RF Test Report

Report No.:	FCC_IC_RF_SL19040901-ROK-004_2.4G Rev 2.0
FCC ID:	TC2-R1028
IC:	5959A-1026
Test Model:	RC-EL1
Received Date:	12/17/2019
Test Date:	12/30/2019/-01/29/2020
Issued Date:	03/17/2020
Applicant:	Roku, Inc.
Address:	150 Winchester Circle, Los Gatos CA 95032
Manufacturer:	Roku, Inc.
Address:	150 Winchester Circle, Los Gatos CA 95032
Issued By:	Bureau Veritas Consumer Products Services, Inc.
Lab Address:	775 Montague Expressway, Milpitas, CA 95035
Test Location (1):	775 Montague Expressway, Milpitas, CA 95035
FCC Registration / Designation Number:	540430
ISED# / CAB identifier:	4842D

ACCREDITED
TESTING CERT # 2742-01

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Release Control Record

Issue No.	Description	Date Issued
FCC_IC_RF_SL19040901-ROK-004_2.4G	Orignal Release	01/29/2020
FCC_IC_RF_SL19040901-ROK-004_2.4G Rev 1.0	Minor typos corrections	03/04/2020
FCC_IC_RF_SL19040901-ROK-004_2.4G Rev 2.0	Update Per Review	03/17/2020

1 Certificate of Conformity

Product:	WiFi Remote Control
Brand:	Roku, Inc.
Test Model:	RC-EL1
Sample Status:	Engineer Sample
Applicant:	Roku, Inc.
Test Date:	12/30/2019/-01/28/2020
Standards:	47 CFR FCC Part 15, Subpart C (Section 15.247) RSS 247 Issue 2, February 2017 ANSI C63.10: 2013 RSS Gen Issue 5, March 2019 KDB 558074 D01 15.247 Meas Guidance v05r02

The above equipment has been tested by **Bureau Veritas Consumer Products Services, Inc., Milpitas Branch**, and found compliance with the requirement of the above standards. The test record, data evaluation & Equipment Under Test (EUT) configurations represented herein are true and accurate accounts of the measurements of the sample's EMC characteristics under the conditions specified in this report.

Prepared by : _____ , **Date:** 03/17/2020

Deon Dai / Test Engineer

Approved by : _____ , **Date:** 03/17/2020

Chen Ge / Engineer Reviewer

2 Summary of Test Results

47 CFR FCC Part 15, Subpart C (Section 15.247) RSS 247 Issue2, RSS Gen Issue5			
Standard	Test Item	Result	Remarks
15.207 RSS Gen 8.8	AC Power Conducted Emission	N/A	N/A
15.205 &15.209 & 15.247(d) RSS 247 5.5	Radiated Emissions and Band Edge Measurement	PASS	Meet the requirement of limit.
15.247(a)(2) RSS 247 5.2 RSS Gen 6.7	6dB bandwidth & 99% bandwidth	PASS	Meet the requirement of limit.
15.247(b) RSS 247 5.4.d	Conducted power	PASS	Meet the requirement of limit.
15.247(e) RSS 247 5.2.b	Power Spectral Density	PASS	Meet the requirement of limit.
15.203	Antenna Requirement	PASS	The EUT uses a chip antenna and permanently attached to the device.

Note: N/A: EUT worked with battery.

2.1 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2:

Measurement	Frequency	Expanded Uncertainty (k=2) (±)
Conducted Emissions at mains ports	150kHz ~ 30MHz	3.51dB
Radiated Emissions up to 1 GHz	30MHz ~ 1GHz	3.73dB
Radiated Emissions above 1 GHz	1GHz ~ 6GHz	4.64dB
	6GHz ~ 18GHz	4.82dB
	18GHz ~ 40GHz	4.91dB

2.2 Modification Record

There were no modifications required for compliance.

3 General Information

3.1 General Description of EUT

Product	WiFi Remote Control
Brand	Roku, Inc.
Test Model	RC-EL1
Identification No. of EUT	N/A
Series Model	N/A
Model Difference	N/A
Status of EUT	Engineer Sample
Power Supply Rating	2 x AAA batteries 1.5V
Modulation Type	CCK, DQPSK, DBPSK for DSSS 64QAM, 16QAM, QPSK, BPSK for OFDM
Modulation Technology	DSSS, OFDM
Transfer Rate	802.11b: up to 11Mbps 802.11g: up to 54Mbps 802.11n: up to 300Mbps
Operating Frequency	2.412 ~ 2.462GHz
Number of Channel	11 for 802.11b, 802.11g, 802.11n (HT20)
Antenna Type	Chip Antenna, 2.9dBi
Antenna Connector	N/A

Note:

1. The EUT uses following adapter.

Brand	-
Model	-
Input Power	-
Output Power	-
Power Line	-

2. The above EUT information is declared by manufacturer and for more detailed features description, please refer to the manufacturer's specifications or user's manual.

3.2 Description of Test Modes

11 channels are provided for 802.11b, 802.11g and 802.11n (HT20):

Channel	Frequency	Channel	Frequency
1	2412MHz	7	2442MHz
2	2417MHz	8	2447MHz
3	2422MHz	9	2452MHz
4	2427MHz	10	2457MHz
5	2432MHz	11	2462MHz
6	2437MHz		

Power setting is as below:

802.11b		802.11g	
Channel	Power Setting	Channel	Power Setting
1	75	1	75
6	75	6	75
11	75	11	75
802.11n			
Channel	Power Setting		
1	75		
6	75		
11	75		

3.2.1 Test Mode Applicability and Tested Channel Detail

EUT CONFIGURE MODE	APPLICABLE TO				DESCRIPTION
	RE≥1G	RE<1G	PLC	APCM	
-	√	√	√	√	-

Where RE≥1G: Radiated Emission above 1GHz & Bandedge Measurement **RE<1G:** Radiated Emission below 1GHz

PLC: Power Line Conducted Emission **APCM:** Antenna Port Conducted Measurement

NOTE: The EUT had been pre-tested on the positioned of each 3 axis. The worst case was found when positioned on **Y-plane**.
NOTE: "-" means no effect.

Radiated Emission Test (Above 1GHz):

☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).

☒ Following channel(s) was (were) selected for the final test as listed below.

EUT CONFIGURE MODE	MODE	AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION TECHNOLOGY	MODULATION TYPE	DATA RATE (Mbps)
-	802.11b	1 to 11	1, 6, 11	DSSS	DBPSK	1
-	802.11g	1 to 11	1, 6, 11	OFDM	BPSK	6
-	802.11n (HT20)	1 to 11	1, 6, 11	OFDM	BPSK	6.5

Radiated Emission Test (Below 1GHz):

☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).

☒ Following channel(s) was (were) selected for the final test as listed below.

EUT CONFIGURE MODE	MODE	AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION TECHNOLOGY	MODULATION TYPE	DATA RATE (Mbps)
-	802.11n (20MHz)	1 to 11	6	OFDM	BPSK	6.5

Power Line Conducted Emission Test:

☐ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).

☐ Following channel(s) was (were) selected for the final test as listed below.

EUT CONFIGURE MODE	MODE	AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION TECHNOLOGY	MODULATION TYPE	DATA RATE (Mbps)
-	802.11n (HT20)	1 to 11	6	OFDM	BPSK	6.5

Antenna Port Conducted Measurement:

☒ This item includes all test value of each mode, but only includes spectrum plot of worst value of each mode.
☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).
☒ Following channel(s) was (were) selected for the final test as listed below.

EUT CONFIGURE MODE	MODE	AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION TECHNOLOGY	MODULATION TYPE	DATA RATE (Mbps)
-	802.11b	1 to 11	1, 6, 11	DSSS	DBPSK	1
-	802.11g	1 to 11	1, 6, 11	OFDM	BPSK	6
-	802.11n (HT20)	1 to 11	1, 6, 11	OFDM	BPSK	6.5

Test Condition:

APPLICABLE TO	ENVIRONMENTAL CONDITIONS	INPUT POWER	TESTED BY
RE≥1G	25deg. C, 65%RH	120Vac, 60Hz	Deon Dai
RE<1G	25deg. C, 65%RH	120Vac, 60Hz	Deon Dai
PLC	25deg. C, 68%RH	120Vac, 60Hz	-
APCM	21deg. C, 60%RH	120Vac, 60Hz	-

3.3 Description of Support Units

The EUT has been tested as an independent unit together with other necessary accessories or support units. The following support units or accessories were used to form a representative test configuration during the tests.

ID	Product	Brand	Model No.	Serial No.	FCC ID	Remarks
A.	Laptop	Dell	Latitude 3550	N/A	N/A	N/A
B.						
C.						
D.						
E.						
F.						
G.						

ID	Descriptions	Qty.	Length (m)	Shielding (Yes/No)	Cores (Qty.)	Remarks
1.	USB	1	0.8m	No	0	Connect from EUT to Laptop
2.						
3.						

3.3.1 Duty Cycle of Test Signal

Duty cycle of test signal is ⩾ 98 %, duty factor is not required.

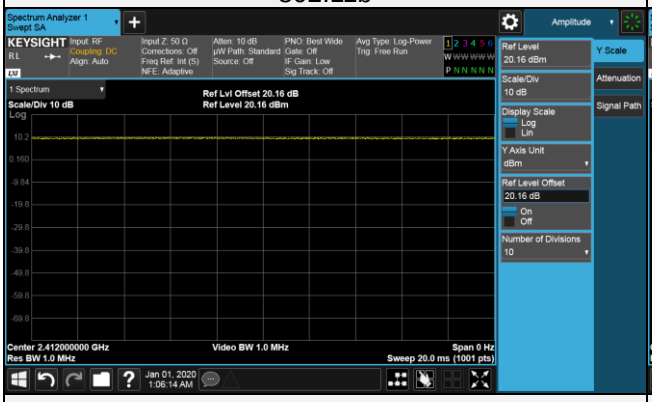
Duty cycle of test signal is < 98 %, duty factor is required.

802.11b: Duty cycle = 100%

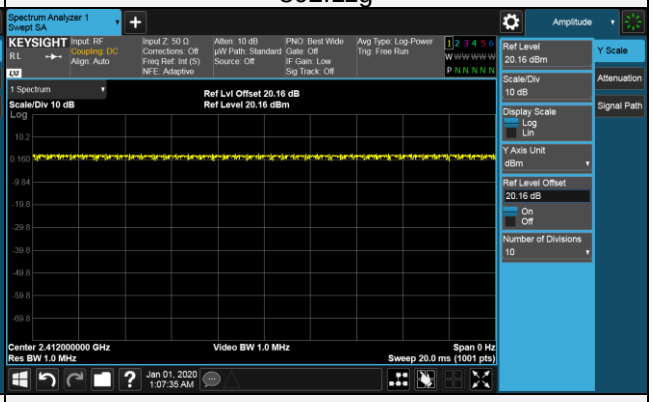
802.11g: Duty cycle = 100%

802.11n: Duty cycle = 100%

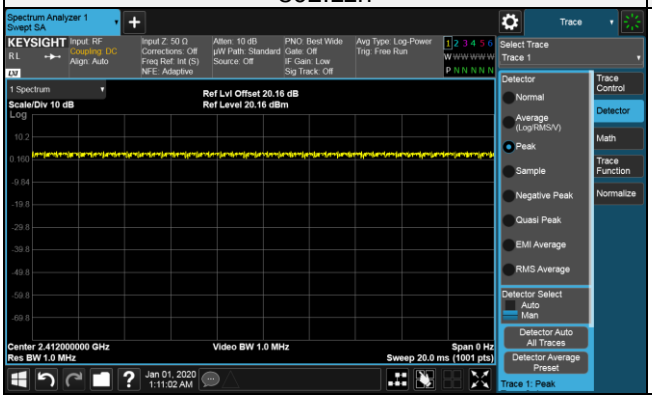
802.11b



802.11g



802.11n



3.4 General Description of Applied Standards

The EUT is a RF Product. According to the specifications of the manufacturer, it must comply with the requirements of the following standards:

47 CFR FCC Part 15, Subpart C (Section 15.247)
RSS 247 Issue2, February 2017
ANSI C63.10: 2013
RSS Gen Issue5, March 2019
558074 D01 15.247 Meas Guidance v05r02

All test items have been performed and recorded as per the above standards.

4 Test Types and Results

4.1 Radiated Emission and Bandedge Measurement

4.1.1 Limits of Radiated Emission and Bandedge Measurement

Radiated emissions which fall in the restricted bands must comply with the radiated emission limits specified as below table. Other emissions shall be at least 20dB below the highest level of the desired power:

Frequencies (MHz)	Field Strength (microvolts/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

NOTE:

1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 log Emission level (uV/m).
3. For frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits, specified above by more than 20dB under any condition of modulation.

4.1.2 Test Instruments

DESCRIPTION & MANUFACTURER	MODEL NO.	SERIAL NO.	DATE OF CALIBRATION	DUE DATE OF CALIBRATION
EMI Receiver	ESW 44	1328.4100K-101662-MH	08/30/2019	08/30/2020
Biconilog Antenna Sunol	JB1	A030702	03/09/2018	03/09/2020
Pre-Amplifier RF Bay, Inc.	LPA-6-30	11170601	04/27/2019	04/27/2020
Horn Antenna ETS-Lindgren	3117	218554	11/22/2019	11/22/2020
Pre-Amplifier RF-Lambda	RAMP00M50GA	17032300048	06/18/2019	06/18/2020

4.1.3 Test Procedures

For Radiated emission below 30MHz

a. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter chamber room. The table was rotated 360 degrees to determine the position of the highest radiation.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. Parallel, perpendicular, and ground-parallel orientations of the antenna are set to make the measurement.

d. For each suspected emission, the EUT was arranged to its worst case and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.

e. The test-receiver system was set to Quasi-Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.

NOTE:

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 9 kHz at frequency below 30MHz.

For Radiated emission above 30MHz

a. The EUT was placed on the top of a rotating table 0.8 meters (for 30MHz ~ 1GHz) / 1.5 meters (for above 1GHz) above the ground at 3 meter chamber room for test. The table was rotated 360 degrees to determine the position of the highest radiation.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. The height of antenna is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.

d. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.

e. The test-receiver system was set to quasi-peak detect function and specified bandwidth with maximum hold mode when the test frequency is below 1 GHz.

f. The test-receiver system was set to peak and average detects function and specified bandwidth with maximum hold mode when the test frequency is above 1 GHz. If the peak reading value also meets average limit, measurement with the average detector is unnecessary.

Note:

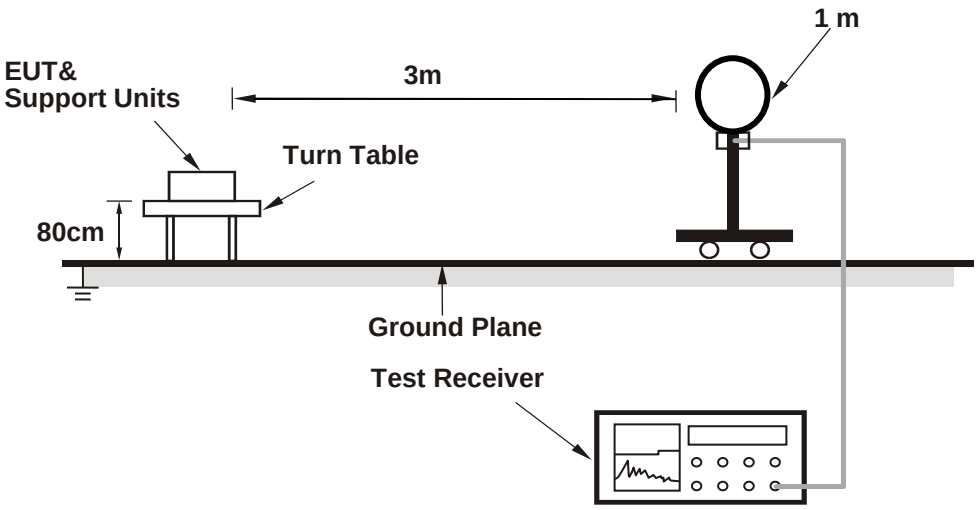
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz for Quasi-peak detection (QP) at frequency below 1GHz.
2. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 3 MHz for Peak detection (PK) at frequency above 1GHz.
3. The resolution bandwidth of test receiver/spectrum analyzer is 1MHz and the video bandwidth is ≥ 1/T (Duty cycle < 98%) or 10Hz (Duty cycle ≥ 98%) for Average detection (AV) at frequency above 1GHz.
4. All modes of operation were investigated and the worst-case emissions are reported.

4.1.4 Deviation from Test Standard

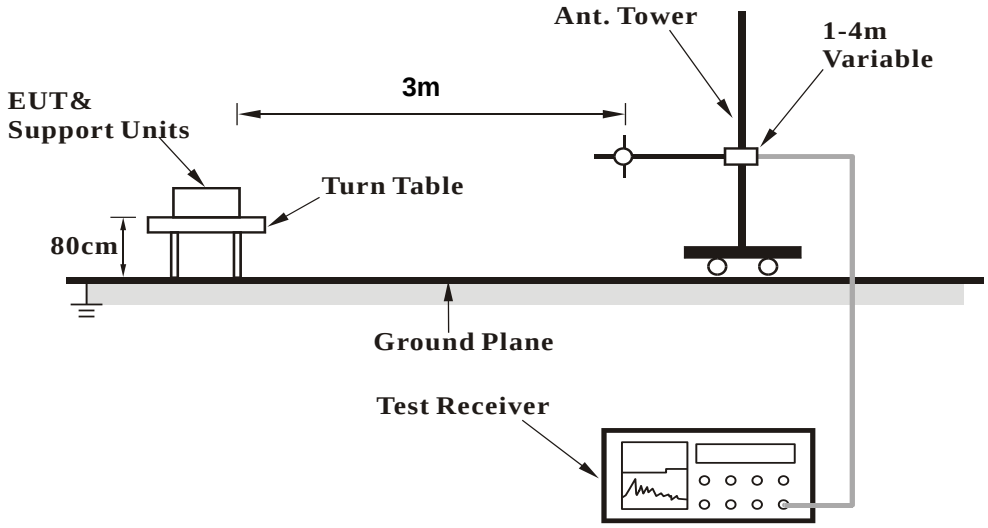
No deviation.

4.1.5 Test Setup

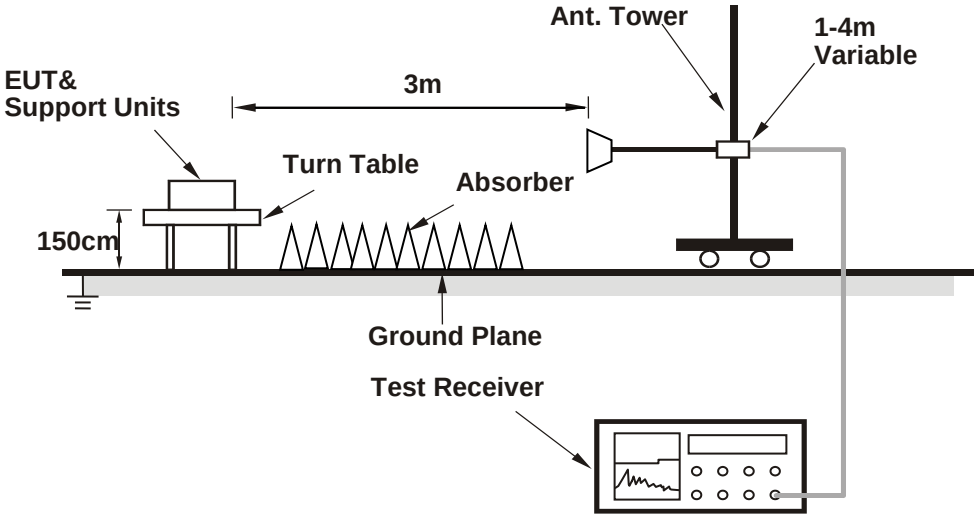
For Radiated emission below 30MHz



For Radiated emission 30MHz to 1GHz



For Radiated emission above 1GHz



For the actual test configuration, please refer to the attached file (Test Setup Photo).

4.1.6 EUT Operating Conditions

a. Connected the EUT with the Notebook Computer which is placed on remote site.
b. Controlling software has been activated to set the EUT on specific status.

4.1.7 Test Results

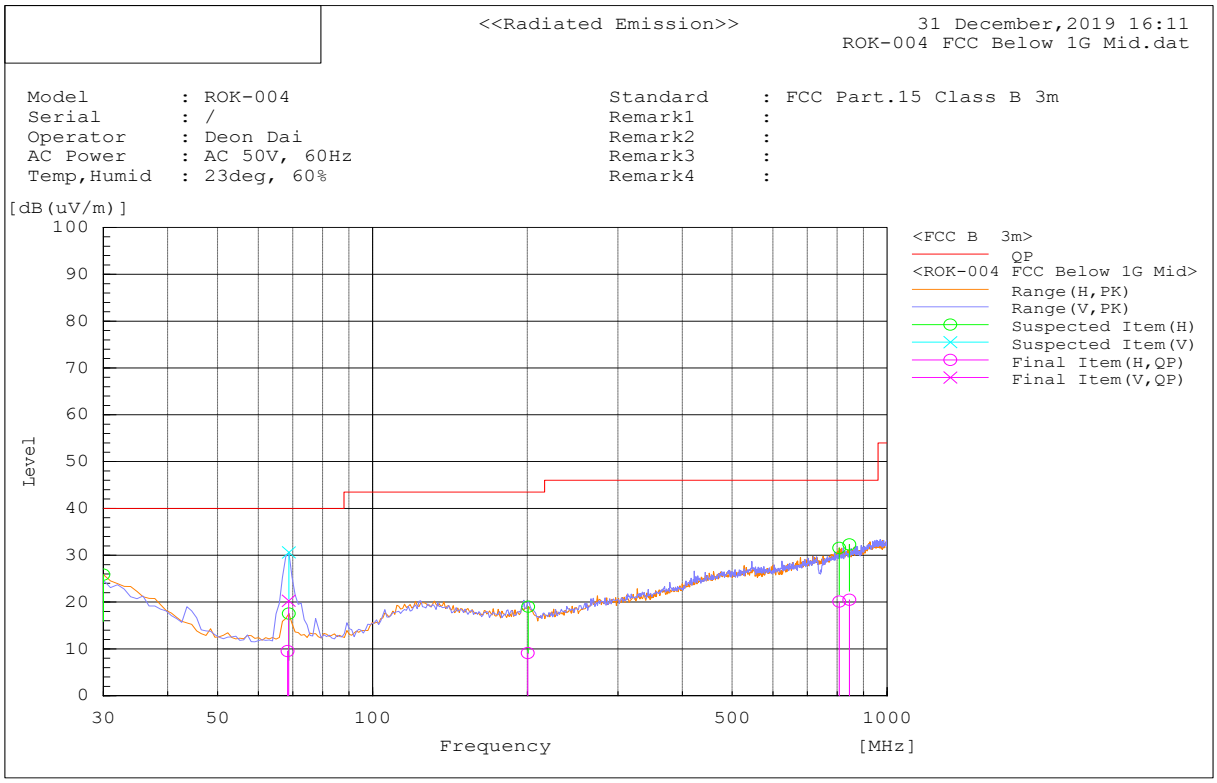
BELOW 1GHz WORST-CASE DATA:

CHANNEL	802.11n Channel 6	**DETECTOR FUNCTION**	Quasi Peak
FREQUENCY RANGE	30MHz – 1GHz		

Antenna Polarity & Test Distance: Vertical and Horizontal at 3m										
No.	Frequency (MHz)	Polarization (H/V)	Reading QP [dB(uV)]	Factor [dB(1/m)]	Level QP [dB(uV/m)]	Limit\QP dB(uV/m)	Margin QP [dB]	Height (cm)	Angle (Deg)	Pass/Fail
1	30.678	H	-0.9	12.7	11.8	40	28.2	158	22.1	Pass
2	68.725	V	7	13.3	20.3	40	19.7	100	290	Pass
3	68.415	H	-3.9	13.4	9.5	40	30.5	120	279	Pass
4	200.31	H	-9.7	18.8	9.1	43.5	34.4	209	360	Pass
5	807.283	H	-9.2	29.3	20.1	46	25.9	271	254	Pass
6	844.335	H	-8.9	29.4	20.5	46	25.5	285	289	Pass

REMARKS:

1. Emission level (dBuV/m) = Reading Value (dBuV) + Factor (dB)
2. AF (dB/m) = Antenna Factor (dB/m) – Preamplifier Gain (dB).
3. The emission levels of other frequencies were less than 20dB margin against the limit.
4. Margin value = Emission level – Limit value.



Above 1GHz Test Data:

Above 1GHz-25GHz – 802.11b – 2412MHz

ANTENNA POLARITY & test distance: HORIZONTAL& Vertical at 3 m									
Frequency [MHz]	Pol	Reading AV [dB(uV)]	Factor [dB(1/m)]	Measurement Type	Level [dB(uV/m)]	Limit [dB(uV/m)]	Margin [dB]	Height [cm]	Angle [deg]
2463.307	H	42.3	-9.5	Average	32.8	54	21.2	177	73
3189.595	V	42.6	-8.5	Average	34.1	54	19.9	147	155.5
7238.852	V	42.5	-1	Average	41.5	54	12.5	100	326.1
2463.307	H	53.9	-9.5	Peak	44.4	74	29.6	177	73
3189.595	V	57.4	-8.5	Peak	48.9	74	25.1	147	155.5
7238.852	V	51.9	-1	Peak	50.9	74	23.1	100	326.1

Above 1GHz-25GHz- 802.11b - 2437MHz

ANTENNA POLARITY & test distance: HORIZONTAL& Vertical at 3 m									
Frequency [MHz]	Pol	Reading AV [dB(uV)]	Factor [dB(1/m)]	Measurement Type	Level [dB(uV/m)]	Limit [dB(uV/m)]	Margin [dB]	Height [cm]	Angle [deg]
1090.16	V	43.4	-15.2	Average	28.2	54	25.8	400	305.5
3185.657	V	43.9	-8.5	Average	35.4	54	18.6	298	70.2
4874.08	H	52.5	-6.1	Average	46.4	54	7.6	132	173.8
1090.16	V	55.8	-15.2	Peak	40.6	74	33.4	400	305.5
3185.657	V	54.6	-8.5	Peak	46.1	74	27.9	298	70.2
4874.08	H	58	-6.1	Peak	51.9	74	22.1	132	173.8

Above 1GHz-25GHz – 802.11b – 2462MHz

ANTENNA POLARITY & test distance: HORIZONTAL& Vertical at 3 m									
Frequency [MHz]	Pol	Reading AV [dB(uV)]	Factor [dB(1/m)]	Measurement Type	Level [dB(uV/m)]	Limit [dB(uV/m)]	Margin [dB]	Height [cm]	Angle [deg]
1334.351	V	45.5	-13.7	Average	31.8	54	22.2	374	213.5
2462.666	H	41.7	-9.5	Average	32.2	54	21.8	103	189.7
4924.116	H	52	-6.1	Average	45.9	54	8.1	208	186.5
1334.351	V	57.4	-13.7	Peak	43.7	74	30.3	374	213.5
2462.666	H	54	-9.5	Peak	44.5	74	29.5	103	189.7
4924.116	H	57.4	-6.1	Peak	51.3	74	22.7	208	186.5

Above 1GHz-25GHz- 802.11g - 2412MHz

ANTENNA POLARITY & test distance: HORIZONTAL& Vertical at 3 m									
Frequency [MHz]	Pol	Reading AV [dB(uV)]	Factor [dB(1/m)]	Measurement Type	Level [dB(uV/m)]	Limit [dB(uV/m)]	Margin [dB]	Height [cm]	Angle [deg]
2462.813	H	42.2	-9.5	Average	32.7	54	21.3	178	252.1
4924.179	H	50.8	-6.1	Average	44.7	54	9.3	298	185.6
7385.495	H	41.5	-1	Average	40.5	54	13.5	238	353.8
2462.813	H	55.6	-9.5	Peak	46.1	74	27.9	178	252.1
4924.179	H	57.1	-6.1	Peak	51	74	23	298	185.6
7385.495	H	51.9	-1	Peak	50.9	74	23.1	238	353.8

Above 1GHz-25GHz – 802.11g – 2437MHz

ANTENNA POLARITY & test distance: HORIZONTAL& Vertical at 3 m									
Frequency [MHz]	Pol	Reading AV [dB(uV)]	Factor [dB(1/m)]	Measurement Type	Level [dB(uV/m)]	Limit [dB(uV/m)]	Margin [dB]	Height [cm]	Angle [deg]
1239.196	H	45.1	-13.8	Average	31.3	54	22.7	201	259.9
1539.86	V	44.2	-14.8	Average	29.4	54	24.6	117	257.2
4875.304	V	41.5	-6.1	Average	35.4	54	18.6	307	338.3
1239.196	H	56.8	-13.8	Peak	43	74	31	201	259.9
1539.86	V	56.4	-14.8	Peak	41.6	74	32.4	117	257.2
4875.304	V	52.7	-6.1	Peak	46.6	74	27.4	307	338.3

Above 1GHz-25GHz- 802.11g - 2462MHz

ANTENNA POLARITY & test distance: HORIZONTAL& Vertical at 3 m									
Frequency [MHz]	Pol	Reading AV [dB(uV)]	Factor [dB(1/m)]	Measurement Type	Level [dB(uV/m)]	Limit [dB(uV/m)]	Margin [dB]	Height [cm]	Angle [deg]
2462.813	H	42.2	-9.5	Average	32.7	54	21.3	178	252.1
4924.179	H	50.8	-6.1	Average	44.7	54	9.3	298	185.6
7385.495	H	41.5	-1	Average	40.5	54	13.5	238	353.8
2462.813	H	55.6	-9.5	Peak	46.1	74	27.9	178	252.1
4924.179	H	57.1	-6.1	Peak	51	74	23	298	185.6
7385.495	H	51.9	-1	Peak	50.9	74	23.1	238	353.8

Above 1GHz-25GHz- 802.11n20 - 2412MHz

ANTENNA POLARITY & test distance: HORIZONTAL& Vertical at 3 m									
Frequency [MHz]	Pol	Reading AV [dB(uV)]	Factor [dB(1/m)]	Measurement Type	Level [dB(uV/m)]	Limit [dB(uV/m)]	Margin [dB]	Height [cm]	Angle [deg]
2668.25	H	45.7	-9	Average	36.7	54	17.3	246	150.9
4823.817	V	41.8	-5.9	Average	35.9	54	18.1	313	17.7
4823.472	H	41.1	-5.9	Average	35.2	54	18.8	201	319.4
2668.25	H	57.2	-9	Peak	48.2	74	25.8	246	150.9
4823.817	V	53.3	-5.9	Peak	47.4	74	26.6	313	17.7
4823.472	H	53	-5.9	Peak	47.1	74	26.9	201	319.4

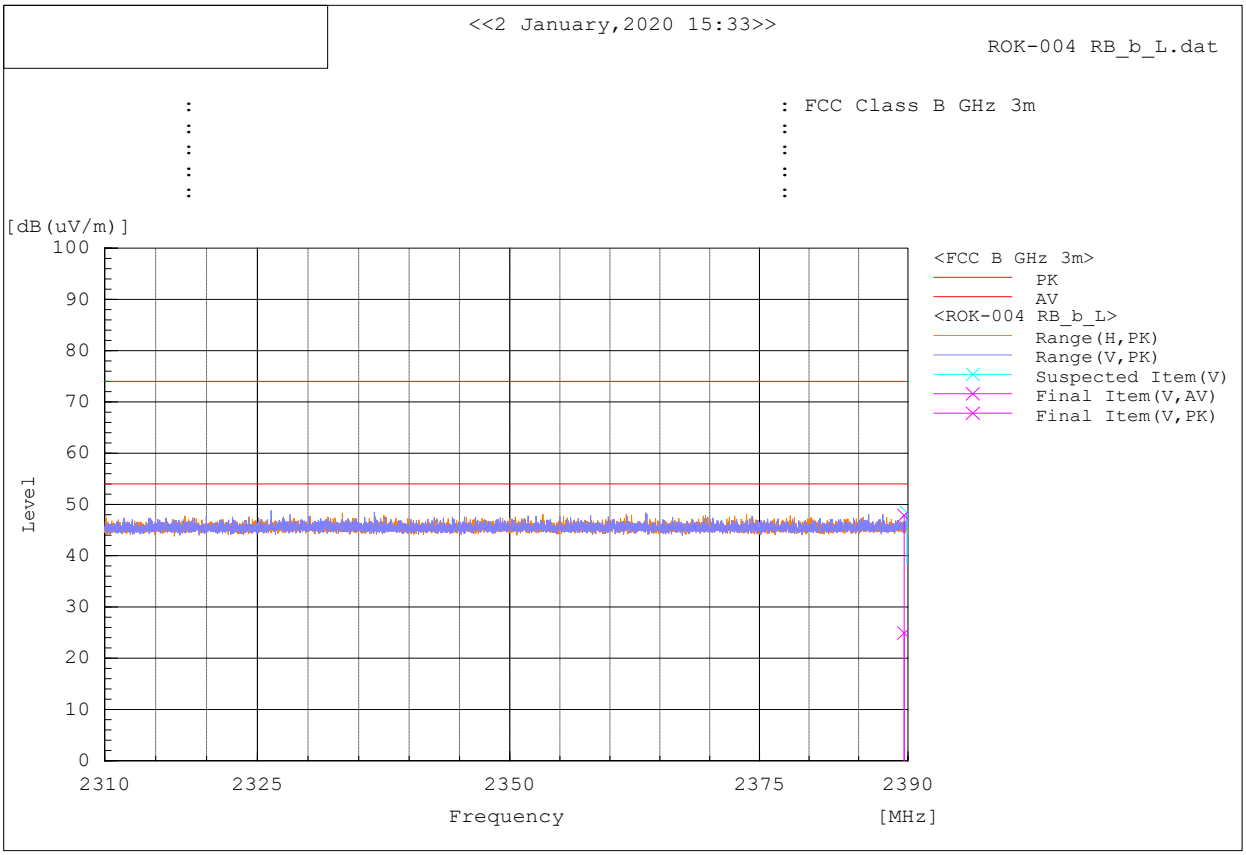
Above 1GHz-25GHz – 802.11n20 – 2437MHz

ANTENNA POLARITY & test distance: HORIZONTAL& Vertical at 3 m									
Frequency [MHz]	Pol	Reading AV [dB(uV)]	Factor [dB(1/m)]	Measurement Type	Level [dB(uV/m)]	Limit [dB(uV/m)]	Margin [dB]	Height [cm]	Angle [deg]
10395.895	V	37.1	3.2	Average	40.3	54	13.7	298	2.7
4873.73	H	41.4	-6.1	Average	35.3	54	18.7	322	244.2
8100.096	H	38.8	0.5	Average	39.3	54	14.7	253	0
10395.895	V	48.6	3.2	Peak	51.8	74	22.2	298	2.7
4873.73	H	53.9	-6.1	Peak	47.8	74	26.2	322	244.2
8100.096	H	49.5	0.5	Peak	50	74	24	253	0

Above 1GHz-25GHz- 802.11n20 - 2462MHz

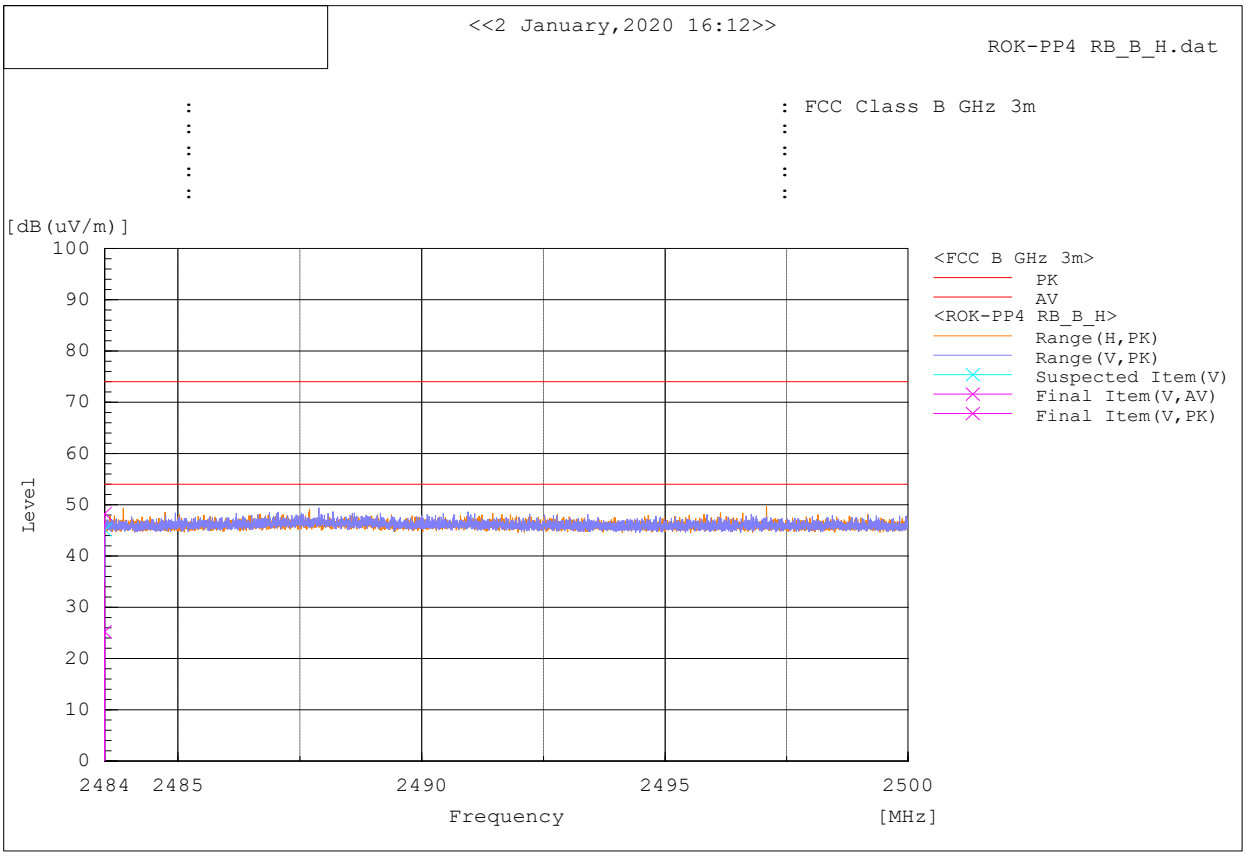
ANTENNA POLARITY & test distance: HORIZONTAL& Vertical at 3 m									
Frequency [MHz]	Pol	Reading AV [dB(uV)]	Factor [dB(1/m)]	Measurement Type	Level [dB(uV/m)]	Limit [dB(uV/m)]	Margin [dB]	Height [cm]	Angle [deg]
4925.2	H	42.5	-6.1	Average	36.4	54	17.6	216	282.2
13444.627	V	37.2	5.9	Average	43.1	54	10.9	367	276.1
3539.069	V	43.4	-8.2	Average	35.2	54	18.8	238	345.8
4925.2	H	53.2	-6.1	Peak	47.1	74	26.9	216	282.2
13444.627	V	48.1	5.9	Peak	54	74	20	367	276.1
3539.069	V	55.9	-8.2	Peak	47.7	74	26.3	238	345.8

RESTRICTED BAND (802.11b LOW CHANNEL)



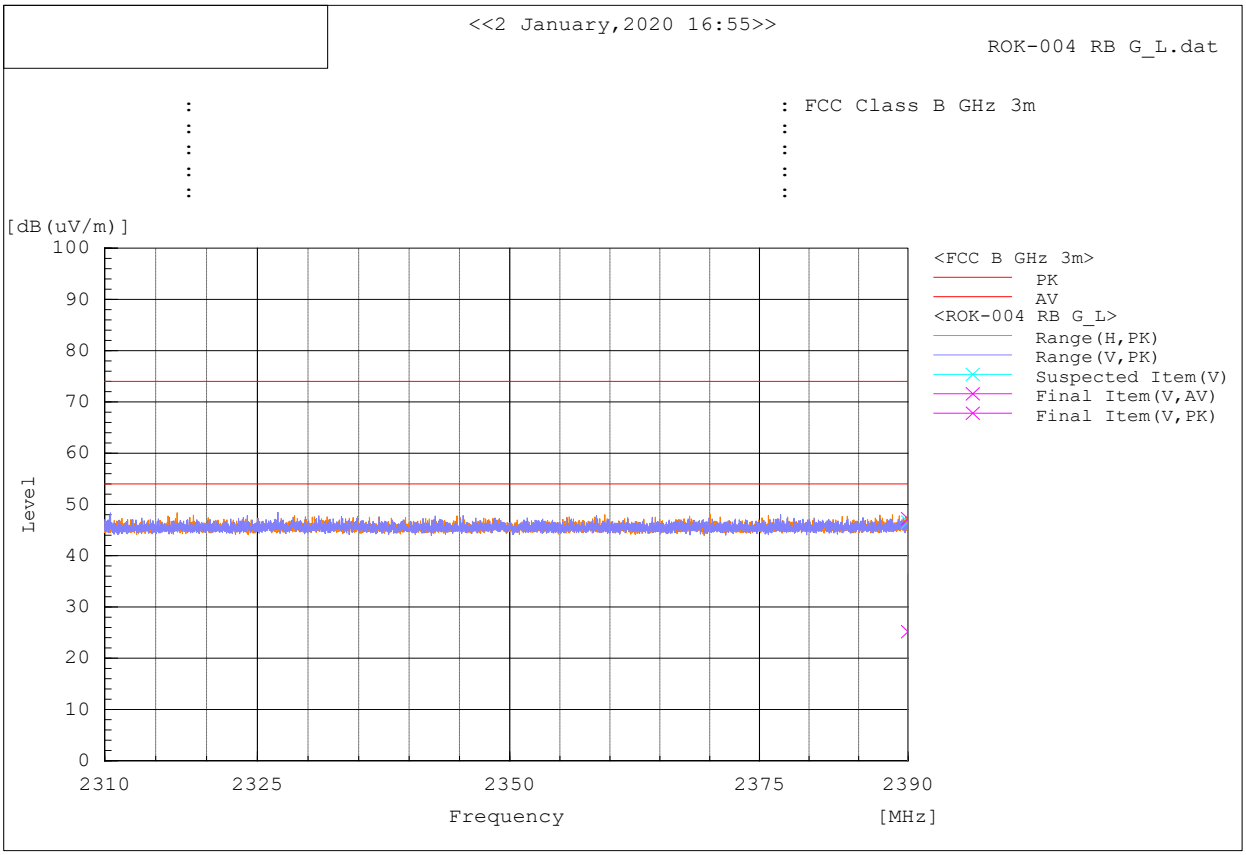
Frequency [MHz]	Pol	Reading [dB(uV)]	Measurement Type	Factor [dB(1/m)]	Level [dB(uV/m)]	Limit [dB(uV/m)]	Margin [dB]	Height [cm]	Angle [deg]
2389.612	V	-8.7	Average	33.6	24.9	54	29.1	274	360
2389.612	V	14.2	Peak	33.6	47.8	74	26.2	274	360

RESTRICTED BAND (802.11b High CHANNEL)



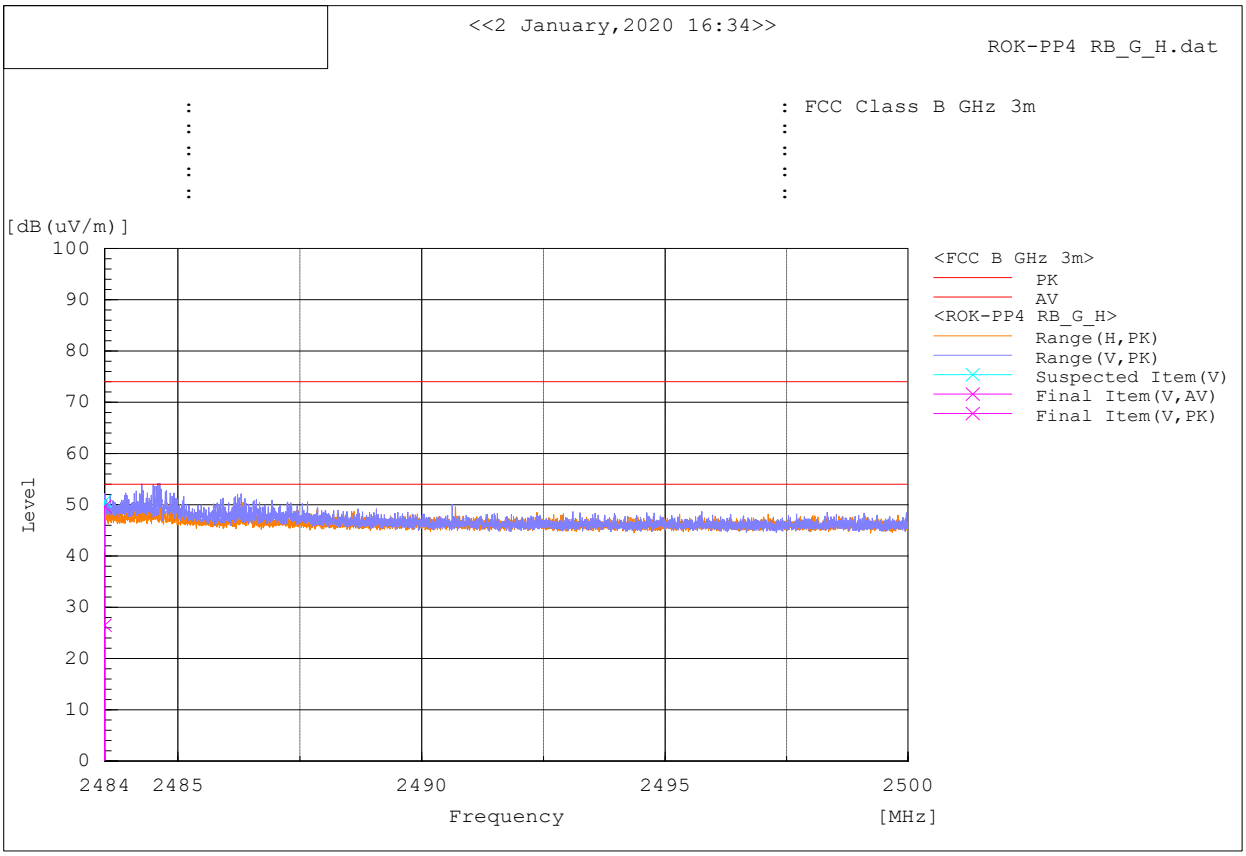
Frequency [MHz]	Pol	Reading [dB(uV)]	Measurement Type	Factor [dB(1/m)]	Level [dB(uV/m)]	Limit [dB(uV/m)]	Margin [dB]	Height [cm]	Angle [deg]
2483.5	V	-8.7	Average	33.9	25.2	54	28.8	220	49.4
2483.5	V	14.4	Peak	33.9	48.3	74	25.7	220	49.4

RESTRICTED BAND (802.11g LOW CHANNEL)



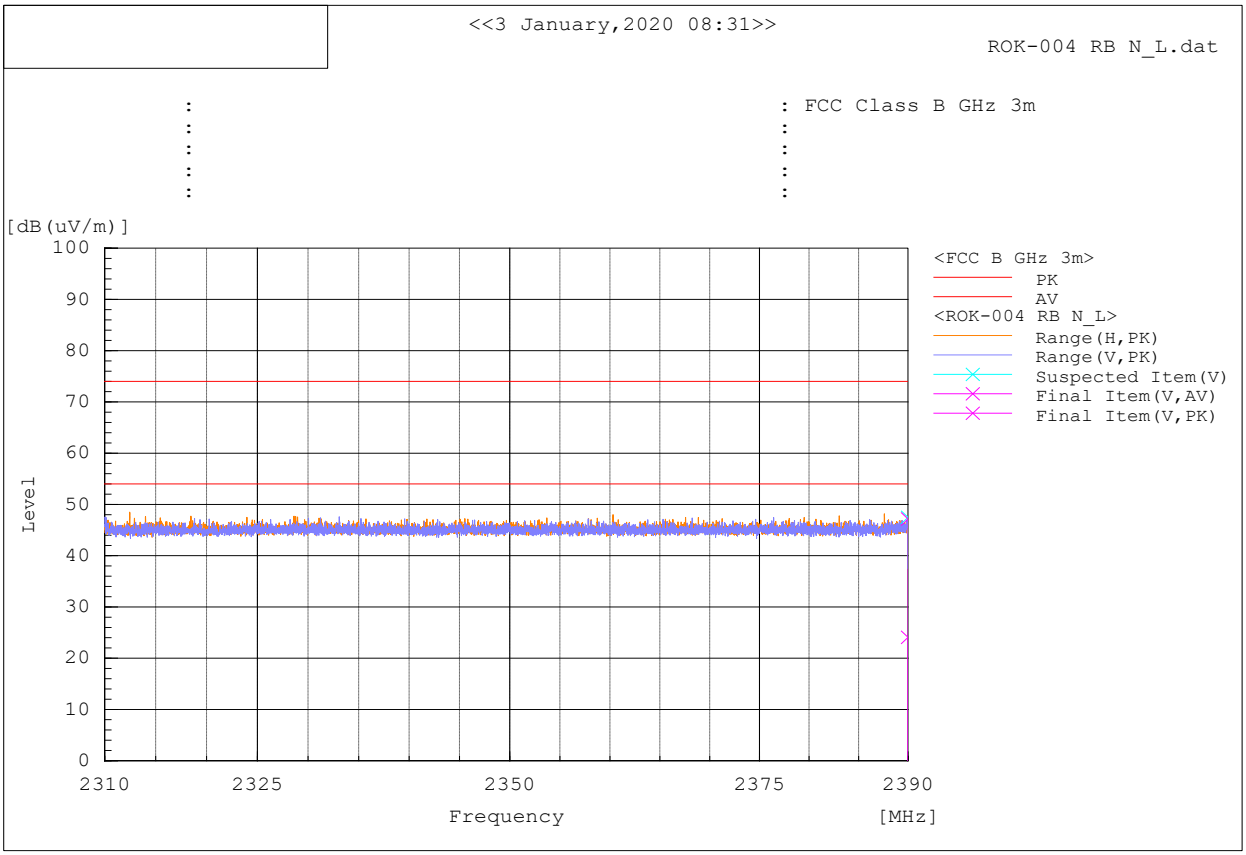
Frequency [MHz]	Pol	Reading [dB(uV)]	Measurement Type	Factor [dB(1/m)]	Level [dB(uV/m)]	Limit [dB(uV/m)]	Margin [dB]	Height [cm]	Angle [deg]
2390	V	-8.4	Average	33.6	25.2	54	28.8	358	269
2390	V	13.6	Peak	33.6	47.2	74	26.8	358	269

RESTRICTED BAND (802.11g High CHANNEL)



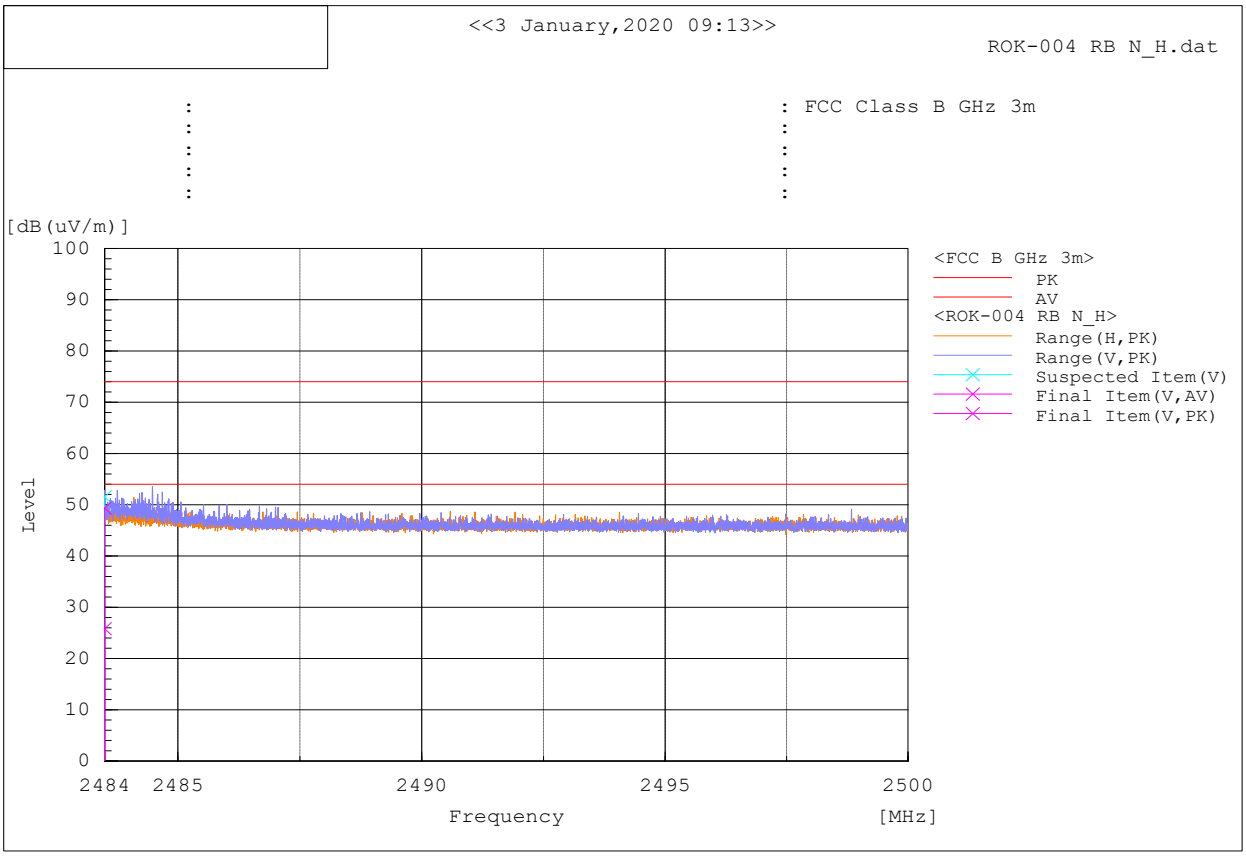
Frequency [MHz]	Pol	Reading [dB(uV)]	Measurement Type	Factor [dB(1/m)]	Level [dB(uV/m)]	Limit [dB(uV/m)]	Margin [dB]	Height [cm]	Angle [deg]
2483.5	V	-7.4	Average	33.9	26.5	54	27.5	226	112
2483.5	V	15.8	Peak	33.9	49.7	74	24.3	226	112

RESTRICTED BAND (802.11n LOW CHANNEL)



Frequency [MHz]	Pol	Reading [dB(uV)]	Measurement Type	Factor [dB(1/m)]	Level [dB(uV/m)]	Limit [dB(uV/m)]	Margin [dB]	Height [cm]	Angle [deg]
2390	V	-9.5	Average	33.6	24.1	54	29.9	317	199
2390	V	13.6	Peak	33.6	47.2	74	26.8	317	199

RESTRICTED BAND (802.11n High CHANNEL)



Frequency [MHz]	Pol	Reading [dB(uV)]	Measurement Type	Factor [dB(1/m)]	Level [dB(uV/m)]	Limit [dB(uV/m)]	Margin [dB]	Height [cm]	Angle [deg]
2483.5	V	-8.1	Average	33.9	25.8	54	28.2	229	102
2483.5	V	15.5	Peak	33.9	49.4	74	24.6	229	102

4.2 Conducted Emission Measurement

4.2.1 Limits of Conducted Emission Measurement

Frequency (MHz)	Conducted Limit (dBuV)	
	Quasi-peak	Average
0.15 - 0.5	66 - 56	56 - 46
0.50 - 5.0	56	46
5.0 - 30.0	60	50

Note: 1. The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50MHz.

4.2.2 Test Instruments

Description & Manufacturer	Model No.	Serial No.	Date Of Calibration	Due Date Of Calibration
EMI Test Receiver ROHDE & SCHWARZ	ESIB 40	100179	08/28/2019	08/28/2020
Transient Limiter ELECTRO-METRICS	EM-7600-5	106	12/31/2019	12/31/2020
LISN EMCO	3816/2NM	214372	03/10/2019	03/10/2020

4.2.3 Test Procedures

a. The EUT was placed 0.4 meters from the conducting wall of the shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). Other support units were connected to the power mains through another LISN. The two LISNs provide 50 ohm/ 50uH of coupling impedance for the measuring instrument.

b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference.

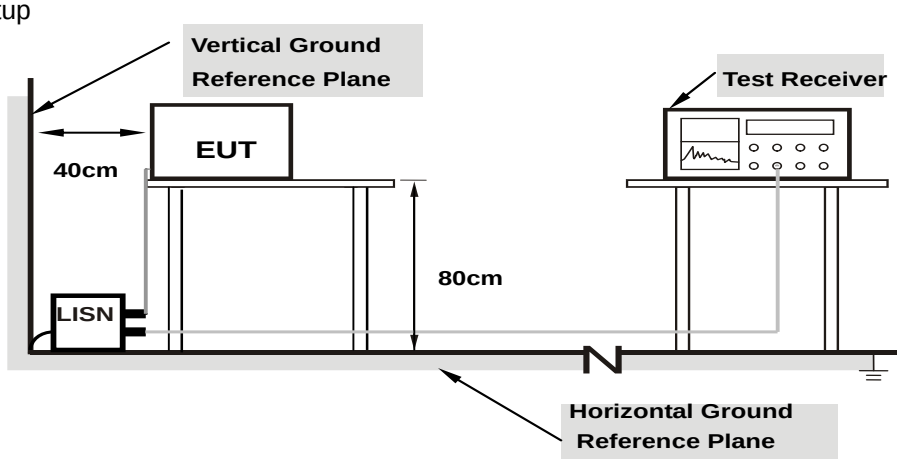
c. The frequency range from 150 kHz to 30MHz was searched. Emission levels under (Limit - 20dB) was not recorded.

NOTE: The resolution bandwidth and video bandwidth of test receiver is 9 kHz for quasi-peak detection (QP) and average detection (AV) at frequency 0.15MHz-30MHz.

4.2.4 Deviation from Test Standard

No deviation.

4.2.5 Test Setup



Note: 1.Support units were connected to second LISN.

For the actual test configuration, please refer to the attached file (Test Setup Photo).

4.2.6 EUT Operating Conditions

Same as 4.1.6.

4.2.7 Test Results

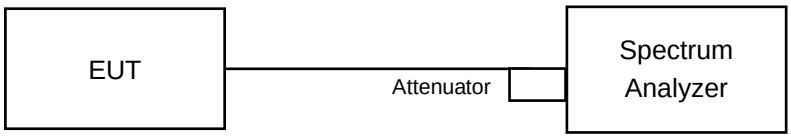
N/A (Work with battery).

4.3 6dB Bandwidth & 99% Bandwidth Measurement

4.3.1 Limits of 6dB Bandwidth Measurement

The minimum of 6dB Bandwidth Measurement is 0.5 MHz.

4.3.2 Test Setup



4.3.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.3.4 Test Procedure

a. Set resolution bandwidth (RBW) = 100kHz
b. Set the video bandwidth (VBW) ≥ 3 x RBW, Detector = Peak.
c. Trace mode = max hold.
d. Sweep = auto couple.
e. Measure the maximum width of the emission that is constrained by the frequencies associated with the two amplitude points (upper and lower) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission

4.3.5 Deviation fromTest Standard

No deviation.

4.3.6 EUT Operating Conditions

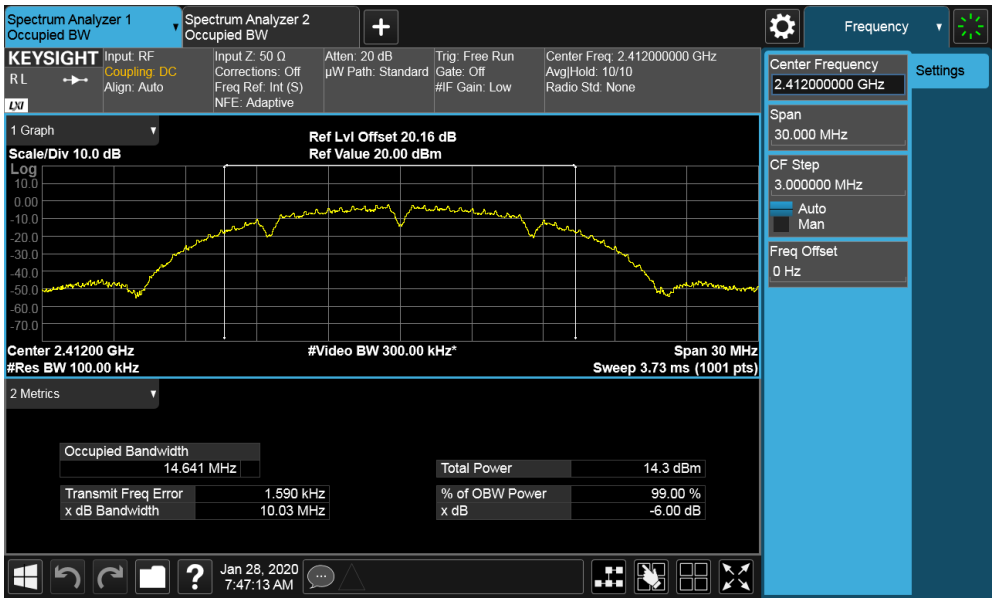
The software provided by client to enable the EUT under transmission condition continuously at lowest, middle and highest channel frequencies individually.

4.3.7 Test Result

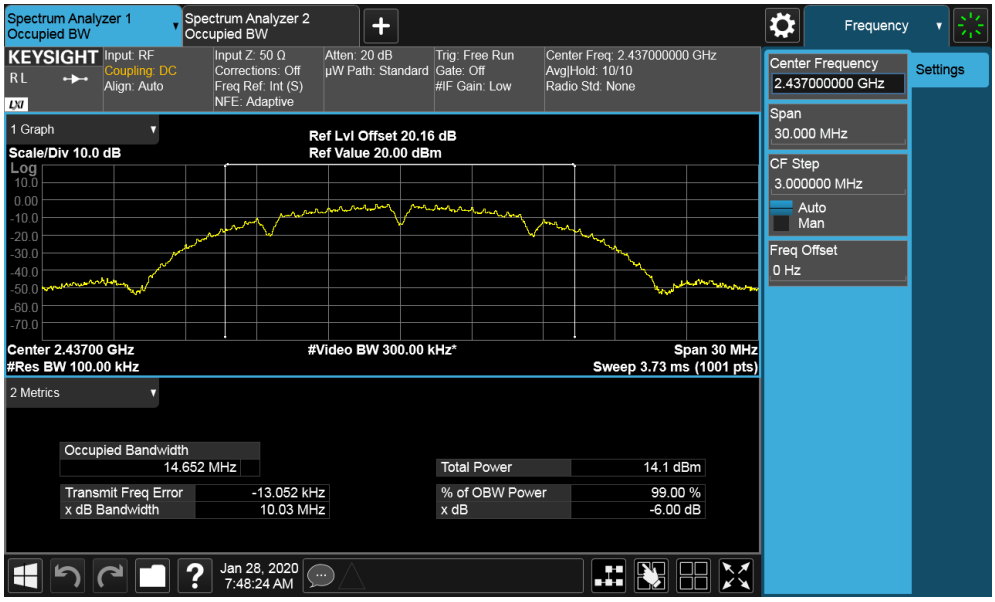
Mode	Channel	Frequency (MHz)	6dB Bandwidth (MHz)	Minimum Limit (MHz)	Pass / Fail
802.11b	1	2412	10.03	0.5	PASS
	6	2437	10.03	0.5	PASS
	11	2462	10.05	0.5	PASS
802.11g	1	2412	16.46	0.5	PASS
	6	2437	16.46	0.5	PASS
	11	2462	16.47	0.5	PASS
802.11n-HT20	1	2412	17.60	0.5	PASS
	6	2437	17.61	0.5	PASS
	11	2462	17.62	0.5	PASS

Mode	Channel	Frequency (MHz)	99% Bandwidth (MHz)
802.11b	1	2412	14.61
	6	2437	14.65
	11	2462	14.66
802.11g	1	2412	16.39
	6	2437	16.40
	11	2462	16.39
802.11n-HT20	1	2412	17.57
	6	2437	17.57
	11	2462	17.57

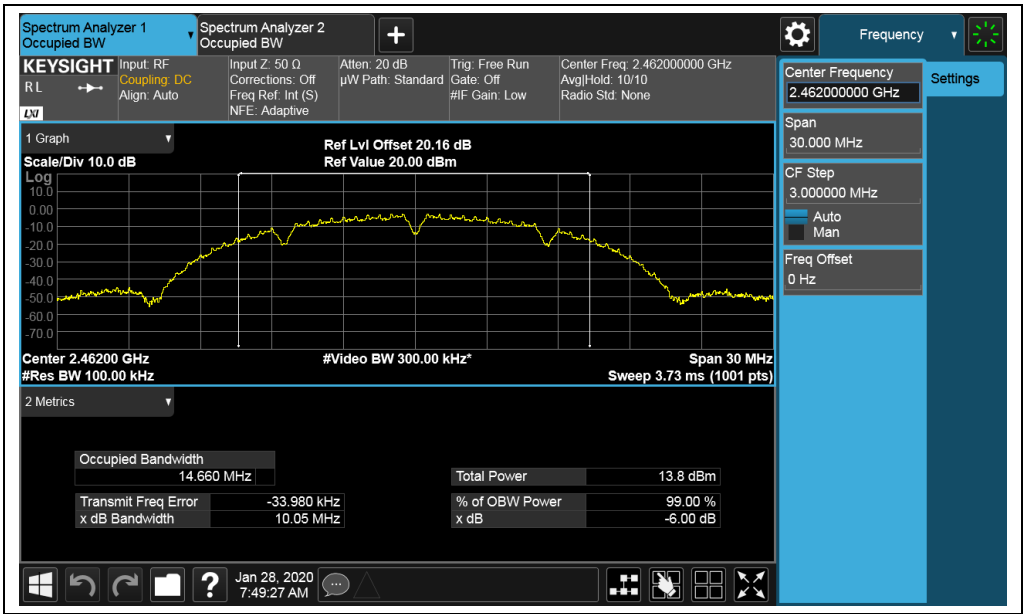
Test Plots:



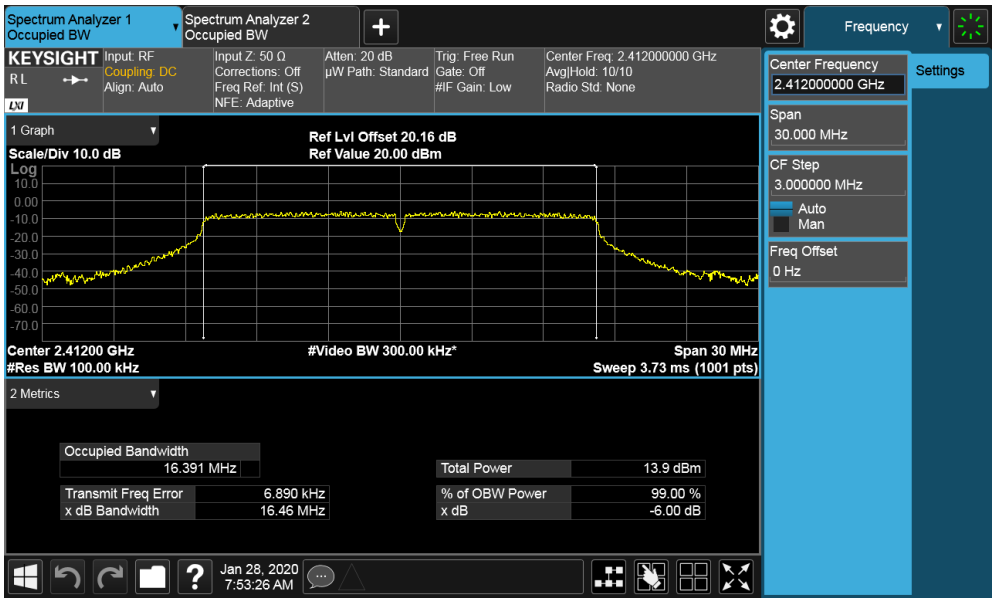
802.11b-2412MHz



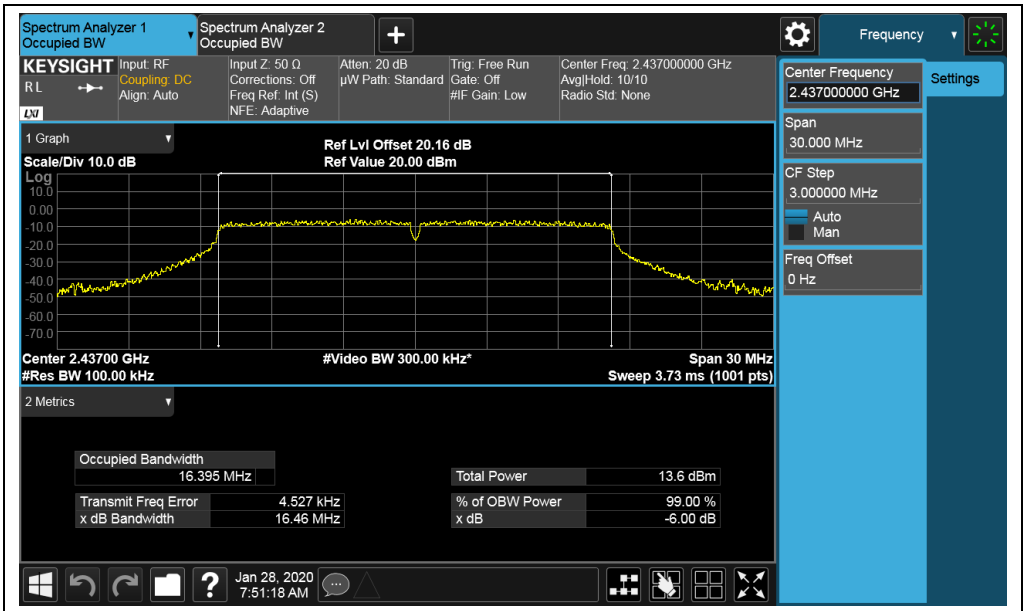
802.11b-2437MHz



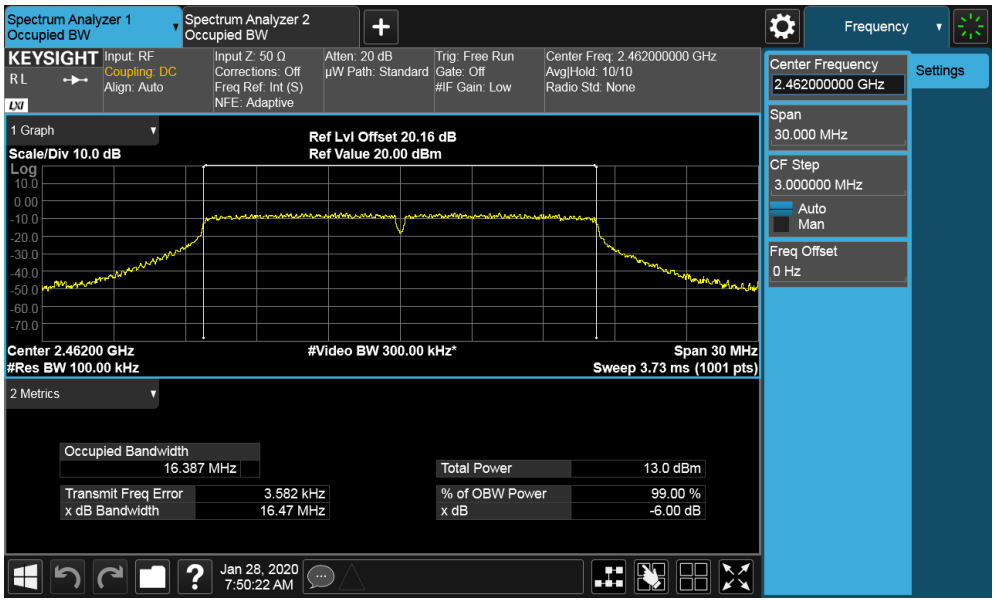
802.11b-2462MHz



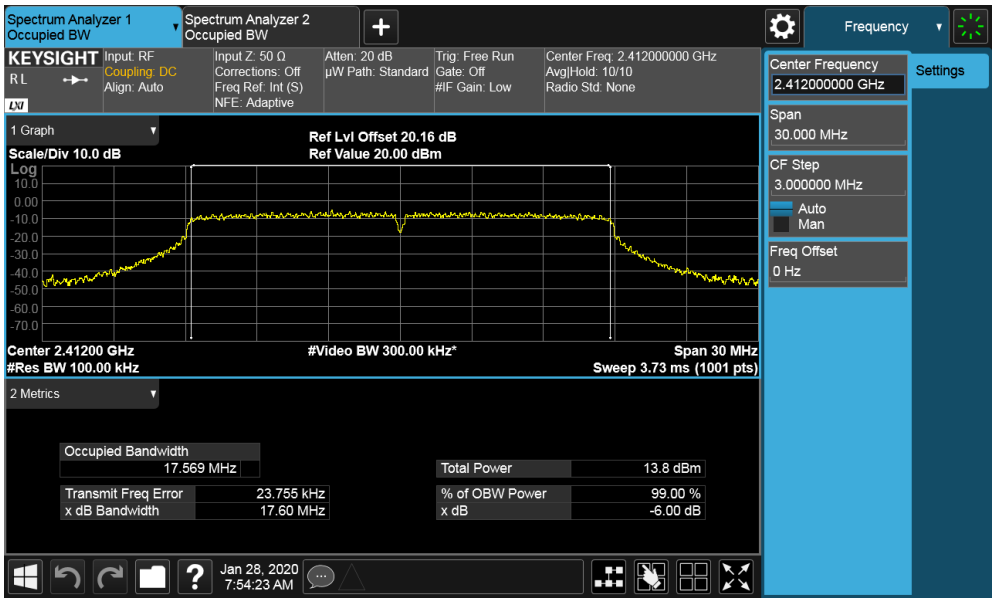
802.11g-2412MHz



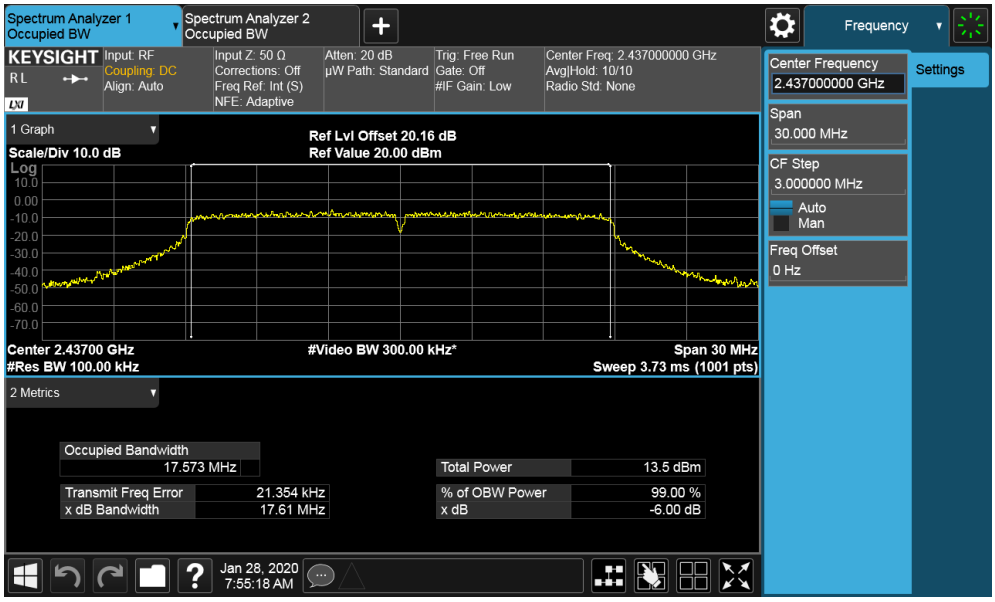
802.11g-2437MHz



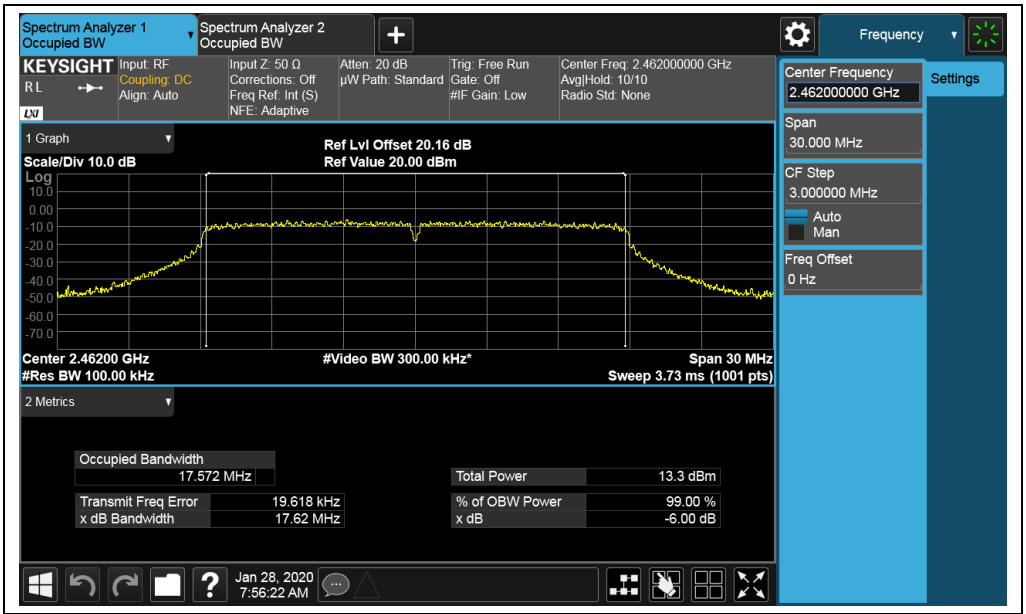
802.11g-2462MHz



802.11n-HT20-2412MHz



802.11n-HT20-2437MHz



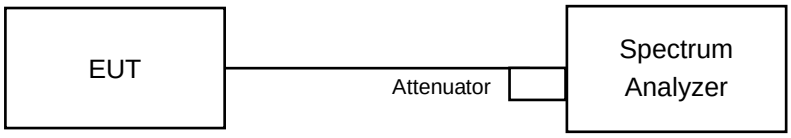
802.11n-HT20-2462MHz

4.4 Conducted Output Power Measurement

4.4.1 Limits of Conducted Output Power Measurement

For systems using digital modulation in the 2400–2483.5 MHz bands: 1 Watt (30dBm)

4.4.2 Test Setup



4.4.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.4.4 Test Procedures

a. Set span to at least 1.5 times the OBW.
b. Set RBW = 1-5% of the OBW, not to exceed 1 MHz.
c. Set VBW ≥ 3 x RBW.
d. Number of points in sweep ≥ 2 × span / RBW
e. Sweep time = auto.
f. Detector = RMS (i.e., power averaging), or sample detector mode.
g. If transmit duty cycle < 98 %, use a sweep trigger with the level set to enable triggering only on full power pulses. If the EUT transmits continuously (i.e., with no off intervals) or at duty cycle ≥ 98 %, and if each transmission is entirely at the maximum power control level, then the trigger shall be set to “free run”.
h. Trace average at least 100 traces in power averaging (i.e., RMS) mode.

4.4.5 Deviation from Test Standard

No deviation.

4.4.6 EUT Operating Conditions

Same as Item 4.3.6.

4.4.7 Test Results

802.11b

Channel	Frequency (MHz)	Conducted Power (dBm)	Limit (dBm)	Pass/Fail
1	2412	8.51	30	Pass
6	2437	8.34	30	Pass
11	2462	7.96	30	Pass

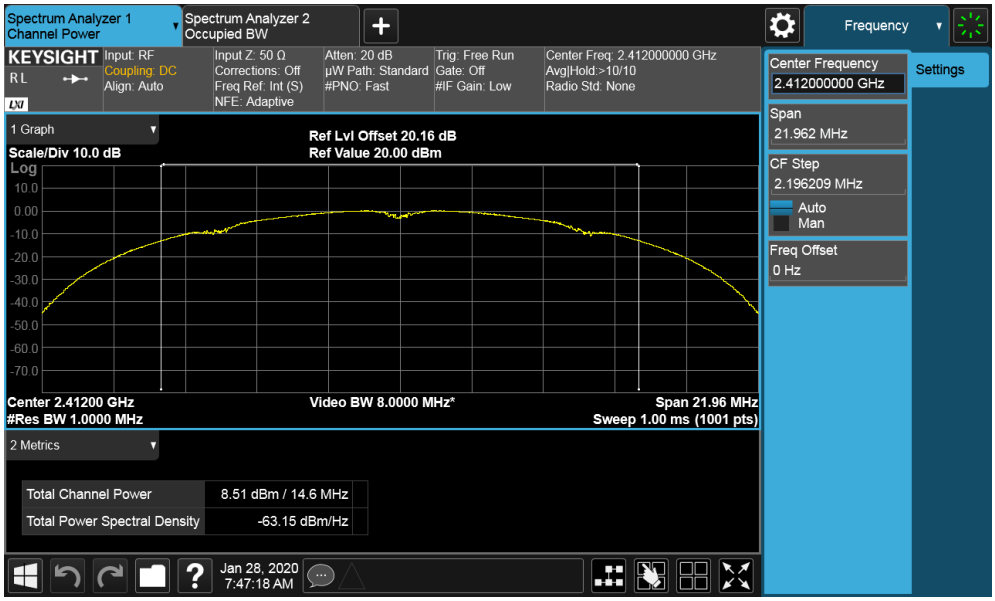
802.11g

Channel	Frequency (MHz)	Conducted Power (dBm)	Limit (dBm)	Pass/Fail
1	2412	8.80	30	Pass
6	2437	8.56	30	Pass
11	2462	7.93	30	Pass

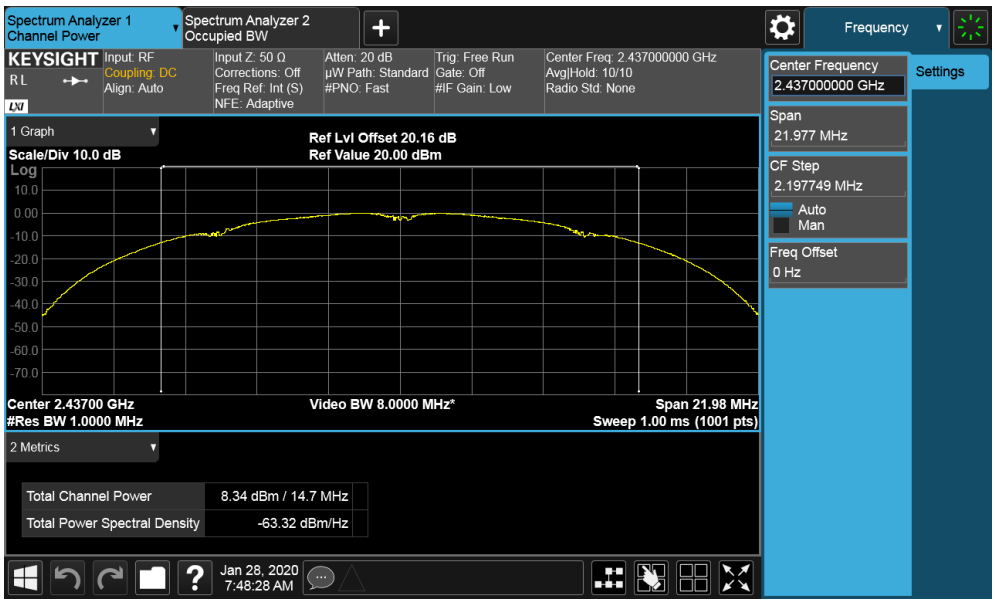
802.11n-HT20

Channel	Frequency (MHz)	Conducted Power (dBm)	Limit (dBm)	Pass/Fail
1	2412	8.76	30	Pass
6	2437	8.46	30	Pass
11	2462	8.32	30	Pass

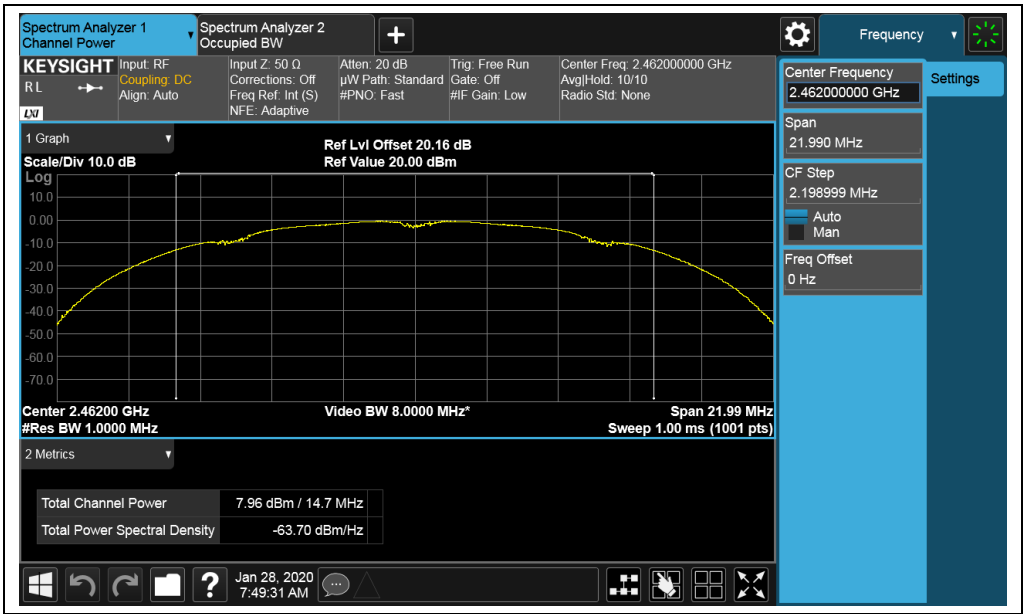
Test Plots:



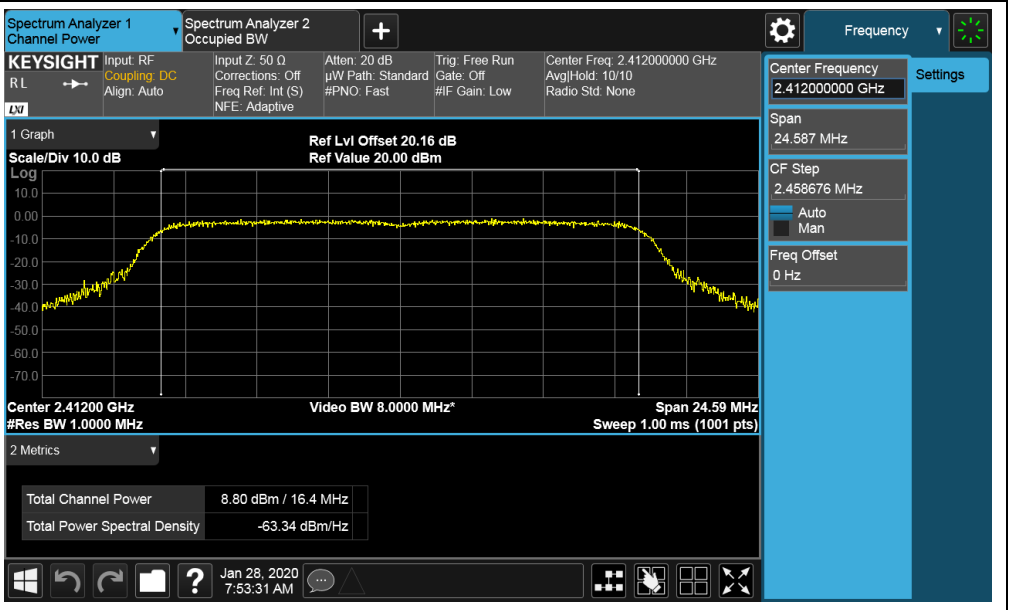
802.11b-2412MHz



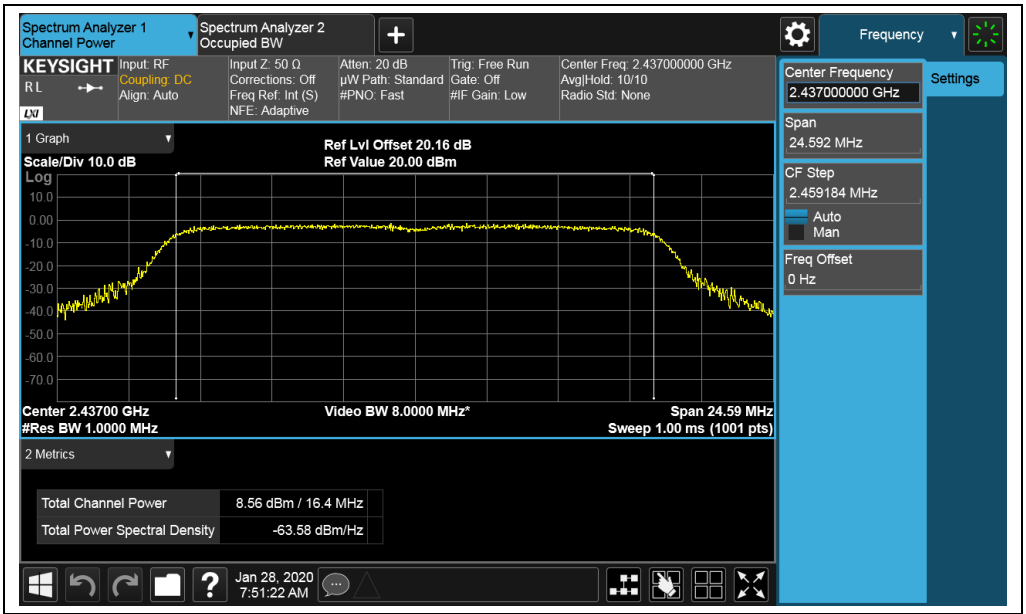
802.11b-2437MHz



802.11b-2462MHz



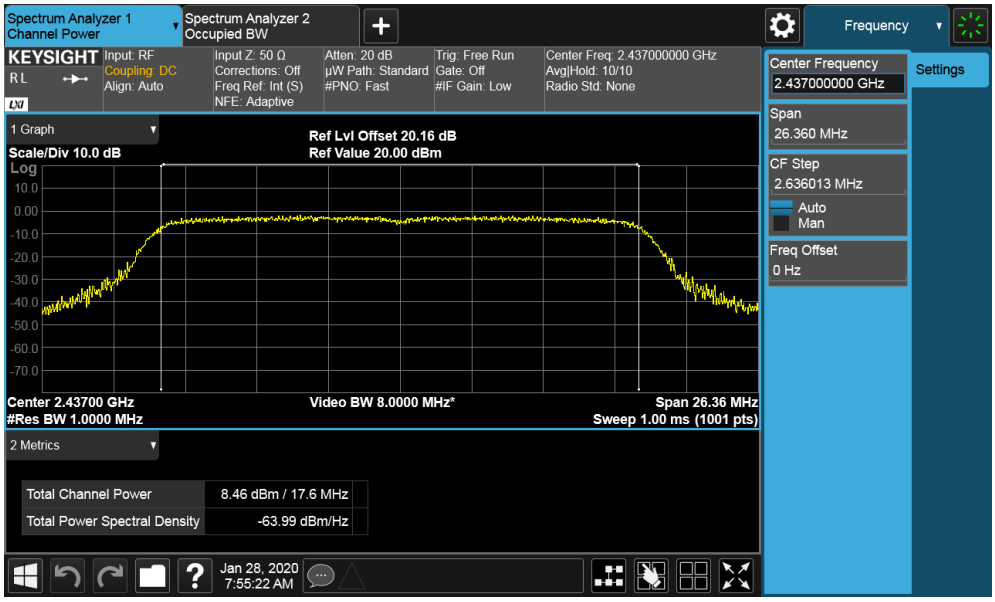
802.11g-2412MHz



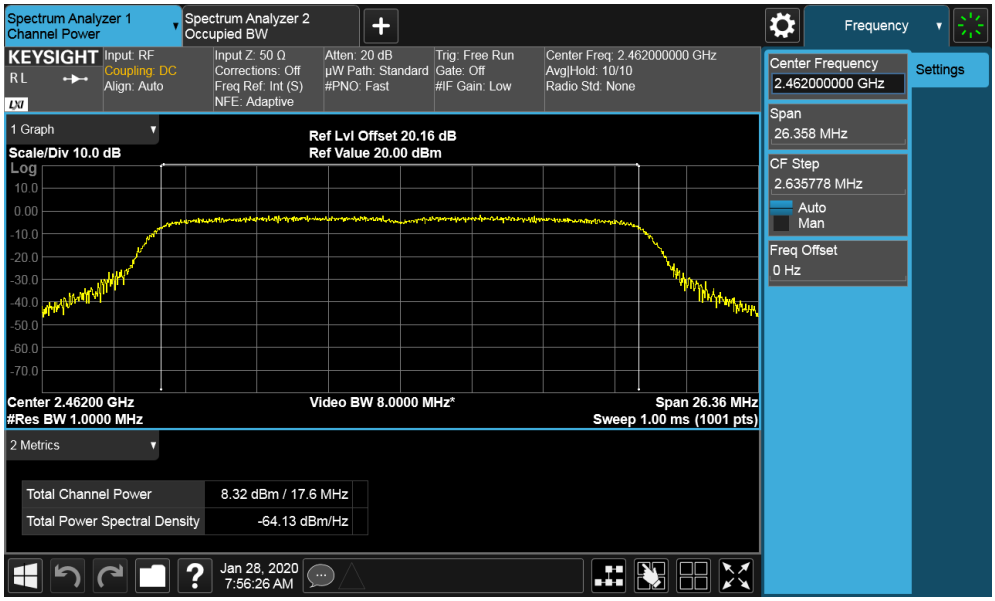
802.11g-2437MHz

802.11g-2462MHz

802.11n-HT20-2412MHz



802.11n-HT20-2437MHz



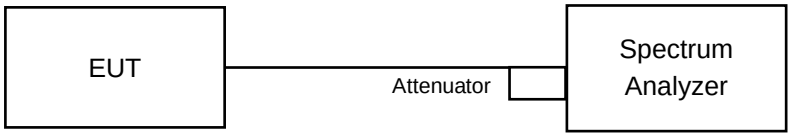
802.11n-HT20-2462MHz

4.5 Power Spectral Density Measurement

4.5.1 Limits of Power Spectral Density Measurement

The Maximum of Power Spectral Density Measurement is 8dBm in any 3 kHz.

4.5.2 Test Setup



4.5.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.5.4 Test Procedure

a. Set analyzer center frequency to DTS channel center frequency.
b. Set the span to 1.5 times the DTS bandwidth.
c. Set the RBW to: 3 kHz ≤ RBW ≤ 100 kHz.
d. Set the VBW ≥ 3 × RBW.
e. Detector = peak.
f. Sweep time = auto couple.
g. Trace mode = max hold.
h. Allow trace to fully stabilize.
i. Use the peak marker function to determine the maximum amplitude level within the RBW.

4.5.5 Deviation from Test Standard

No deviation.

4.5.6 EUT Operating Condition

Same as Item 4.3.6

4.5.7 Test Results

802.11b

Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Pass/Fail
1	2402	-21.45	8	Pass
6	2440	-21.59	8	Pass
11	2480	-21.99	8	Pass

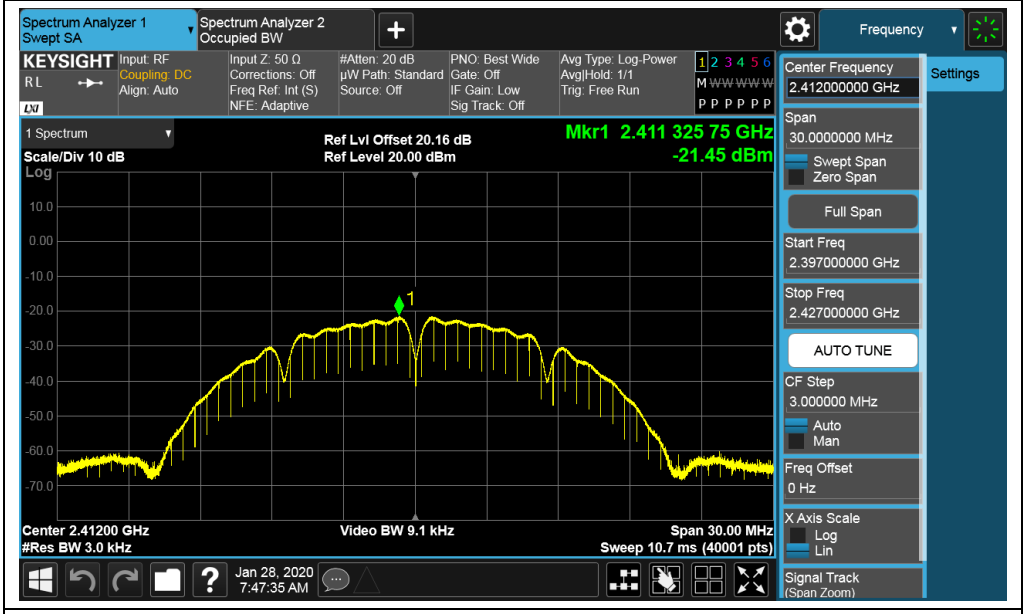
802.11g

Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Pass/Fail
1	2402	-19.58	8	Pass
6	2440	-19.74	8	Pass
11	2480	-20.35	8	Pass

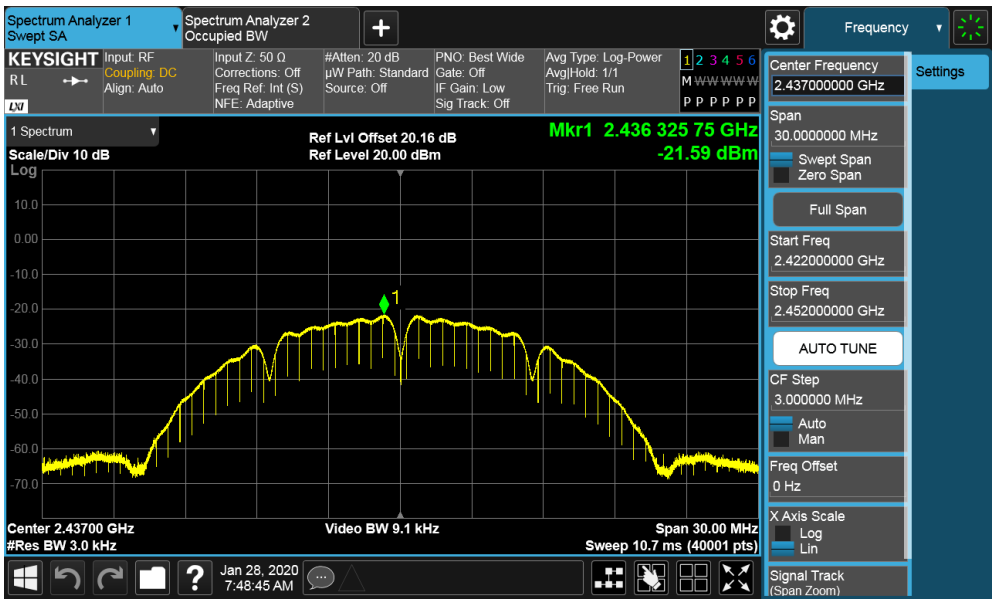
802.11n-HT20

Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Pass/Fail
1	2402	-19.01	8	Pass
6	2440	-19.33	8	Pass
11	2480	-19.42	8	Pass

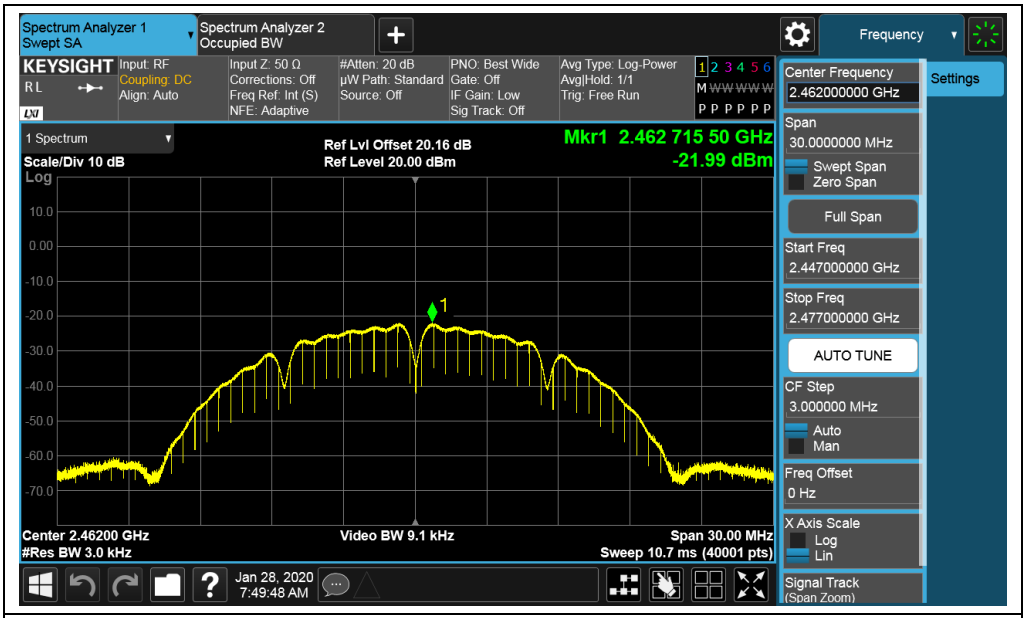
Test Plots:



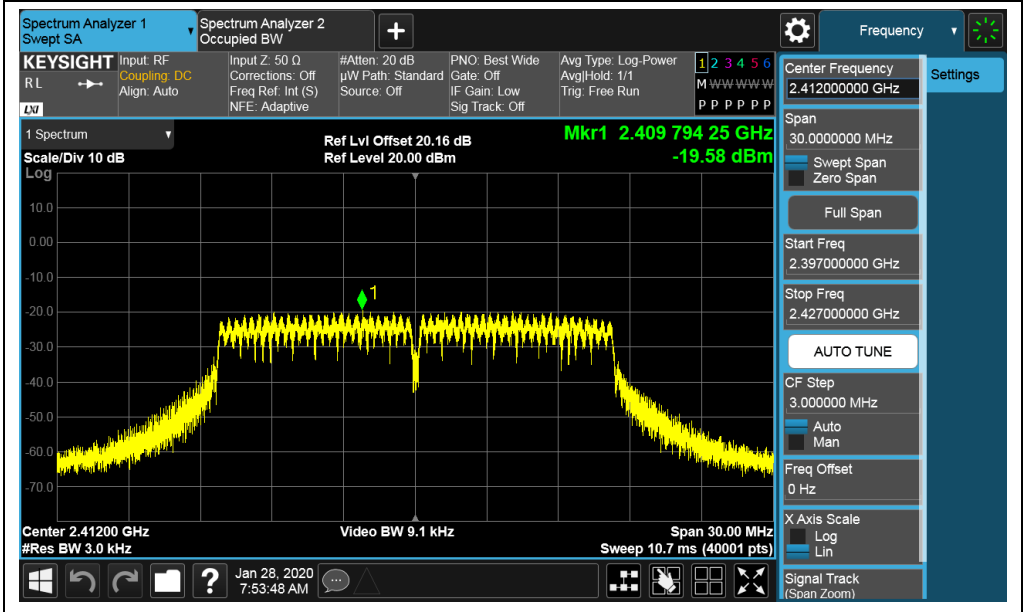
802.11b-2412MHz



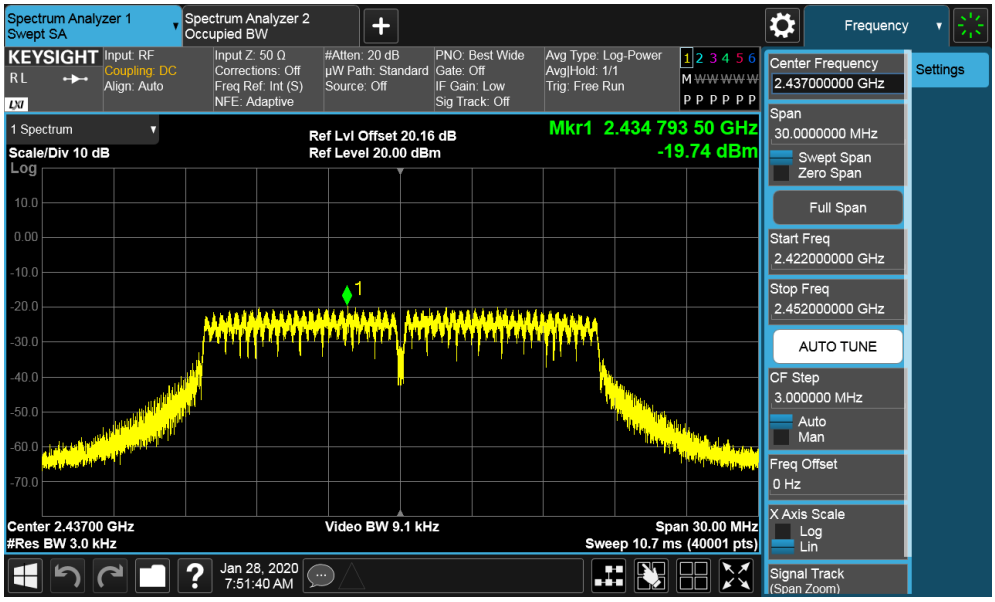
802.11b-2437MHz



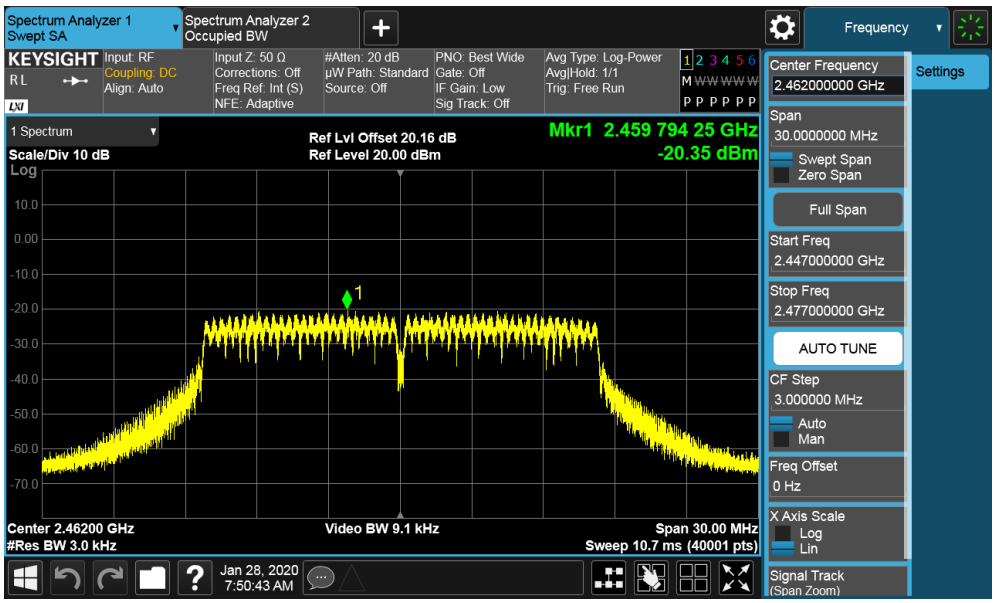
802.11b-2462MHz



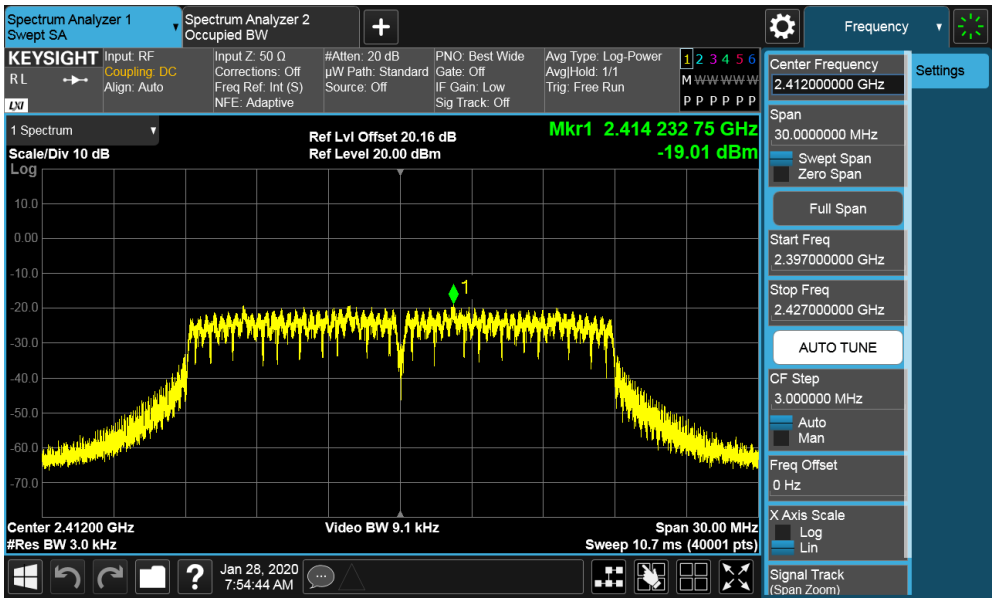
802.11g-2412MHz



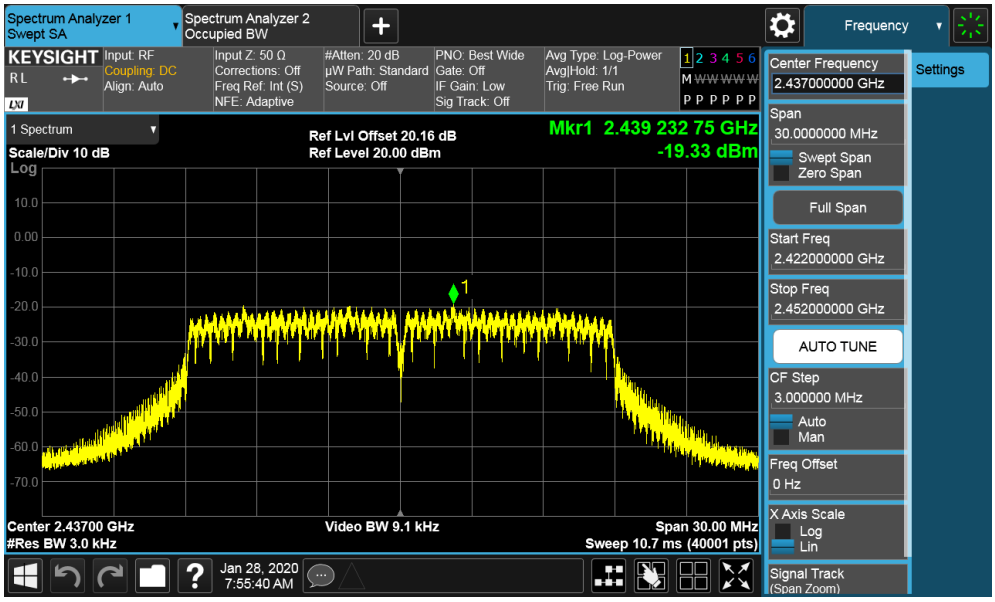
802.11g-2437MHz



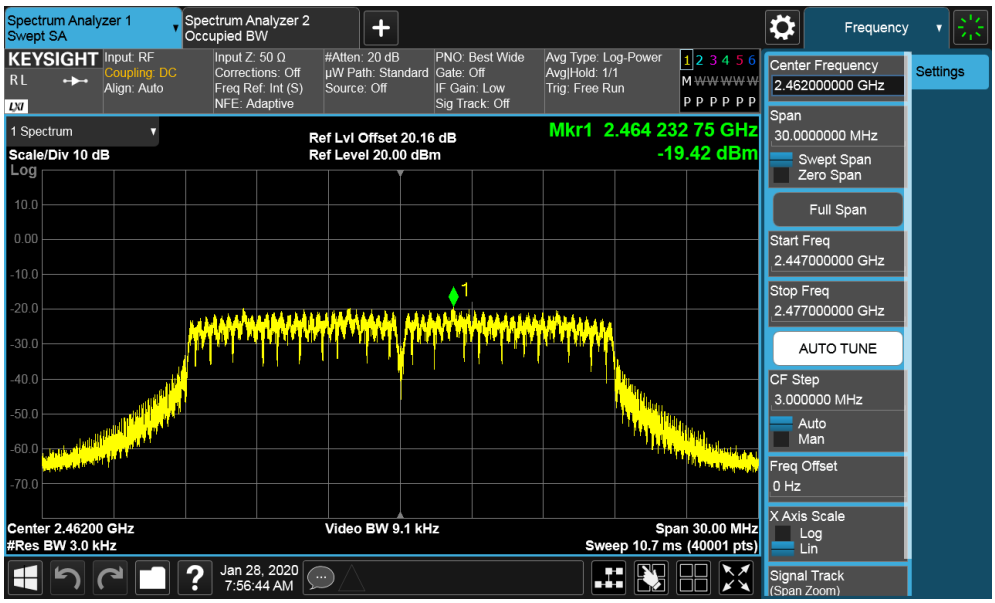
802.11g-2462MHz



802.11n-HT20-2412MHz



802.11n-HT20-2437MHz



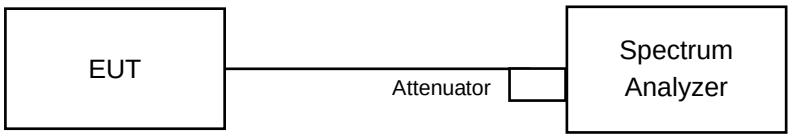
802.11n-HT20-2462MHz

4.6 Conducted Out of Band Emission Measurement

4.6.1 Limits of Conducted Out of Band Emission Measurement

Below 30dB of the highest emission level of operating band (in 100 kHz Resolution Bandwidth).

4.6.2 Test Setup



4.6.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.6.4 Test Procedure

MEASUREMENT PROCEDURE REF

1. Set the RBW = 100 kHz.
2. Set the VBW ≥ 300 kHz.
3. Detector = peak.
4. Sweep time = auto couple.
5. Trace mode = max hold.
6. Allow trace to fully stabilize.
7. Use the peak marker function to determine the maximum power level in any 100 kHz band segment within the fundamental EBW.

MEASUREMENT PROCEDURE OOBE

1. Set RBW = 100 kHz.
2. Set VBW ≥ 300 kHz.
3. Detector = peak.
4. Sweep = auto couple.
5. Trace Mode = max hold.
6. Allow trace to fully stabilize.
7. Use the peak marker function to determine the maximum amplitude level.

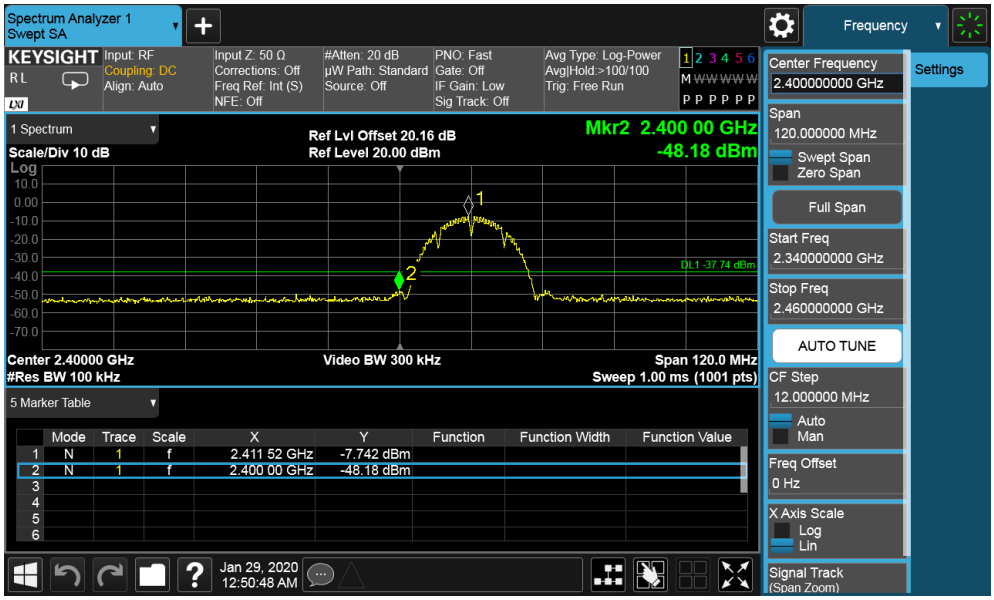
4.6.5 Deviation from Test Standard

No deviation.

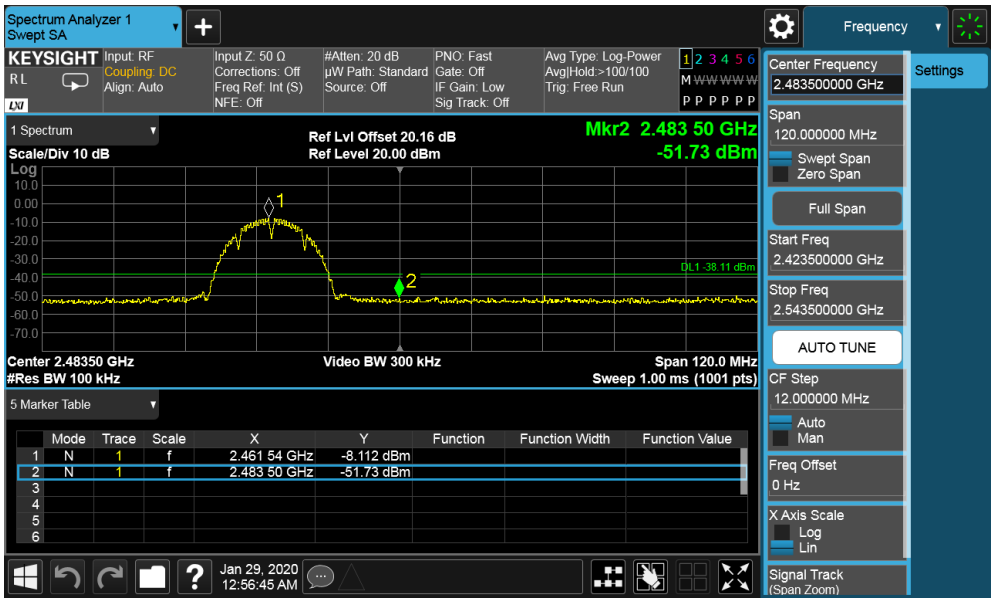
4.6.6 EUT Operating Condition

Same as Item 4.3.6

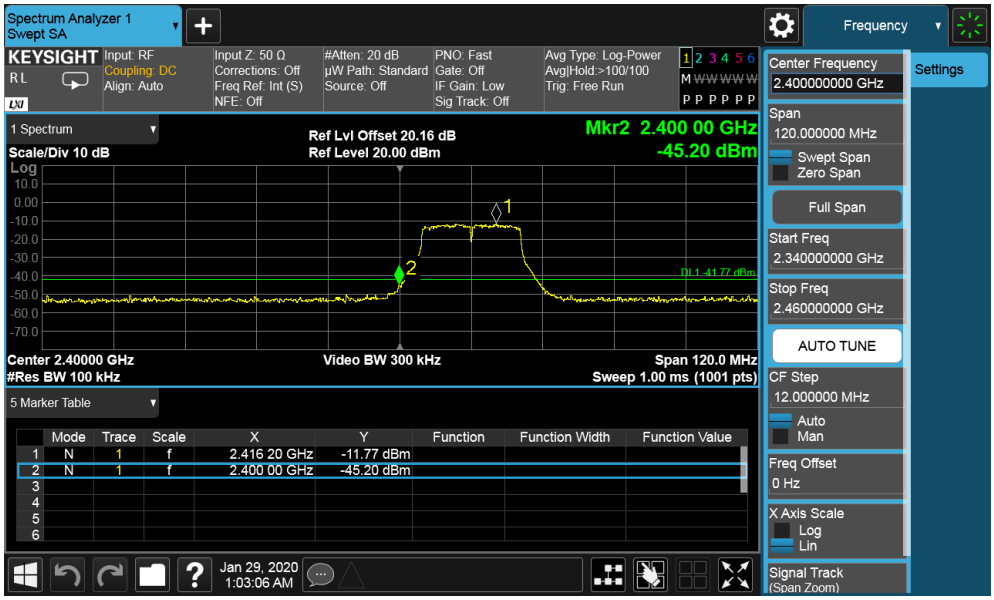
4.6.7 Test Results



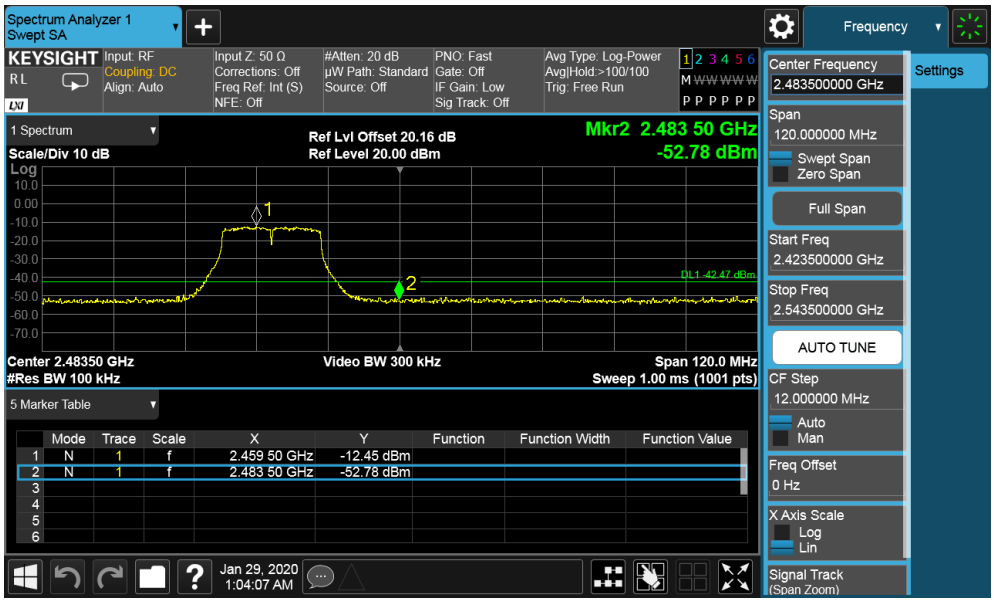
802.11b-2412MHz



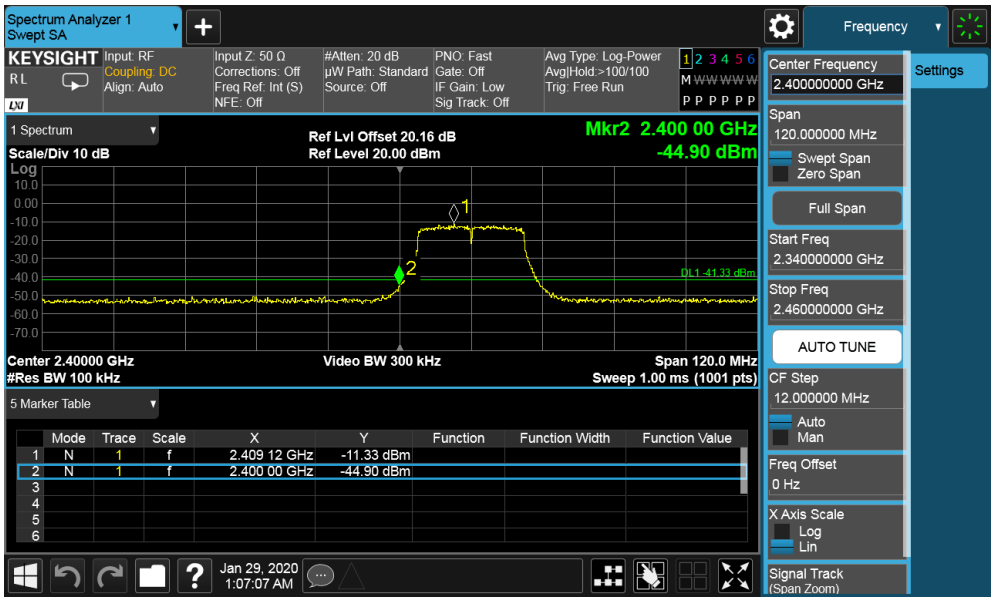
802.11b-2462MHz



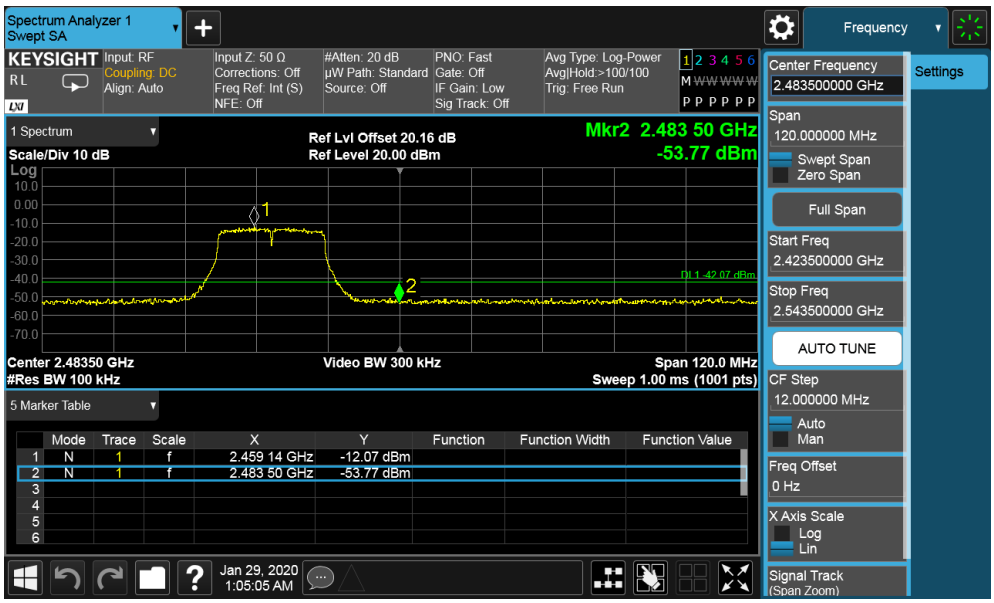
802.11g-2412MHz



802.11g-2462MHz



802.11n-HT20-2412MHz



802.11n-HT20-2462MHz

5 Pictures of Test Arrangements

Please see setup photo file.

Appendix – Information on the Testing Laboratories

Bureau Veritas is a global leader in testing, inspection and certification (TIC) services. We help businesses improve safety, sustainability and productivity; and our clients include the majority of leading brands in retail, manufacturing and other industries. With a presence in every major country around the world, our quality assurance and compliance solutions are vital in helping our customers enhance product quality and concept-to-consumer journeys. We also assist with increasing speed to market, profitability and brand equity throughout the supply chain. Bureau Veritas is a leading wireless/IoT testing, inspection, audit and certification provider, with a global network of test laboratories to support the IoT industry in areas of connectivity, security, interoperability as well as quality, health & safety, and environmental/chemical requirements.

If you have any comments, please feel free to contact us at the following:

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The address and road map of all our labs can be found in our web site also.

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