufacturer	Type No.	Asset No.	Cali. Interval	Cali. Due Date
Signal Analyzer	R&S	FSV40	MRTTWA00007	1 year	2018/03/02
EMI Test Receiver	R&S	ESR3	MRTTWA00009	1 year	2018/03/16
Broadband Preamplifier	SCHWARZBECK	BBV 9718	MRTTWA00005	1 year	2018/04/06
Broadband Amplifier	SCHWARZBECK	BBV 9721	MRTTWA00006	1 year	2018/04/06
Acitve Loop Antenna	SCHWARZBECK	FMZB 1519B	MRTTWA00002	1 year	2018/04/06
Broadband TRILOG Antenna	SCHWARZBECK	VULB 9162	MRTTWA00001	1 year	2018/04/06
Broadband Hornantenna	SCHWARZBECK	BBHA 9120D	MRTTWA00003	1 year	2018/04/06
Breitband Hornantenna	SCHWARZBECK	BBHA 9170	MRTTWA00004	1 year	2018/04/06
Temperature/Humidity Meter	TFA	35.1078.10.IT	MRTTWA00033	1 year	2018/06/08

Conducted Test Equipment - SR1

Instrument	Manufacturer	Type No.	Asset No.	Cali. Interval	Cali. Due Date
EXA Signal Analyzer	KEYSIGHT	N9010A	MRTTWA00012	1 year	2018/07/10
X-Series USB Peak and Average Power Sensor	KEYSIGHT	U2021XA	MRTTWA00014	1 year	2018/03/18
X-Series USB Peak and Average Power Sensor	KEYSIGHT	U2021XA	MRTTWA00015	1 year	2018/03/18
Programmable Temperature & Humidity Chamber	TEN BILLION	TTH-B3UP	MRTTWA00036	1 year	2018/05/11
Temperature/Humidity Meter	TFA	35.1078.10.IT	MRTTWA00033	1 year	2018/06/08

Software	**Version**	**Function**
e3	V 8.3.5	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.

AC Conducted Emission Measurement - SR1
Measuring Uncertainty for a Level of Confidence of 95% (U=2Uc(y)): 150kHz~30MHz: 3.46dB
Radiated Emission Measurement - AC1
Measuring Uncertainty for a Level of Confidence of 95% (U=2Uc(y)): 9kHz ~ 1GHz: 4.18dB 1GHz ~ 40GHz: 4.76dB

7. TEST RESULT

7.1. Summary

Company Name: **Yuneec Technology Co., Limited**

FCC ID: **2ACS5-YUNFBD**

IC: **11554B-YUNFBD**

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	≥ 500kHz		Pass	Section 7.3
15.407(a)(1)(iii), (3)	Maximum Conducted Output Power	Refer to section 7.4		Pass	Section 7.4
15.407(a)(1)(iii), (3), (5)	Peak Power Spectral Density	Refer to section 7.5		Pass	Section 7.5
15.407(g)	Frequency Stability	N/A		Pass	Section 7.6
15.407(b)(1), (4)(i)	Undesirable Emissions	≤ -27dBm/MHz EIRP Detail see section 7.8	Radiated	Pass	Section 7.7 & 7.8
15.205, 15.209 15.407(b)(5), (6), (7)	General Field Strength Limits (Restricted Bands and Radiated Emission Limits)	Emissions in restricted bands must meet the radiated limits detailed in 15.209		Pass	
15.207	AC Conducted Emissions 150kHz - 30MHz	< FCC 15.207 limits	Line Conducted	Pass	Section 7.9

RSS Section(s)	Test Description	Test Limit	Test Condition	Test Result	Reference
RSS-247 §6.2	99% Bandwidth	N/A	Conducted	Pass	Section 7.2
RSS-247 §6.2.4	6dB Bandwidth	>500kHz		Pass	Section 7.3
RSS-247 §6.2.4	Max Conducted Output Power	Refer to section 7.4		Pass	Section 7.4
RSS-247 §6.2.4	Peak Power Spectral Density	Refer to section 7.5		Pass	Section 7.5
RSS-Gen [8.11]	Frequency Stability	N/A		Pass	Section 7.6
RSS-247 §6.2.4	Out-of-Band Emissions	Refer to section 7.8	Radiated	Pass	Section 7.7 & 7.8
RSS-247 §6.2.4	General Field Strength Limits (Restricted Bands and Radiated Emission Limits)	Emissions in restricted bands must meet the radiated limits detailed in RSS-Gen [8.9]		Pass	
RSS-Gen [8.8]	AC Conducted Emissions 150kHz - 30MHz	≤ RSS-Gen [8.8] Limit	Line Conducted	Pass	Section 7.9

Notes:

1) All channels, modes, and modulations/data rates were investigated among all UNII bands. The test results shown in the following sections represent the worst case emissions.
2) 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.

7.2. 26dB Bandwidth Measurement

7.2.1.Test Limit

N/A

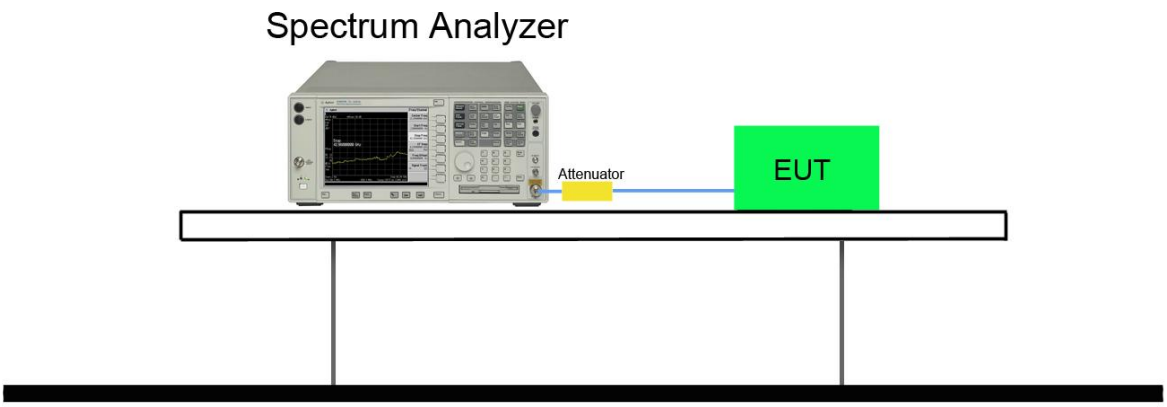
7.2.2.Test Procedure used

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 ≥ 3 × RBW.
4. Detector = Peak.
5. Trace mode = max hold.

7.2.4.Test Setup



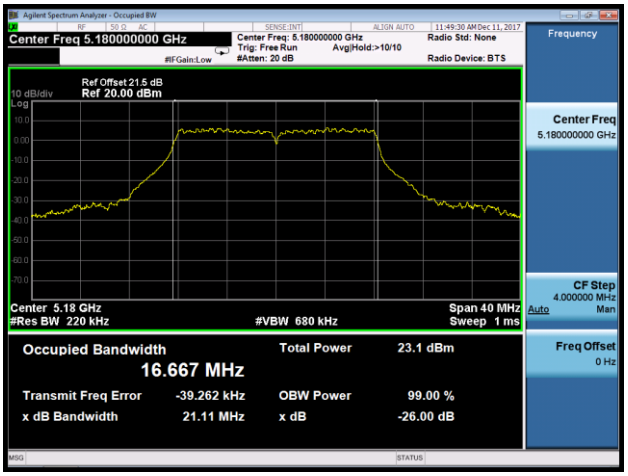
7.2.5.Test Result

Product	Firebird FPV	Temperature	24°C
Test Engineer	Kevin Ker	Relative Humidity	59%
Test Site	SR1	Test Date	2017/12/11

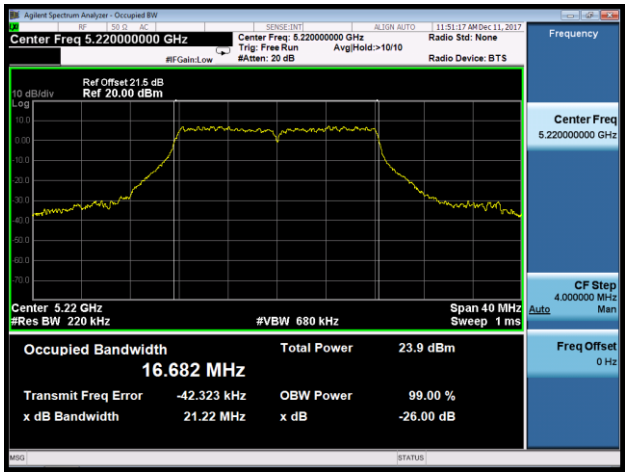
Test Mode	Data Rate (Mbps)	Channel No.	Frequency (MHz)	26dB Bandwidth (MHz)	99% Bandwidth (MHz)
Ant A					
802.11a	6	36	5180	21.11	16.67
802.11a	6	44	5220	21.22	16.68
802.11a	6	48	5240	21.01	16.66
802.11a	6	149	5745	21.35	16.70
802.11a	6	157	5785	21.14	16.73
802.11a	6	165	5825	21.37	16.73
802.11n-HT20	MCS0	36	5180	21.57	17.79
802.11n-HT20	MCS0	44	5220	21.65	17.80
802.11n-HT20	MCS0	48	5240	21.59	17.80
802.11n-HT20	MCS0	149	5745	21.70	17.80
802.11n-HT20	MCS0	157	5785	21.77	17.79
802.11n-HT20	MCS0	165	5825	21.71	17.79
Ant A / Ant A + B					
802.11n-HT20	MCS0	36	5180	21.60	17.82
802.11n-HT20	MCS0	44	5220	21.56	17.79
802.11n-HT20	MCS0	48	5240	21.65	17.75
802.11n-HT20	MCS0	149	5745	21.48	17.78
802.11n-HT20	MCS0	157	5785	21.52	17.75
802.11n-HT20	MCS0	165	5825	21.44	17.74

802.11a 26dB Bandwidth & 99% Bandwidth - Ant A

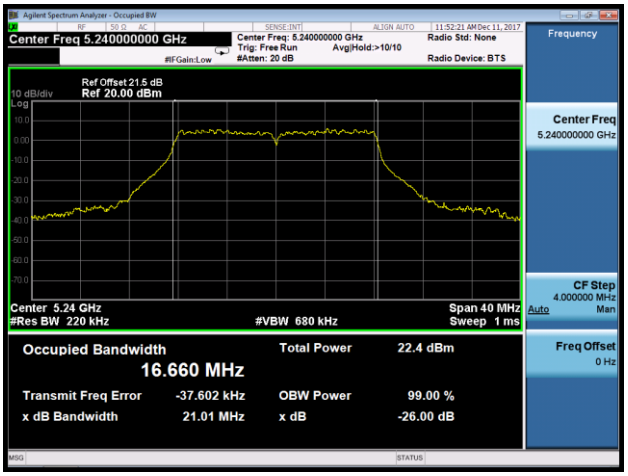
Channel 36 (5180MHz)



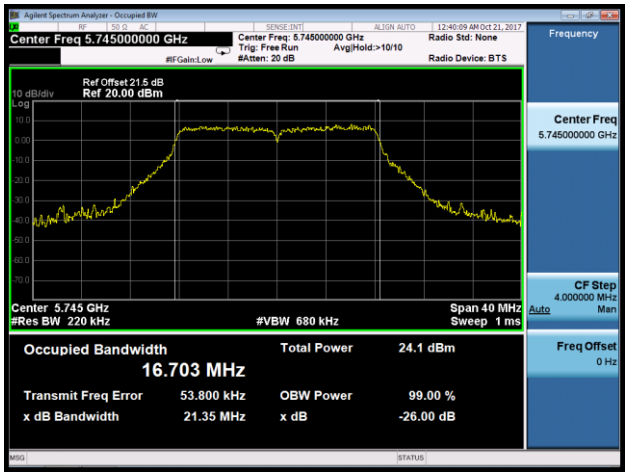
Channel 44 (5220MHz)



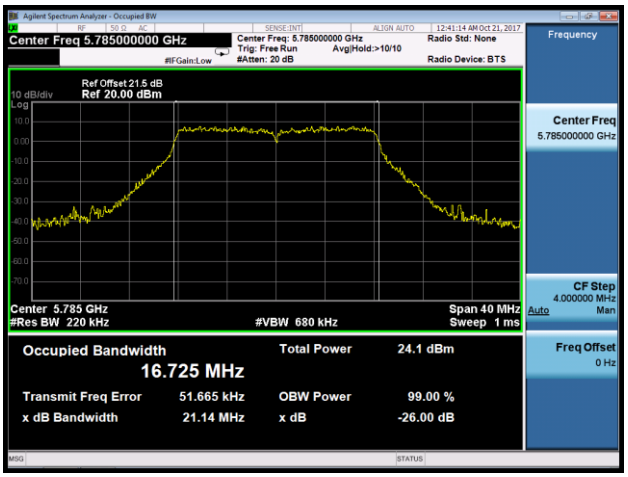
Channel 48 (5240MHz)



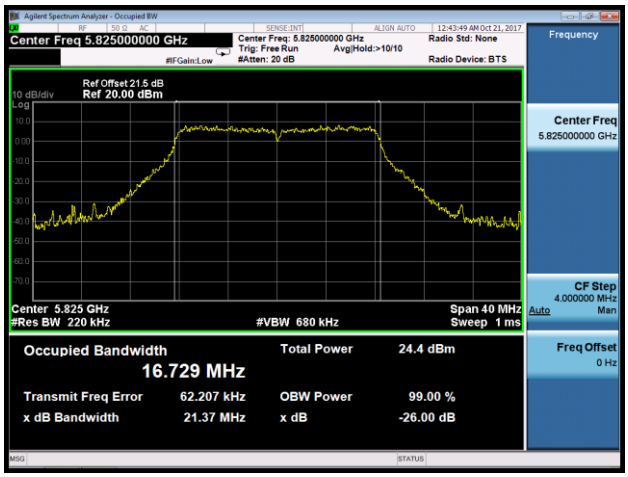
Channel 149 (5745MHz)



Channel 157 (5785MHz)

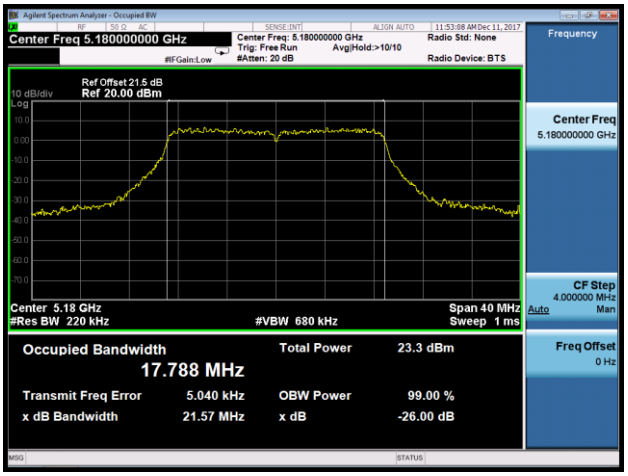


Channel 165 (5825MHz)

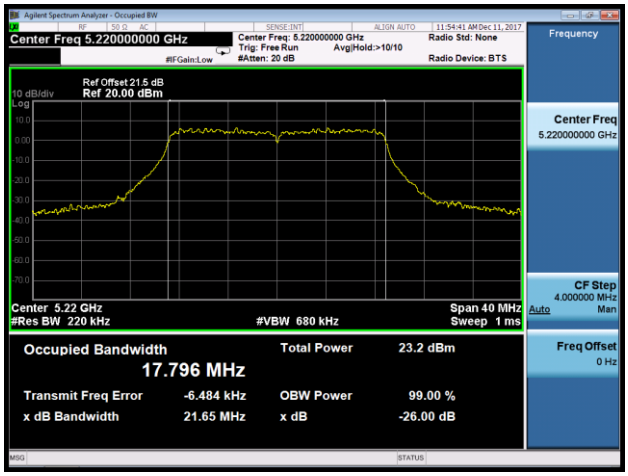


802.11n-HT20 26dB Bandwidth & 99% Bandwidth - Ant A

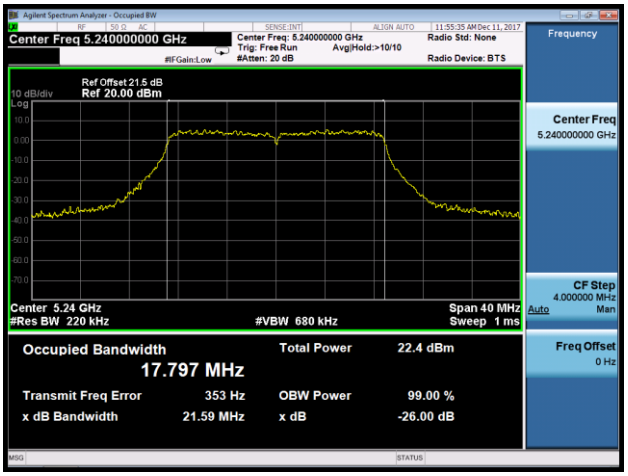
Channel 36 (5180MHz)



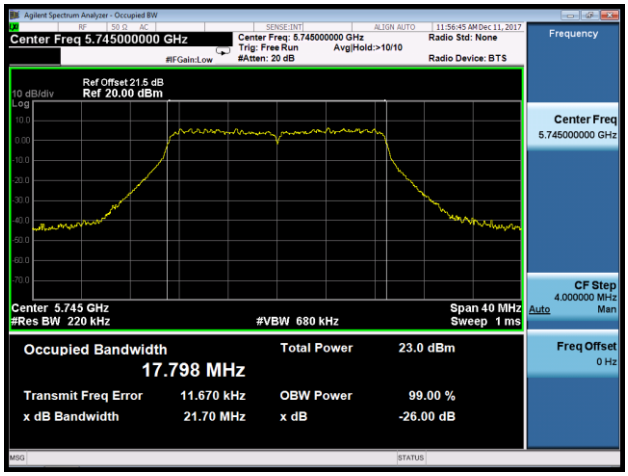
Channel 44 (5220MHz)



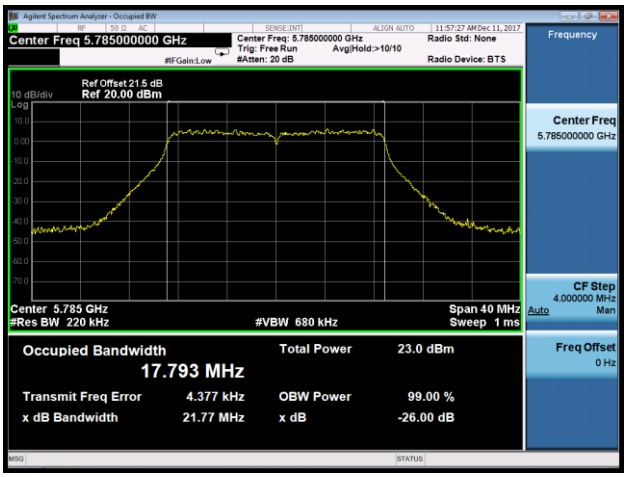
Channel 48 (5240MHz)



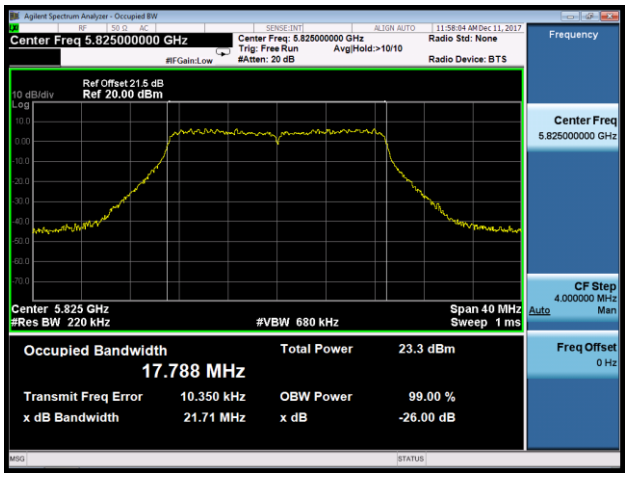
Channel 149 (5745MHz)



Channel 157 (5785MHz)

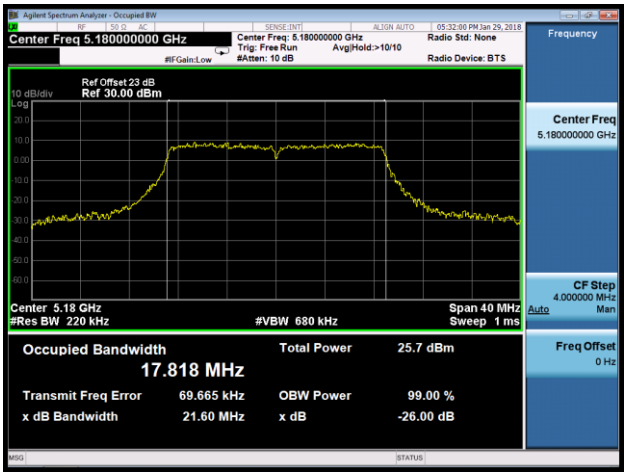


Channel 165 (5825MHz)

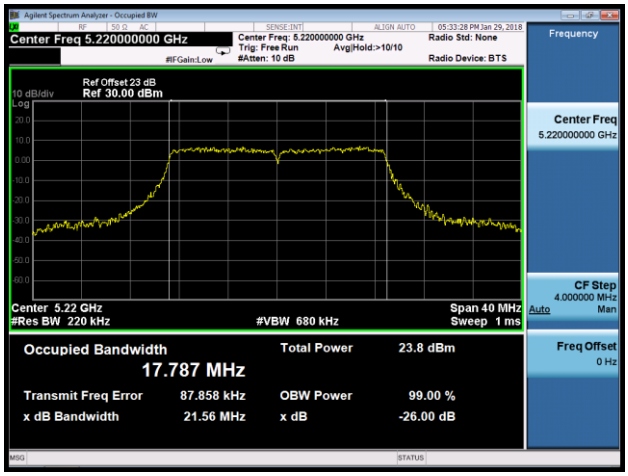


802.11n-HT20 26dB Bandwidth & 99% Bandwidth - Ant A / Ant A + B

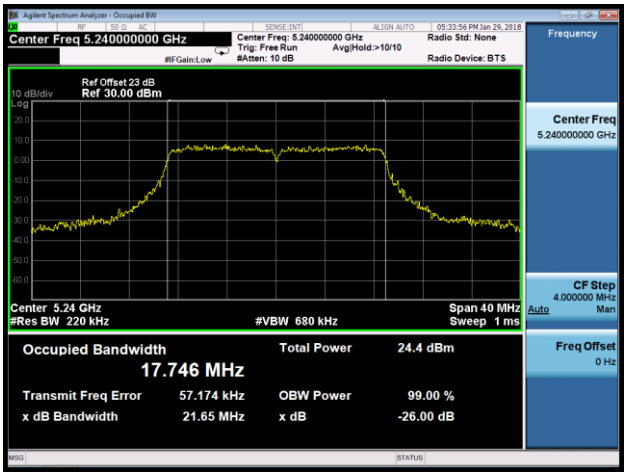
Channel 36 (5180MHz)



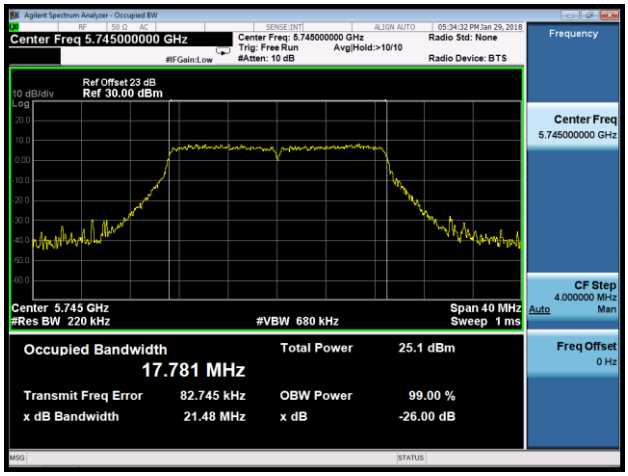
Channel 44 (5220MHz)



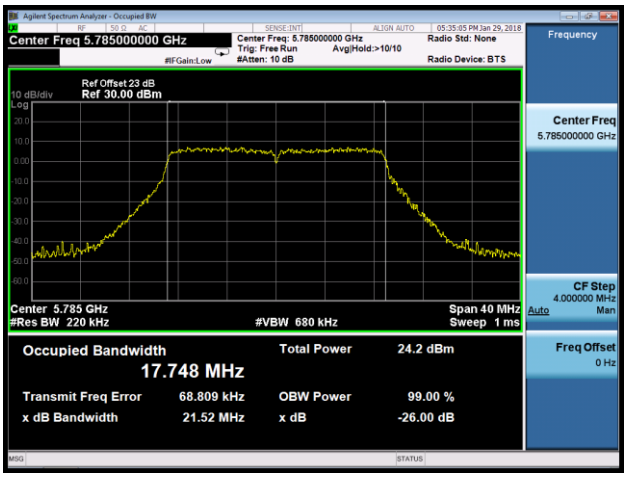
Channel 48 (5240MHz)



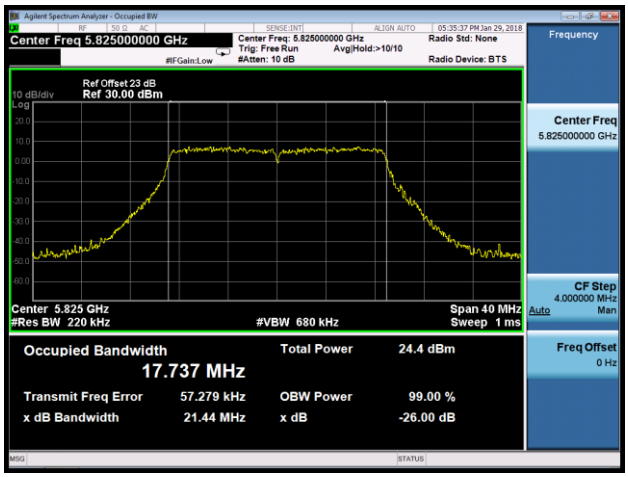
Channel 149 (5745MHz)



Channel 157 (5785MHz)



Channel 165 (5825MHz)



7.3. 6dB Bandwidth Measurement

7.3.1.Test Limit

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

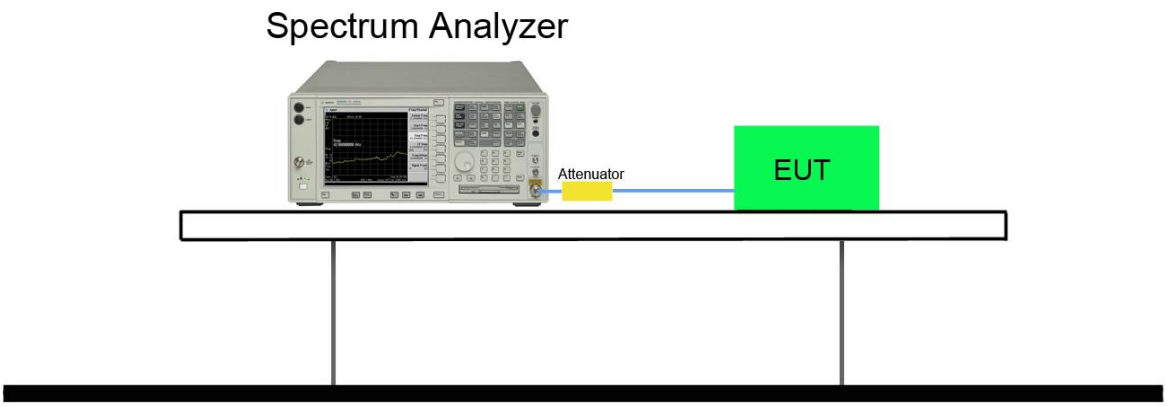
7.3.2.Test Procedure used

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 ≥ 3 × 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.

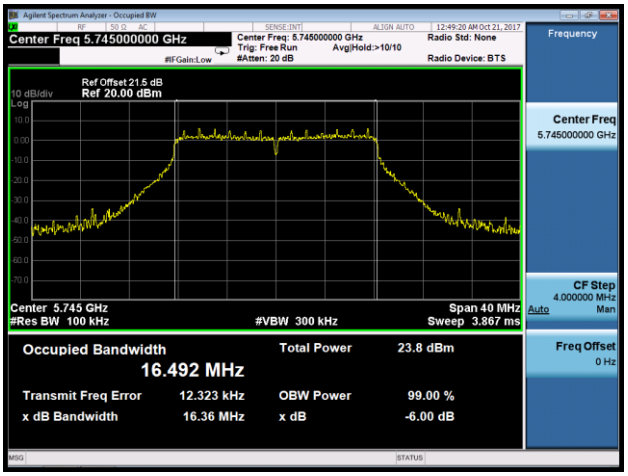
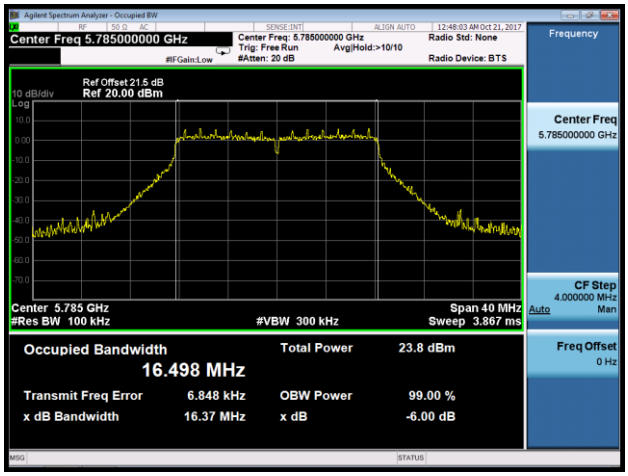
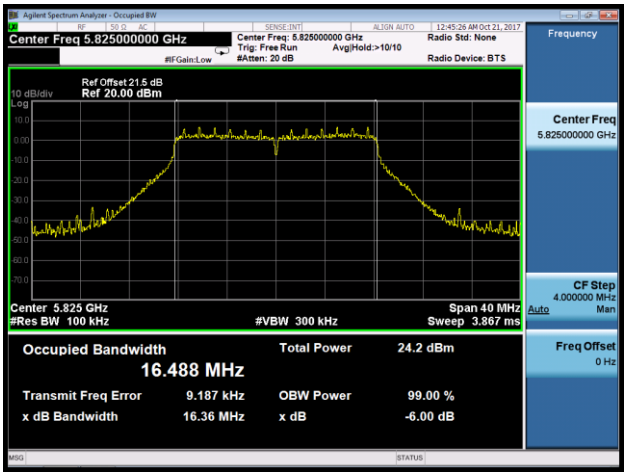
7.3.4.Test Setup

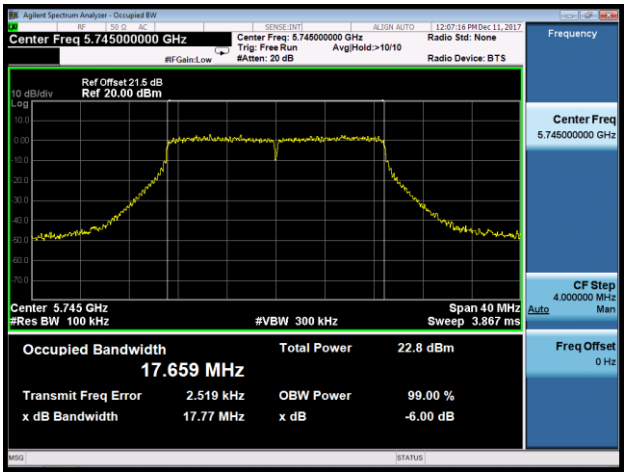
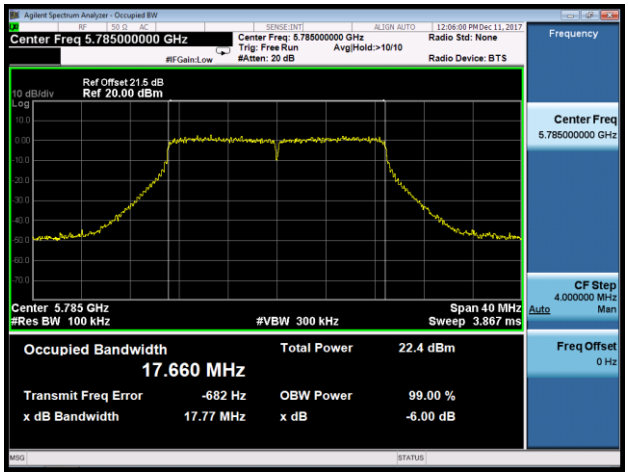
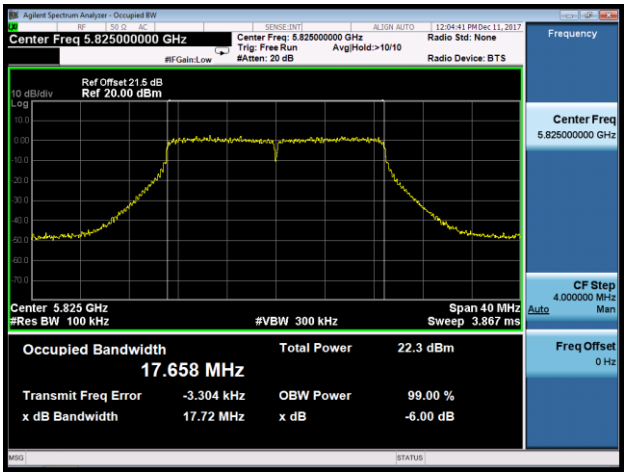


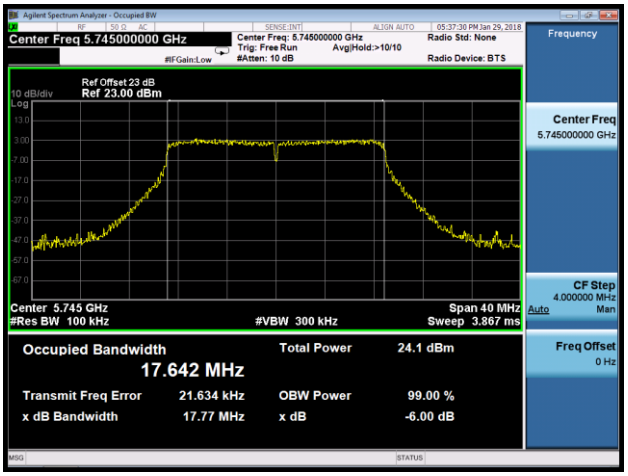
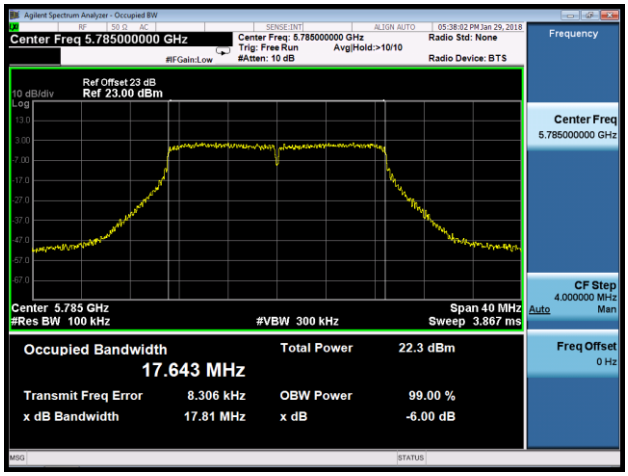
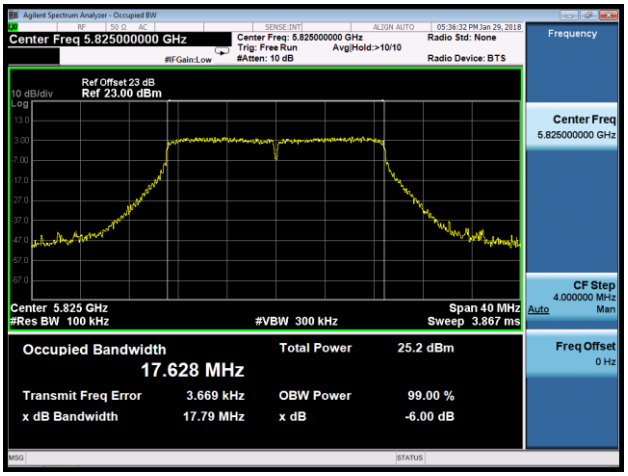
7.3.5.Test Result

Product	Firebird FPV	Temperature	24°C
Test Engineer	Kevin Ker	Relative Humidity	59%
Test Site	SR1	Test Date	2017/10/21

Test Mode	Data Rate (Mbps)	Channel No.	Frequency (MHz)	6dB Bandwidth (MHz)	Limit (MHz)	Result
Ant A						
802.11a	6	149	5745	16.36	≥ 0.5	Pass
802.11a	6	157	5785	16.37	≥ 0.5	Pass
802.11a	6	165	5825	16.36	≥ 0.5	Pass
802.11n-HT20	MCS0	149	5745	17.77	≥ 0.5	Pass
802.11n-HT20	MCS0	157	5785	17.77	≥ 0.5	Pass
802.11n-HT20	MCS0	165	5825	17.72	≥ 0.5	Pass
Ant A / Ant A + B						
802.11n-HT20	MCS0	149	5745	17.77	≥ 0.5	Pass
802.11n-HT20	MCS0	157	5785	17.81	≥ 0.5	Pass
802.11n-HT20	MCS0	165	5825	17.79	≥ 0.5	Pass

802.11a 6dB Bandwidth - Ant A	
Channel 149 (5745MHz)	Channel 157 (5785MHz)
	
Channel 165 (5825MHz)	
	

802.11n-HT20 6dB Bandwidth - Ant A	
Channel 149 (5745MHz)	Channel 157 (5785MHz)
	
Channel 165 (5825MHz)	
	

802.11n-HT20 6dB Bandwidth - Ant A / Ant A + B	
Channel 149 (5745MHz)	Channel 157 (5785MHz)
	
Channel 165 (5825MHz)	
	

7.4. Output Power Measurement

7.4.1.Test Limit

For FCC

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. 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.

For the band 5.725-5.85 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W (30dBm). If transmitting antennas of directional gain greater than 6 dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

For IC

For the 5.725-5.85 GHz band, the maximum conducted output power shall not exceed 1 W.

If transmitting antennas of directional gain greater than 6dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi.

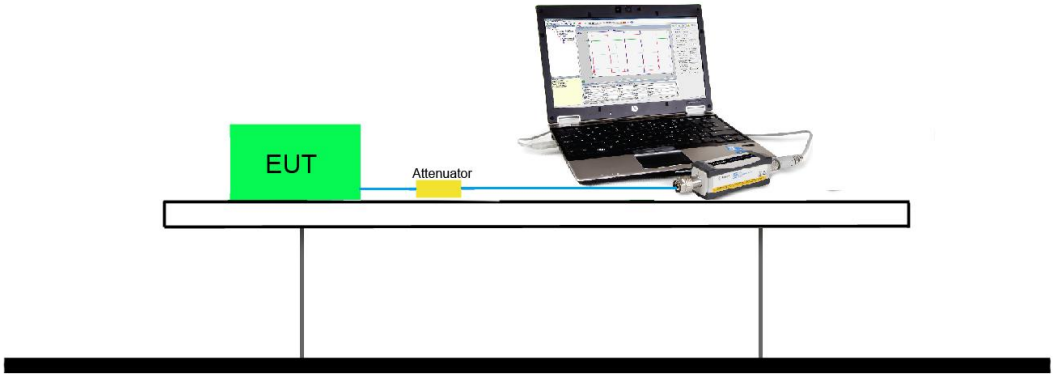
7.4.2.Test Procedure Used

KDB 789033 D02v02r01 - Section E) 3) b) Method PM-G

7.4.3.Test Setting

Average power measurements were perform only when the EUT was transmitting at its maximum power control level using a broadband power meter with a pulse sensor. The power meter implemented triggering and gating capabilities which were set up such that power measurements were recorded only during the ON time of the transmitter.

7.4.4.Test Setup



7.4.5.Test Result

Power output test was verified over all data rates of each mode shown as below table, and then choose the maximum power output (Gray Marker) for final test of each channel.

Output power at various data rates for Ant A port:

Test Mode	Frequency (MHz)	Data Rate (Mbps)	Average Power (dBm)
802.11a	5785	6	20.75
		24	20.24
		54	19.79
802.11n-HT20	5785	MCS0	20.83
		MCS3	20.39
		MCS7	19.82

Product	Firebird FPV	Temperature	22°C
Test Engineer	Kevin Ker	Relative Humidity	54%
Test Site	SR1	Test Date	2018/01/29
Test Item	FCC & IC Output Power		

Test Mode	Data Rate (Mbps)	Channel No.	Freq. (MHz)	Average Power (dBm)	Average Power Limit (dBm)	Result
Ant A						
802.11a	6	36	5180	20.73	≤ 30.00	Pass
802.11a	6	44	5220	20.85	≤ 30.00	Pass
802.11a	6	48	5240	20.81	≤ 30.00	Pass
802.11a	6	149	5745	20.73	≤ 30.00	Pass
802.11a	6	157	5785	20.75	≤ 30.00	Pass
802.11a	6	165	5825	20.92	≤ 30.00	Pass
802.11n-HT20	MCS0	149	5180	20.89	≤ 30.00	Pass
802.11n-HT20	MCS0	157	5220	20.84	≤ 30.00	Pass
802.11n-HT20	MCS0	165	5240	20.93	≤ 30.00	Pass
802.11n-HT20	MCS0	149	5745	20.73	≤ 30.00	Pass
802.11n-HT20	MCS0	157	5785	20.83	≤ 30.00	Pass
802.11n-HT20	MCS0	165	5825	20.89	≤ 30.00	Pass

Test Mode	Data Rate (Mbps)	Channel No.	Freq. (MHz)	Ant A Average Power (dBm)	Ant B Average Power (dBm)	Total Average Power (dBm)	Average Power Limit (dBm)	Result
Ant A + B								
802.11n-HT20	MCS0	149	5180	20.78	20.88	23.84	≤ 30.00	Pass
802.11n-HT20	MCS0	157	5220	20.85	20.76	23.82	≤ 30.00	Pass
802.11n-HT20	MCS0	165	5240	20.73	20.78	23.77	≤ 30.00	Pass
802.11n-HT20	MCS0	149	5745	20.76	20.96	23.87	≤ 30.00	Pass
802.11n-HT20	MCS0	157	5785	20.97	20.83	23.91	≤ 30.00	Pass
802.11n-HT20	MCS0	165	5825	20.88	20.96	23.93	≤ 30.00	Pass

Note: Total Average Power (dBm) = $10*\log\{10^{(\text{Ant A Average Power} / 10)} + 10^{(\text{Ant B Average Power} / 10)}\}$ (dBm).

7.5. Power Spectral Density Measurement

7.5.1.Test Limit

For FCC

For fixed point-to-point access points operating in the band 5.15-5.25 GHz, the maximum power spectral density shall not exceed 17 dBm in any 1 megahertz band. Fixed point-to-point U-NII devices may employ antennas with directional gain up to 23 dBi without any corresponding reduction in the 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 power spectral density is required for each 1 dB of antenna gain in excess of 23 dBi.

For the band 5.725-5.85 GHz, the maximum power spectral density shall not exceed 30 dBm in any 500-kHz band.

If transmitting antennas of directional gain greater than 6dBi are used, the peak power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi.

For IC

For the 5.725-5.85 GHz band, the power spectral density shall not exceed 30 dBm in any 500 kHz band.

If transmitting antennas of directional gain greater than 6dBi are used, the peak power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi.

7.5.2.Test Procedure Used

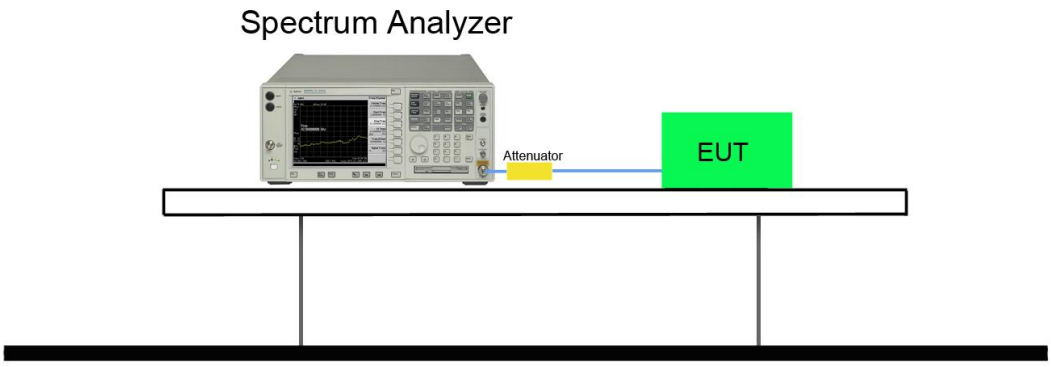
KDB 789033 D02v02r01 - Section F

7.5.3.Test Setting

1. Analyzer was set to the center frequency of the UNII channel under investigation
2. Span was set to encompass the entire 26dB OBW of the signal.
3. RBW = 1MHz, if measurement bandwidth of Maximum PSD is specified in 500 kHz,
   RBW = 100 kHz
4. VBW = 3MHz
5. Number of sweep points ≥ 2 × (span / RBW)
6. Detector = power averaging (RMS)
7. Sweep time = auto
8. Trigger = free run

9. Use the peak search function on the instrument to find the peak of the spectrum and record its value.
10. Add 10*log(1/x), where x is the duty cycle, to the measured power in order to compute the average power during the actual transmission times (because the measurement represents an average over both the on and off times of the transmission). For example, add 10*log(1/0.25) = 6 dB if the duty cycle is 25 percent.
11. When the measurement bandwidth of Maximum PSD is specified in 500 kHz, add a constant factor 10*log(500kHz/100kHz) = 6.99 dB to the measured result.

7.5.4.Test Setup



7.5.5.Test Result

Product	Firebird FPV	Temperature	24°C
Test Engineer	Kevin Ker	Relative Humidity	59%
Test Site	SR1	Test Date	2018/01/29
Test Item	Power Spectral Density (FCC NII-Band1)		

Test Mode	Data Rate (Mbps)	Channel No.	Freq. (MHz)	PSD (dBm/ MHz)	Duty Cycle (%)	Final PSD (dBm/ MHz)	PSD Limit (dBm/ MHz)	Result
Ant A								
802.11a	6	36	5180	7.30	91.32	7.69	≤ 17	Pass
802.11a	6	44	5220	8.80	91.32	9.19	≤ 17	Pass
802.11a	6	48	5240	9.13	91.32	9.52	≤ 17	Pass
802.11n-HT20	MCS0	36	5180	9.15	90.77	9.57	≤ 17	Pass
802.11n-HT20	MCS0	44	5220	9.69	90.77	10.11	≤ 17	Pass
802.11n-HT20	MCS0	48	5240	8.60	90.77	9.02	≤ 17	Pass

Note: When EUT duty cycle < 98%, the Final PSD (dBm/MHz) = PSD (dBm/MHz) + 10*log (1/Duty Cycle).

Test Mode	Data Rate (Mbps)	Channel No.	Freq. (MHz)	Duty Cycle (%)	Ant A PSD (dBm/ MHz)	Ant B PSD (dBm/ MHz)	Final PSD (dBm/ MHz)	PSD Limit (dBm/ MHz)	Result
Ant A + B									
802.11n-HT20	MCS0	36	5180	90.77	10.03	9.14	13.04	≤ 17	Pass
802.11n-HT20	MCS0	44	5220	90.77	9.34	8.89	12.55	≤ 17	Pass
802.11n-HT20	MCS0	48	5240	90.77	9.19	7.52	11.87	≤ 17	Pass

Note: When EUT duty cycle < 98%, the Final PSD (dBm/MHz) = 10*log $\{10^{(\text{Ant A PSD}/10)} + 10^{(\text{Ant B PSD}/10)}\}$ (dBm/MHz) + 10*log (1/Duty Cycle).

Product	Firebird FPV	Temperature	24°C
Test Engineer	Kevin Ker	Relative Humidity	59%
Test Site	SR1	Test Date	2018/01/29
Test Item	Power Spectral Density (FCC & IC NII-Band 3)		

Test Mode	Data Rate (Mbps)	Channel No.	Freq. (MHz)	PSD (dBm/ 100KHz)	Duty Cycle (%)	Constant Factor	Final PSD (dBm/ 500kHz)	Limit (dBm/ 500kHz)	Result
Ant A									
802.11a	6	149	5745	-1.24	91.32	6.99	6.14	≤ 30.00	Pass
802.11a	6	157	5785	-0.07	91.32	6.99	7.31	≤ 30.00	Pass
802.11a	6	165	5825	0.43	91.32	6.99	7.81	≤ 30.00	Pass
802.11n-HT20	MCS0	149	5745	-1.10	90.77	6.99	6.31	≤ 30.00	Pass
802.11n-HT20	MCS0	157	5785	-1.17	90.77	6.99	6.24	≤ 30.00	Pass
802.11n-HT20	MCS0	165	5825	-0.65	90.77	6.99	6.76	≤ 30.00	Pass

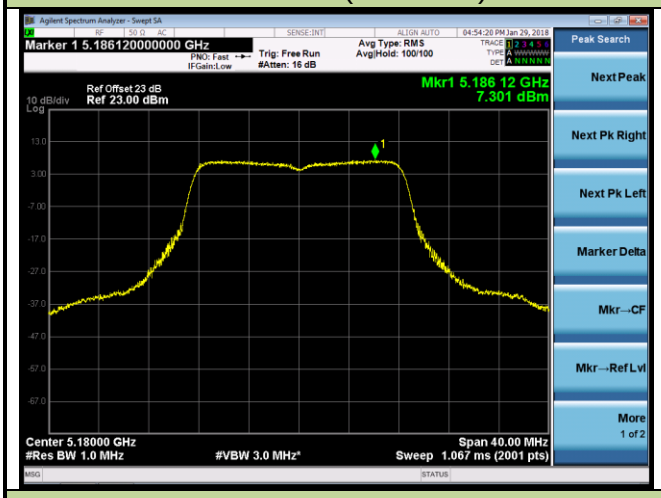
Note: When EUT duty cycle < 98%, the Final PSD (dBm/500kHz) = PSD (dBm/100kHz) + Constant Factor + 10*log (1/Duty Cycle).

Test Mode	Data Rate (Mbps)	Channel No.	Freq. (MHz)	Duty Cycle (%)	Constant Factor	Ant A PSD (dBm/ 100kHz)	Ant B PSD (dBm/ 100kHz)	Final PSD (dBm/ 500kHz)	PSD Limit (dBm/ 500kHz)	Result
Ant A + B										
802.11n-HT20	MCS0	149	5745	90.77	6.99	-0.16	0.91	10.83	≤ 30.00	Pass
802.11n-HT20	MCS0	157	5785	90.77	6.99	-1.11	0.94	10.46	≤ 30.00	Pass
802.11n-HT20	MCS0	165	5825	90.77	6.99	-1.34	-0.44	9.55	≤ 30.00	Pass

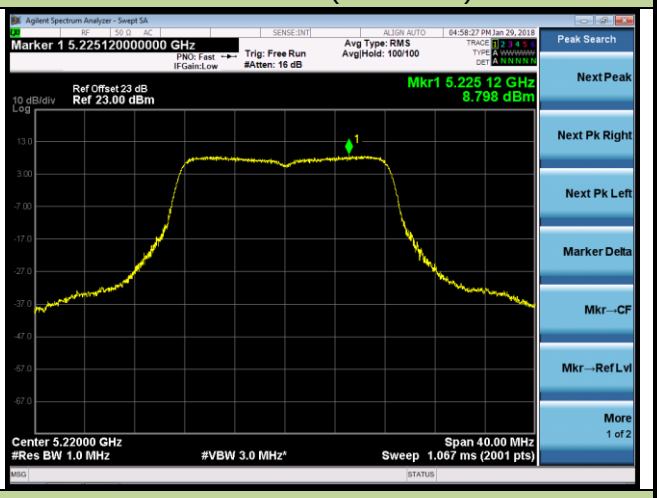
Note: When EUT duty cycle < 98%, the Final PSD (dBm/500kHz) = 10*log {$10^{(\text{Ant A PSD}/10)}$ + $10^{(\text{Ant B PSD}/10)}$} (dBm/100kHz) + Constant Factor + 10*log (1/Duty Cycle).

802.11a Power Spectral Density - Ant A

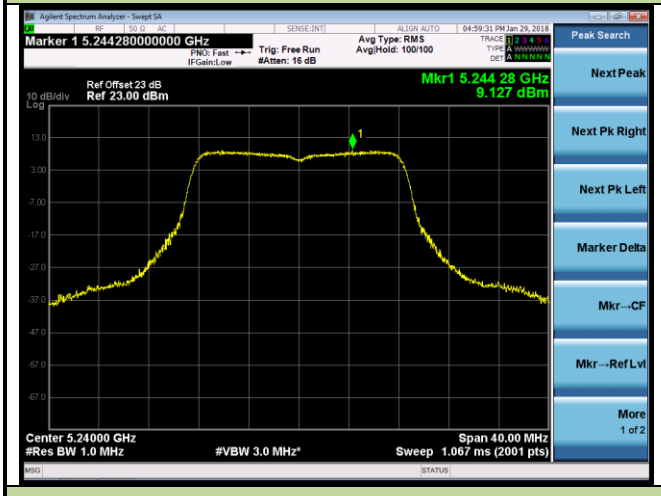
Channel 36 (5180MHz)



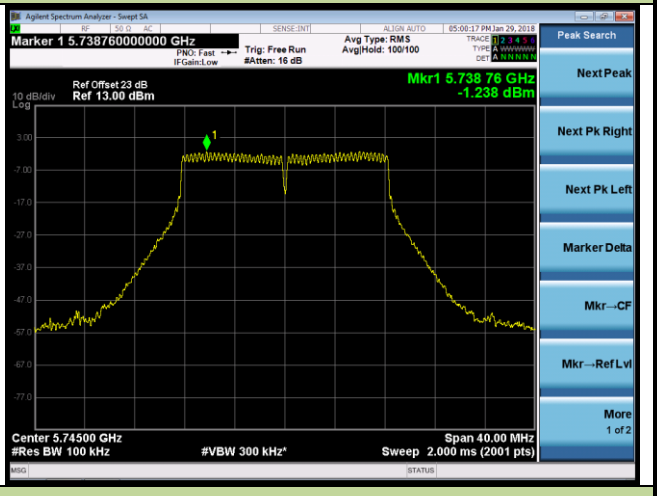
Channel 44 (5220MHz)



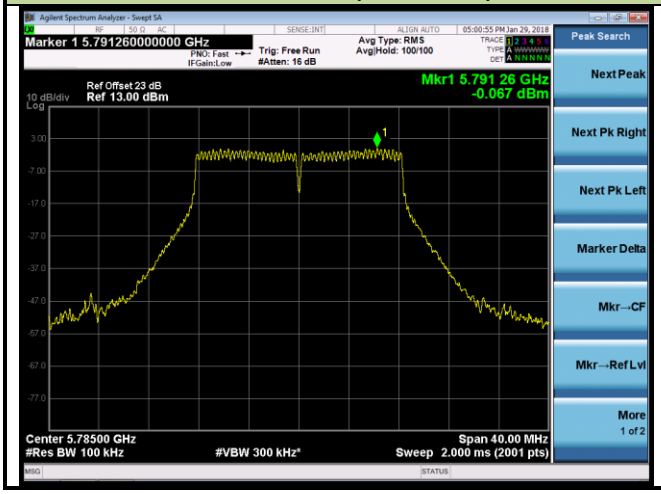
Channel 48 (5240MHz)



Channel 149 (5745MHz)



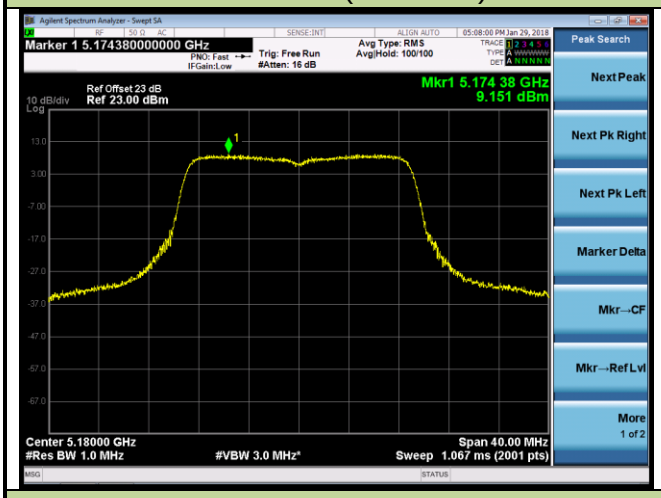
Channel 157 (5785MHz)



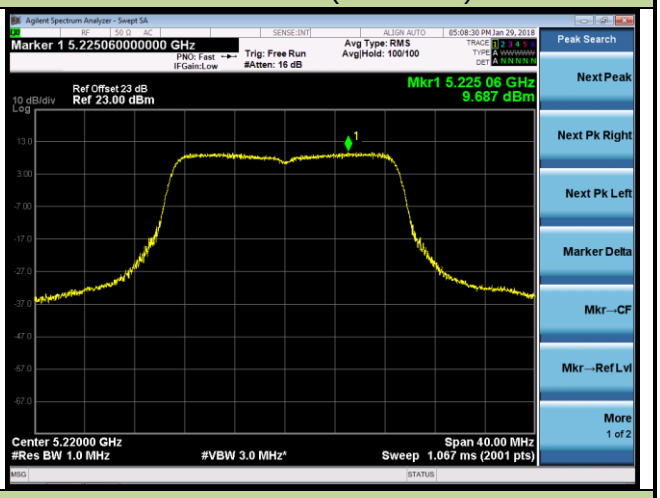
Channel 165 (5825MHz)

802.11n-HT20 Power Spectral Density - Ant A

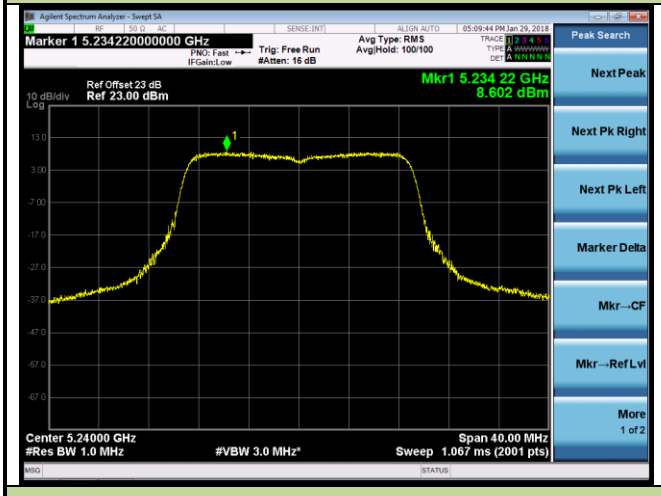
Channel 36 (5180MHz)



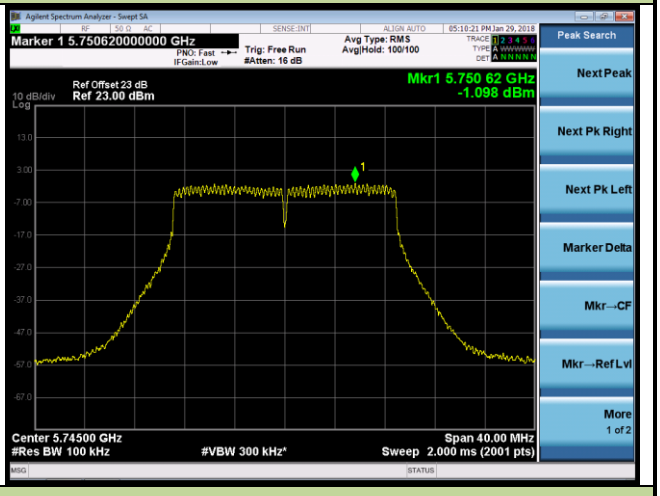
Channel 44 (5220MHz)



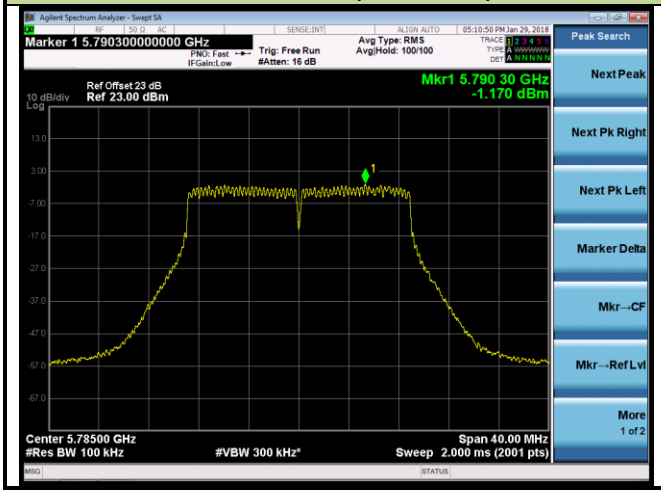
Channel 48 (5240MHz)



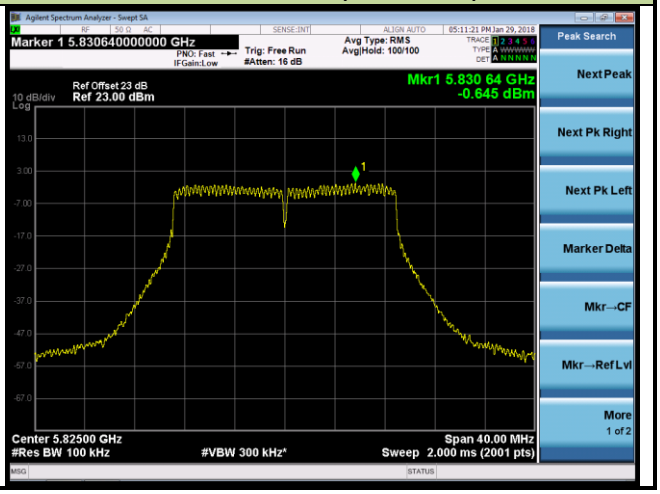
Channel 149 (5745MHz)



Channel 157 (5785MHz)

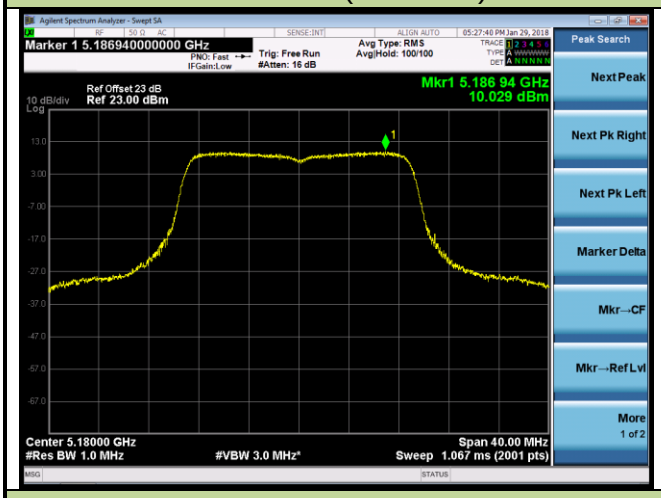


Channel 165 (5825MHz)

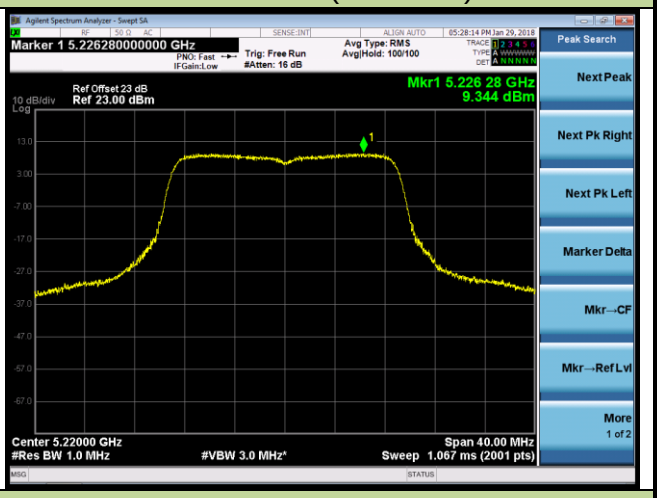


802.11n-HT20 Power Spectral Density - Ant A / Ant A + B

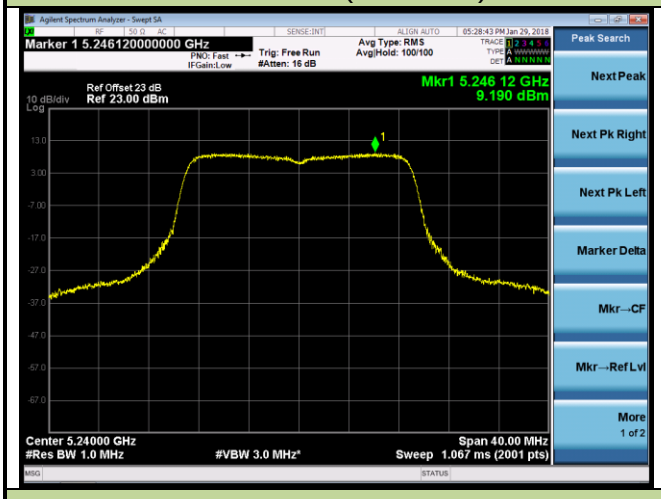
Channel 36 (5180MHz)



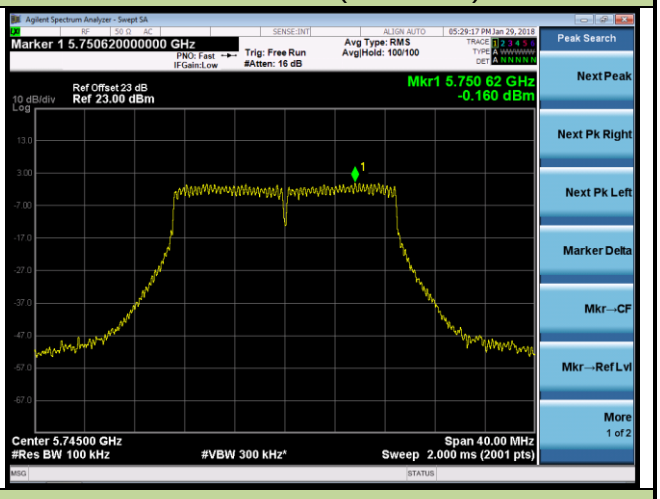
Channel 44 (5220MHz)



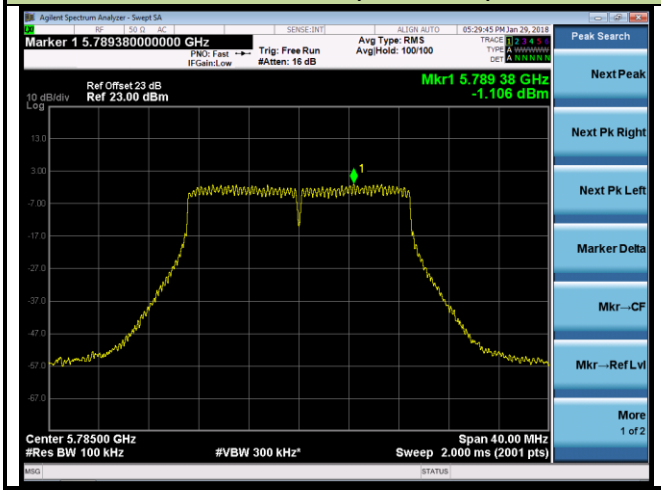
Channel 48 (5240MHz)



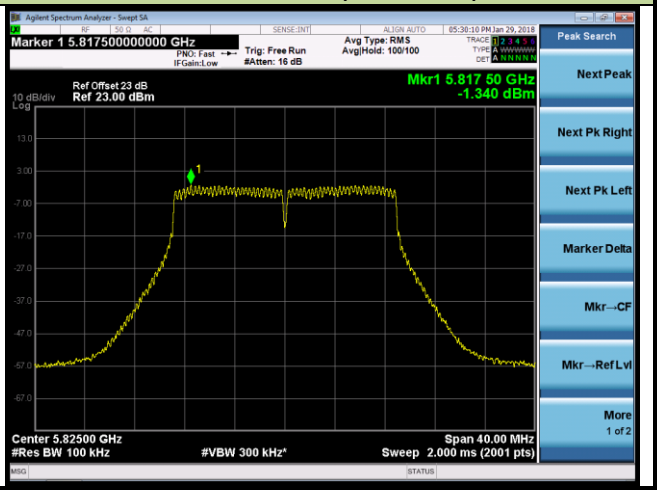
Channel 149 (5745MHz)



Channel 157 (5785MHz)

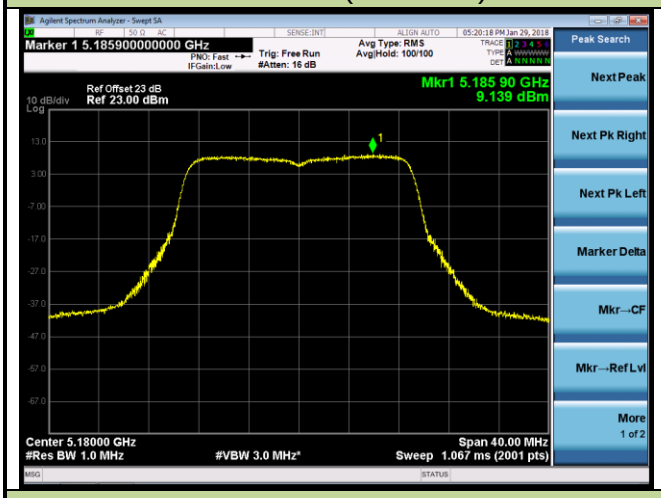


Channel 165 (5825MHz)

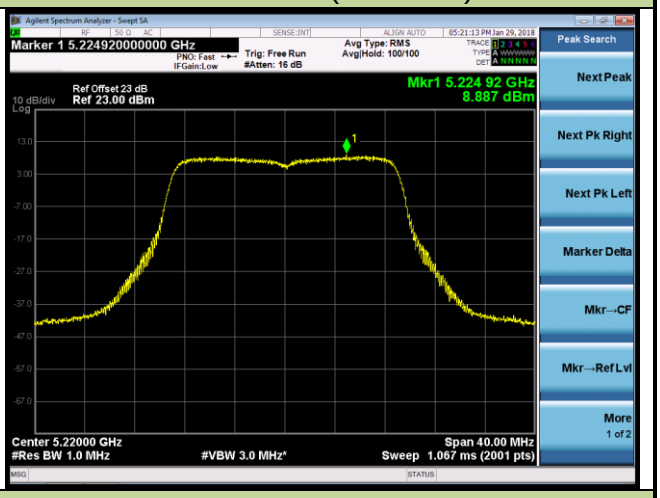


802.11n-HT20 Power Spectral Density - Ant B / Ant A + B

Channel 36 (5180MHz)

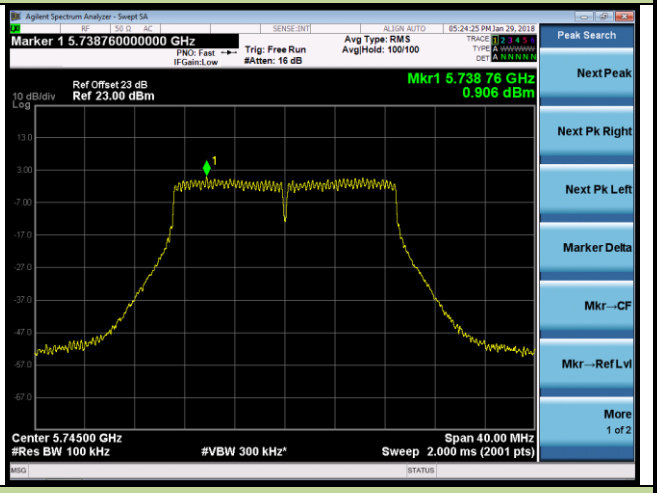


Channel 44 (5220MHz)

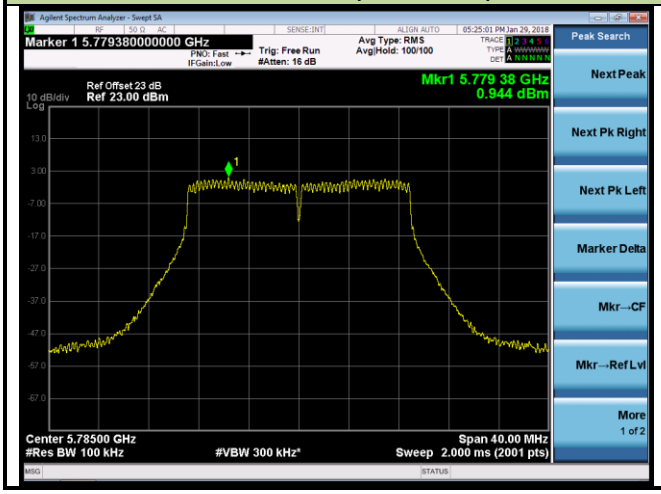


Channel 48 (5240MHz)

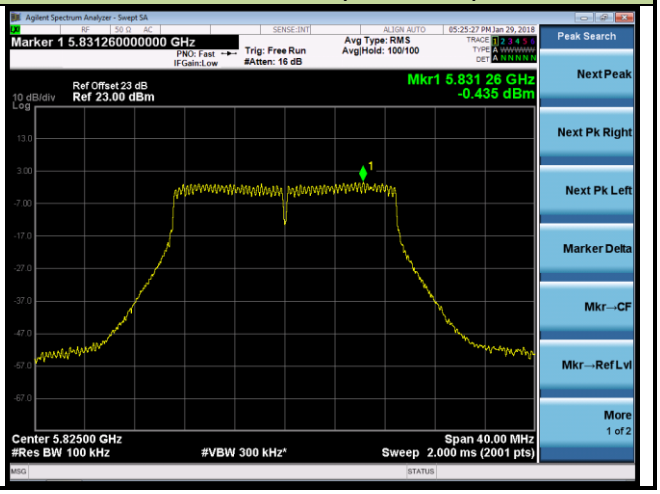
Channel 149 (5745MHz)



Channel 157 (5785MHz)



Channel 165 (5825MHz)



7.6. Frequency Stability Measurement

7.6.1.Test Limit

Manufactures of U-NII devices are responsible for ensuring frequency stability such that an emission is maintained within the band of operation under all conditions of normal operation as specified in the user's manual.

The transmitter center frequency tolerance shall be ±20 ppm maximum for the 5GHz band (IEEE 802.11 specification).

7.6.2.Test Procedure Used

Frequency Stability Under Temperature Variations:

The equipment under test was connected to an external AC or DC power supply and input rated voltage. RF output was connected to a frequency counter or spectrum analyzer via feed through attenuators. The EUT was placed inside the temperature chamber. Set the spectrum analyzer RBW low enough to obtain the desired frequency resolution and measure EUT 20°C operating frequency as reference frequency. Turn EUT off and set the chamber temperature to highest. After the temperature stabilized for approximately 30 minutes recorded the frequency. Repeat step measure with 10°C decreased per stage until the lowest temperature reached.

Frequency Stability Under Voltage Variations:

Set chamber temperature to 20°C. Use a variable AC power supply / DC power source to power the EUT and set the voltage to rated voltage. Set the spectrum analyzer RBW low enough to obtain the desired frequency resolution and recorded the frequency.

Reduce the input voltage to specify extreme voltage variation (±15%) and endpoint, record the maximum frequency change.