



FCC TEST REPORT

FCC ID: 2ADMF-ESP32

On Behalf of

Shenzhen KEYES DIY Robot Co.,Ltd

ESP32 Core Board(Black and Eco-friendly)

Model No.: ESP 32 WIFI board

Prepared for : Shenzhen KEYES DIY Robot Co.,Ltd
Address : Room9A Jingxing Building, Changyong Road,Long Hua Xin Qu
District, Shenzhen, China

Prepared By : Shenzhen Alpha Product Testing Co., Ltd.
Address : Building i, No.2, Lixin Road, Fuyong Street, Bao'an District, 518103,
Shenzhen, Guangdong, China

Report Number : A1912206-C06-R03
Date of Receipt : December 23, 2019
Date of Test : December 23, 2019-April 27,2020
Date of Report : April 27,2020
Version Number : V0

TABLE OF CONTENTS

Description	Page
1. Summary of Standards And Results -----	6
1.1. Description of Standards and Results -----	6
2. General Information -----	7
2.1. Description of Device (EUT)-----	7
2.2. Accessories of Device (EUT) -----	8
2.3. Tested Supporting System Details -----	8
2.4. Block Diagram of connection between EUT and simulators -----	8
2.5. Test Mode Description -----	9
2.6. Test Conditions -----	10
2.7. Test Facility -----	10
2.8. Measurement Uncertainty -----	11
2.9. Test Equipment List -----	12
3. Spurious Emission -----	13
3.1. Test Limits -----	13
3.2. Test Procedure -----	13
3.3. Test Setup -----	14
3.4. Test Results -----	15
4. Power line Conducted Emission -----	21
4.1. Test Limits -----	21
4.2. Test Procedure -----	21
4.3. Test Setup -----	21
4.4. Test Results -----	22
5. Conducted Maximum Output Power -----	23
5.1. Test limits -----	23
5.2. Test Procedure -----	23
5.3. Test Setup -----	23
5.4. Test Results -----	23
6. Peak Power Spectral Density -----	25
6.1. Test limits -----	25
6.2. Test Procedure -----	25
6.3. Test Setup -----	25
6.4. Test Results -----	26
7. Bandwidth -----	33
7.1. Test limits -----	33
7.2. Test Procedure -----	33
7.3. Test Setup -----	33
7.4. Test Results -----	33
8. Band Edge Check -----	46
8.1. Test limits -----	46
8.2. Test Procedure -----	46
8.3. Test Setup -----	46
8.4. Test Results -----	46
9. Antenna Requirement -----	55

9.1.	Standard Requirement -----	55
9.2.	Antenna Connected Construction-----	55
9.3.	Results -----	55
10.	Test setup photo-----	56
10.1.	Photos of Radiated emission -----	56
10.2.	Photos of Conducted Emission test-----	57
11.	EUT photo-----	58

TEST REPORT DECLARATION

Applicant : Shenzhen KEYES DIY Robot Co.,Ltd
Address : Room9A Jingxing Building, Changyong Road,Long Hua Xin Qu District, Shenzhen, China
Manufacturer : Shenzhen KEYES DIY Robot Co.,Ltd
Address : Room9A Jingxing Building, Changyong Road,Long Hua Xin Qu District, Shenzhen, China
EUT Description : ESP32 Core Board(Black and Eco-friendly)
(A) Model No. : ESP 32 WIFI board
(B) Trademark : Inland; Keyestudio

Measurement Standard Used:

FCC Rules and Regulations Part 15 Subpart C Section 15.247

ANSI C63.10:2013

The device described above is tested by Shenzhen Alpha Product Testing Co., Ltd. to determine the maximum emission levels emanating from the device. The maximum emission levels are compared to the FCC Part 15 Subpart C limits both conducted and radiated emissions. The test results are contained in this test report and Shenzhen Alpha Product Testing Co., Ltd. is assumed of full responsibility for the accuracy and completeness of these tests.

After the test, our opinion is that EUT compliance with the requirement of the above standards.

This report applies to above tested sample only. This report shall not be reproduced in parts without written approval of Shenzhen Alpha Product Testing Co., Ltd.

Tested by (name + signature).....: Lucas Pang
Project Engineer



Approved by (name + signature).....: Simple Guan
Project Manager



Date of issue.....: April 27,2020

Revision History

Revision	Issue Date	Revisions	Revised By
V0	April 27,2020	Initial released Issue	Lucas Pang

1. SUMMARY OF STANDARDS AND RESULTS

1.1. Description of Standards and Results

The EUT have been tested according to the applicable standards as referenced below:

Test Item	Test Requirement	Standards Paragraph	Result
Conducted Emission	FCC PART 15	15.207	P
6dB Bandwidth	FCC PART 15	15.247 (a)(2)	P
Output Power	FCC PART 15	15.247 (b)(3)	P
Radiated Spurious Emission	FCC PART 15	15.247 (c)	P
Conducted Spurious & Band Edge Emission	FCC PART 15	15.247 (d)	P
Power Spectral Density	FCC PART 15	15.247 (e)	P
Radiated Band Edge Emission	FCC PART 15	15.205	P
Antenna Requirement	FCC PART 15	15.203	P
Note: 1. P is an abbreviation for Pass. 2. F is an abbreviation for Fail. 3. N/A is an abbreviation for Not Applicable.			

2. GENERAL INFORMATION

2.1. Description of Device (EUT)

Description	: ESP32 Core Board(Black and Eco-friendly)
Model Number	: ESP 32 WIFI board
Diff	: N/A
Trademark	: Inland; Keyestudio
Test Voltage	: DC 5V input
Operation frequency	: 2412MHz-2462MHz for IEEE 802.11 b, g,n/HT20, 2422MHz~2452MHz for IEEE802.11n/HT40
Channel No.	: 802.11b/802.11g /802.11n(HT20): 11CH 802.11(HT40): 7CH IEEE 802.11b: DSSS(CCK,DQPSK,DBPSK)
Modulation type	: IEEE 802.11g: OFDM(64QAM, 16QAM, QPSK, BPSK) IEEE 802.11n :OFDM(64QAM, 16QAM, QPSK, BPSK)
Antenna Type	: PCB antenna, Maximum Gain is 2.3dBi

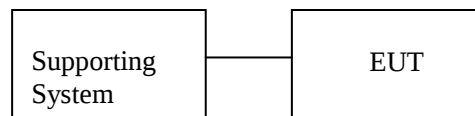
2.2.Accessories of Device (EUT)

Accessories1 : /
Manufacturer : /
Model : /
Input : /
Output : /

2.3.Tested Supporting System Details

No.	Description	Manufacturer	Model	Serial Number	Certification
1	Notebook	ACER	ZQT	N/A	N/A

2.4.Block Diagram of connection between EUT and simulators



2.5.Test Mode Description

Duty cycle :100%Keeping TX			
Mode	data rate (Mbps)(see Note)	Channel	Frequency (MHz)
IEEE 802.11b	1	Low :CH1	2412
	1	Middle: CH6	2437
	1	High: CH11	2462
IEEE 802.11g	6	Low :CH1	2412
	6	Middle: CH6	2437
	6	High: CH11	2462
IEEE 802.11 n/HT20 with 2.4G	6.5	Low :CH1	2412
	6.5	Middle: CH6	2437
	6.5	High: CH11	2462
IEEE 802.11 n/HT40 with 2.4G	13	Low :CH3	2422
	13	Middle: CH6	2437
	13	High: CH9	2452
Note: According exploratory test, EUT will have maximum output power in those data rate. so those data rate were used for all test.			

Channel list:					
For IEEE 802.11b, g, n/HT20 with 2.4G					
Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
CH1	2412	CH5	2432	CH9	2452
CH2	2417	CH6	2437	CH10	2457
CH3	2422	CH7	2442	CH11	2462
CH4	2427	CH8	2447		
For IEEE 802.11 n/HT40 with 2.4G					
Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
CH1	2422	CH5	2442		
CH2	2427	CH6	2447		
CH3	2432	CH7	2452		
CH4	2437				

Setting output power (Max)			
802.11b	802.11g	802.11n(HT20)	802.11n(HT40)
0 ±1dBm	0 ±1dBm	0 ±1dBm	0 ±1dBm

2.6. Test Conditions

Items	Required	Actual
Temperature range:	15-35℃	24℃
Humidity range:	25-75%	56%
Pressure range:	86-106kPa	98kPa

2.7. Test Facility

Shenzhen Alpha Product Testing Co., Ltd
Building i, No.2, Lixin Road, Fuyong Street, Bao'an District, 518103,
Shenzhen, Guangdong, China

June 21, 2018 File on Federal Communication Commission
Registration Number: 293961

July 15, 2019 Certificated by IC
Registration Number: CN0085

2.8.Measurement Uncertainty

(95% confidence levels, k=2)

Item	Uncertainty
Uncertainty for Power point Conducted Emissions Test	2.74dB
Uncertainty for Radiation Emission test in 3m chamber (below 30MHz)	2.13 dB(Polarize: V)
	2.57dB(Polarize: H)
Uncertainty for Radiation Emission test in 3m chamber (30MHz to 1GHz)	3.77dB(Polarize: V)
	3.80dB(Polarize: H)
Uncertainty for Radiation Emission test in 3m chamber (1GHz to 25GHz)	4.13dB(Polarize: H)
	4.16dB(Polarize: V)
Uncertainty for radio frequency	5.4×10^{-8}
Uncertainty for conducted RF Power	0.37dB
Uncertainty for temperature	0.2°C
Uncertainty for humidity	1%
Uncertainty for DC and low frequency voltages	0.06%

2.9.Test Equipment List

Equipment	Manufacture	Model No.	Serial No.	Last cal.	Cal Interval
9*6*6 anechoic chamber	CHENYU	9*6*6	N/A	2019.09.06	3Year
Spectrum analyzer	ROHDE&SCHWARZ	FSV40-N	102137	2019.09.05	1Year
Spectrum analyzer	Agilent	N9020A	MY499100060	2019.09.05	1Year
Receiver	ROHDE&SCHWARZ	ESR	1316.3003K03-102082-Wa	2019.09.06	1Year
Receiver	R&S	ESCI	101165	2019.09.05	1Year
Bilog Antenna	Schwarzbeck	VULB 9168	VULB9168-438	2019.09.07	2Year
Horn Antenna	SCHWARZBECK	BBHA 9120 D	BBHA 9120 D(1201)	2020.04.12	2Year
Active Loop Antenna	SCHWARZBECK	FMZB 1519B	00059	2019.09.07	2Year
Cable	Resenberger	N/A	No.1	2019.09.05	1Year
Cable	Resenberger	N/A	No.2	2019.09.05	1Year
Cable	Resenberger	N/A	No.3	2019.09.05	1Year
Pre-amplifier	HP	HP8347A	2834A00455	2019.09.05	1Year
Pre-amplifier	Agilent	8449B	3008A02664	2019.09.05	1Year
L.I.S.N.#1	Schwarzbeck	NSLK8126	8126466	2019.09.05	1Year
L.I.S.N.#2	ROHDE&SCHWARZ	ENV216	101043	2019.09.05	1 Year
20db Attenuator	ICPROBING	IATS1	82347	2019.08.26	1 Year
Horn Antenna	SCHWARZBECK	BBHA9170	00946	2019.09.07	2 Year
Preamplifier	SKET	LNPA_1840-50	SK2018101801	2019.09.06	1 Year
Power Meter	Agilent	E9300A	MY41496625	2019.09.06	1 Year
Temp. & Humid. Chamber	Weihuang	WHTH-1000-40-880	100631	2019.09.06	1 Year
Switching Mode Power Supply	JUNKE	JK12010S	20140927-6	2019.09.05	1 Year

3. SPURIOUS EMISSION

3.1. Test Limits

Frequencies (MHz)	Field Strength (micровolts/meter)	Measurement Distance (meters)
0.009~0.490	2400/F(KHz)	300
0.490~1.705	24000/F(KHz)	30
1.705~30.0	30	30
30~88	100	3
88~216	150	3
216~960	200	3
Above 960	500	3

Harmonic emissions limits comply with below 54 dBuV/m at 3m. Other emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or comply with the radiated emissions limits specified in section 15.209(a) limit in the table below has to be followed.

NOTE:

- The tighter limit applies at the band edges.
- Emission Level(dB uV/m)=20log Emission Level(Uv/m)

3.2. Test Procedure

The measuring distance of 3m shall be used for measurements at frequency below 1GHz and above 1GHz, The EUT was placed on a rotating 80cm above the ground plane inside a semi-anechoic chamber for below 1GHz and 150cm above the ground plane inside a semi-anechoic chamber for above 1GHz, The table was rotated 360 degrees to determine the position of the highest radiation.

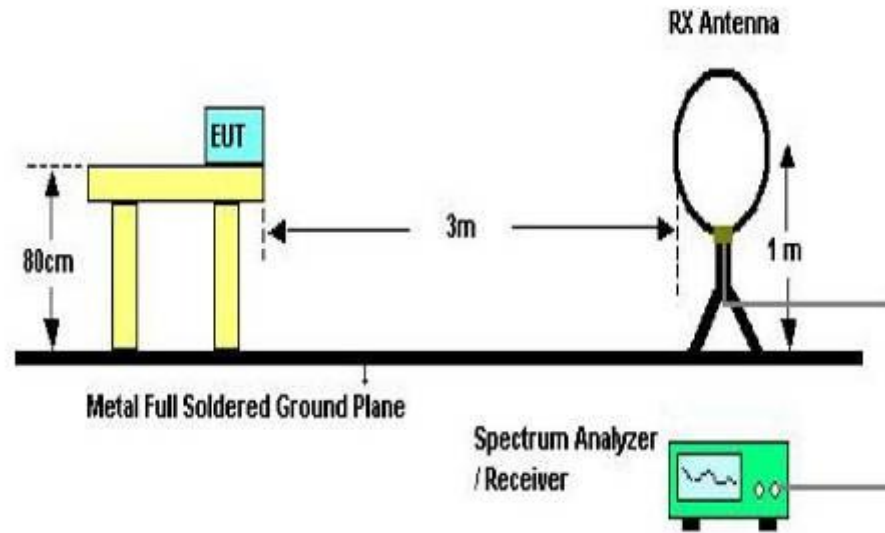
The Test antenna shall vary between 1m and 4m, Both Horizontal and Vertical antenna are set of make measurement.

The initial step in collecting conducted emission data is a spectrum analyzer Peak detector mode pre-scanning the measurement frequency range. Significant Peaks are then marked. and then Qusia Peak Detector mode premeasured.

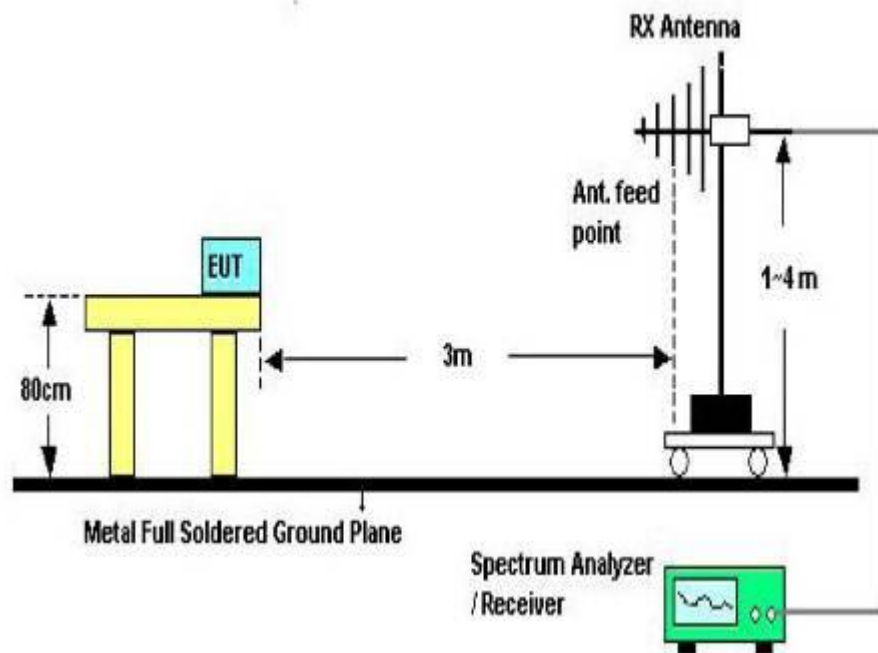
If Peak value comply with QP limit Below 1GHz.The EUT deemed to comply with QP limit. But the Peak value and average value both need to comply with applicable limit above 1GHz.

For the actual test configuration, please see the test setup photo.

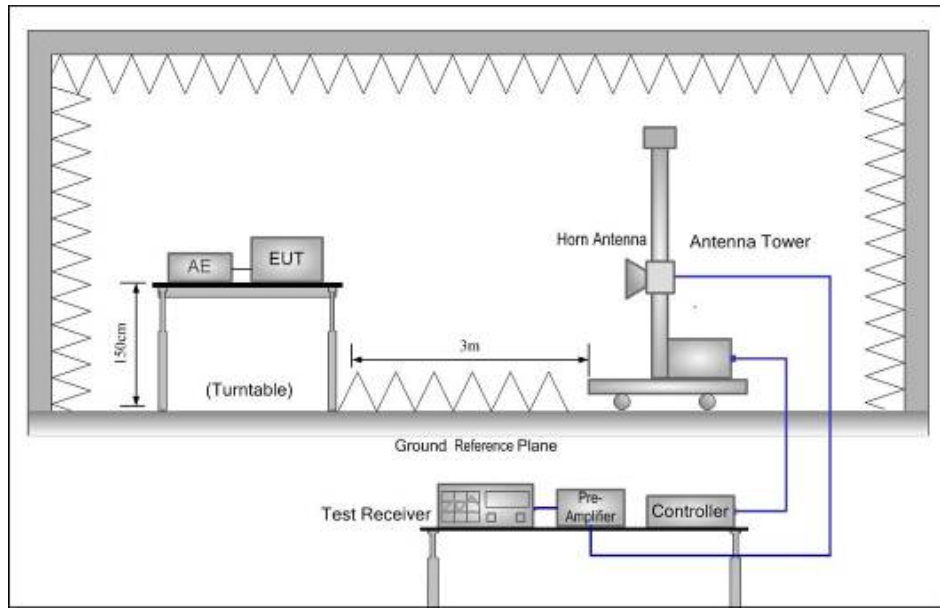
3.3. Test Setup



Below 30MHz Test Setup



Above 30MHz Test Setup



Above 1GHz Test Setup

3.4. Test Results

Test Condition

Continual Transmitting in maximum power.

9KHz~150KHz	RBW200Hz	VBW1KHz
150KHz~30MHz	RBW9KHz	VBW 30KHz
30MHz~1GHz	RBW120KHz	VBW 300KHz
Above1GHz	RBW1MHz	VBW 3MHz

We have scanned the 10th harmonic from 9 kHz to the EUT.

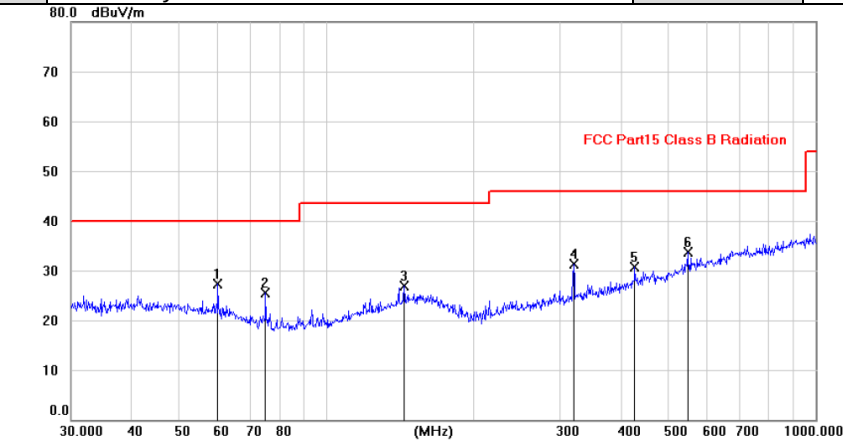
Detailed information please see the following page.

From 9KHz to 30MHz: Conclusion: PASS

Note:1.The amplitude of spurious emissions which are attenuated by more than 20dB below the permissible value has no need to be reported.

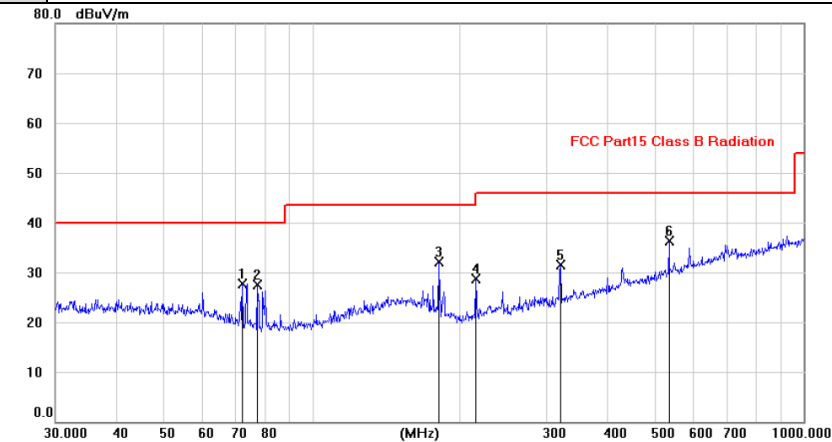
2.Only show the test data of the worst Channel in this report.

EUT Description	ESP32 Core Board(Black and Eco-friendly)	Model No.	ESP 32 WIFI board
Temperature	24°C	Humidity	56%
Pol	Vertical	Test date	2020/1/19
Test Voltage	DC 5V by Notebook	Test mode	802.11b (2412MHz)



No.	Mk.	Freq.	Reading Level	Correct Factor	Measurement	Limit	Margin	Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	cm	degree	Comment
1		59.9849	13.36	13.94	27.30	40.00	-12.70	peak		
2		75.1296	14.33	11.19	25.52	40.00	-14.48	peak		
3		144.1325	11.32	15.61	26.93	43.50	-16.57	peak		
4		320.0492	15.58	15.82	31.40	46.00	-14.60	peak		
5		426.6706	12.47	18.18	30.65	46.00	-15.35	peak		
6	*	548.6346	13.24	20.56	33.80	46.00	-12.20	peak		

Pol	Horizontal
------------	------------



No.	Mk.	Freq.	Reading Level	Correct Factor	Measurement	Limit	Margin	Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	cm	degree	Comment
1		72.1855	16.01	11.72	27.73	40.00	-12.27	peak		
2		77.5112	16.54	10.90	27.44	40.00	-12.56	peak		
3		181.0293	18.57	13.58	32.15	43.50	-11.35	peak		
4		216.0240	16.11	12.55	28.66	46.00	-17.34	peak		
5		320.0492	15.78	15.82	31.60	46.00	-14.40	peak		
6	*	533.4578	15.96	20.26	36.22	46.00	-9.78	peak		

Remark: All modes have been tested, and only worst data of 802.11b (2412MHz) was listed in this report.

Test Mode: IEEE 802.11b TX Low									
Freq (MHz)	Read Level (dBuV/m)	Polar (H/V)	Antenna Factor (dB/m)	Cable loss(dB)	Amp Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
4824	45.44	V	33.95	10.18	34.26	55.31	74	18.69	PK
4824	35.54	V	33.95	10.18	34.26	45.41	54	8.59	AV
7236	/	/	/	/	/	/	/	/	/
9648	/	/	/	/	/	/	/	/	/
4824	48.63	H	33.95	10.18	34.26	58.50	74	15.50	PK
4824	37.80	H	33.95	10.18	34.26	47.67	54	6.33	AV
7236	/	/	/	/	/	/	/	/	/
9648	/	/	/	/	/	/	/	/	/
Test Mode: IEEE 802.11b TX Mid									
4874	43.57	V	33.93	10.2	34.29	53.41	74	20.59	PK
4874	33.35	V	33.93	10.2	34.29	43.19	54	10.81	AV
7311	/	/	/	/	/	/	/	/	/
9748	/	/	/	/	/	/	/	/	/
4874	48.08	H	33.93	10.2	34.29	57.92	74	16.08	PK
4874	32.15	H	33.93	10.2	34.29	41.99	54	12.01	AV
7311	/	/	/	/	/	/	/	/	/
9748	/	/	/	/	/	/	/	/	/
Test Mode: IEEE 802.11b TX High									
4924	47.40	V	33.98	10.22	34.25	57.35	74	16.65	PK
4924	37.45	V	33.98	10.22	34.25	47.40	54	6.60	AV
7386	/	/	/	/	/	/	/	/	/
9848	/	/	/	/	/	/	/	/	/
4924	48.20	H	33.98	10.22	34.25	58.15	74	15.85	PK
4924	33.01	H	33.98	10.22	34.25	42.96	54	11.04	AV
7386	/	/	/	/	/	/	/	/	/
9848	/	/	/	/	/	/	/	/	/
Note:									
1, Result = Read level + Antenna factor + cable loss-Amp factor									
2, All the other emissions not reported were too low to read and deemed to comply with FCC limit.									

Test Mode: IEEE 802.11g TX Low									
Freq (MHz)	Read Level (dBuV/m)	Polar (H/V)	Antenna Factor (dB/m)	Cable loss(dB)	Amp Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
4824	47.00	V	33.95	10.18	34.26	56.87	74	17.13	PK
4824	38.48	V	33.95	10.18	34.26	48.35	54	5.65	AV
7236	/	/	/	/	/	/	/	/	/
9648	/	/	/	/	/	/	/	/	/
4824	49.79	H	33.95	10.18	34.26	59.66	74	14.34	PK
4824	38.07	H	33.95	10.18	34.26	47.94	54	6.06	AV
7236	/	/	/	/	/	/	/	/	/
9648	/	/	/	/	/	/	/	/	/
Test Mode: IEEE 802.11g TX Mid									
4874	46.41	V	33.93	10.2	34.29	56.25	74	17.75	PK
4874	31.03	V	33.93	10.2	34.29	40.87	54	13.13	AV
7311	/	/	/	/	/	/	/	/	/
9748	/	/	/	/	/	/	/	/	/
4874	45.05	H	33.93	10.2	34.29	54.89	74	19.11	PK
4874	33.22	H	33.93	10.2	34.29	43.06	54	10.94	AV
7311	/	/	/	/	/	/	/	/	/
9748	/	/	/	/	/	/	/	/	/
Test Mode: IEEE 802.11g TX High									
4924	47.27	V	33.98	10.22	34.25	57.22	74	16.78	PK
4924	37.42	V	33.98	10.22	34.25	47.37	54	6.63	AV
7386	/	/	/	/	/	/	/	/	/
9848	/	/	/	/	/	/	/	/	/
4924	47.51	H	33.98	10.22	34.25	57.46	74	16.54	PK
4924	35.55	H	33.98	10.22	34.25	45.50	54	8.50	AV
7386	/	/	/	/	/	/	/	/	/
9848	/	/	/	/	/	/	/	/	/

Note:

1, Result = Read level + Antenna factor + cable loss-Amp factor

2, All the other emissions not reported were too low to read and deemed to comply with FCC limit.

Test Mode:IEEE 802.11n HT20 TX Low									
Freq (MHz)	Read Level (dBuV/m)	Polar (H/V)	Antenna Factor (dB/m)	Cable loss(dB)	Amp Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
4824	45.65	V	33.95	10.18	34.26	55.52	74	18.48	PK
4824	35.56	V	33.95	10.18	34.26	45.43	54	8.57	AV
7236	/	/	/	/	/	/	/	/	/
9648	/	/	/	/	/	/	/	/	/
4824	50.51	H	33.95	10.18	34.26	60.38	74	13.62	PK
4824	38.75	H	33.95	10.18	34.26	48.62	54	5.38	AV
7236	/	/	/	/	/	/	/	/	/
9648	/	/	/	/	/	/	/	/	/
Test Mode:IEEE 802.11n HT20 TX Mid									
4874	46.30	V	33.93	10.2	34.29	56.14	74	17.86	PK
4874	33.99	V	33.93	10.2	34.29	43.83	54	10.17	AV
7311	/	/	/	/	/	/	/	/	/
9748	/	/	/	/	/	/	/	/	/
4874	47.70	H	33.93	10.2	34.29	57.54	74	16.46	PK
4874	33.87	H	33.93	10.2	34.29	43.71	54	10.29	AV
7311	/	/	/	/	/	/	/	/	/
9748	/	/	/	/	/	/	/	/	/
Test Mode:IEEE 802.11n HT20 TX High									
4924	45.01	V	33.98	10.22	34.25	54.96	74	19.04	PK
4924	36.26	V	33.98	10.22	34.25	46.21	54	7.79	AV
7386	/	/	/	/	/	/	/	/	/
9848	/	/	/	/	/	/	/	/	/
4924	48.64	H	33.98	10.22	34.25	58.59	74	15.41	PK
4924	33.31	H	33.98	10.22	34.25	43.26	54	10.74	AV
7386	/	/	/	/	/	/	/	/	/
9848	/	/	/	/	/	/	/	/	/

Note:

1, Result = Read level + Antenna factor + cable loss-Amp factor

2, All the other emissions not reported were too low to read and deemed to comply with FCC limit.

Test Mode:IEEE 802.11n HT40 TX Low									
Freq (MHz)	Read Level (dBuV/m)	Polar (H/V)	Antenna Factor (dB/m)	Cable loss(dB)	Amp Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
4844	47.49	V	33.95	10.18	34.26	57.36	74	16.64	PK
4844	37.88	V	33.95	10.18	34.26	47.75	54	6.25	AV
7266	/	/	/	/	/	/	/	/	/
9688	/	/	/	/	/	/	/	/	/
4844	47.97	H	33.95	10.18	34.26	57.84	74	16.16	PK
4844	38.01	H	33.95	10.18	34.26	47.88	54	6.12	AV
7266	/	/	/	/	/	/	/	/	/
9688	/	/	/	/	/	/	/	/	/
Test Mode:IEEE 802.11n HT40 TX Mid									
4874	43.63	V	33.93	10.2	34.29	53.47	74	20.53	PK
4874	32.59	V	33.93	10.2	34.29	42.43	54	11.57	AV
7311	/	/	/	/	/	/	/	/	/
9748	/	/	/	/	/	/	/	/	/
4874	47.88	H	33.93	10.2	34.29	57.72	74	16.28	PK
4874	33.85	H	33.93	10.2	34.29	43.69	54	10.31	AV
7311	/	/	/	/	/	/	/	/	/
9748	/	/	/	/	/	/	/	/	/
Test Mode:IEEE 802.11n HT40 TX High									
4904	45.47	V	33.98	10.22	34.25	55.42	74	18.58	PK
4904	36.93	V	33.98	10.22	34.25	46.88	54	7.12	AV
7356	/	/	/	/	/	/	/	/	/
9808	/	/	/	/	/	/	/	/	/
4904	46.55	H	33.98	10.22	34.25	56.50	74	17.50	PK
4904	34.55	H	33.98	10.22	34.25	44.50	54	9.50	AV
7356	/	/	/	/	/	/	/	/	/
9808	/	/	/	/	/	/	/	/	/

Note:

1, Result = Read level + Antenna factor + cable loss-Amp factor

2, All the other emissions not reported were too low to read and deemed to comply with FCC limit.

4. POWER LINE CONDUCTED EMISSION

4.1. Test Limits

Frequency MHz	Limits dB(μ V)	
	Quasi-peak Level	Average Level
0.15 -0.50	66 -56*	56 - 46*
0.50 -5.00	56	46
5.00 -30.00	60	50

Notes: 1. *Decreasing linearly with logarithm of frequency.

2. The lower limit shall apply at the transition frequencies.

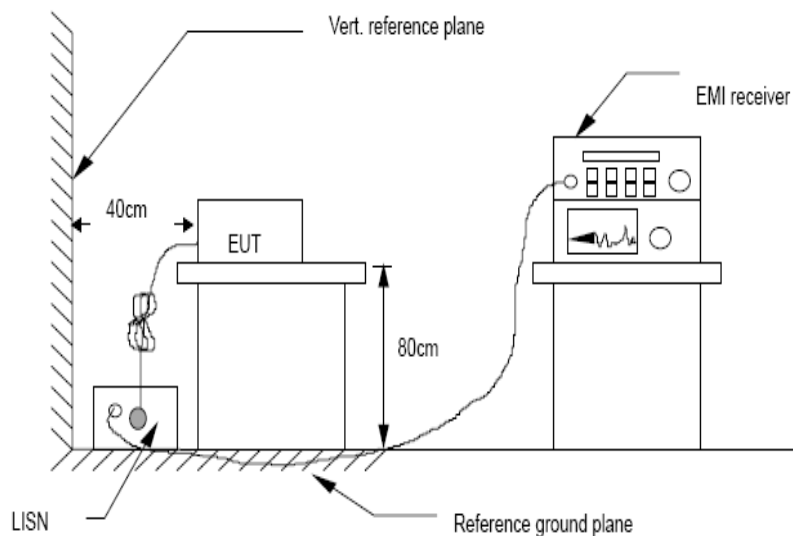
3. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50 MHz.

4.2. Test Procedure

The EUT is put on the plane 0.8m high above the ground by insulating support and is connected to the power mains through a line impedance stabilization network (L.I.S.N.). This provides a 50ohm coupling impedance for the EUT system. Please refer the block diagram of the test setup and photographs. Both sides of AC lines are checked to find out the maximum conducted emission. In order to find the maximum emission levels, the relative positions of equipment and all of the interface cables shall be changed according to ANSI C63.10:2013 on Conducted Emission Measurement.

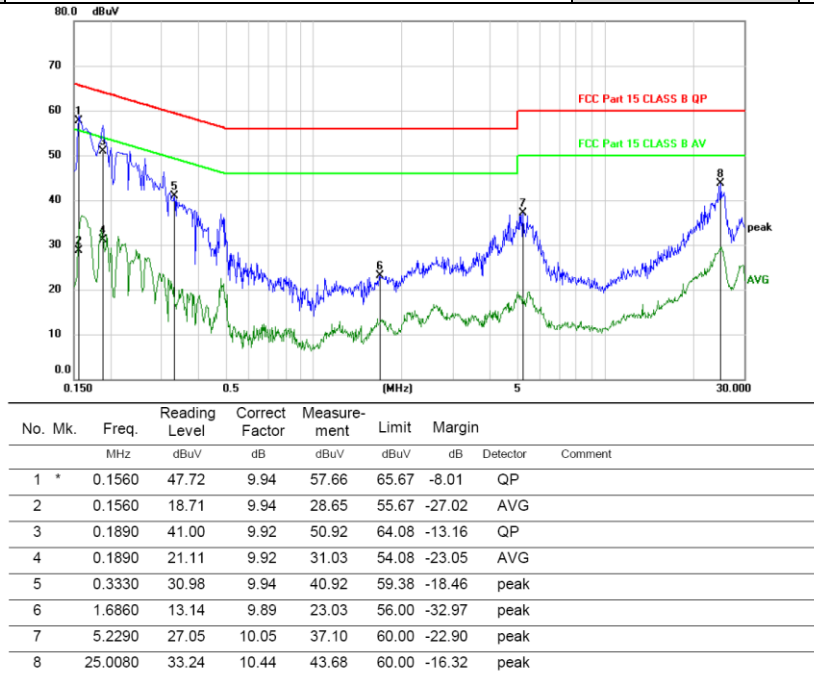
The bandwidth of test receiver is set at 9 kHz.

4.3. Test Setup

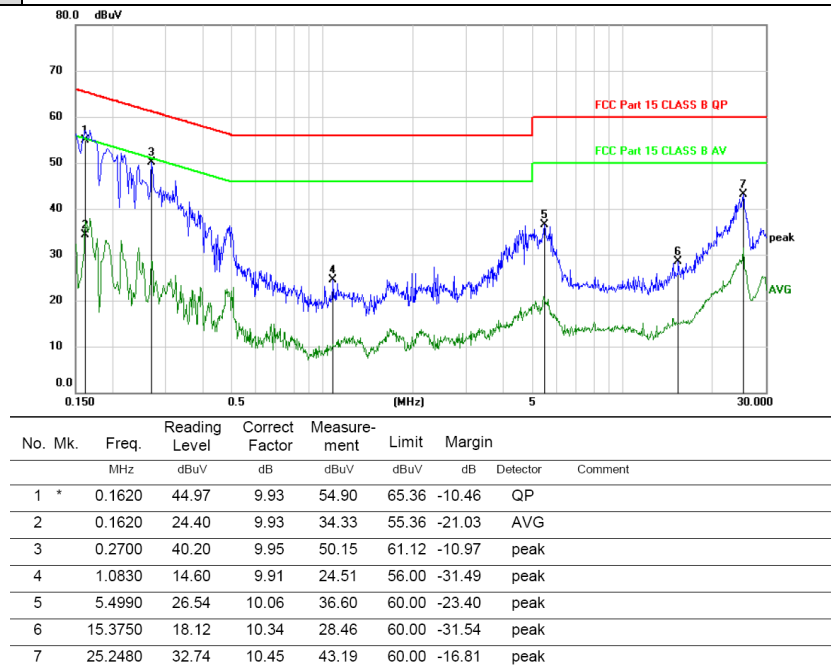


4.4. Test Results

EUT Description	ESP32 Core Board(Black and Eco-friendly)	Model No.	ESP 32 WIFI board
Temperature	24℃	Humidity	56%
Pol	Line	Test date	2020/01/19
Test Voltage	AC 120V/60Hz	Test mode	802.11b (2412MHz)



Pol	Neutral
------------	---------



Note: 1. *:Maximum data; x:Over limit; !:over margin.

2.Measurement=Reading Level+Correct Factor; Correct Factor=Antenna Factor+Cable Loss.

Remark: All modes have been tested, and only worst data of 802.11b (2412MHz) was listed in this report.

5. CONDUCTED MAXIMUM OUTPUT POWER

5.1. Test limits

Please refer section 15.247.

Regulation 15.247(b) The limit of Maximum PK Output Power Measurement is 1 W(30dBm)

5.2. Test Procedure

Details see the KDB558074 D01 Meas Guidance v05r02

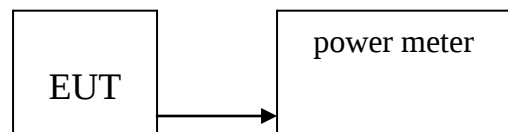
5.2.1 Place the EUT on the table and set it in transmitting mode.

5.2.2 Connected the EUT's antenna port to PK power meter by 20dB attenuator.

5.2.3 Measure out each mode and each bands PK output power of EUT.

Note: The cable loss and attenuator loss were offset into measure device as amplitude offset.

5.3. Test Setup



5.4. Test Results

PASS

Detailed information please see the following page.

Mode	Frequency (MHz)	PK Output power(dBm)	Limit (dBm)	Result
IEEE 802.11 b	CH1: 2412	0.959	30	PASS
	CH6: 2437	0.078	30	PASS
	CH11: 2462	0.788	30	PASS
IEEE 802.11 g	CH1: 2412	0.259	30	PASS
	CH6: 2437	0.399	30	PASS
	CH11: 2462	0.669	30	PASS
IEEE 802.11 n/HT20	CH1: 2412	0.274	30	PASS
	CH6: 2437	0.201	30	PASS
	CH11: 2462	0.187	30	PASS
IEEE 802.11 n/HT40	CH3: 2422	0.736	30	PASS
	CH6: 2437	0.265	30	PASS
	CH9: 2452	0.630	30	PASS

6. POWER SPECTRAL DENSITY

6.1. Test limits

6.1.1 Please refer section 15.247.

6.1.2 For direct sequence systems, the Average power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8dBm in any 3kHz band during any time interval of continuous transmission.

6.1.3 The direct sequence operating of the hybrid system, with the frequency hopping operation turned off, shall comply with the power density requirements of paragraph (d) of this section.

6.2. Test Procedure

Details see the KDB558074 D01 Meas Guidance v05r02

6.2.1 Place the EUT on the table and set it in transmitting mode.

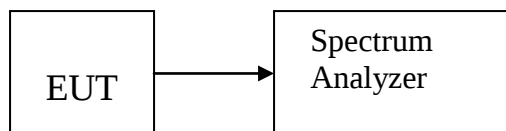
6.2.2 Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.

6.2.3 Detector = RMS. Set the spectrum analyzer as RBW = 3kHz (Set the RBW to: $3\text{ kHz} \leq \text{RBW} \leq 100\text{ kHz}$.), VBW = 10kHz (Set the VBW $\geq 3 \times \text{RBW}$), span = $1.5 \times \text{DTS bandwidth}$., detail see the test plot.

6.2.4 Record the max reading.

6.2.5 Repeat the above procedure until the measurements for all frequencies are completed.

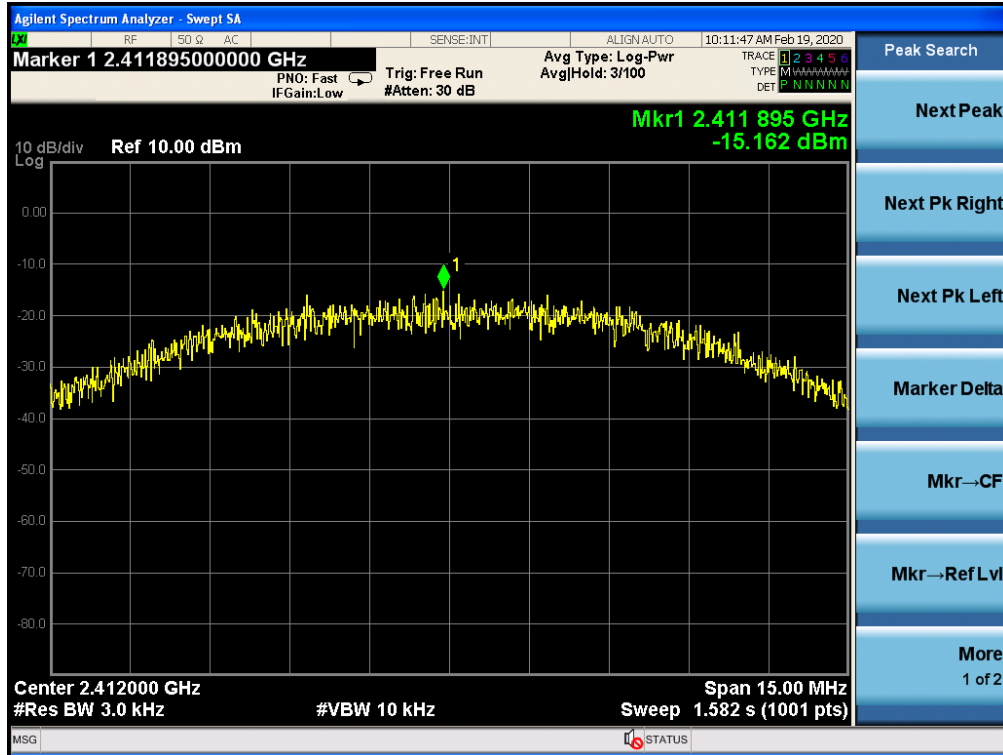
6.3. Test Setup



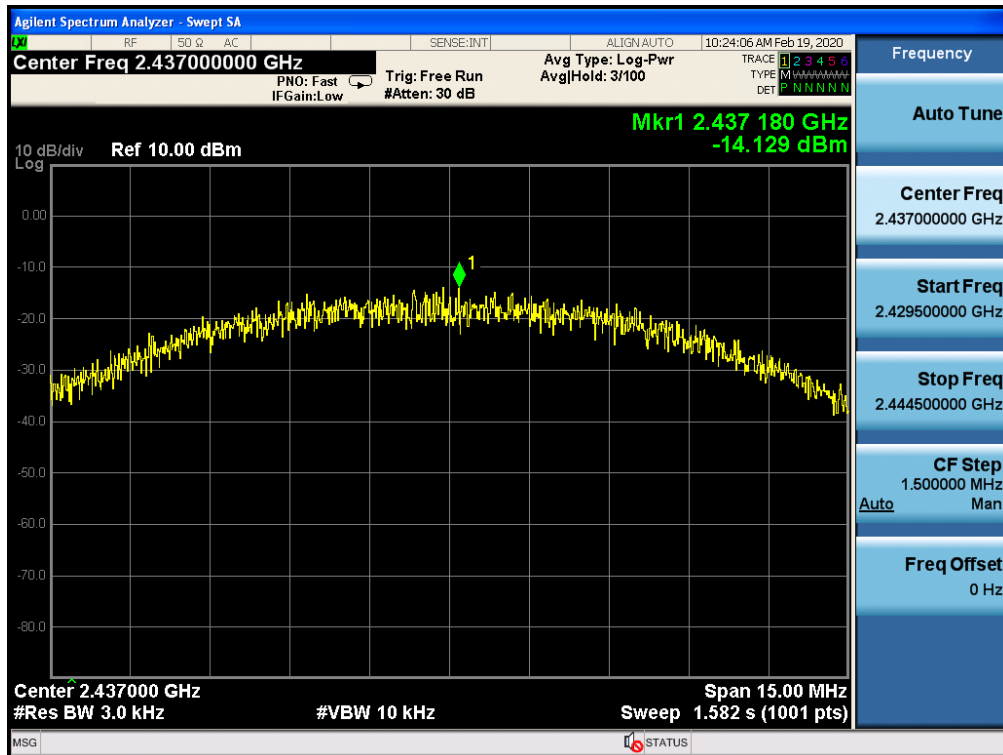
6.4. Test Results

Condition	Mode	Frequency (MHz)	Max PSD (dBm/3kHz)	Limit (dBm/3kHz)	Verdict
NVNT	802.11b	2412	-15.162	8	Pass
NVNT	802.11b	2437	-14.129	8	Pass
NVNT	802.11b	2462	-16.675	8	Pass
NVNT	802.11g	2412	-16.606	8	Pass
NVNT	802.11g	2437	-17.247	8	Pass
NVNT	802.11g	2462	-20.587	8	Pass
NVNT	802.11n(HT20)	2412	-15.275	8	Pass
NVNT	802.11n(HT20)	2437	-17.653	8	Pass
NVNT	802.11n(HT20)	2462	-20.055	8	Pass
NVNT	802.11n(HT40)	2422	-20.239	8	Pass
NVNT	802.11n(HT40)	2437	-20.766	8	Pass
NVNT	802.11n(HT40)	2452	-22.503	8	Pass

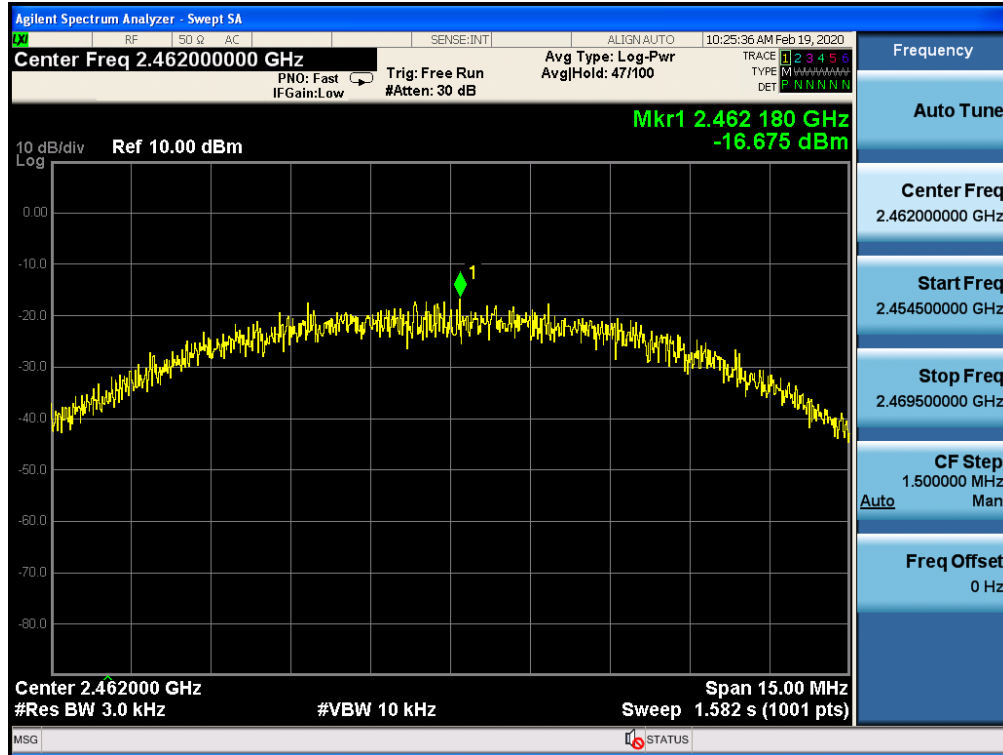
PSD NVNT 802.11b 2412MHz Ant1



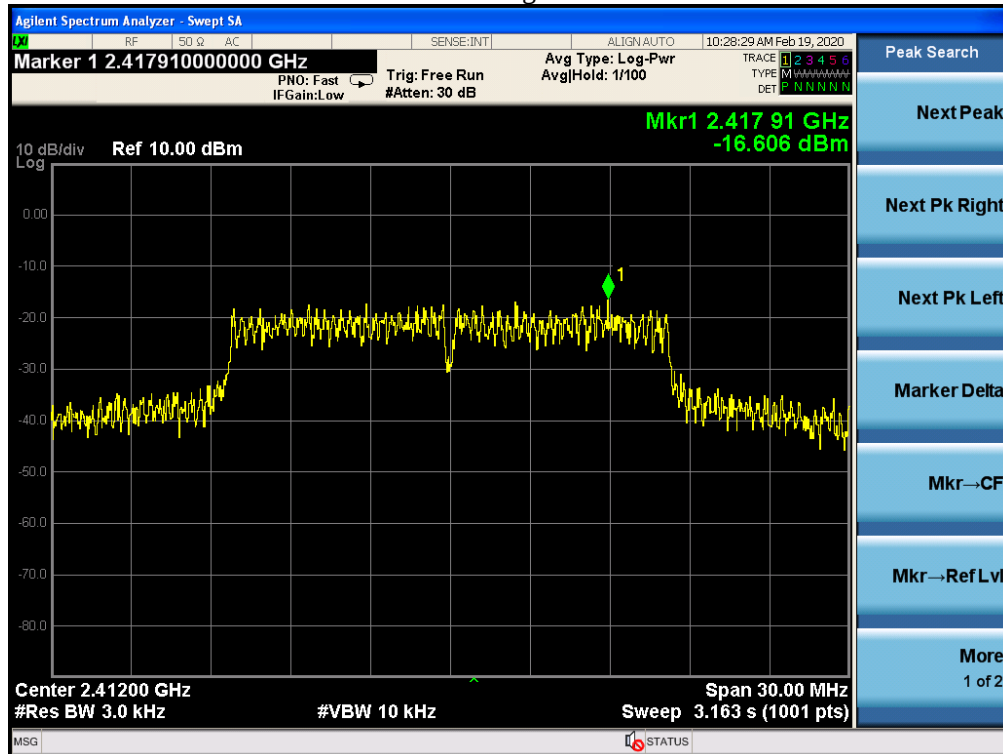
PSD NVNT 802.11b 2437MHz Ant1



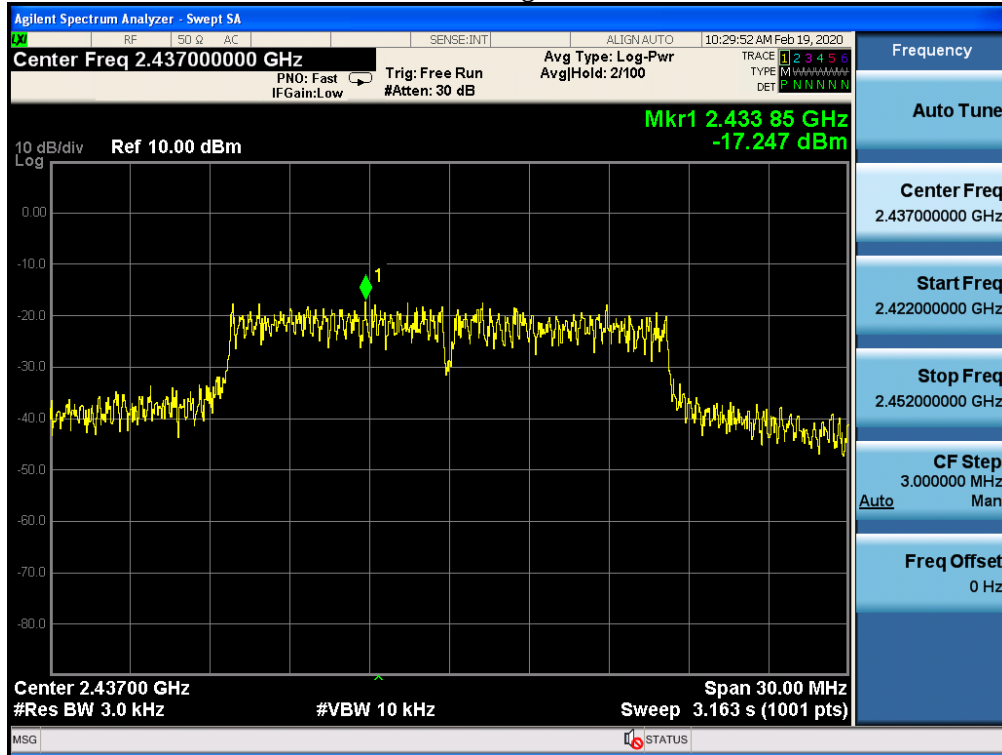
PSD NVNT 802.11b 2462MHz Ant1



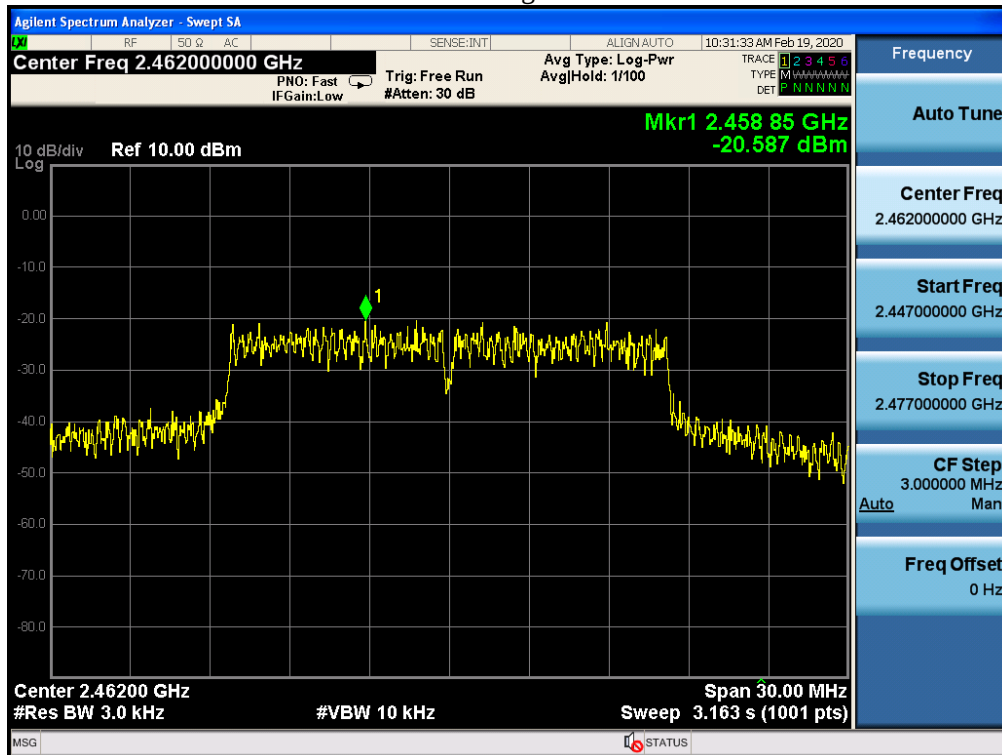
PSD NVNT 802.11g 2412MHz Ant1



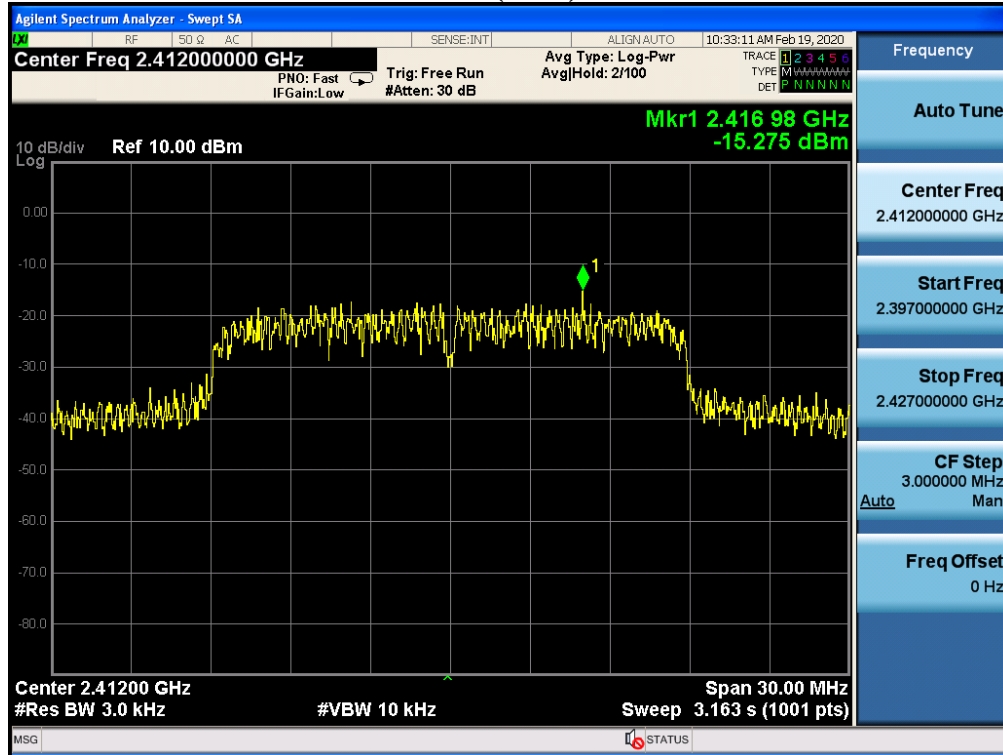
PSD NVNT 802.11g 2437MHz Ant1



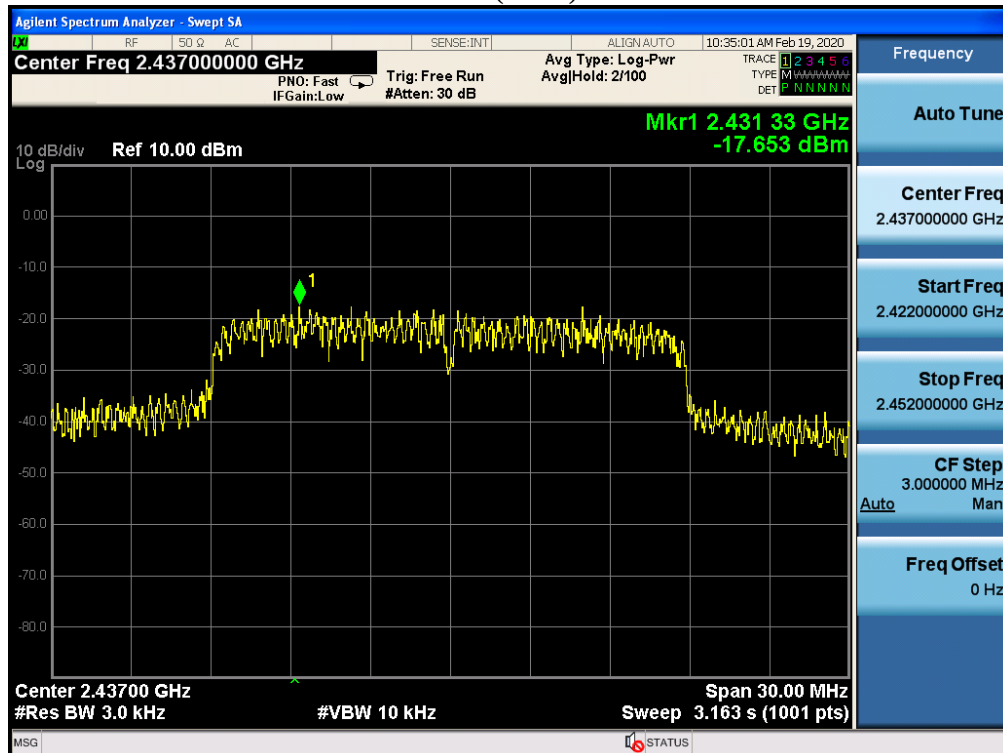
PSD NVNT 802.11g 2462MHz Ant1



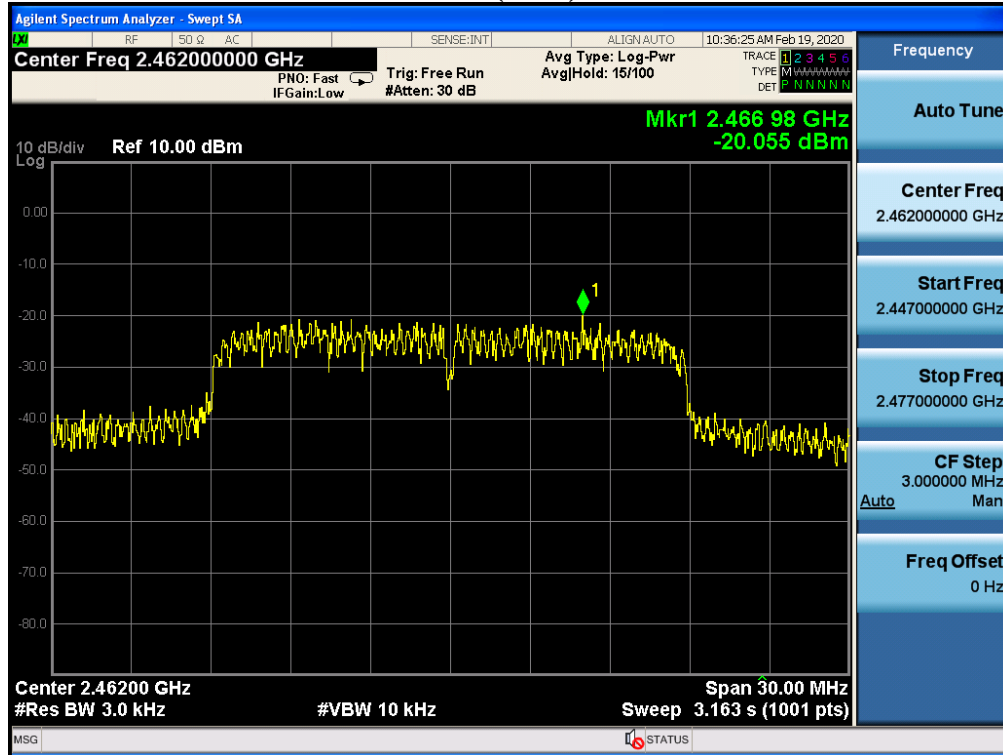
PSD NVNT 802.11n(HT20) 2412MHz Ant1



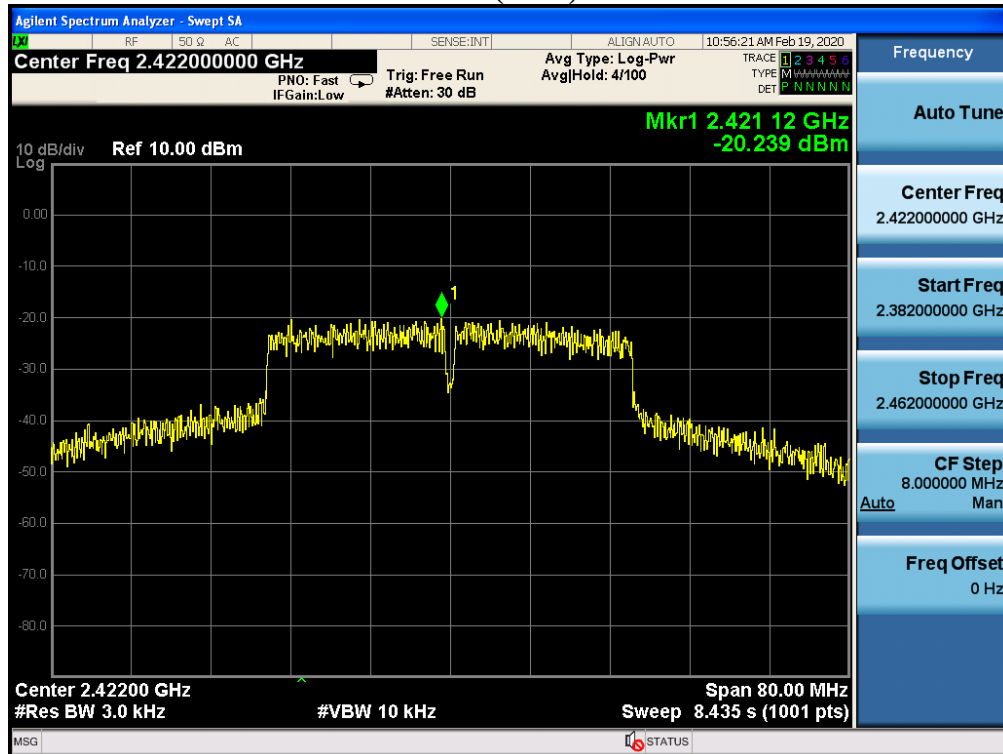
PSD NVNT 802.11n(HT20) 2437MHz Ant1



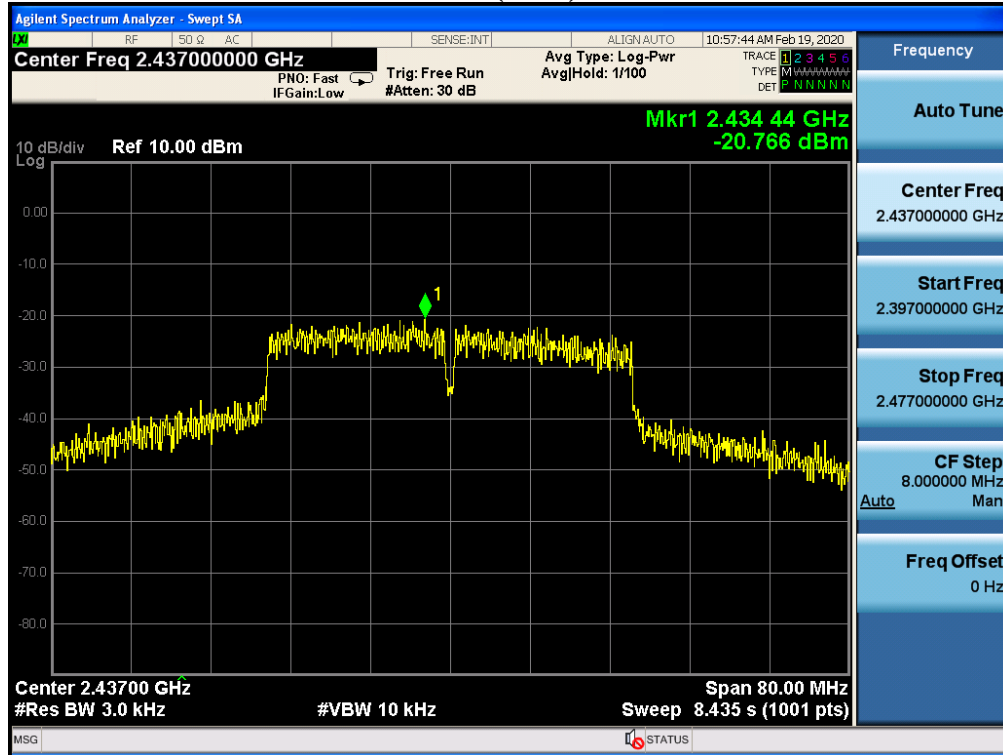
PSD NVNT 802.11n(HT20) 2462MHz Ant1



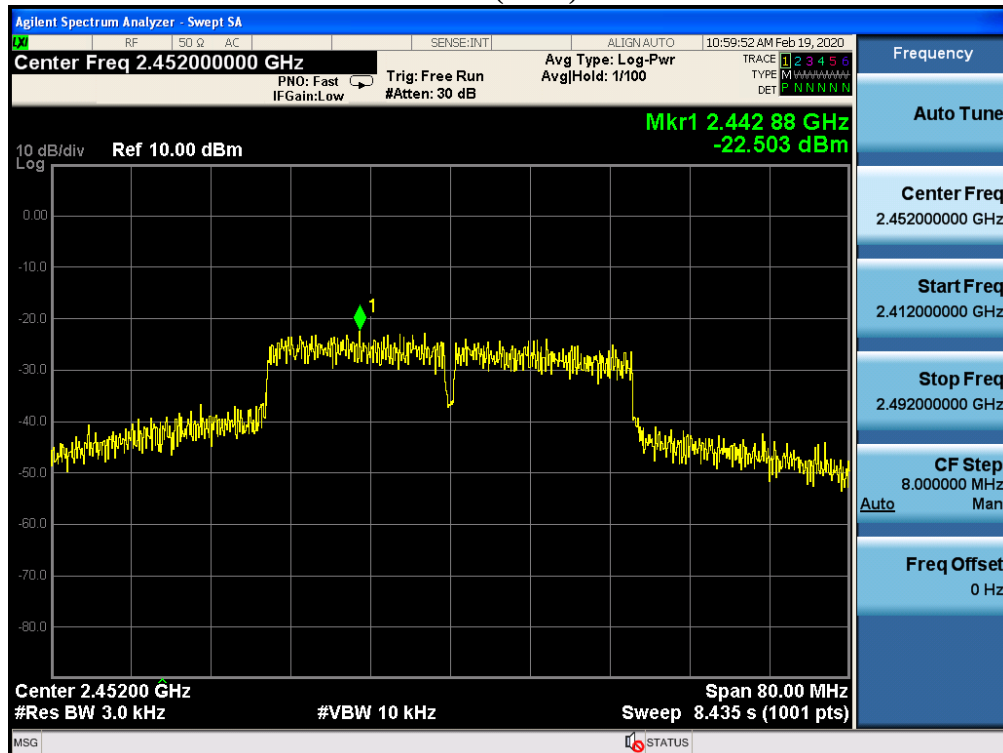
PSD NVNT 802.11n(HT40) 2422MHz Ant1



PSD NVNT 802.11n(HT40) 2437MHz Ant1



PSD NVNT 802.11n(HT40) 2452MHz Ant1



7. BANDWIDTH

7.1. Test limits

Please refer section 15.247

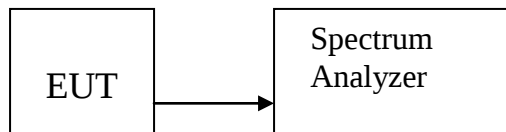
For direct sequence systems, the minimum 6dB bandwidth shall be at least 500 kHz.

7.2. Test Procedure

Details see the KDB558074 D01 Meas Guidance v05r02

- a) The bandwidth is measured at an amplitude level reduced 20dB from the reference level. The reference level is the level of the highest amplitude signal observed from the transmitter at the fundamental frequency. Once the reference level is established, the equipment is conditioned with typical modulating signal to produce the worst-case (i.e. the widest) bandwidth.
- b) The test receiver set RBW = 100kHz, VBW $\geq 3 \times$ RBW = 300kHz, Peak Detector, Sweep time set auto, detail see the test plot.

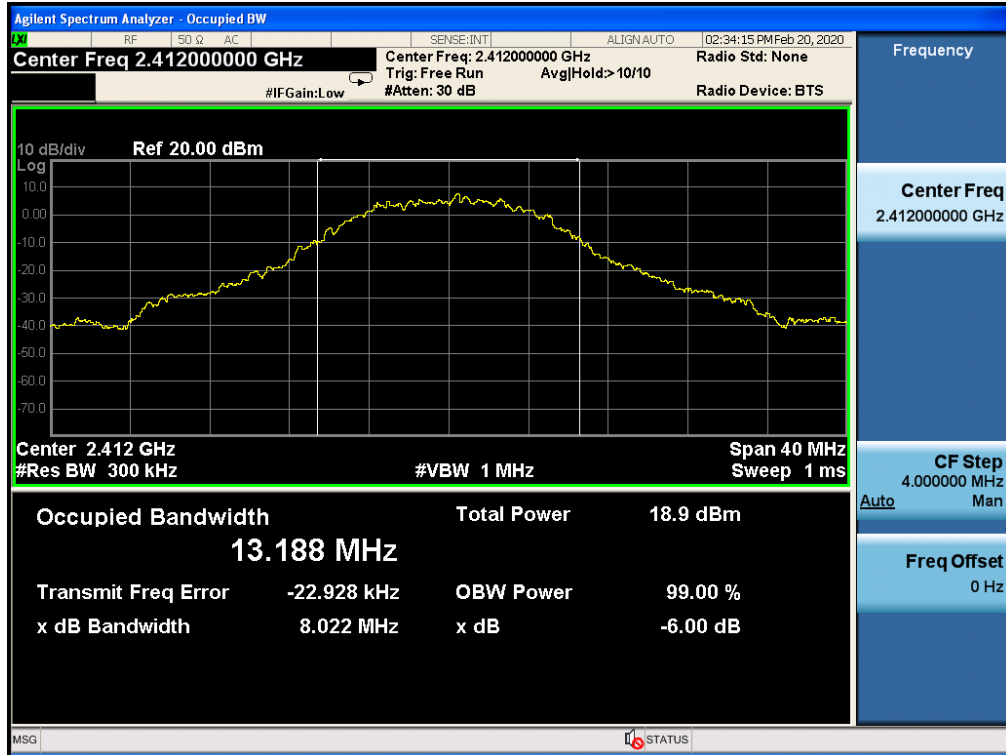
7.3. Test Setup



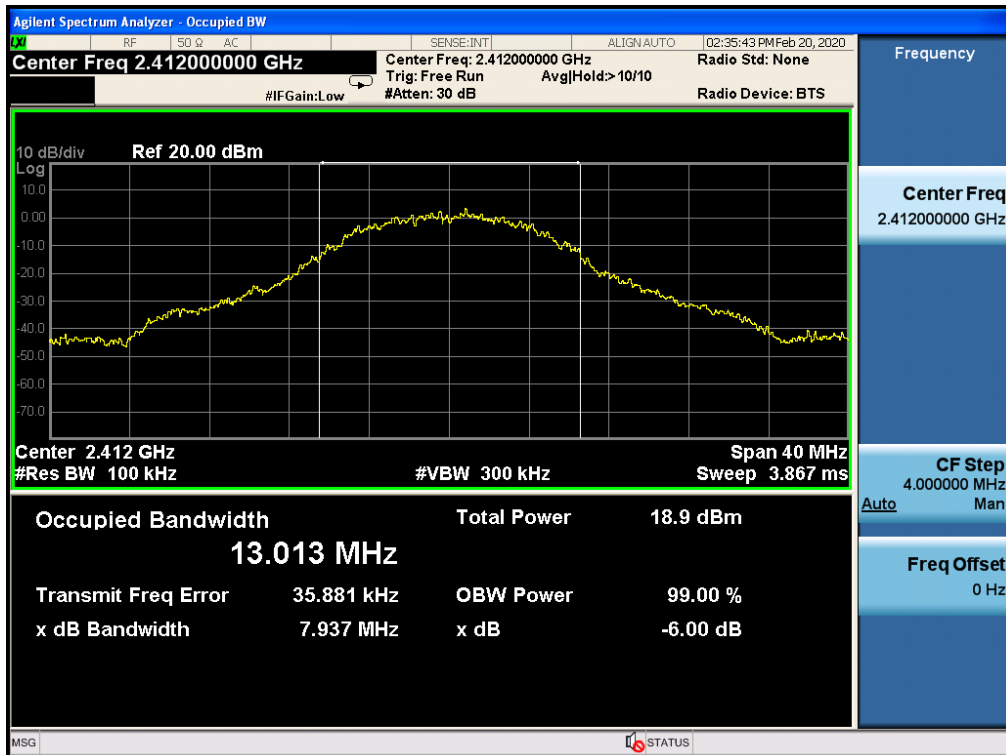
7.4. Test Results

Condition	Mode	Frequency (MHz)	99% OBW (MHz)	-6 dB Bandwidth (MHz)	Limit -6 dB Bandwidth (MHz)	Verdict
NVNT	802.11b	2412	13.188	7.937	0.5	Pass
NVNT	802.11b	2437	13.806	8.745	0.5	Pass
NVNT	802.11b	2462	13.096	8.704	0.5	Pass
NVNT	802.11g	2412	18.224	15.73	0.5	Pass
NVNT	802.11g	2437	18.338	15.75	0.5	Pass
NVNT	802.11g	2462	16.881	15.72	0.5	Pass
NVNT	802.11n(HT20)	2412	17.926	16.02	0.5	Pass
NVNT	802.11n(HT20)	2437	19.425	15.75	0.5	Pass
NVNT	802.11n(HT20)	2462	17.688	16.28	0.5	Pass
NVNT	802.11n(HT40)	2422	36.971	35.21	0.5	Pass
NVNT	802.11n(HT40)	2437	37.351	34.30	0.5	Pass
NVNT	802.11n(HT40)	2452	37.561	35.52	0.5	Pass

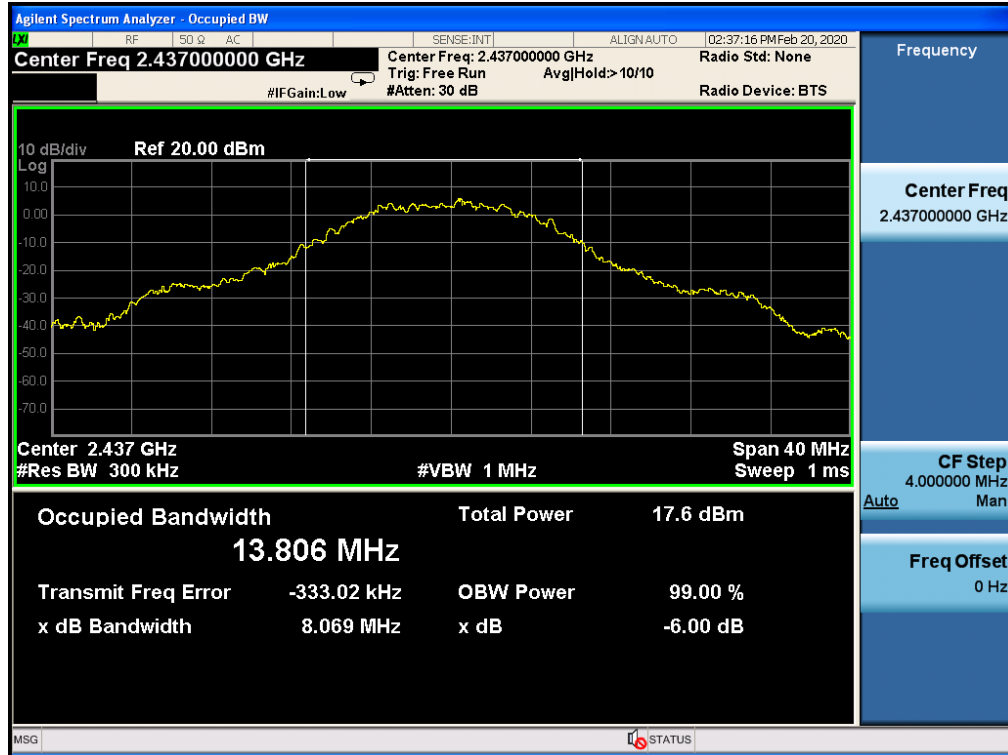
OBW NVNT 802.11b 2412MHz Ant1



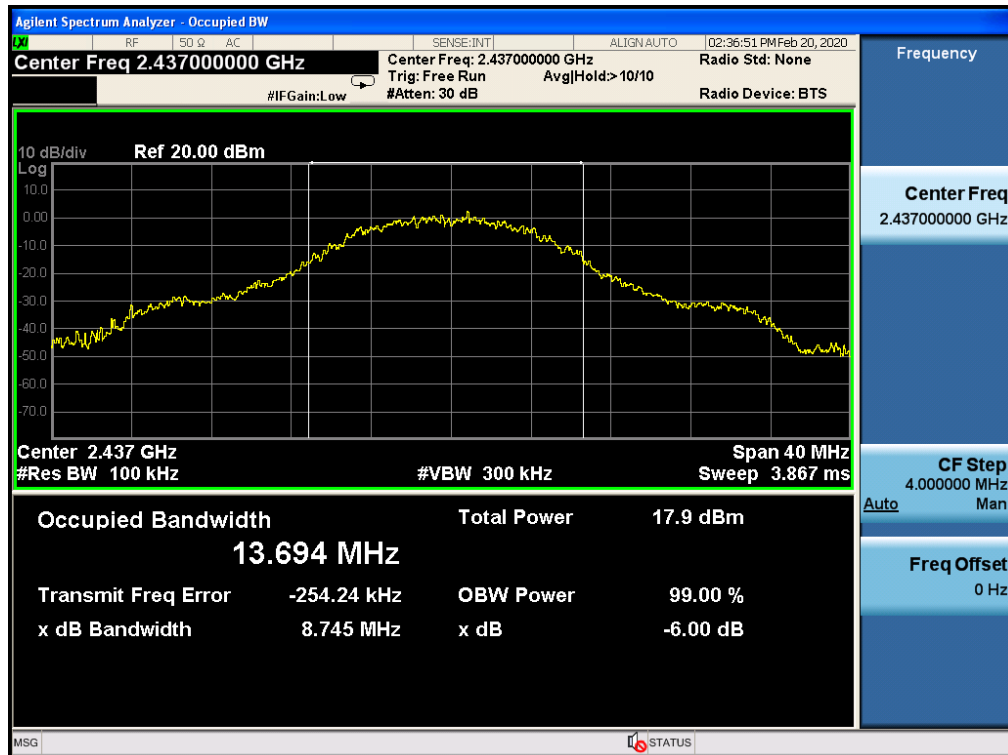
-6 dB BW NVNT 802.11b 2412MHz Ant1



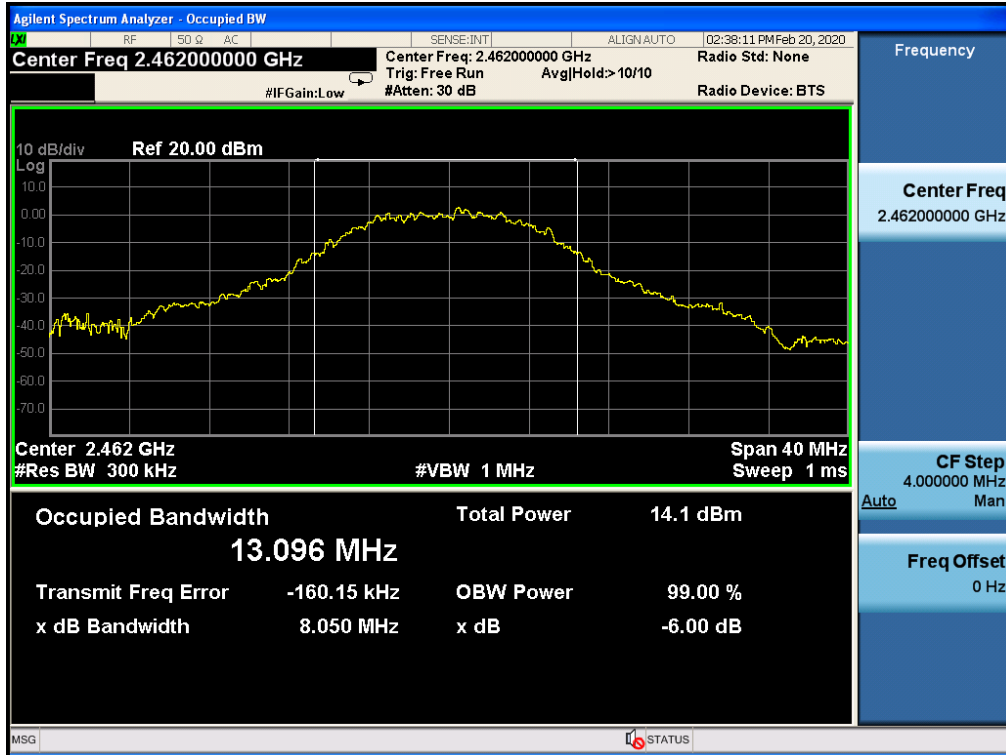
OBW NVNT 802.11b 2437MHz Ant1



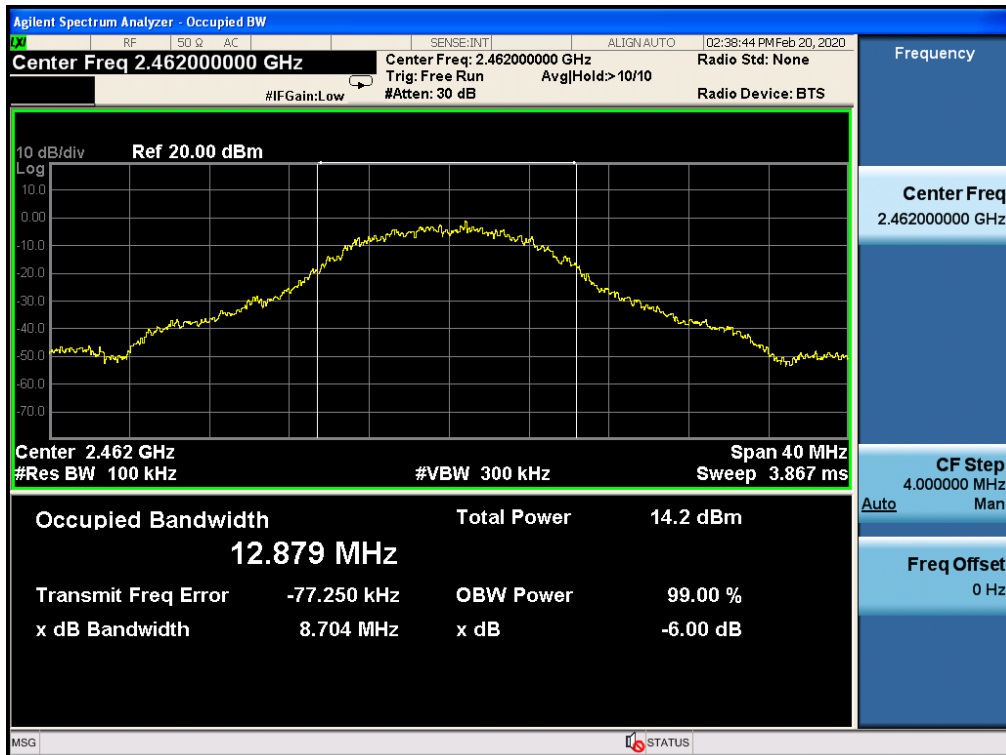
-6 dB BW NVNT 802.11b 2437MHz Ant1



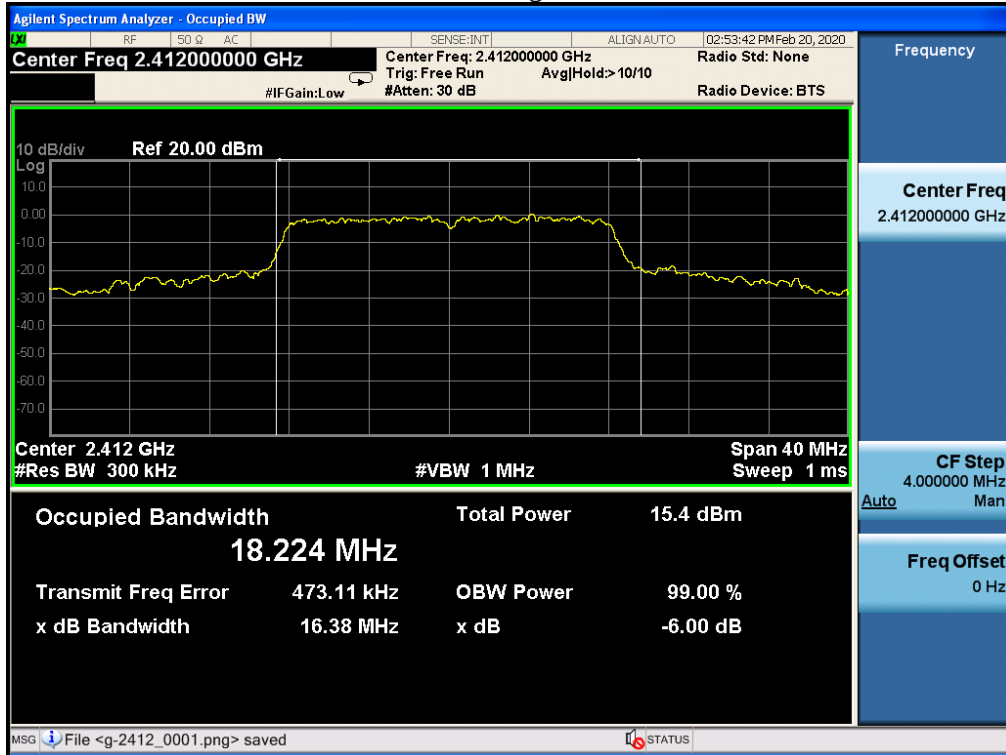
OBW NVNT 802.11b 2462MHz Ant1



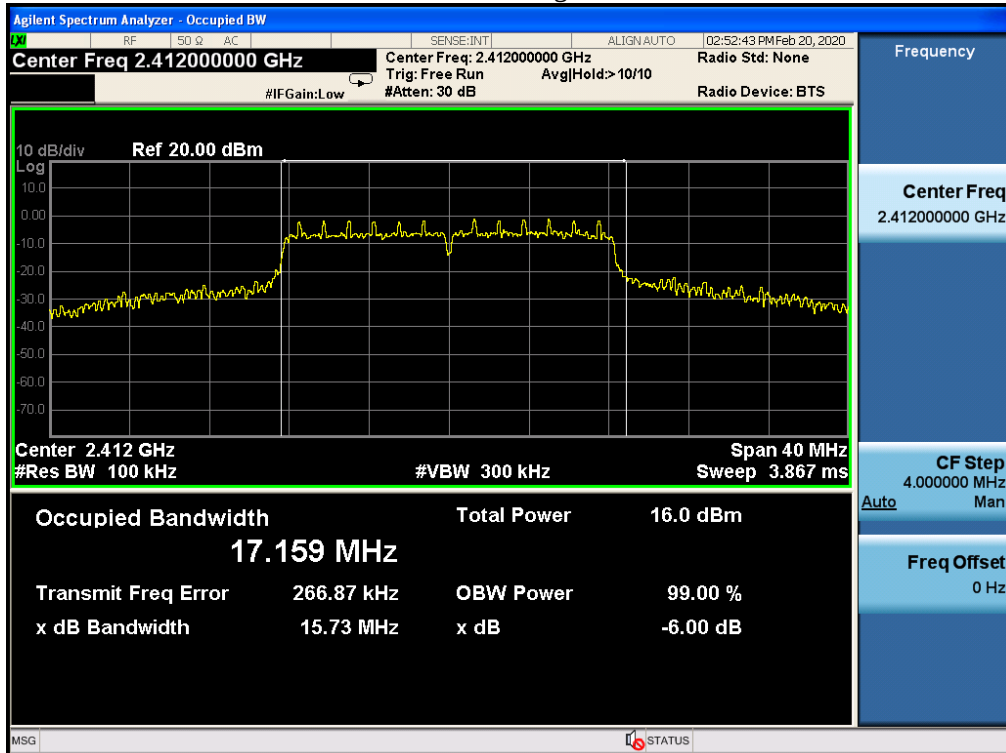
-6 dB BW NVNT 802.11b 2462MHz Ant1



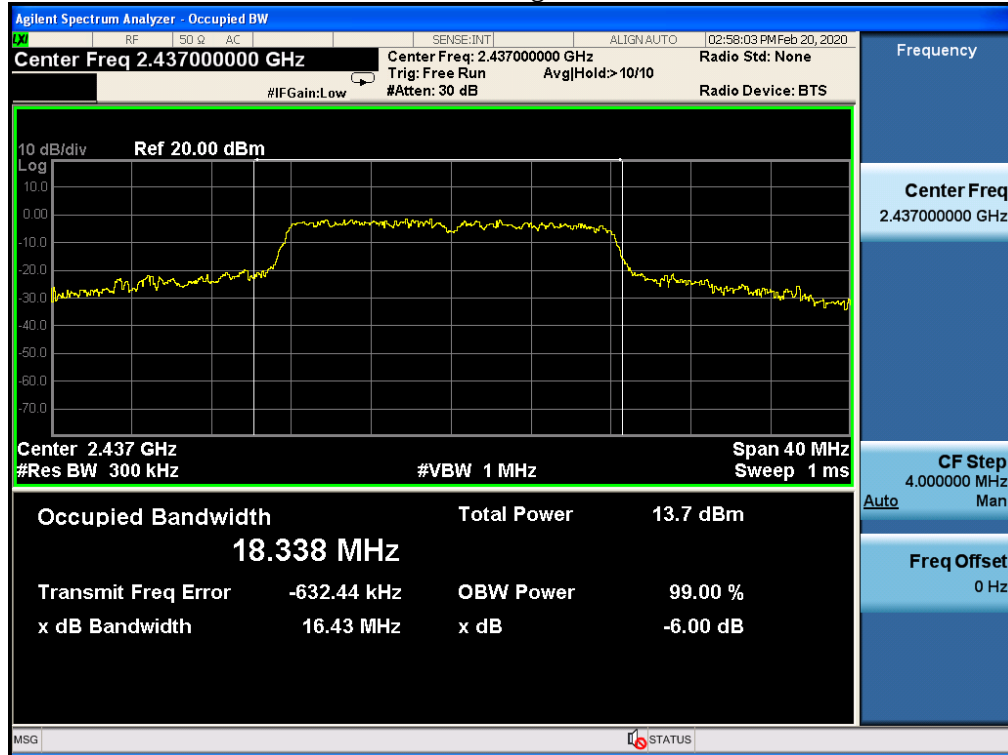
OBW NVNT 802.11g 2412MHz Ant1



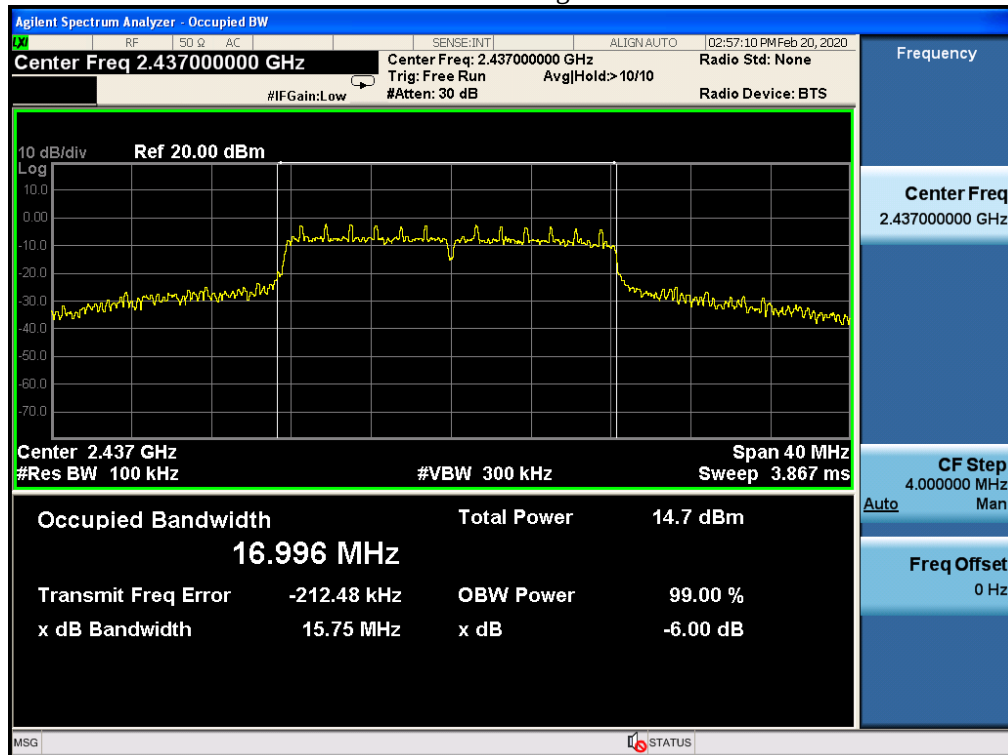
-6 dB BW NVNT 802.11g 2412MHz Ant1



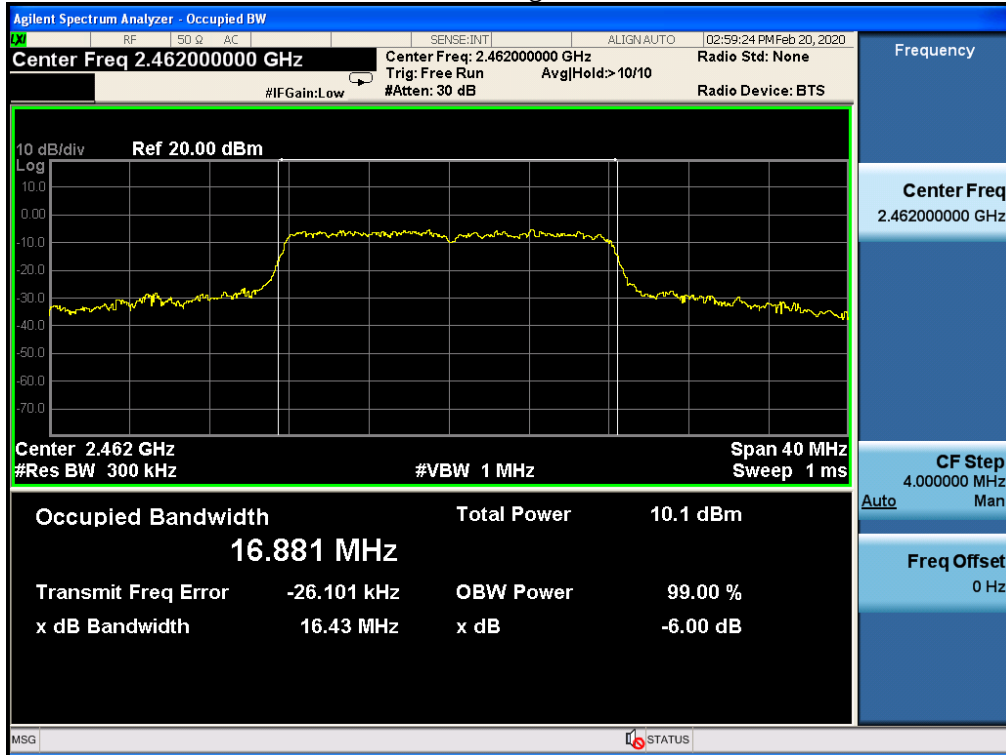
OBW NVNT 802.11g 2437MHz Ant1



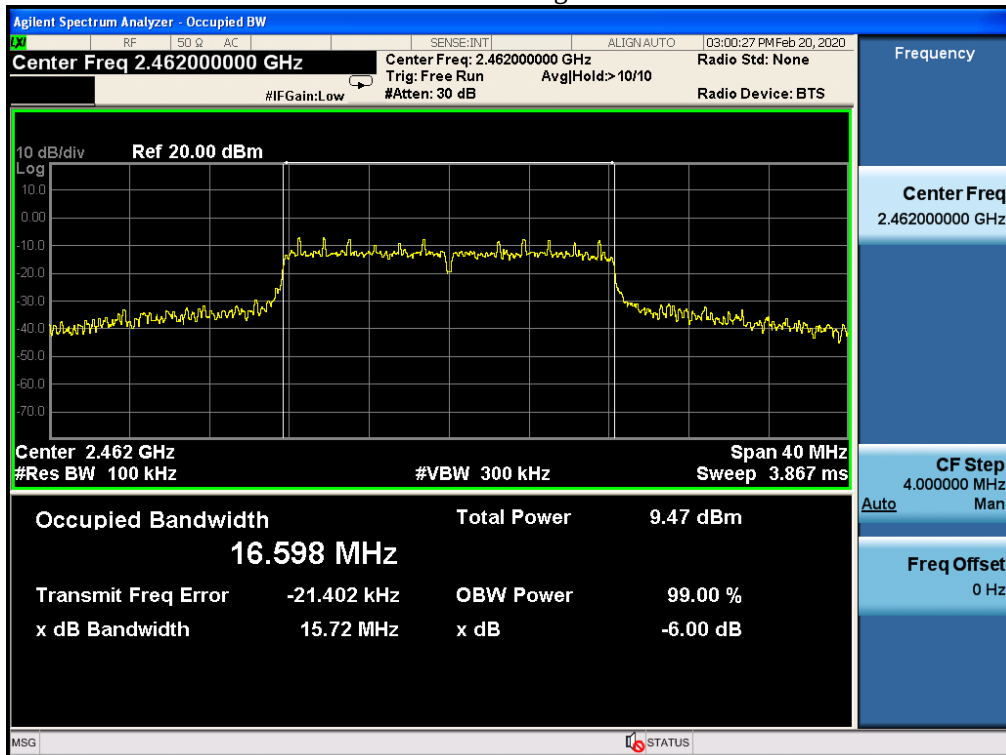
-6 dB BW NVNT 802.11g 2437MHz Ant1



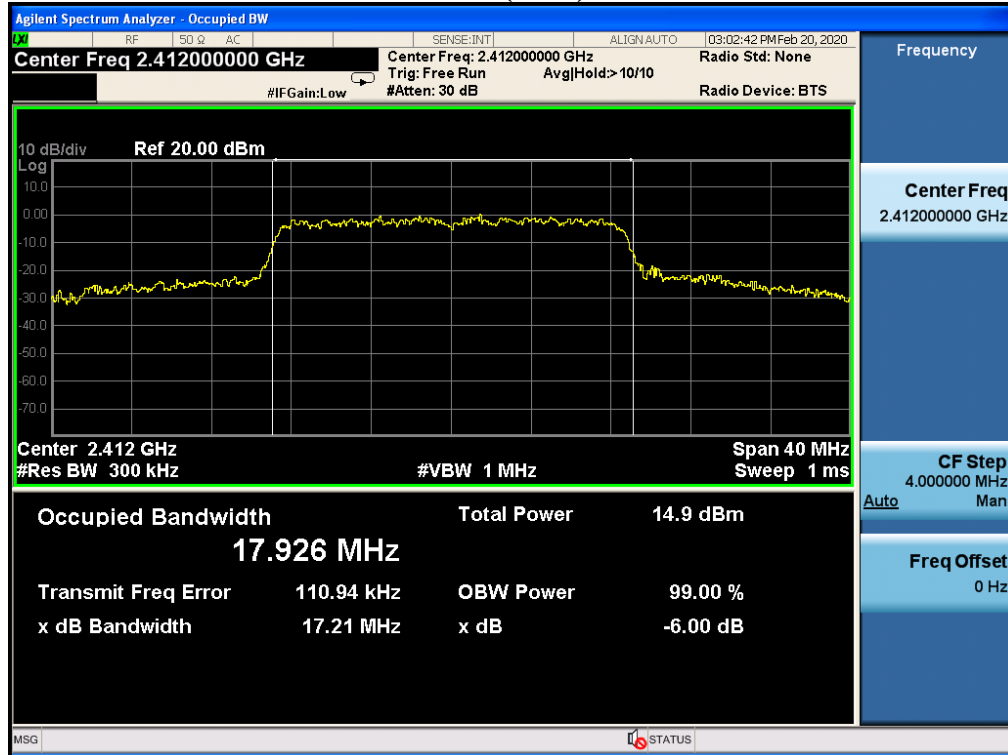
OBW NVNT 802.11g 2462MHz Ant1



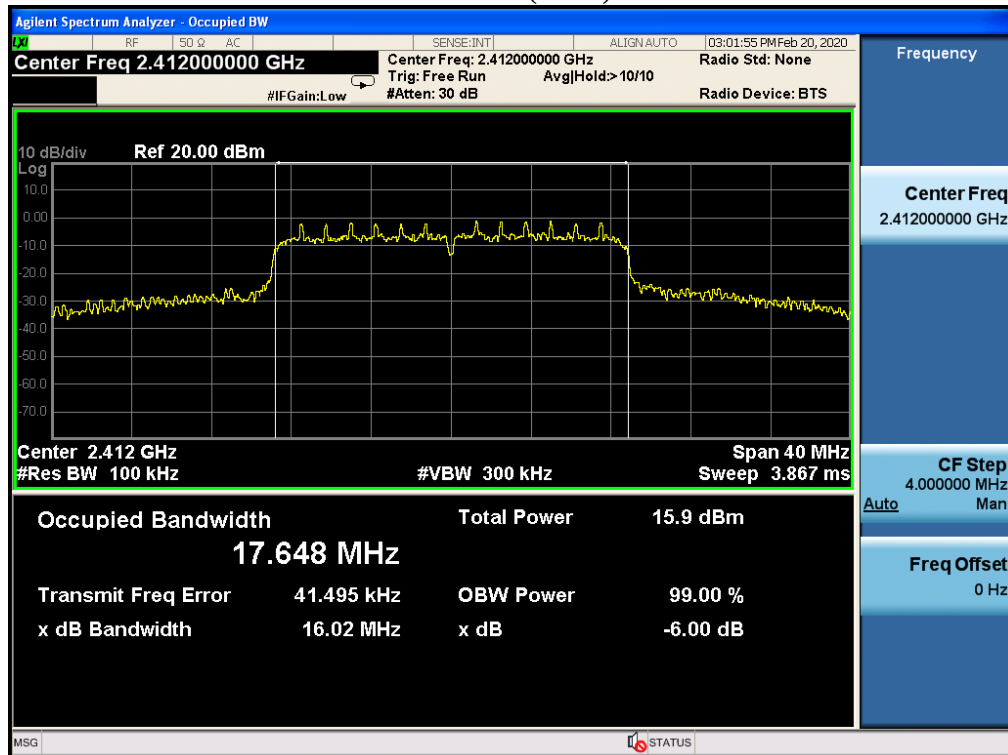
-6 dB BW NVNT 802.11g 2462MHz Ant1



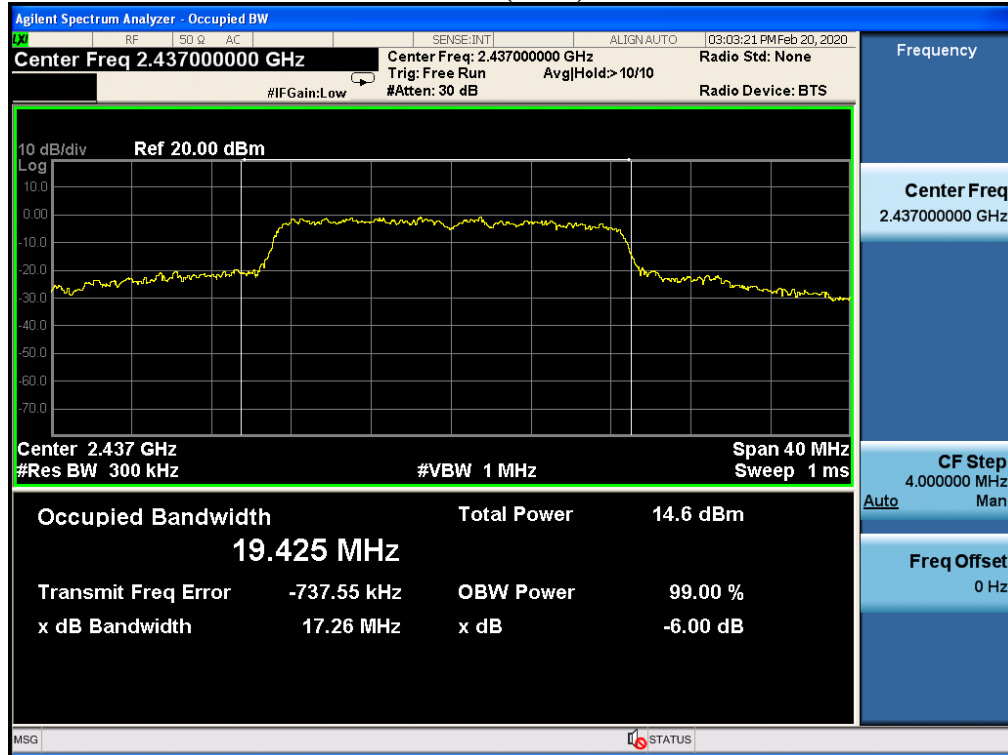
OBW NVNT 802.11n(HT20) 2412MHz Ant1



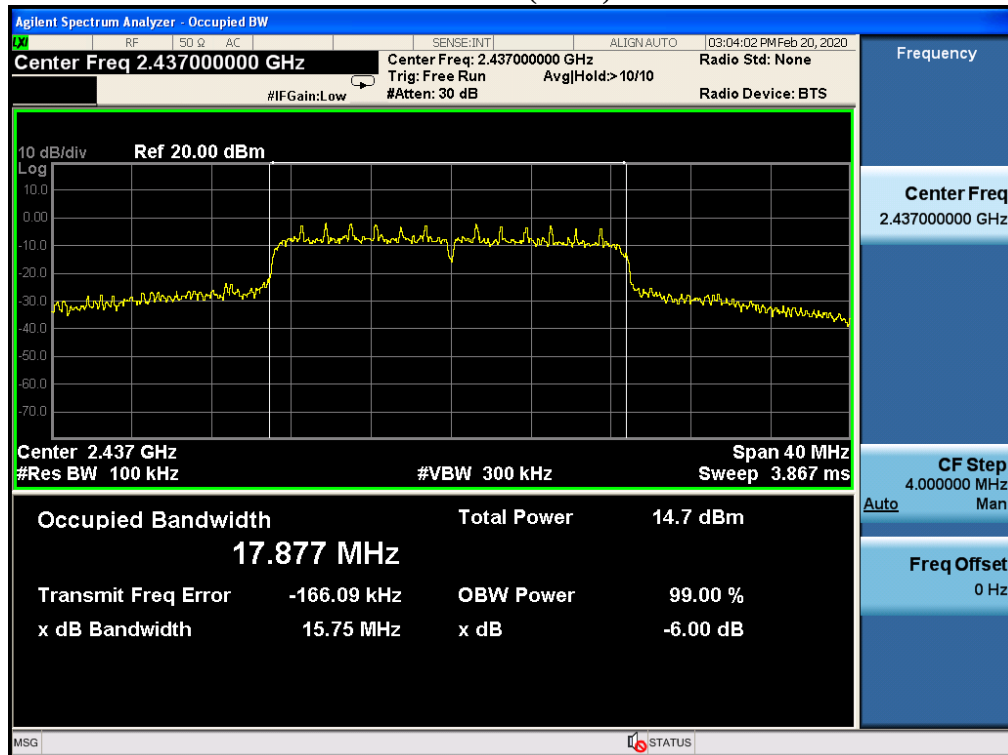
-6 dB BW NVNT 802.11n(HT20) 2412MHz Ant1



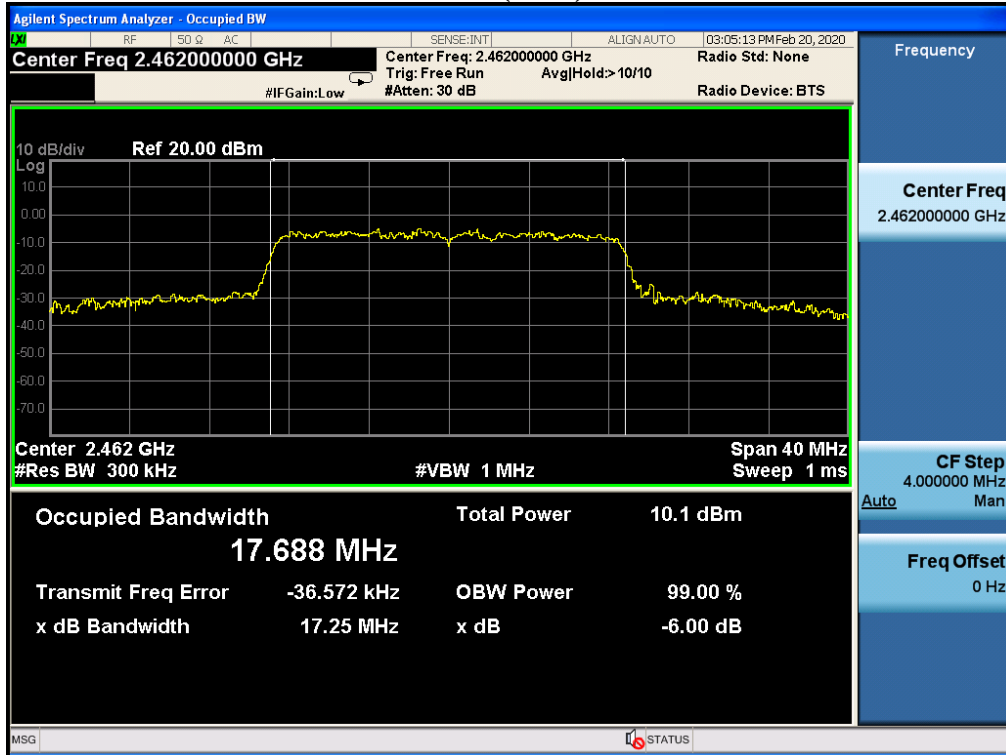
OBW NVNT 802.11n(HT20) 2437MHz Ant1



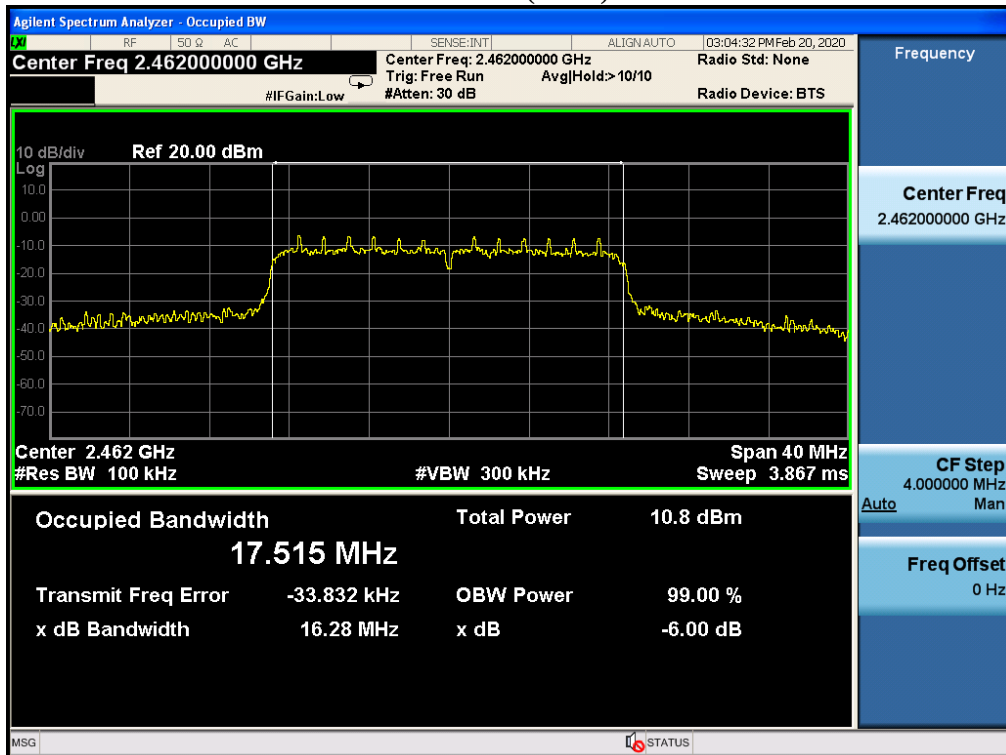
-6 dB BW NVNT 802.11n(HT20) 2437MHz Ant1



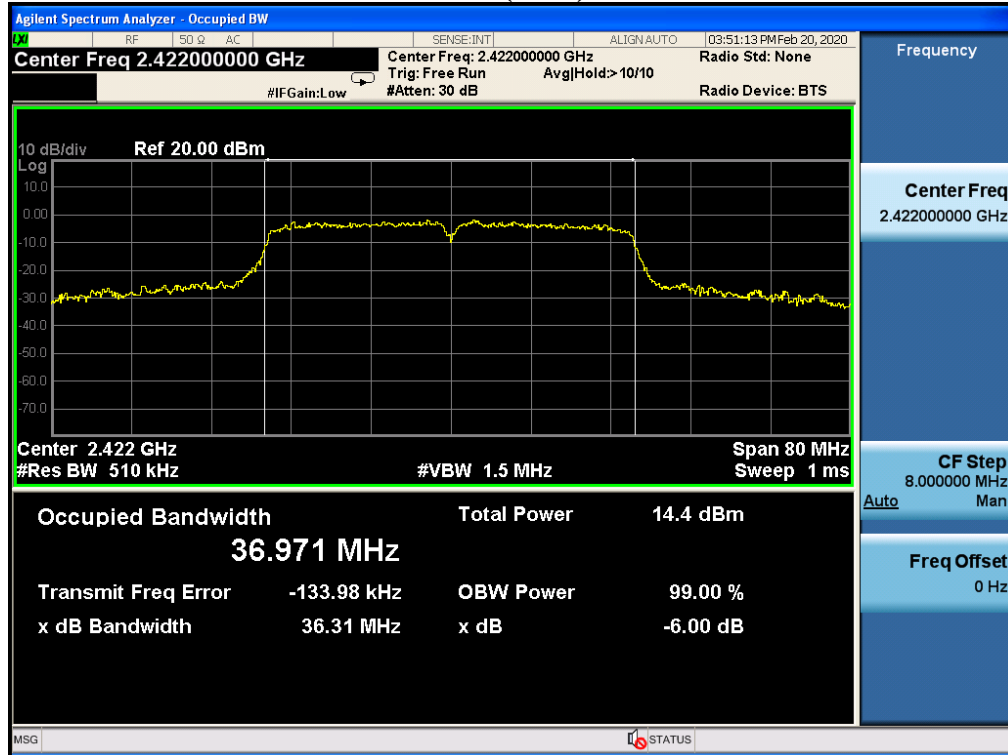
OBW NVNT 802.11n(HT20) 2462MHz Ant1



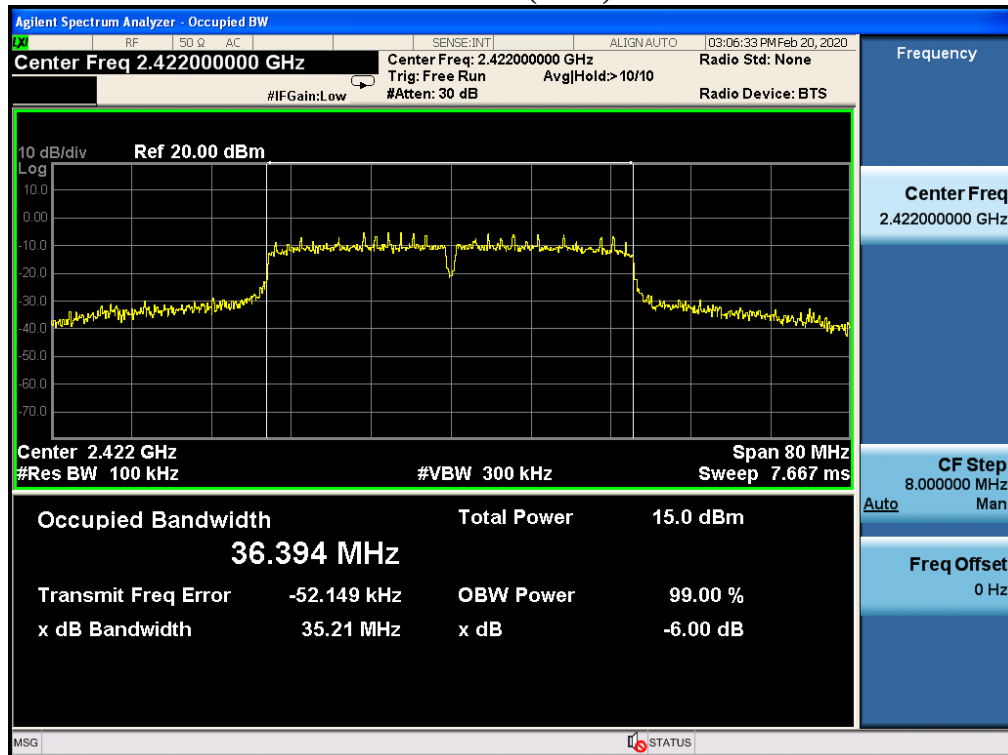
-6 dB BW NVNT 802.11n(HT20) 2462MHz Ant1



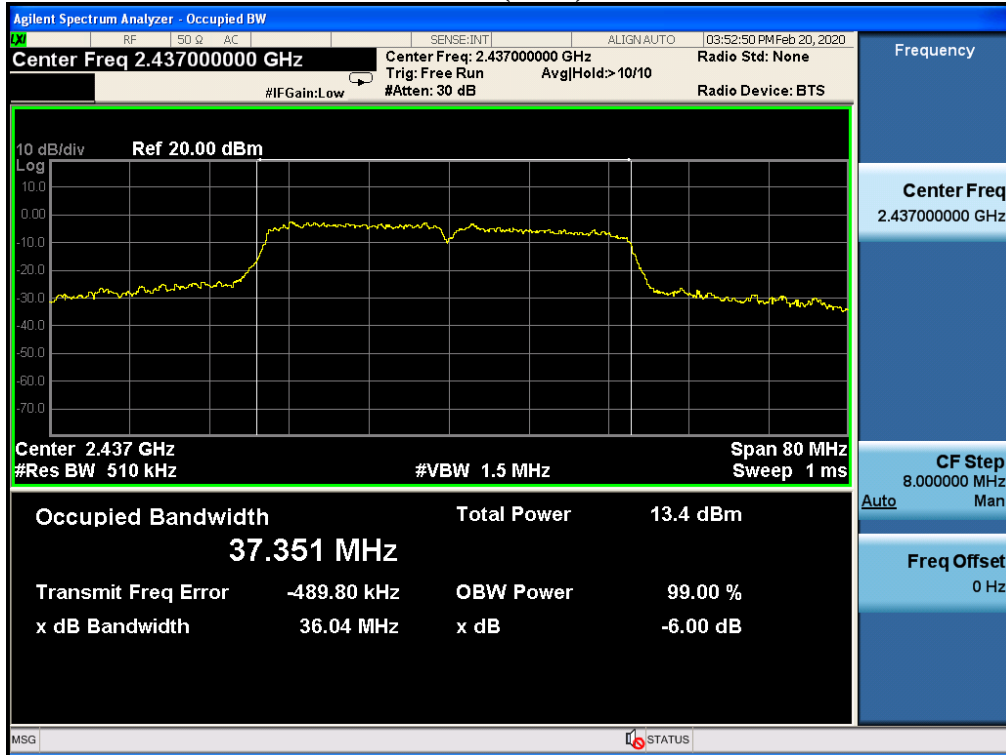
OBW NVNT 802.11n(HT40) 2422MHz Ant1



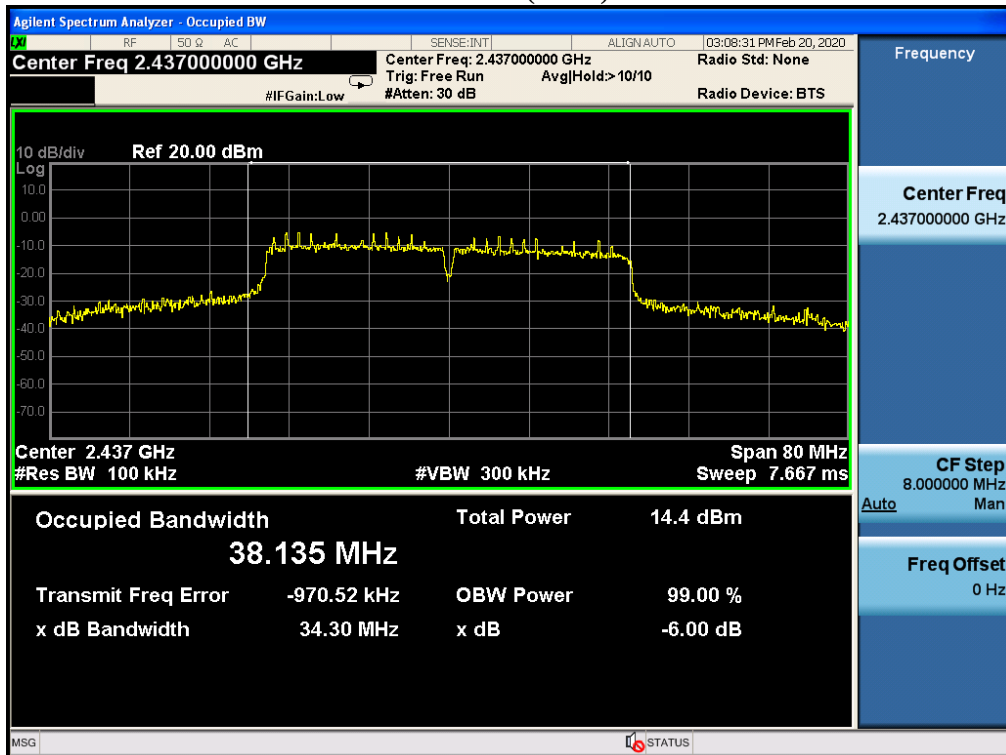
-6 dB BW NVNT 802.11n(HT40) 2422MHz Ant1



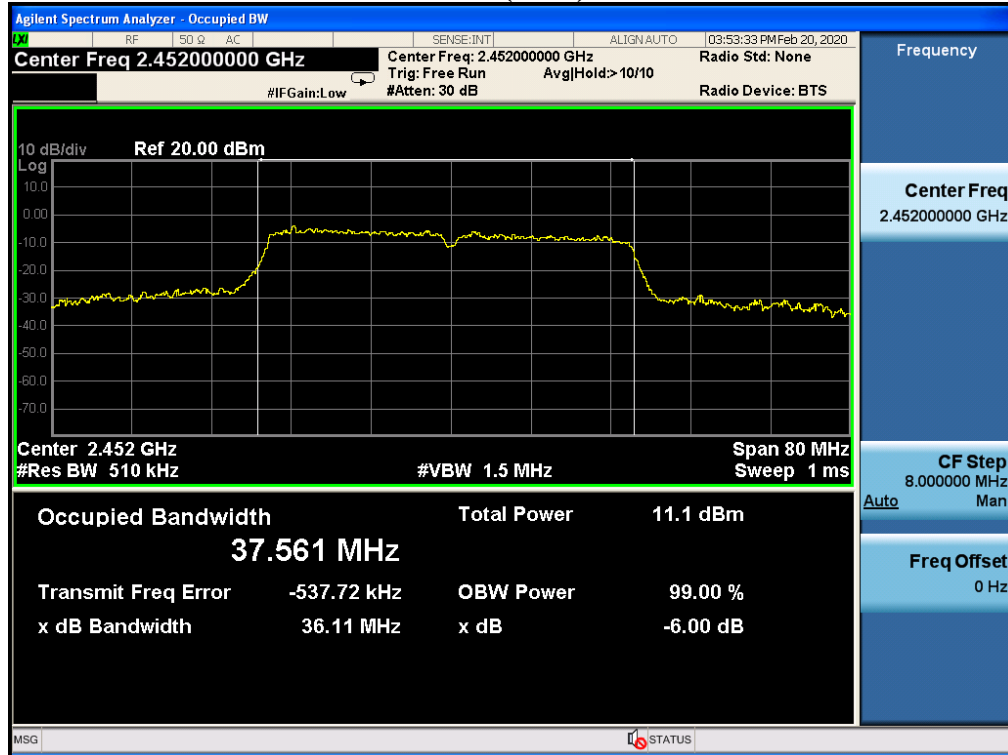
OBW NVNT 802.11n(HT40) 2437MHz Ant1



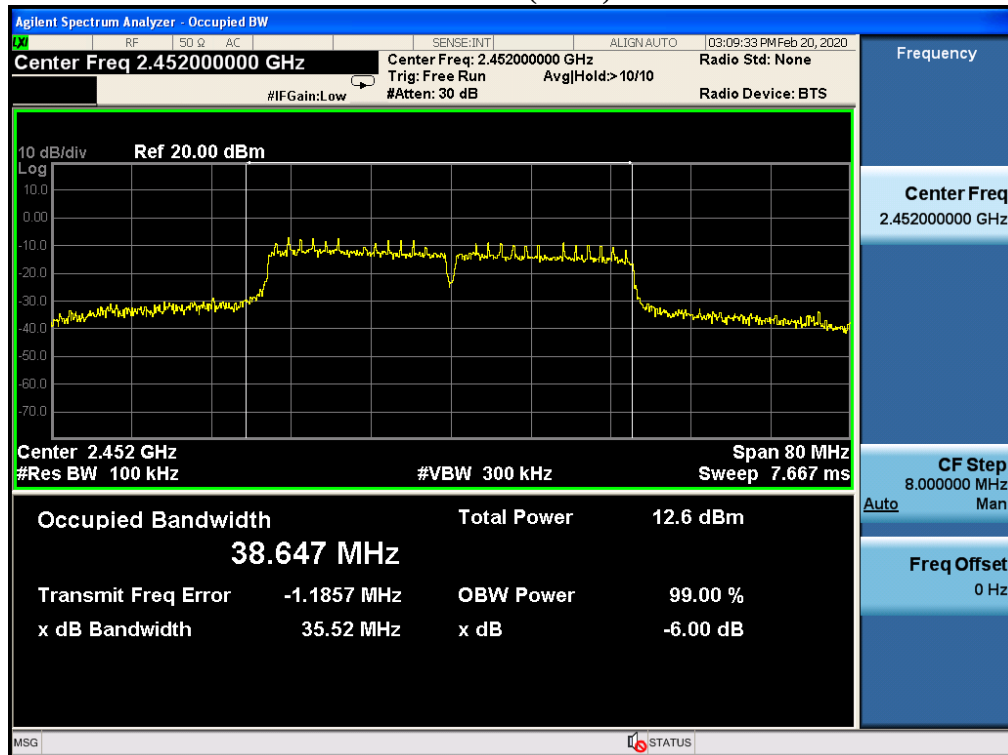
-6 dB BW NVNT 802.11n(HT40) 2437MHz Ant1



OBW NVNT 802.11n(HT40) 2452MHz Ant1



-6 dB BW NVNT 802.11n(HT40) 2452MHz Ant1



8. BAND EDGE CHECK

8.1. Test limits

Please refer section 15.247

All the lower and upper band-edges emissions appearing within 2310MHz to 2390MHz and 2483.5MHz to 2500MHz restricted frequency bands shall not exceed the limits shown in 15.209, all the other emissions outside operation frequency band 2400MHz to 2483.5MHz and 5725MHz to 5850MHz shall be at least 20dB below the fundamental emissions, or comply with 15.209 limits.

8.2. Test Procedure

Details see the KDB558074 D01 Meas Guidance v05r02

8.2.1 Put the EUT on a 1.5m high table, power on the EUT. Emissions were scanned and measured rotating the EUT to 360 degrees, Find the maximum Emission

8.2.2 Check the spurious emissions out of band.

8.2.3 RBW 1MHz, VBW 3MHz, peak detector for peak value , RBW 1MHz ,VBW 10Hz , RMS detector for AV value.

8.3. Test Setup

Same as 5.2.2.

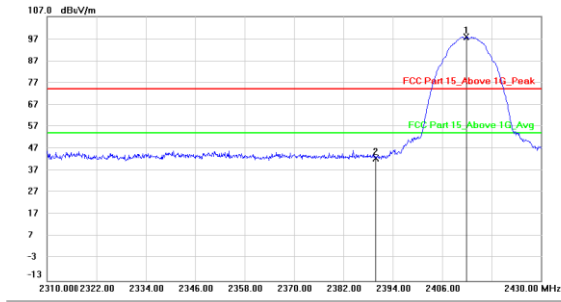
8.4. Test Results

PASS.

Detailed information please see the following page.

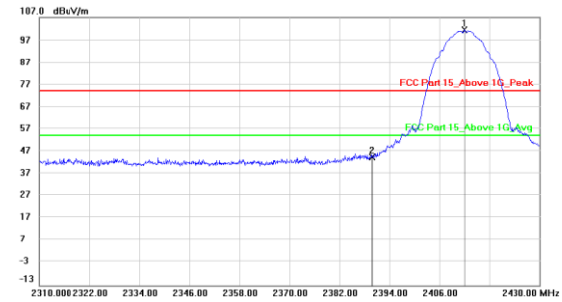
Test Mode: IEEE 802.11b-Low

Polarization: Vertical



No.	Mk.	Freq.	Reading Level	Correct Factor	Measurement	Limit	Margin	Antenna Height	Table Degree	Comment
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	cm	degree	
1	*	2411.880	101.39	-3.40	97.99	74.00	23.99	peak		
2		2390.000	46.20	-3.40	42.80	74.00	-31.20	peak		

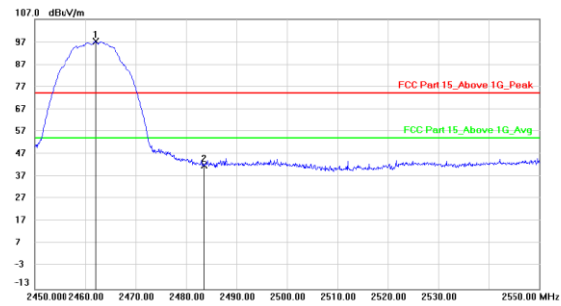
Polarization: Horizontal



No.	Mk.	Freq.	Reading Level	Correct Factor	Measurement	Limit	Margin	Antenna Height	Table Degree	Comment
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	cm	degree	
1	*	2412.000	104.82	-3.40	101.42	74.00	27.42	peak		
2		2390.000	47.99	-3.40	44.59	74.00	-29.41	peak		

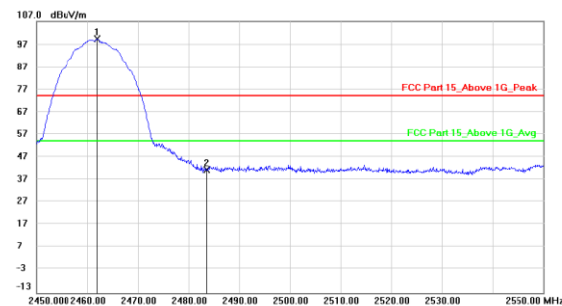
Test Mode: IEEE 802.11b-High

Polarization: Vertical



No.	Mk.	Freq.	Reading Level	Correct Factor	Measurement	Limit	Margin	Antenna Height	Table Degree	Comment
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	cm	degree	
1	*	2462.000	100.53	-3.40	97.13	74.00	23.13	peak		
2		2483.500	45.43	-3.38	42.05	74.00	-31.95	peak		

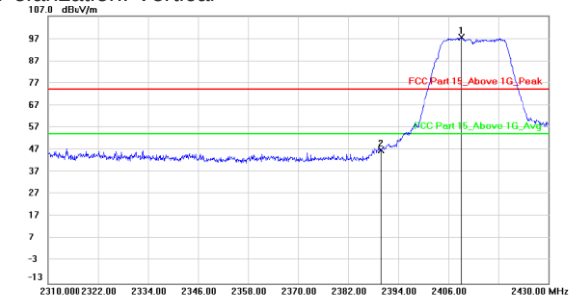
Polarization: Horizontal



No.	Mk.	Freq.	Reading Level	Correct Factor	Measurement	Limit	Margin	Antenna Height	Table Degree	Comment
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	cm	degree	
1	*	2461.900	102.74	-3.40	99.34	74.00	25.34	peak		
2		2483.500	44.69	-3.38	41.31	74.00	-32.69	peak		

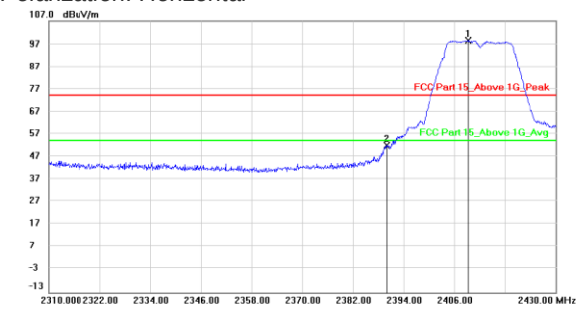
Test Mode: IEEE 802.11g-Low

Polarization: Vertical



No.	Mk.	Freq.	Reading Level	Correct Factor	Measurement	Limit	Margin	Antenna Height	Table Degree	Comment
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	cm	degree	
1	*	2409.120	100.86	-3.40	97.46	74.00	23.46			peak
2		2390.000	50.35	-3.40	46.95	74.00	-27.05			peak

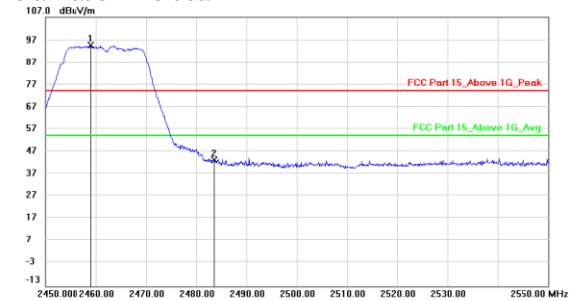
Polarization: Horizontal



No.	Mk.	Freq.	Reading Level	Correct Factor	Measurement	Limit	Margin	Antenna Height	Table Degree	Comment
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	cm	degree	
1	*	2409.240	101.75	-3.40	98.35	74.00	24.35			peak
2		2390.000	55.32	-3.40	51.92	74.00	-22.08			peak

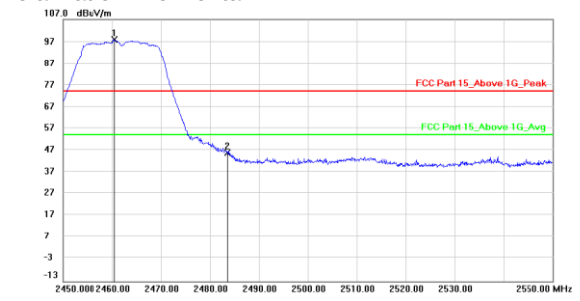
Test Mode: IEEE 802.11g-High

Polarization: Vertical



No.	Mk.	Freq.	Reading Level	Correct Factor	Measurement	Limit	Margin	Antenna Height	Table Degree	Comment
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	cm	degree	
1	*	2459.000	97.85	-3.39	94.46	74.00	20.46			peak
2		2483.500	46.60	-3.38	43.22	74.00	-30.78			peak

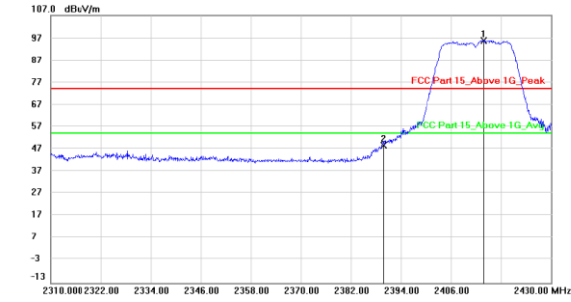
Polarization: Horizontal



No.	Mk.	Freq.	Reading Level	Correct Factor	Measurement	Limit	Margin	Antenna Height	Table Degree	Comment
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	cm	degree	
1	*	2460.500	101.22	-3.39	97.83	74.00	23.83			peak
2		2483.500	49.37	-3.38	45.99	74.00	-28.01			peak

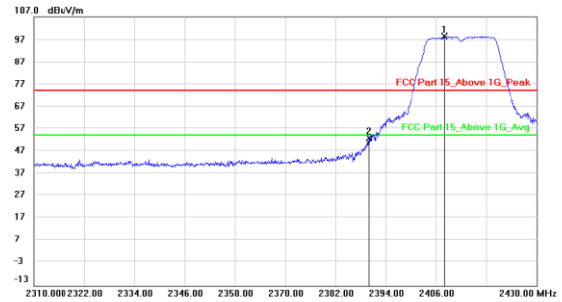
Test Mode: IEEE 802.11n20-Low

Polarization: Vertical



No.	Mk.	Freq.	Reading Level	Correct Factor	Measurement	Limit	Margin	Antenna Height	Table Degree	Comment
		MHz	dBuV	dB	dBuV/m	dB	dB	cm	degree	
1	*	2413.920	99.30	-3.41	95.89	74.00	21.89	peak		
2		2390.000	52.06	-3.40	48.66	74.00	-25.34	peak		

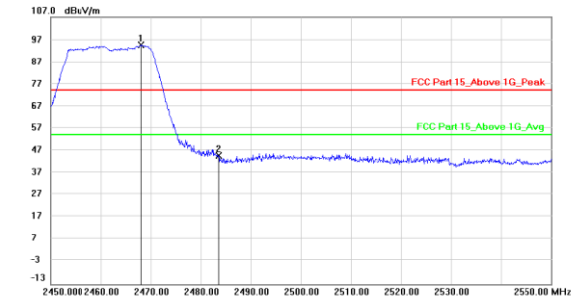
Polarization: Horizontal



No.	Mk.	Freq.	Reading Level	Correct Factor	Measurement	Limit	Margin	Antenna Height	Table Degree	Comment
		MHz	dBuV	dB	dBuV/m	dB	dB	cm	degree	
1	*	2407.920	101.97	-3.40	98.57	74.00	24.57	peak		
2		2390.000	56.36	-3.40	52.96	74.00	-21.04	peak		

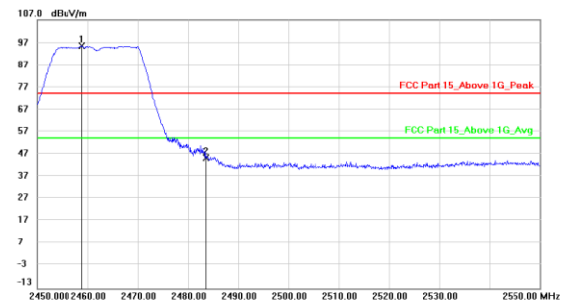
Test Mode: IEEE 802.11n20-High

Polarization: Vertical



No.	Mk.	Freq.	Reading Level	Correct Factor	Measurement	Limit	Margin	Antenna Height	Table Degree	Comment
		MHz	dBuV	dB	dBuV/m	dB	dB	cm	degree	
1	*	2468.100	97.83	-3.39	94.44	74.00	20.44	peak		
2		2483.500	48.07	-3.38	44.69	74.00	-29.31	peak		

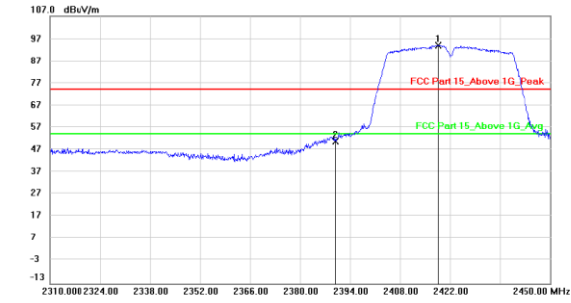
Polarization: Horizontal



No.	Mk.	Freq.	Reading Level	Correct Factor	Measurement	Limit	Margin	Antenna Height	Table Degree	Comment
		MHz	dBuV	dB	dBuV/m	dB	dB	cm	degree	
1	*	2458.800	98.89	-3.39	95.50	74.00	21.50	peak		
2		2483.500	48.58	-3.38	45.20	74.00	-28.80	peak		

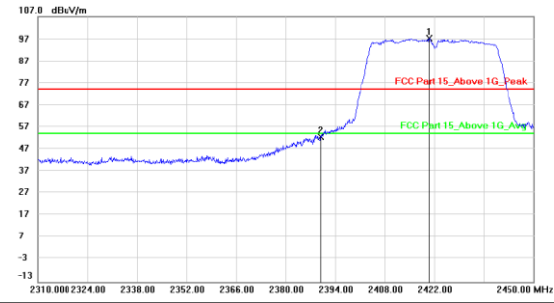
Test Mode: IEEE 802.11n40-Low

Polarization: Vertical



No.	Mk.	Freq.	Reading	Correct	Measure-	Limit	Margin	Antenna	Table	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree
1	*	2418.640	97.40	-3.41	93.99	74.00	19.99	peak		
2		2390.000	54.28	-3.40	50.88	74.00	-23.12	peak		

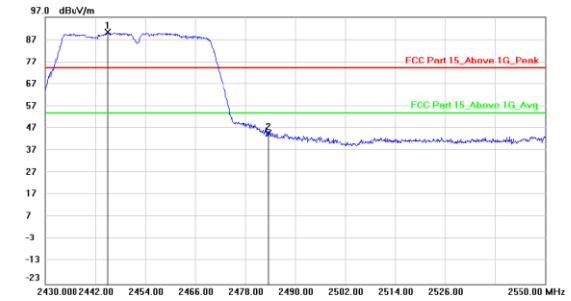
Polarization: Horizontal



No.	Mk.	Freq.	Reading	Correct	Measure-	Limit	Margin	Antenna	Table	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree
1	*	2420.600	100.58	-3.41	97.17	74.00	23.17	peak		
2		2390.000	55.92	-3.40	52.52	74.00	-21.48	peak		

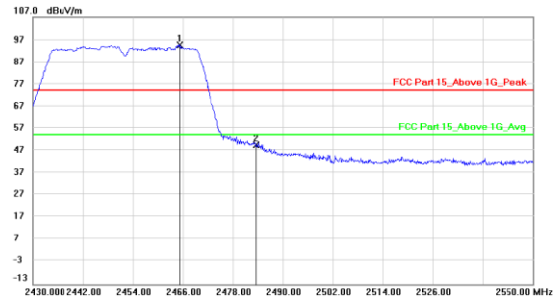
Test Mode: IEEE 802.11n40-High

Polarization: Vertical



No.	Mk.	Freq.	Reading	Correct	Measure-	Limit	Margin	Antenna	Table	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree
1	*	2445.000	93.62	-3.40	90.22	74.00	16.22	peak		
2		2483.500	48.01	-3.38	44.63	74.00	-29.37	peak		

Polarization: Horizontal



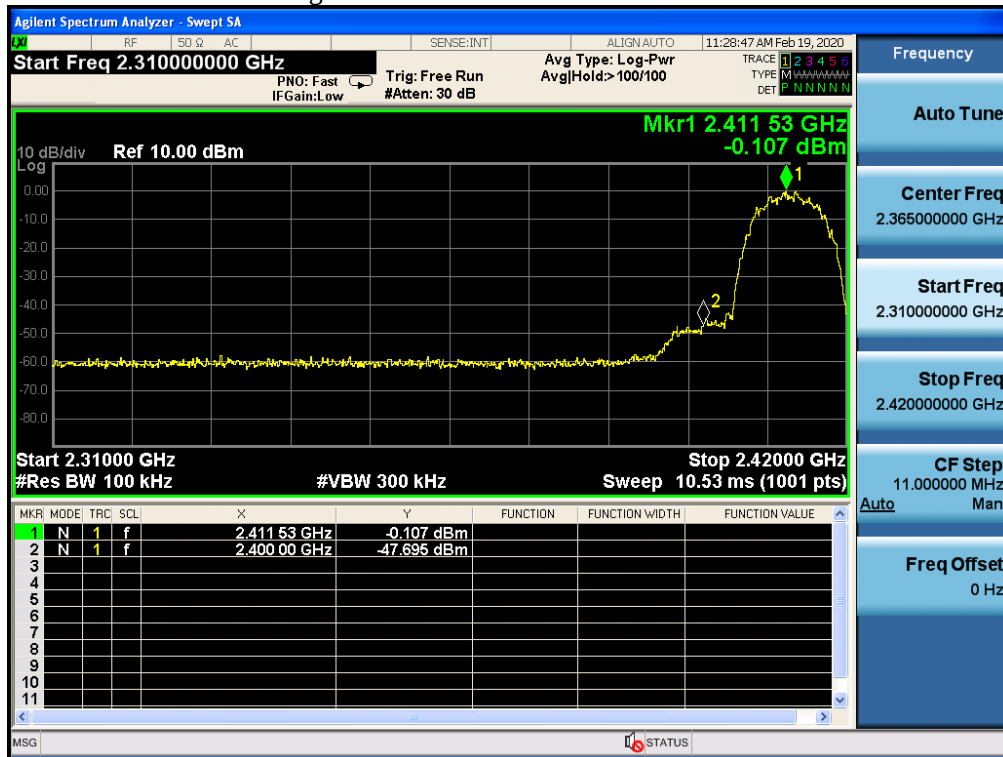
No.	Mk.	Freq.	Reading	Correct	Measure-	Limit	Margin	Antenna	Table	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree
1	*	2465.280	97.88	-3.39	94.49	74.00	20.49	peak		
2		2483.500	53.03	-3.38	49.65	74.00	-24.35	peak		

Note: 1. *: Maximum data; x: Over limit; !: over margin.

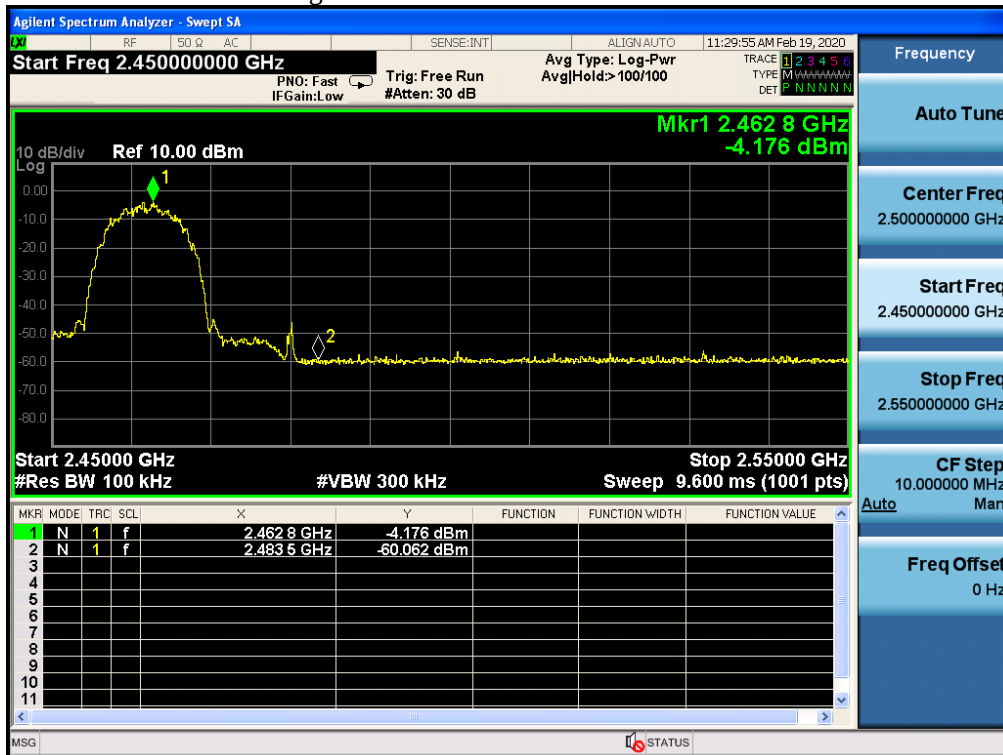
2. Measurement = Reading Level + Correct Factor; Correct Factor = Antenna Factor + Cable Loss.

Conduction Band Edge:

Band Edge NVNT 802.11b 2412MHz Ant1 Emission



Band Edge NVNT 802.11b 2462MHz Ant1 Emission



[illegible]

Agilent Spectrum Analyzer - Swept SA

RF 150 Ω AC SENSE:INT ALIGN:AUTO 11:31:39 AM Feb 19, 2020

Start Freq 2.45000000 GHz PNO: Fast IF Gain: Low Trig: Free Run #Atten: 30 dB Avg Type: Log-Pwr Avg/Hold: > 100/100

TRACE 1 2 3 4 5 6 TYPE M N H W W W W W DET P N N N N N N

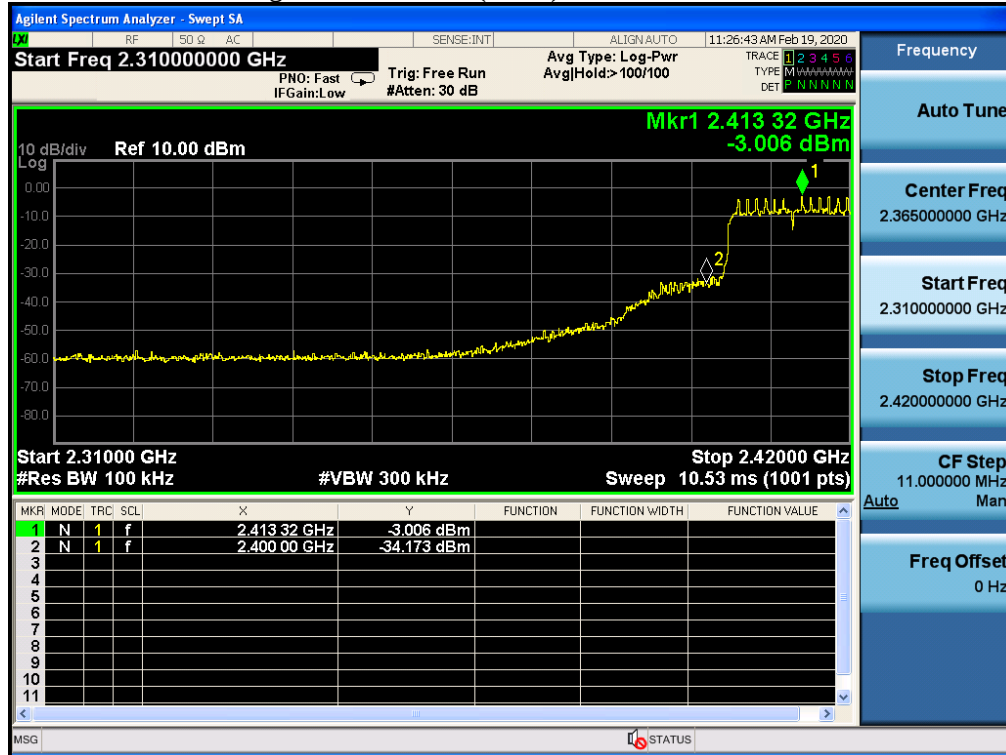
Mkr1 2.462 8 GHz -12.743 dBm

10 dB/div Ref 10.00 dBm

MKR	MODE	TRC	SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE
1	N	1	f	2.462 8 GHz	-12.743 dBm			
2	N	1	f	2.483 5 GHz	-44.703 dBm			
3								
4								
5								
6								
7								
8								
9								
10								
11								

Start 2.45000 GHz Stop 2.55000 GHz
#Res BW 100 kHz #VBW 300 kHz Sweep 9.600 ms (1001 pts)

Band Edge NVNT 802.11n(HT20) 2412MHz Ant1 Emission



Band Edge NVNT 802.11n(HT20) 2462MHz Ant1 Emission



[illegible]

Agilent Spectrum Analyzer - Swept SA

RF 150 Ω AC SENSE:INT ALIGN:AUTO 11:21:20 AM Feb 19, 2020

Start Freq 2.43000000 GHz PNO: Fast IF Gain: Low Trig: Free Run #Atten: 30 dB Avg Type: Log-Pwr Avg/Hold: >100/100

TRACE 1 2 3 4 5 6 TYPE M A W H W H W H DET P N N N N N N

Mkr1 2.433 24 GHz -6.923 dBm

10 dB/div Ref 10.00 dBm

MKR	MODE	TRC	SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE
1	N	1	f	2.433 24 GHz	-6.923 dBm			
2	N	1	f	2.483 50 GHz	-55.355 dBm			
3								
4								
5								
6								
7								
8								
9								
10								
11								

Start 2.43000 GHz Stop 2.55000 GHz
#Res BW 100 kHz #VBW 300 kHz Sweep 11.53 ms (1001 pts)

Auto Tune Center Freq 2.490000000 GHz Start Freq 2.430000000 GHz Stop Freq 2.550000000 GHz CF Step 12.000000 MHz Mar

Freq Offset 0 Hz

MSG STATUS

9. ANTENNA REQUIREMENT

9.1. Standard Requirement

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall 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 manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

9.2. Antenna Connected Construction

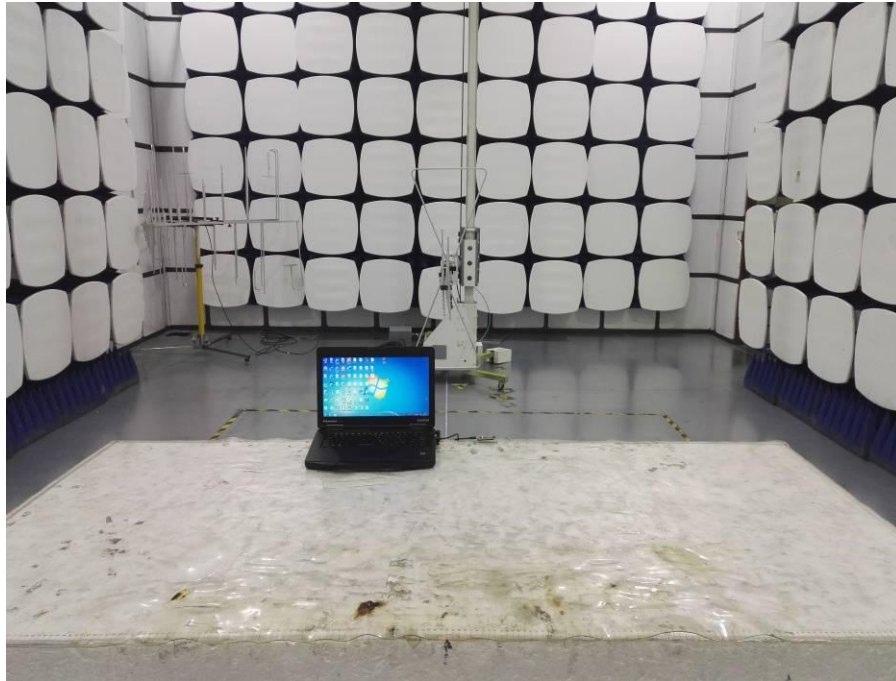
The antenna connector is unique antenna and no consideration of replacement. Please see EUT photo for details.

9.3. Results

The EUT antenna is PCB antenna. It complies with the standard requirement.

10.TEST SETUP PHOTO

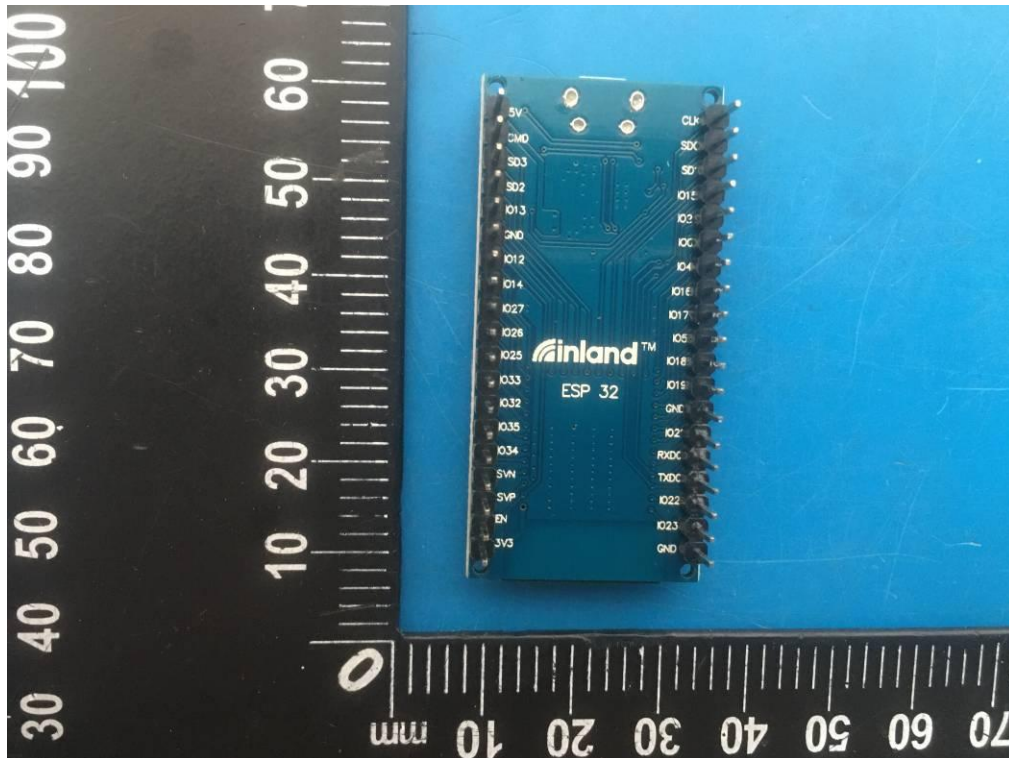
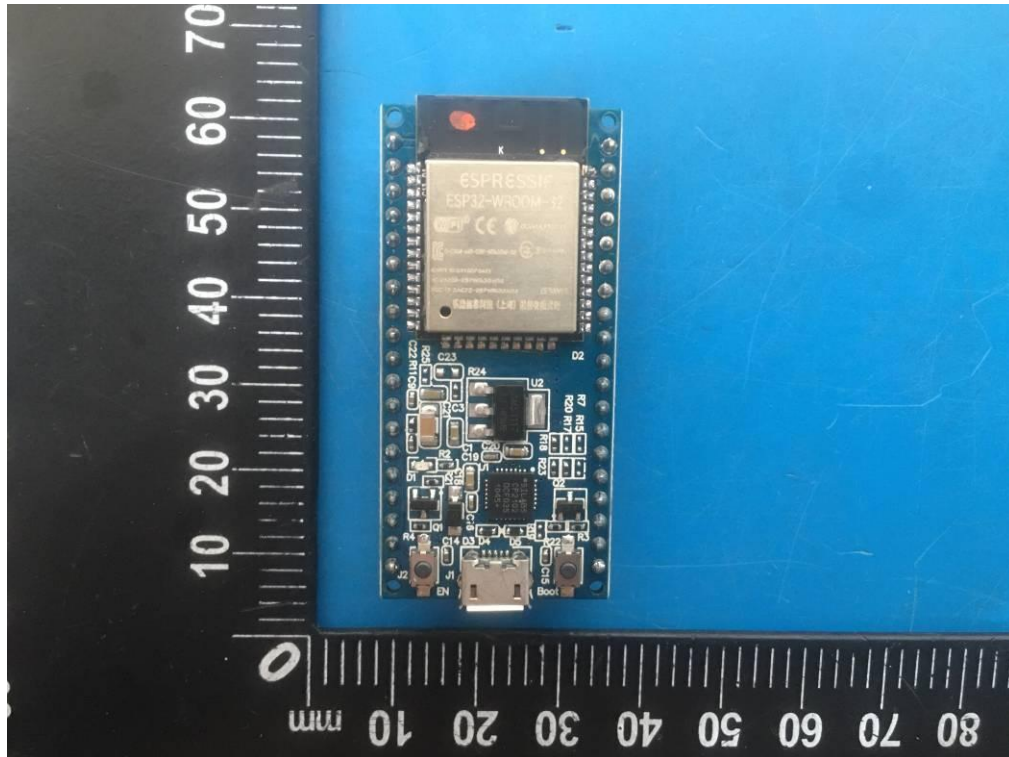
10.1.Photos of Radiated emission

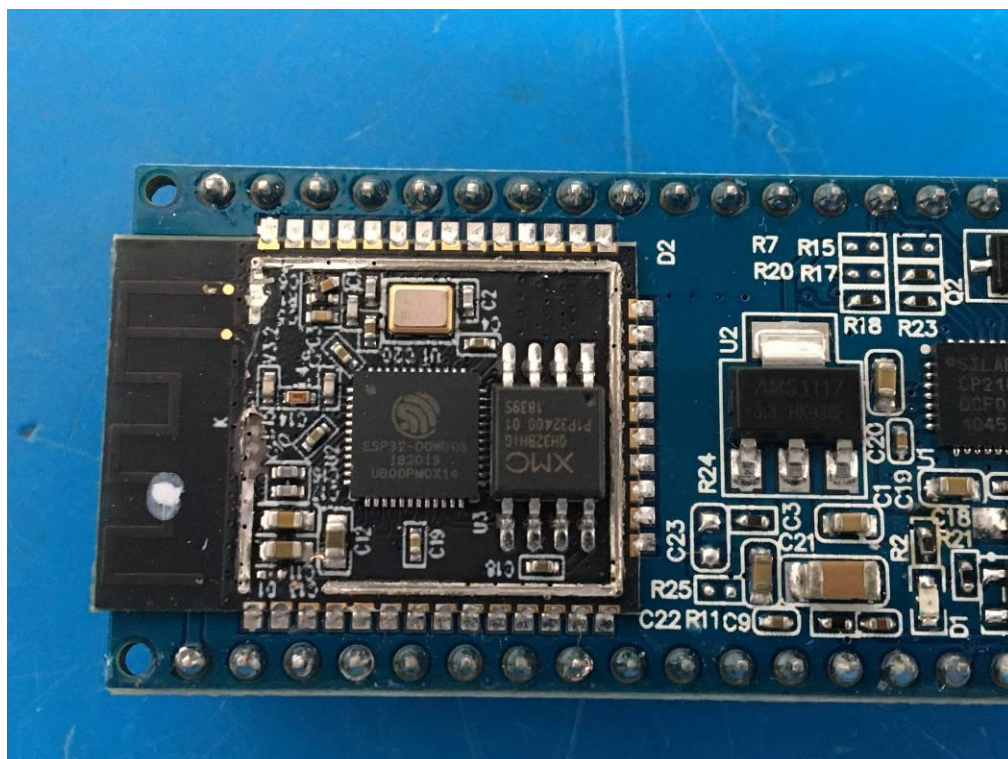


10.2.Photos of Conducted Emission test



11.EUT PHOTO





-----THE END OF REPORT-----