TEST REPORT

of

JAPAN MIC

Product:	**ESP32 WROOM-32 module**
Brand:	**Fanstel**
Model:	**ESP32M4; ESP32E4; ESP32F4; ESP32M16; ESP32E16; ESP32F16**
Model Difference:	**Different in memory and antenna. Please see page 5 for detail**
Applicant:	**Fanstel Corporation, Taipei**
Address	**10F-10, No. 79, Sec. 1, Hsin Tai Wu Rd.,Hsi-Chih, New Taipei City 221 Taiwan**

Test Performed by:

International Standards Laboratory Corp. LT Lab.
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No. 120, Lane 180, Hsin Ho Rd., Lung-Tan Dist., Tao Yuan City 325, Taiwan

Report No.: **ISL-20LR045JAP**
Issue Date : **August 24, 2021**

VERIFICATION OF COMPLIANCE

Applicant:	Fanstel Corporation, Taipei
Equipment Under Test:	ESP32 WROOM-32 module
Brand:	Fanstel
Model Number:	ESP32M4; ESP32E4; ESP32F4; ESP32M16; ESP32E16; ESP32F16
Model Difference:	Different in memory and antenna. Please see page 5 for detail
Date of Test:	August 3, 2021 ~ August 24, 2021
Date of EUT Received:	August 3, 2021

APPLICABLE STANDARDS	
STANDARD	**TEST RESULT**
ARIB STD-T66	Complied

The above equipment was tested by International Standards Laboratory Corp. for compliance with the requirements in the Radio equipment stipulated in the certification ordinance Item 19, Paragraph 1, Article 2. The results of testing in this report apply to the product/system that was tested only. Other similar equipment will not necessarily produce the same results due to production tolerance and measurement uncertainties. The antenna specification is provided by the applicant, and ISL does not bear the relevant responsibility.

Test By: Weitin Chen ***Date:*** August 24, 2021

Weitin Chen / Senior Engineer

Prepared By: Elisa Chen ***Date:*** August 24, 2021

Elisa Chen / Senior Engineer

Approved By: Jerry Liu ***Date:*** August 24, 2021

Jerry Liu / Assistant Manager

Version

Version No.	Date	Description
00	August 24, 2021	Initial creation of document

TABLE OF CONTENTS

1. Description of Equipment under Test (EUT)

1.1 General Information

General:

Product Name:	ESP32 WROOM-32 module
Brand Name:	Fanstel
Model Name:	ESP32M4; ESP32E4; ESP32M16; ESP32E16; ESP32F16; ESP32F4
Model Difference:	Different in memory and antenna. Please see table below for detail.
Power Supply:	5Vdc from USB port

Model Summaries:

module	ESP32M4	ESP32F4.	ESP32E4.	ESP32M16	ESP32F16	ESP32E16.
SoC	ESP32-D0WD	ESP32-D0WD	ESP32-D0WD	ESP32-D0WD	ESP-D0WD	ESP32-D0WD
Flash memory	4MB, IS25LP032-JBLE	4MB, IS25LP032-JBLE	4MB, IS25LP032-JBLE	16MB, IS25LP128-JBLE	16MB, IS25LP128-JBLE	16MB, IS25LP128-JBLE
Size	18x25.5	18x25.5	18x25.5	18x25.5	20x29.5	18x25.5
WIFI	PCB trace	PCB trace	u.FL	PCB trace	PCB trace	u.FL
Operating temp.	-40°C to +105°C	-40°C to +105°C	-40°C to +105°C	-40°C to +105°C	-40°C to +105°C	-40°C to +105°C

WLAN: 1TX, 1 RX

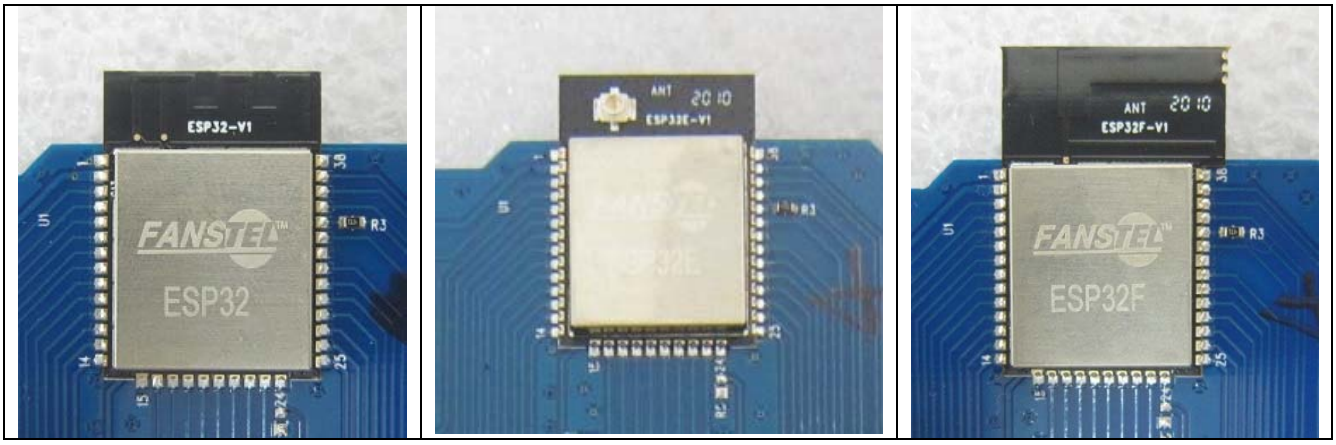
Wi-Fi	Frequency Range (MHz)	Channels	Rated Power (mW/MHz)	Modulation Technology
802.11b	2412 – 2472 (DTS)	13	7	DSSS
802.11g	2412 – 2472 (DTS)	13	4.5	OFDM
802.11n	HT20 2412 – 2472 (DTS)	13	5	
	HT40 2422 – 2462 (DTS)	9	1.45	
Modulation type		CCK, DQPSK, DBPSK for DSSS 256QAM.64QAM. 16QAM, QPSK, BPSK for OFDM		

1.2 Antenna Specification

Antenna Type	ESP32M: PCB Antenna ESP32F: PCB Antenna ESP32E: Dipole Antenna
Peak Gain	ESP32M: 2.22 dBi ESP32F: 1.70 dBi ESP32E: 0 dBi
Impedance	50.0 ohms
Radiation pattern	Omni

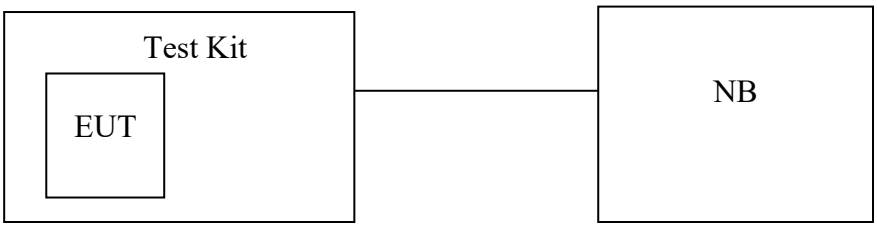
1.3 Assemble

There is a shielding soldered on the module.



1.4 Support Equipment

Configuration of Tested System



Equipment Used in Tested System

Item	Equipment	Mrf/Brand	Model name	Series No	Data Cable	Power Cable
1	Notebook	Lenovo	X220i	N/A	N/A	Non-shielded
2	Test Kit	N/A	N/A	N/A	N/A	N/A

2. Description of Test Modes

The EUT has been tested at continuous TX and RX modes. And software was used to control the EUT for staying in above description test modes.
Test data of model ESP32M is the worst case which is reported.

Wifi:
802.11b mode: Channel lowest (2412MHz), mid (2437MHz) and highest (2472MHz) with 1Mbps data rate are chosen for full testing.
802.11g mode: Channel lowest (2412MHz), mid (2437MHz) and highest (2472MHz) with 6Mbps data rate are chosen for full testing.
802.11n HT20: Channel lowest (2412MHz), mid (2437MHz) and highest (2472MHz) with 6.5 Mbps are chosen for full testing.
802.11n HT40: Channel lowest (2422MHz), mid (2437MHz) and highest (2462MHz) with 6.5 Mbps are chosen for full testing.

Test conditions

Temperature & humidity	Normal
Normal voltage	5.0 Vdc
Lower extreme voltage	4.5 Vdc
Higher extreme voltage	5.5 Vdc

3. General Description of Applied Standards

The EUT According to the Specifications, it must comply with the requirements of the following standards:

Radio equipment stipulated in the certification ordinance Item 19, Paragraph 1, Article 2.

4. Measurement Uncertainty

ISO/IEC 17025 requires that an estimate of measurement uncertainties associated with the emissions test results be included in the report. The measurement uncertainties given below are based on a 95% confidence level (based on a coverage factor (k=2)).

Parameters	Uncertainty
Frequency Error	± 727.3 Hz
Conducted Power	± 1.55 dB
Power Density	± 1.67 dB
Conducted Spurious Emission	± 1.55 dB
Adjacent Channel Power	± 1.55 dB
Time	± 0.01 %
DC Voltage	± 1 %

5. Summary of Tests

Article reference	Parameter	Status (Note 1)
General provisions		
5	Frequency tolerance	C
6	Occupied bandwidth	C
7	Spurious emission	C
Transmitting equipment		
14	Antenna Power	C
14.2	SAR	N/A
15	Frequency stabilization	C
Transmitting equipment		
20	Type configuration etc of transmitting antenna	C
22	Directional pattern of transmitting antenna	C
Receiving equipment		
24	Spurious emission of receiver	C
26	Refer to all articles for transmitting antenna	C
Operating frequency 2400-2483.5MHz		
49.20(1); a	High Frequency/modulation section cannot be operated easily	C
49.20(1); b	Communication method	C
49.20(1); c	Communication method	C
49.20(1); d	Spread Spectrum method	C
49.20(1); e	Antenna Power	C
49.20(1); f(1)	Absolute gain of transmitting antenna	C
49.20(1); f(2)	Angular width of principal radiation (AWPR)	C
49.20(1); g	Number of carriers within 1MHz bandwidth in OFDM	C
49.20(1); h	Diffusion bandwidth	C
49.20(1); i	Spreading factor	C
49.20(1); j	Frequency retention time (FH employed)	C
Note 1: C=Confirm NC=Not Confirm NT=Not Tested NA= Not Applicable		

5.1 Antenna Power and Tolerance

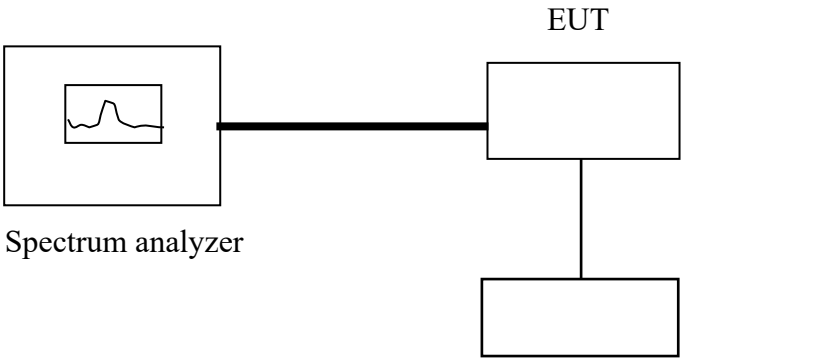
5.1.1 Limit

BT: Antenna power: 3mW/MHz
Wifi(1-14): Antenna power: 10mW/MHz
BT 4.0 Antenna power: 10mW
Antenna power tolerance: + 20% to – 80%

5.1.2 Measurement Equipment Used

Refer to section Appendix A: Equipment List for detail.

5.1.3 Test Setup



5.1.4 Test Procedure

1. Set the EUT at hopping off and modulation on.
2. Set the ETU operates at channel low, mid and high and normal/Upper/Lower voltage.
3. Connect the EUT to power meter.
4. Record the power level.
5. Varied input voltage to + 10% and - 10% normal voltage and repeat procedure 1 to 4 again.

5.1.5 Test Results

Ambient temperature: 24℃ Relative humidity: 63% Test Date: 2021/08/12

802.11b

Rated Power Density(for 2412-2472) = 7mW/MHz

Antenna Gain=2.22dBi

		Channel Low	Channel Mid	Channel High	Limit
Normal Voltage 5 V	Conducted Power (dBm/MHz)	8.080	8.570	8.790	N/A
	Conducted Power (mW/MHz)	6.427	7.194	7.568	10mW/MHz
	Power Tolerance	-8.187	2.778	8.119	+20% to -80%
Upper Voltage 5.5 V	Conducted Power (dBm/MHz)	8.120	8.460	8.840	N/A
	Conducted Power (mW/MHz)	6.486	7.015	7.656	10mW/MHz
	Power Tolerance	-7.338	0.208	9.371	+20% to -80%
Lower Voltage 4.5 V	Conducted Power (dBm/MHz)	8.210	8.590	8.710	N/A
	Conducted Power (mW/MHz)	6.622	7.228	7.430	10mW/MHz
	Power Tolerance	-5.398	3.253	6.146	+20% to -80%

Remark:

1. Conducted Power (mW/MHz)= 10^(Conducted Power(dBm/MHz)/10)
2. P (mW/MHz) = Raw power (in mW, measured by power sensor) / [spreading bandwidth (MHz) x duty-cycle]

802.11g

Rated Power Density = 4.5mW/MHz

Antenna Gain=2.22dBi

		Channel Low	Channel Mid	Channel High	Limit
Normal Voltage 5 V	Conducted Power (dBm/MHz)	6.255	6.783	6.418	N/A
	Conducted Power (mW/MHz)	4.222	4.768	4.383	10mW/MHz
	Power Tolerance	-6.186	5.948	-2.594	+20% to -80%
Upper Voltage 5.5 V	Conducted Power (dBm/MHz)	6.37	7.25	6.913	N/A
	Conducted Power (mW/MHz)	4.335	5.309	4.912	10mW/MHz
	Power Tolerance	-3.663	17.972	9.166	+20% to -80%
Lower Voltage 4.5 V	Conducted Power (dBm/MHz)	6.393	7.244	6.892	N/A
	Conducted Power (mW/MHz)	4.358	5.302	4.889	10mW/MHz
	Power Tolerance	-3.16	17.817	8.639	+20% to -80%

Remark:

1. Conducted Power (mW/MHz)= 10^(Conducted Power(dBm/MHz)/10)
2. P (mW/MHz) = Raw power (in mW, measured by power sensor) / [spreading bandwidth (MHz) x duty-cycle]

802.11n HT20

Rated Power Density = 5mW/MHz

Antenna Gain=2.22dBi

		Channel Low	Channel Mid	Channel High	Limit
Normal Voltage 5 V	Conducted Power (dBm/MHz)	6.765	7.638	6.206	N/A
	Conducted Power (mW/MHz)	4.748	5.805	4.174	10mW/MHz
	Power Tolerance	-5.046	16.106	-16.511	+20% to -80%
Upper Voltage 5.5 V	Conducted Power (dBm/MHz)	6.804	7.698	6.496	N/A
	Conducted Power (mW/MHz)	4.791	5.886	4.463	10mW/MHz
	Power Tolerance	-4.179	17.715	-10.746	+20% to -80%
Lower Voltage 4.5 V	Conducted Power (dBm/MHz)	6.777	7.661	6.203	N/A
	Conducted Power (mW/MHz)	4.761	5.836	4.172	10mW/MHz
	Power Tolerance	-4.785	16.719	-16.569	+20% to -80%

Remark:

1. Conducted Power (mW/MHz)= 10^(Conducted Power(dBm/MHz)/10)
2. P (mW/MHz) = Raw power (in mW, measured by power sensor) / [spreading bandwidth (MHz) x duty-cycle]

802.11n HT40

Rated Power Density = 1.45mW/MHz

Antenna Gain=2.22dBi

		Channel Low	Channel Mid	Channel High	Limit
Normal Voltage 5 V	Conducted Power (dBm/MHz)	0.44	1.649	1.66	N/A
	Conducted Power (mW/MHz)	1.107	1.462	1.466	5mW/MHz
	Power Tolerance	-23.675	0.826	1.072	+20% to -80%
Upper Voltage 5.5 V	Conducted Power (dBm/MHz)	0.853	1.695	1.62	N/A
	Conducted Power (mW/MHz)	1.217	1.477	1.452	5mW/MHz
	Power Tolerance	-16.075	1.882	0.146	+20% to -80%
Lower Voltage 4.5 V	Conducted Power (dBm/MHz)	0.952	1.669	1.667	N/A
	Conducted Power (mW/MHz)	1.245	1.469	1.468	5mW/MHz
	Power Tolerance	-14.133	1.277	1.235	+20% to -80%

Remark:

1. Conducted Power (mW/MHz)= 10^(Conducted Power(dBm/MHz)/10)
2. P (mW/MHz) = Raw power (in mW, measured by power sensor) / [spreading bandwidth (MHz) x duty-cycle]

5.2 Frequency Tolerance

5.2.1 Limit:

50ppm

5.2.2 Measurement Equipment Used

Refer to section Appendix A: Equipment List for detail.

5.2.3 Test Setup

Refer to section 5.1.3 for detail.

5.2.4 Test Procedure

1. Set the EUT modulation off.
2. Set the ETU operates at channel low, mid and high and normal voltage.
3. Set the spectrum analyzer RBW = 300Hz, VBW=300Hz and Span = 20kHz
4. Max hold, View, Peak High, Mark and snap the screen and record the mark.
5. Varied input voltage to + 10% and - 10% normal voltage and repeat procedure 1 to 4 again.

5.2.5 Test Results

Ambient temperature: 24℃ Relative humidity: 63% Test Date: 2021/08/12

802.11b

		Channel Low	Channel Mid	Channel High	Limit
Normal Voltage 5 V	Measured Frequency (MHz)	2412.003	2437.002	2472.001	+/-50ppm
	Frequency Tolerance (ppm)	1.244	0.821	0.405	
Upper Voltage 5.5 V	Measured Frequency (MHz)	2412.003	2437.003	2472.001	+/-50ppm
	Frequency Tolerance (ppm)	1.244	1.231	0.405	
Lower Voltage 4.5 V	Measured Frequency (MHz)	2412.002	2437.003	2472.003	+/-50ppm
	Frequency Tolerance (ppm)	0.829	1.231	1.214	

802.11g

		Channel Low	Channel Mid	Channel High	Limit
Normal Voltage 5 V	Measured Frequency (MHz)	2412.003	2437.001	2472.001	+/-50ppm
	Frequency Tolerance (ppm)	1.244	0.41	0.405	
Upper Voltage 5.5 V	Measured Frequency (MHz)	2412.002	2437.002	2472.002	+/-50ppm
	Frequency Tolerance (ppm)	0.829	0.821	0.809	
Lower Voltage 4.5 V	Measured Frequency (MHz)	2412.003	2437.002	2472.001	+/-50ppm
	Frequency Tolerance (ppm)	1.244	0.821	0.405	

802.11n HT20

		Channel Low	Channel Mid	Channel High	Limit
Normal Voltage 5 V	Measured Frequency (MHz)	2412.002	2437.002	2472.003	+/-50ppm
	Frequency Tolerance (ppm)	0.829	0.821	1.214	
Upper Voltage 5.5 V	Measured Frequency (MHz)	2412.002	2437.003	2472.002	+/-50ppm
	Frequency Tolerance (ppm)	0.829	1.231	0.809	
Lower Voltage 4.5 V	Measured Frequency (MHz)	2412.003	2437.001	2472.002	+/-50ppm
	Frequency Tolerance (ppm)	1.244	0.41	0.809	

802.11n HT40

		Channel Low	Channel Mid	Channel High	Limit
Normal Voltage 5 V	Measured Frequency (MHz)	2422.003	2437.002	2462.002	+/-50ppm
	Frequency Tolerance (ppm)	1.239	0.821	0.812	
Upper Voltage 5.5 V	Measured Frequency (MHz)	2422.002	2437.003	2462.001	+/-50ppm
	Frequency Tolerance (ppm)	0.826	1.231	0.406	
Lower Voltage 4.5 V	Measured Frequency (MHz)	2422.001	2437.003	2462.001	+/-50ppm
	Frequency Tolerance (ppm)	0.413	1.231	0.406	

5.3 Occupied Bandwidth

5.3.1 Limit

802.11 b/g /n(HT20), BT(LE) < 26MHz
802.11 n(HT40) < 38MHz
BT normal mode < 83.5MHz

5.3.2 Measurement Equipment Used

Refer to section Appendix A: Equipment List for detail.

5.3.3 Test Setup

Refer to section 5.1.3 for detail.

5.3.4 Test Procedure:

1. Set the EUT modulation on.
2. Set the ETU operate at channel low, mid and high and normal voltage.
3. Set the spectrum analyzer RBW = 300kHz, VBW=1MHz
4. Set span large enough to capture all products of the modulation process.
5. Turn on 99% spectrum OBW function on, Max hold, View, and snap the screen and record the mark.
6. Varied input voltage to + 10% and - 10% normal voltage and repeat procedure 1 to 4 again.

5.3.5 Test Result

Ambient temperature: 24℃ Relative humidity: 63% Test Date: 2021/08/12

802.11b

	CH Low	CH Mid	CH High	Limit	Remark
Normal Voltage 5 V	13.073	13.061	13.03	<26MHz	Pass
Upper Voltage 5.5 V	13.067	13.053	13.033	<26MHz	Pass
Lower Voltage 4.5 V	13.061	13.056	13.037	<26MHz	Pass

802.11g

	CH Low	CH Mid	CH High	Limit	Remark
Normal Voltage 5 V	16.728	16.725	16.562	<26MHz	Pass
Upper Voltage 5.5 V	16.729	16.723	16.561	<26MHz	Pass
Lower Voltage 4.5 V	16.729	16.725	16.564	<26MHz	Pass

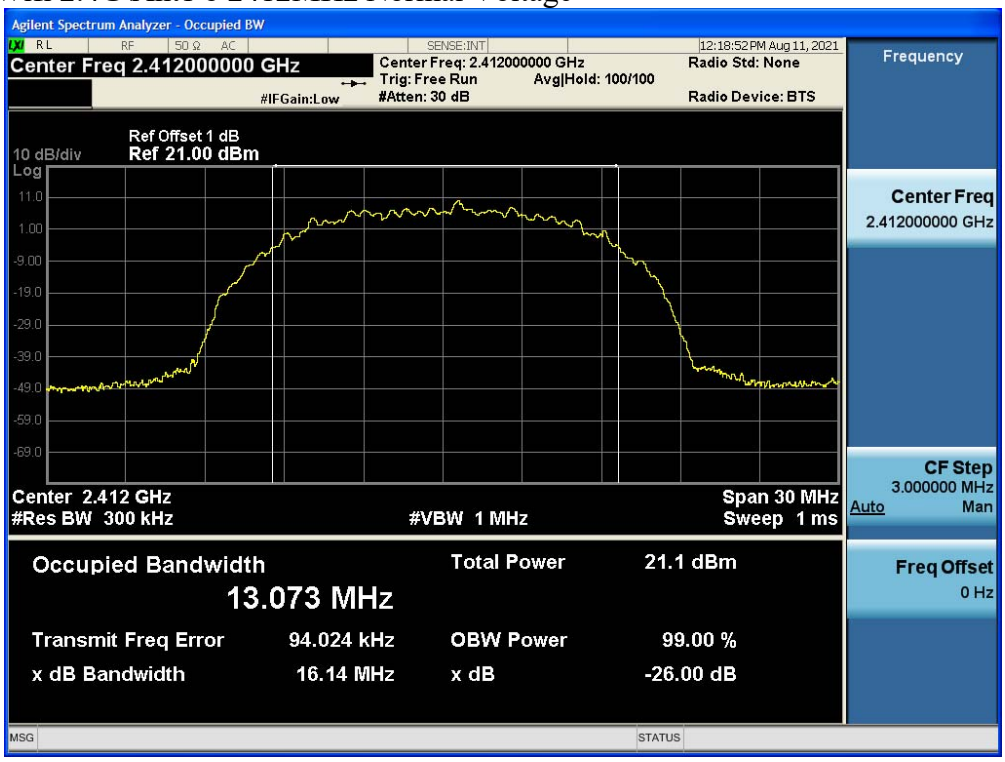
802.11n HT20

	CH Low	CH Mid	CH High	Limit	Remark
Normal Voltage 5 V	17.533	17.532	17.361	<26MHz	Pass
Upper Voltage 5.5 V	17.54	17.535	17.366	<26MHz	Pass
Lower Voltage 4.5 V	17.535	17.536	17.364	<26MHz	Pass

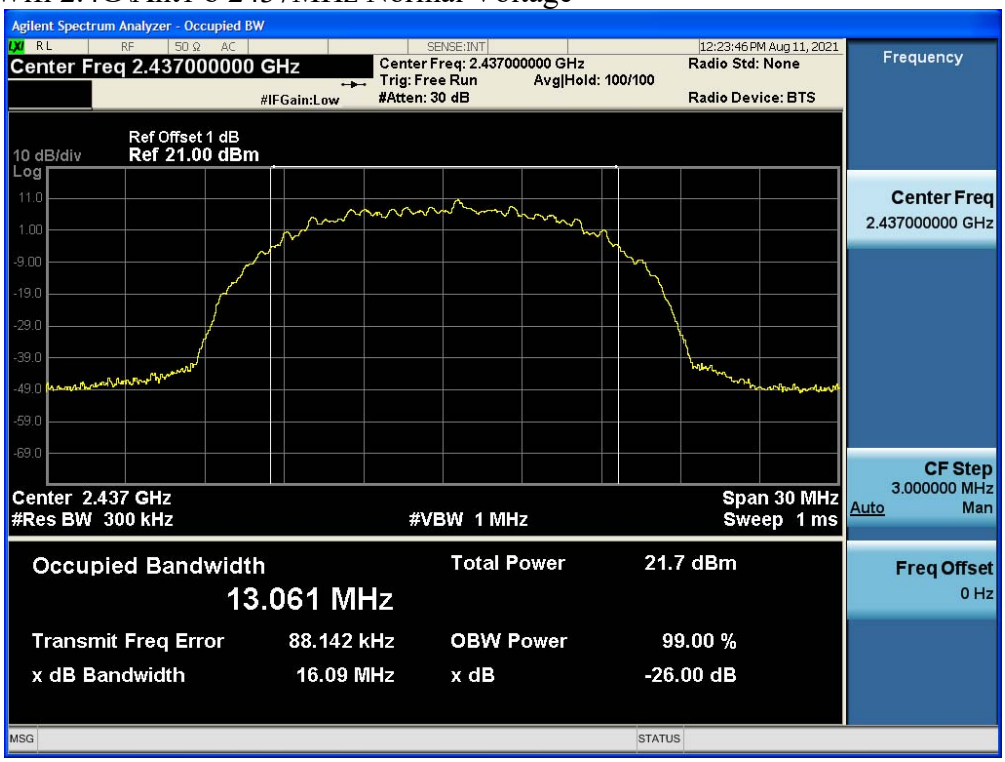
802.11n HT40

	CH Low	CH Mid	CH High	Limit	Remark
Normal Voltage 5 V	36.302	36.302	36.178	<38MHz	Pass
Upper Voltage 5.5 V	36.31	36.308	36.172	<38MHz	Pass
Lower Voltage 4.5 V	36.312	36.319	36.162	<38MHz	Pass

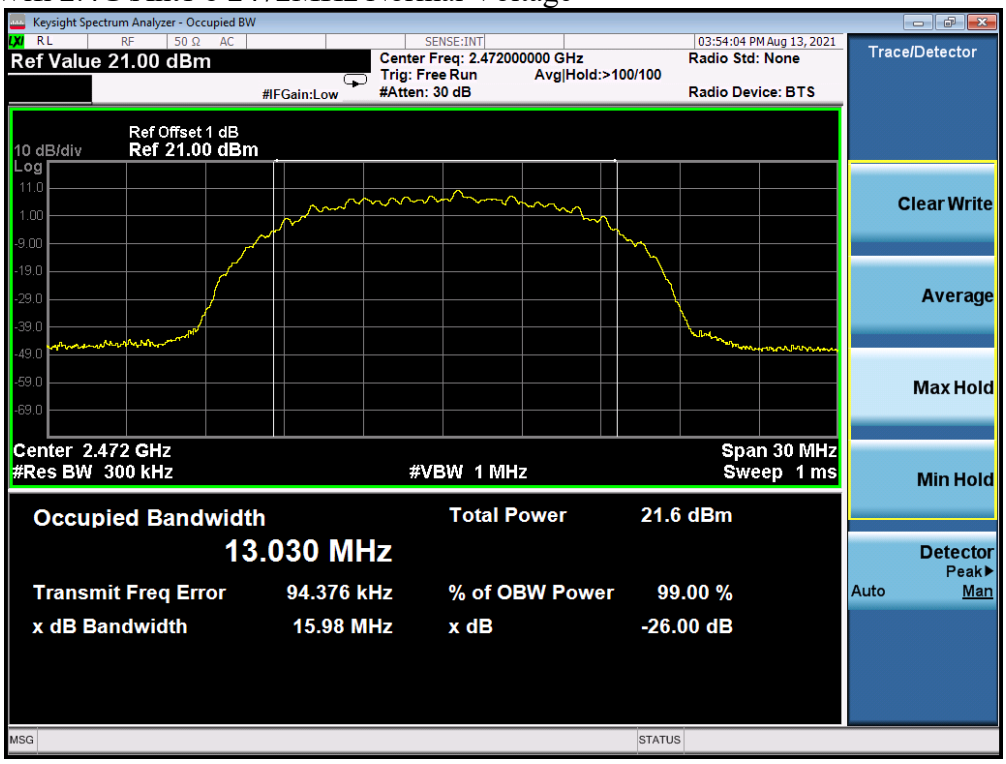
Test Data: Wifi 2.4G\Ant1 b 2412MHz Normal Voltage



Test Data: Wifi 2.4G\Ant1 b 2437MHz Normal Voltage



Test Data: Wifi 2.4G\Ant1 b 2472MHz Normal Voltage



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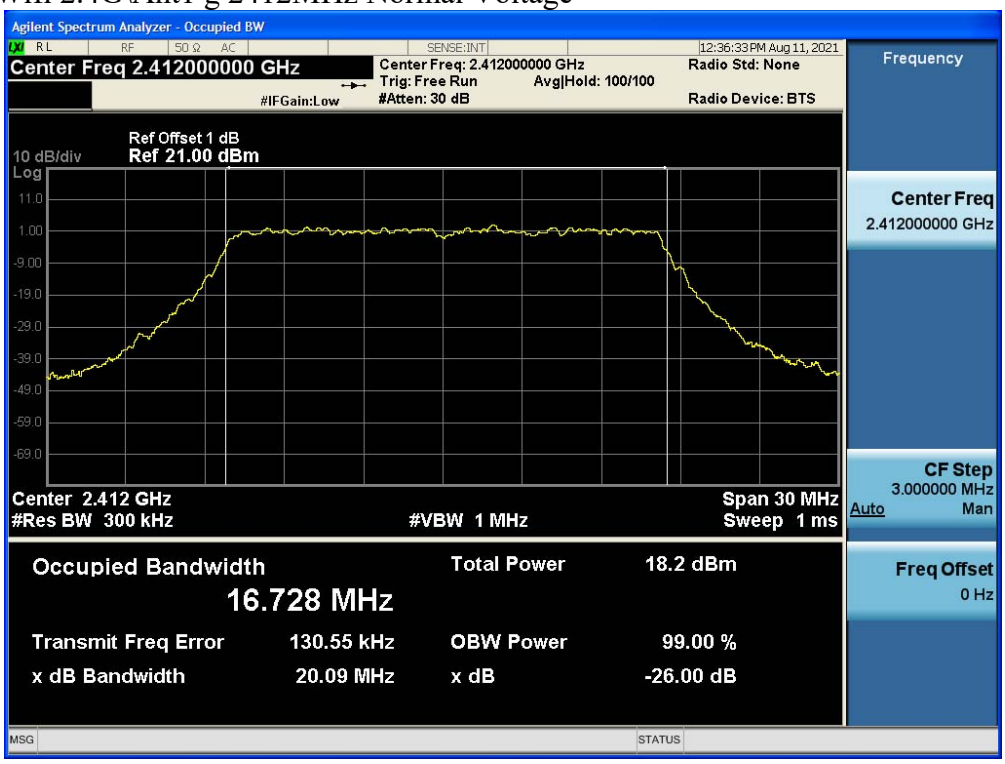

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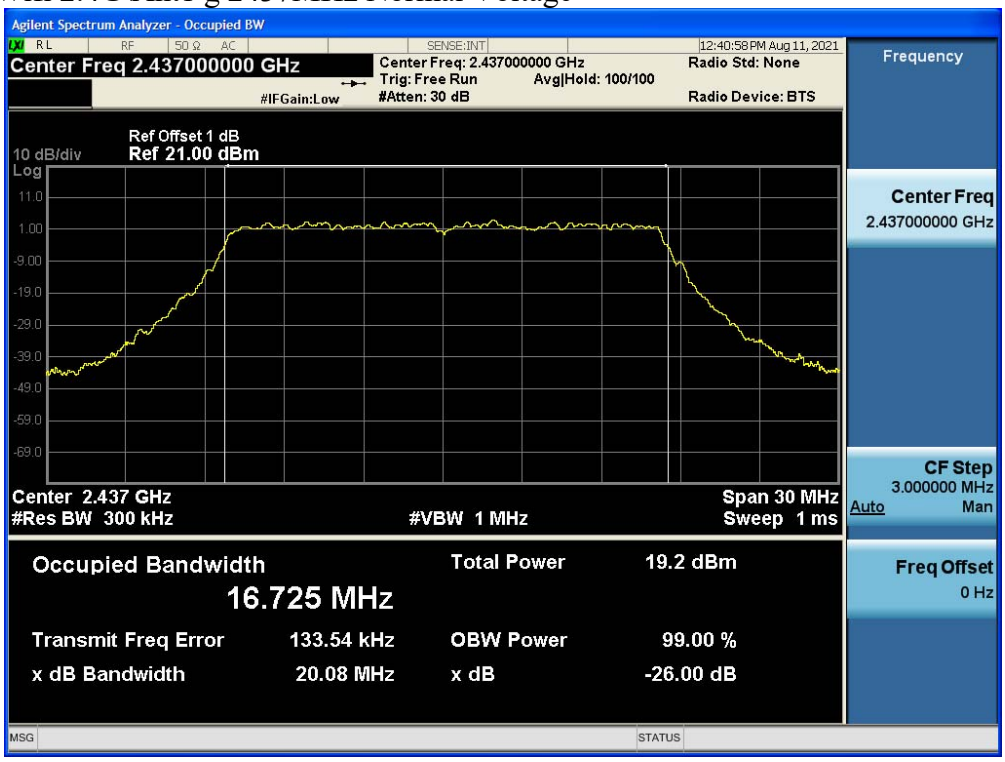
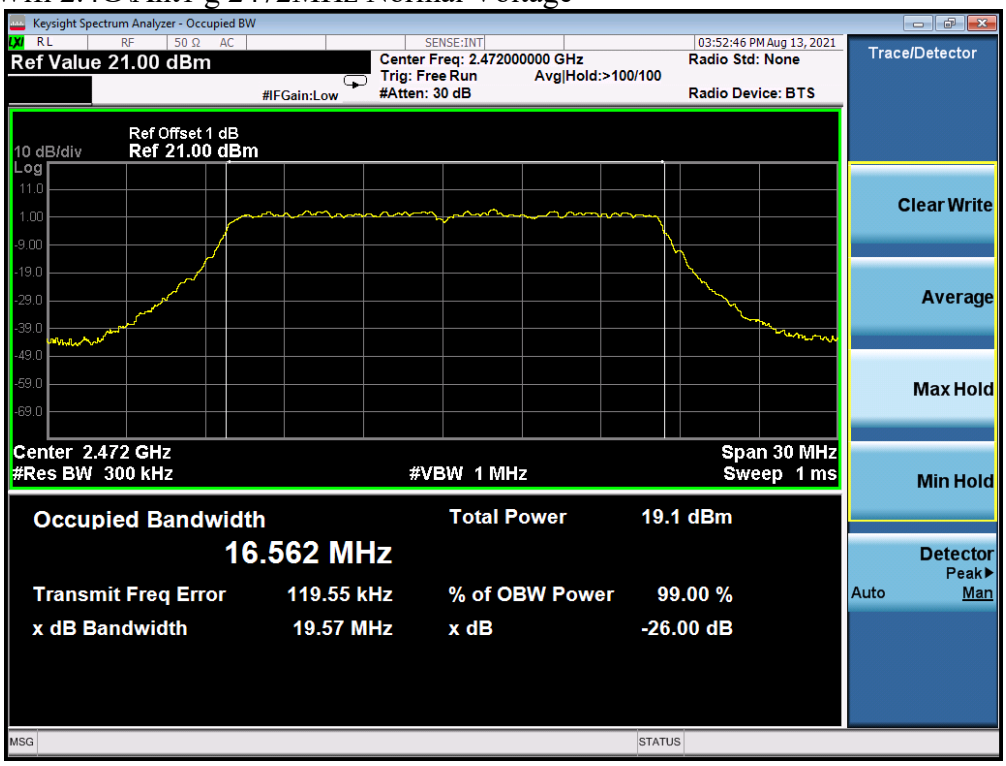


Test Data: Wifi 2.4G\Ant1 g 2472MHz Normal Voltage



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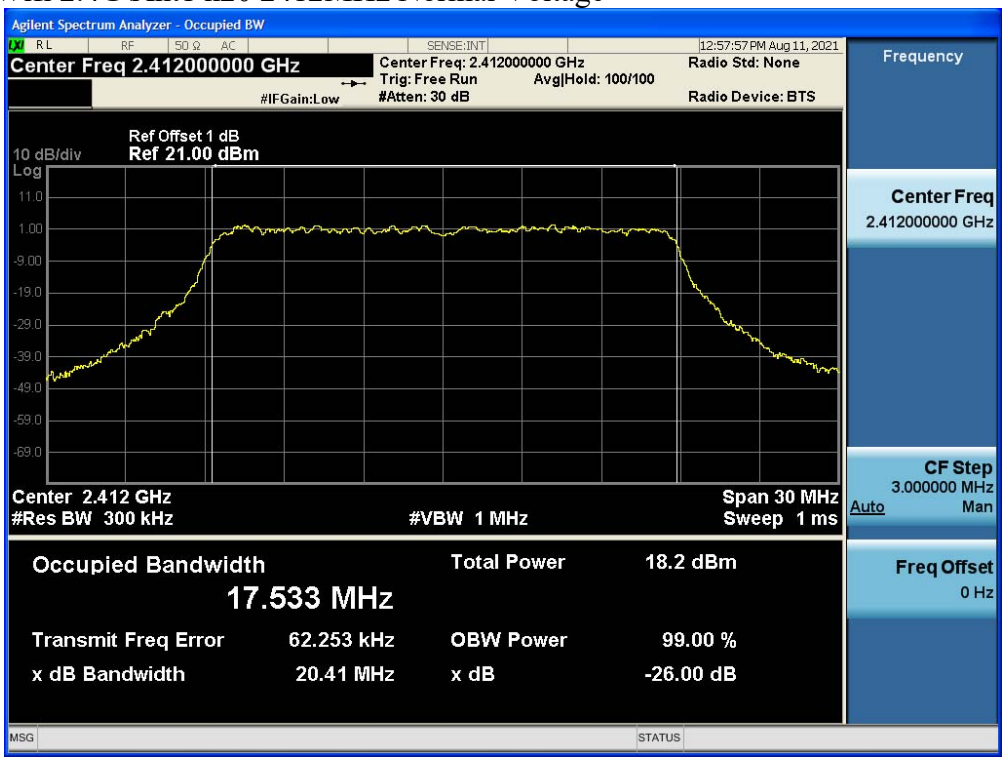
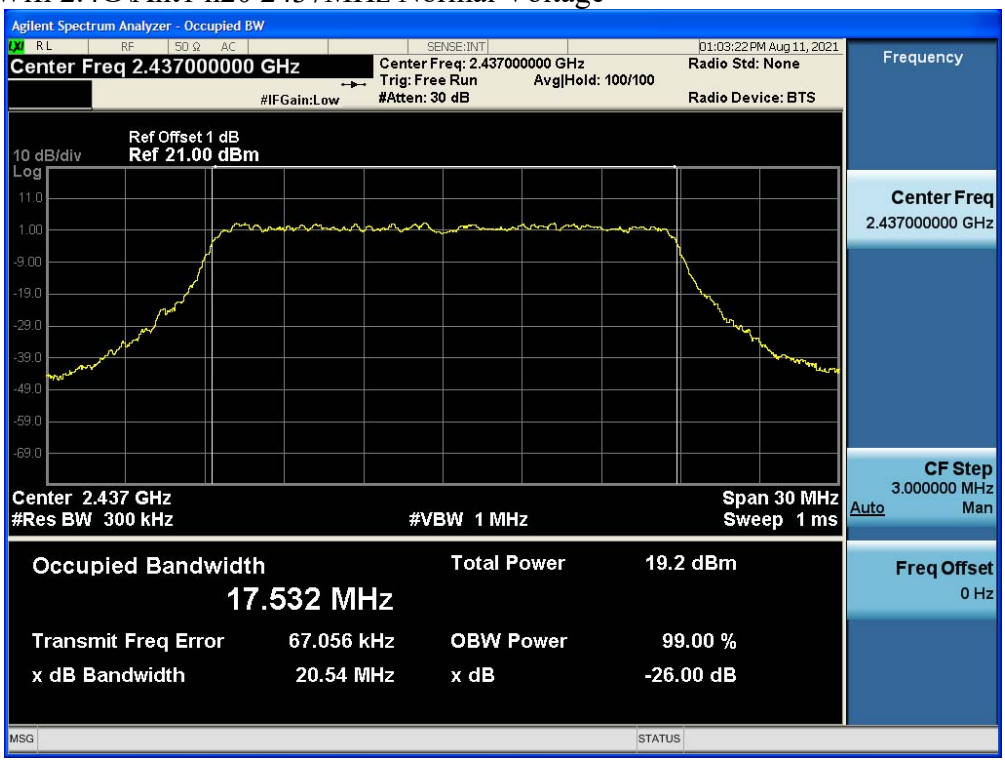


Test Data: Wifi 2.4G\Ant1 n20 2437MHz Normal Voltage



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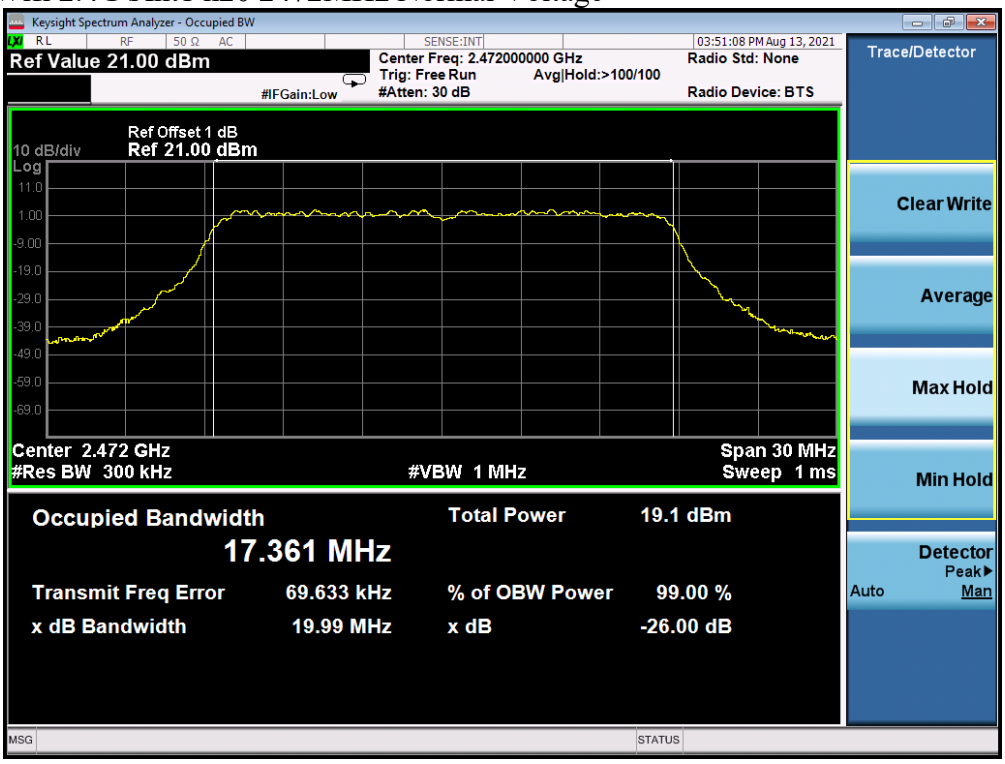

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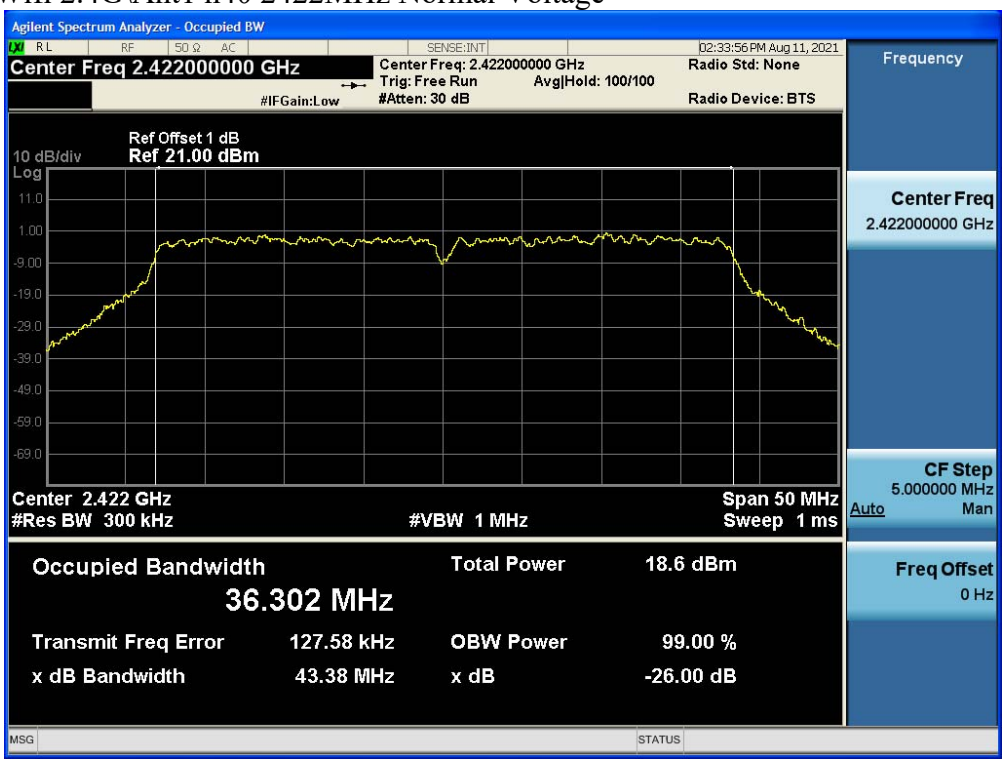
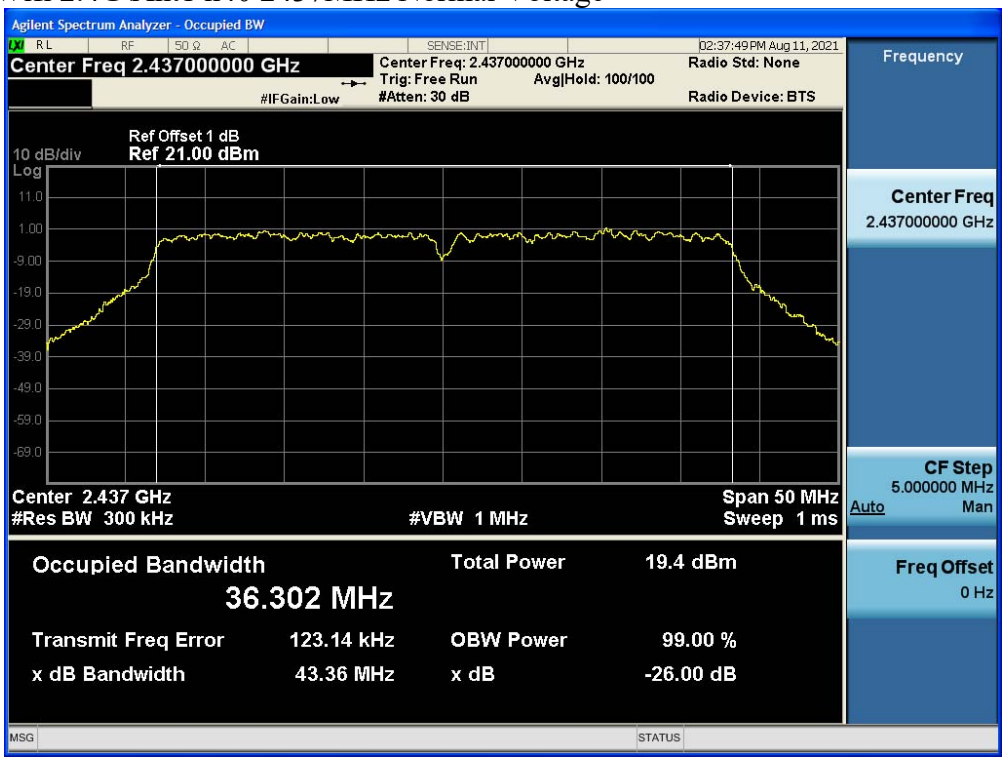
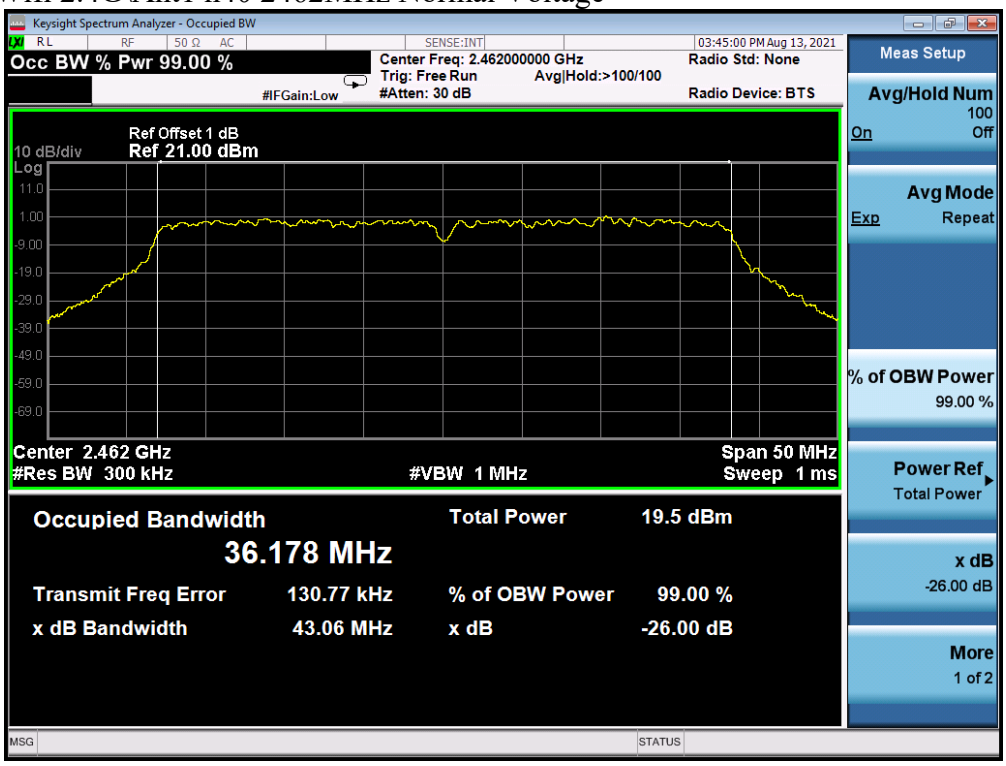


Test Data: Wifi 2.4G\Ant1 n40 2437MHz Normal Voltage



Test Data: Wifi 2.4G\Ant1 n40 2462MHz Normal Voltage



5.4 Spreading Bandwidth (90%)

5.4.1 Limit

> 500kHz
Spread Factor: 1~13ch>5, 14ch >10

5.4.2 Measurement Equipment Used

Refer to section Appendix A: Equipment List for detail.

5.4.3 Test Setup

Refer to section 5.1.3 for detail.

5.4.4 Test Procedure

1. Set the EUT modulation on.
2. Set the ETU operate at channel low, mid and high and normal voltage.
3. Set the spectrum analyzer RBW = 300kHz, VBW=1MHz, and Set span large enough to capture all products of the modulation process.
4. Turn on 90% spectrum OBW function, Max hold, View, and snap the screen and record the mark.
5. Varied input voltage to + 10% and - 10% normal voltage and repeat procedure 1 to 4 again.

5.4.5 Test Results

Ambient temperature: 24℃ Relative humidity: 63% Test Date: 2021/08/12

802.11b

	CH Low	CH Mid	CH High	Limit	Symbol Rated kBd	Spread Factor Min.Value	Limit
Normal Voltage 5 V	9.62	9.608	9.589	>500kHz	1.375	6.974	>5
Upper Voltage 5.5 V	9.617	9.612	9.584	>500kHz	1.375	6.97	>5
Lower Voltage 4.5 V	9.631	9.596	9.589	>500kHz	1.375	6.974	>5

802.11g

	CH Mid	CH High	CH Low	Limit	Symbol Rated kBd	Spread Factor Min.Value	Limit
Normal Voltage 5 V	14.742	14.735	14.637	>500kHz	1.5	9.758	>5
Upper Voltage 5.5 V	14.736	14.722	14.633	>500kHz	1.5	9.756	>5
Lower Voltage 4.5 V	14.736	14.728	14.632	>500kHz	1.5	9.755	>5

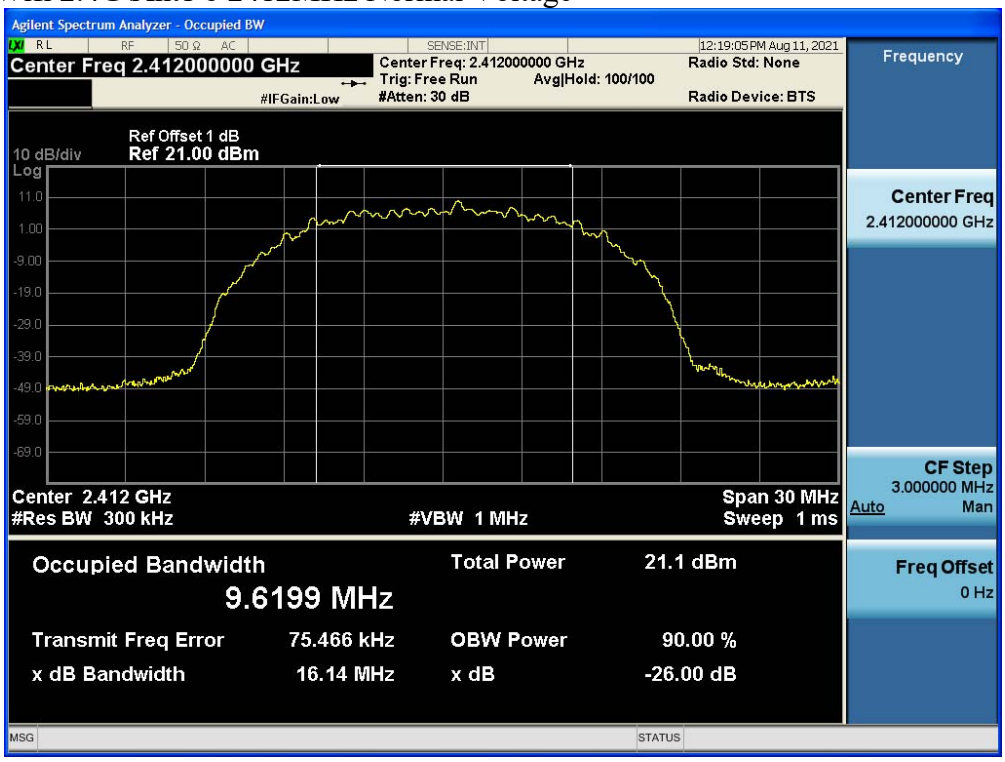
802.11n HT20

	CH Low	CH Mid	CH High	Limit	Symbol Rated kBd	Spread Factor Min.Value	Limit
Normal Voltage 5 V	15.565	15.574	15.331	>500kHz	1.5	10.221	>5
Upper Voltage 5.5 V	15.575	15.568	15.312	>500kHz	1.5	10.208	>5
Lower Voltage 4.5 V	15.583	15.565	15.329	>500kHz	1.5	10.219	>5

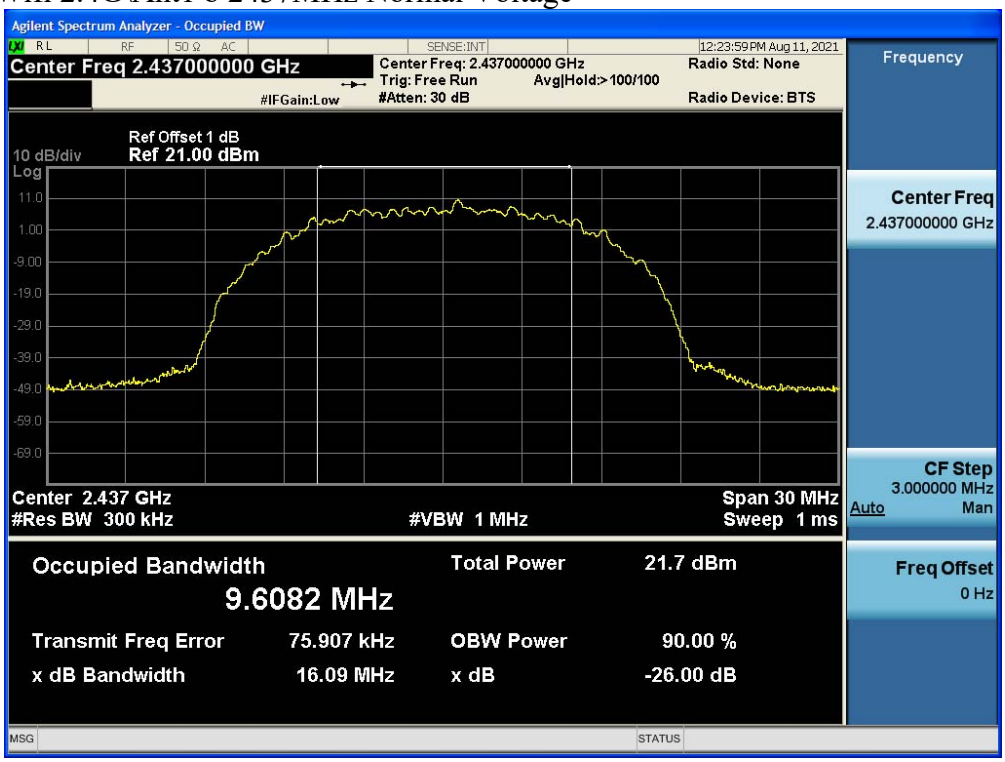
802.11n HT40

	CH Low	CH Mid	CH High	Limit	Symbol Rated kBd	Spread Factor Min.Value	Limit
Normal Voltage 5 V	32.35	32.333	32.109	>500kHz	1.875	17.125	>5
Upper Voltage 5.5 V	32.349	32.166	32.117	>500kHz	1.875	17.129	>5
Lower Voltage 4.5 V	32.383	32.123	32.123	>500kHz	1.875	17.132	>5

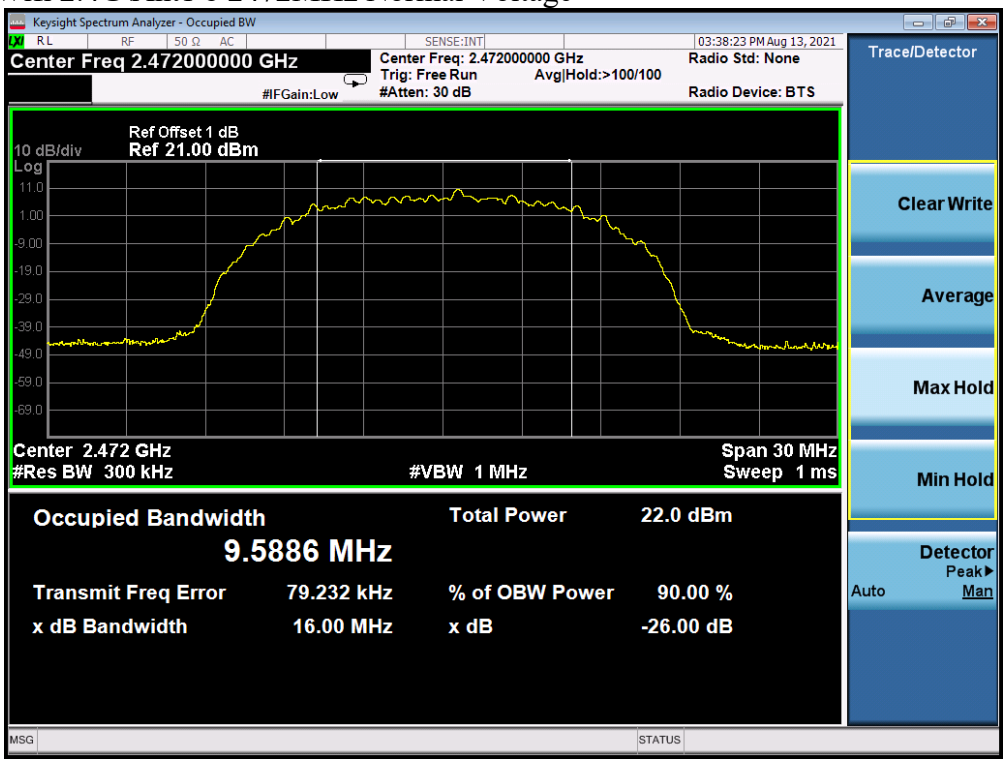
Test Data: Wifi 2.4G\Ant1 b 2412MHz Normal Voltage



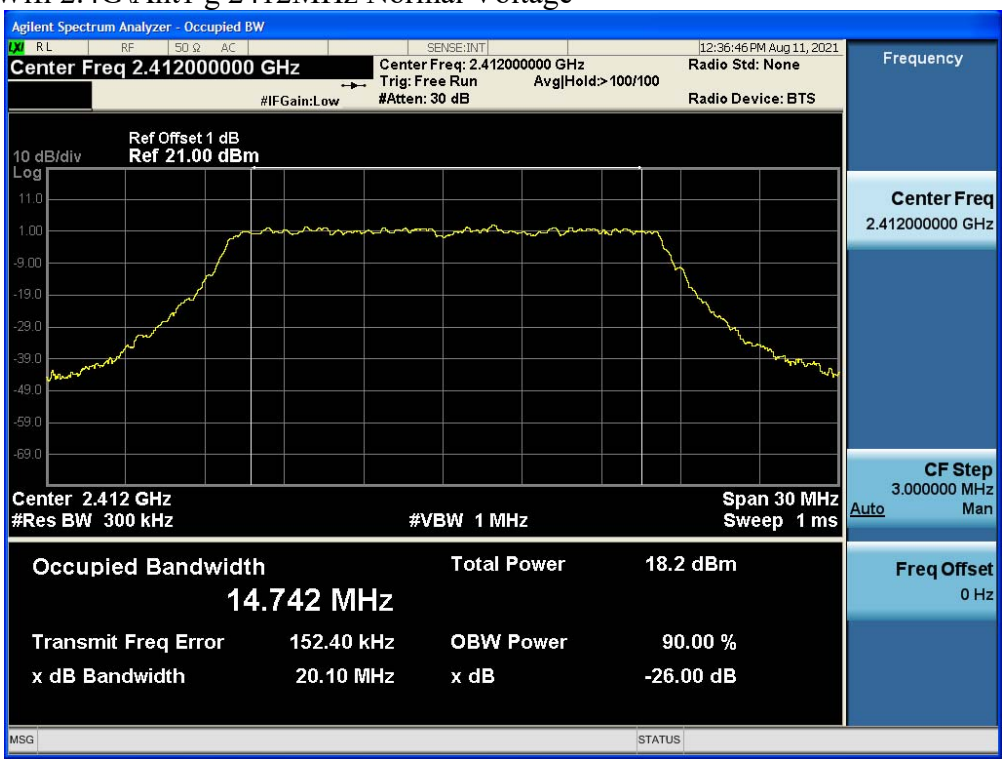
Test Data: Wifi 2.4G\Ant1 b 2437MHz Normal Voltage



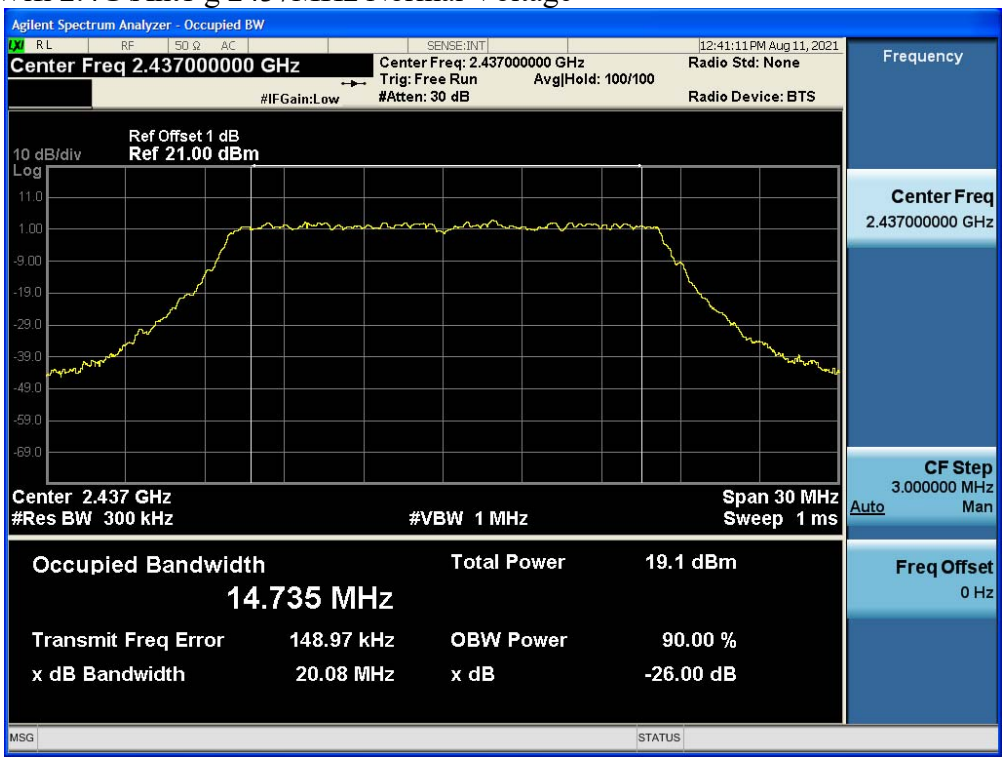
Test Data: Wifi 2.4G\Ant1 b 2472MHz Normal Voltage



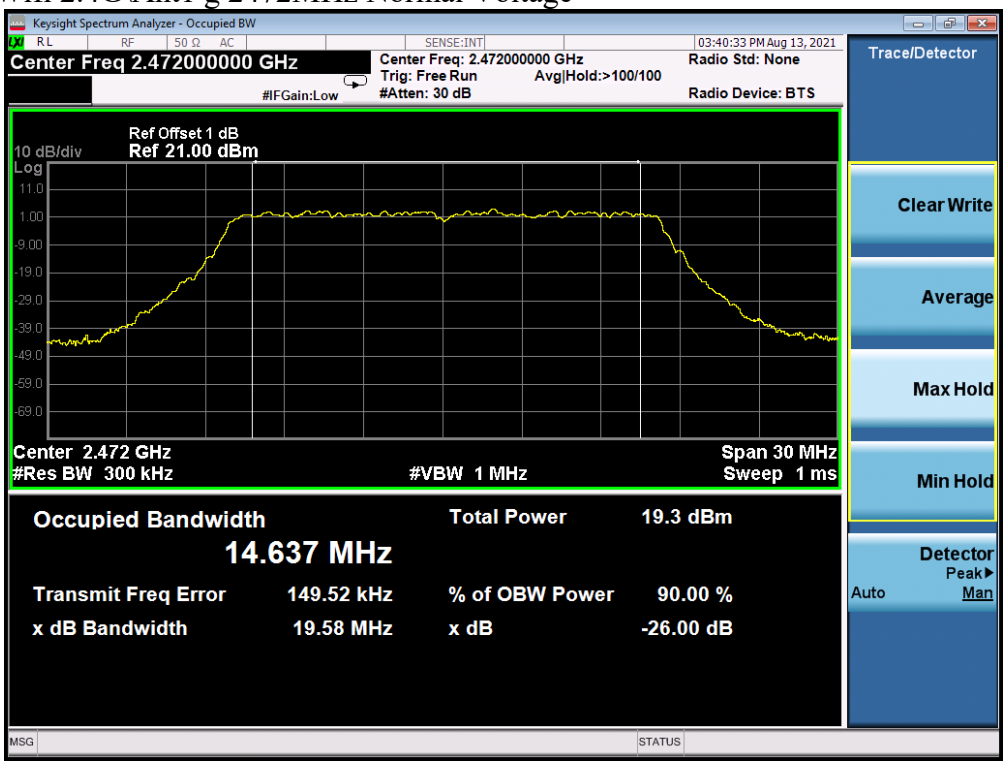
Test Data: Wifi 2.4G\Ant1 g 2412MHz Normal Voltage



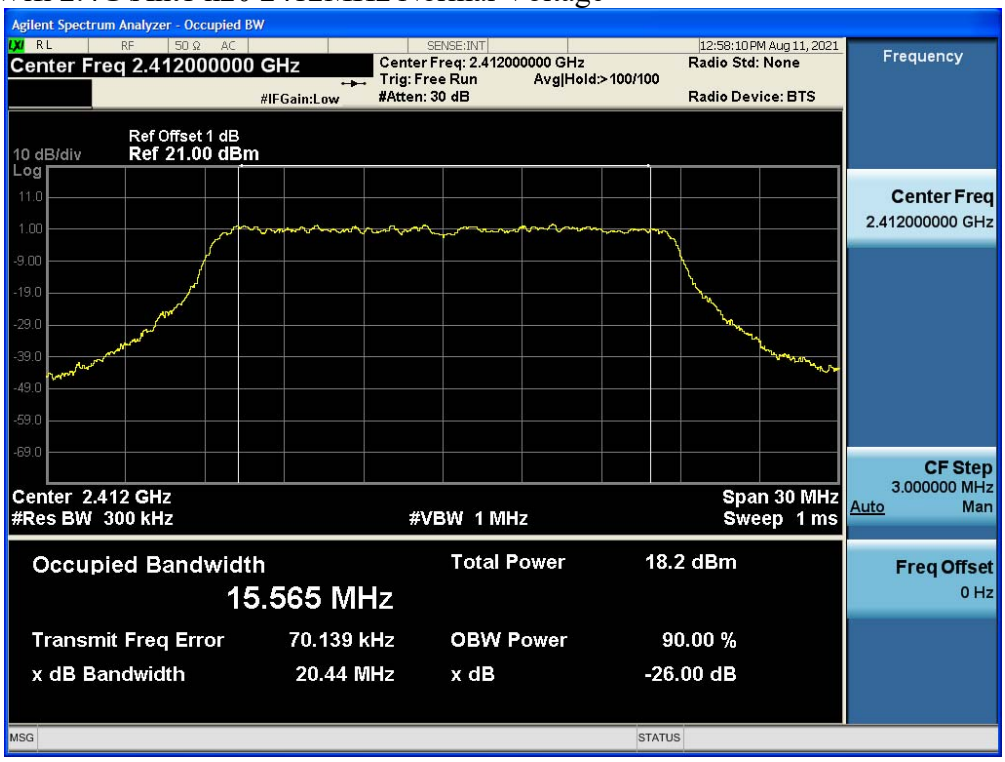
Test Data: Wifi 2.4G\Ant1 g 2437MHz Normal Voltage



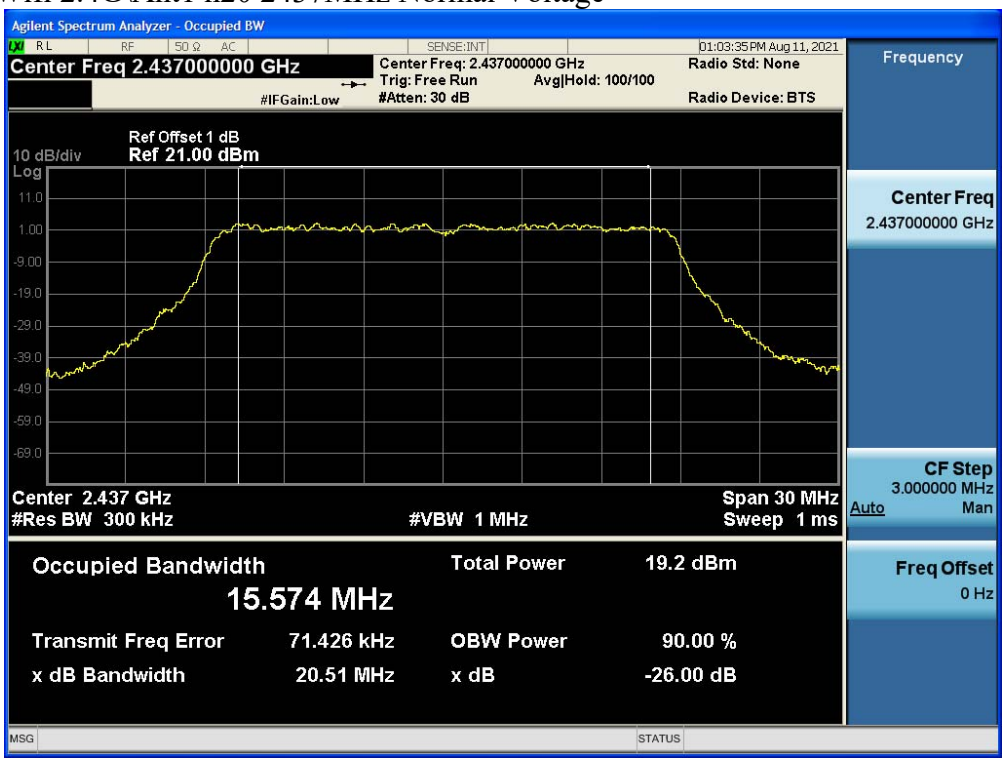
Test Data: Wifi 2.4G\Ant1 g 2472MHz Normal Voltage



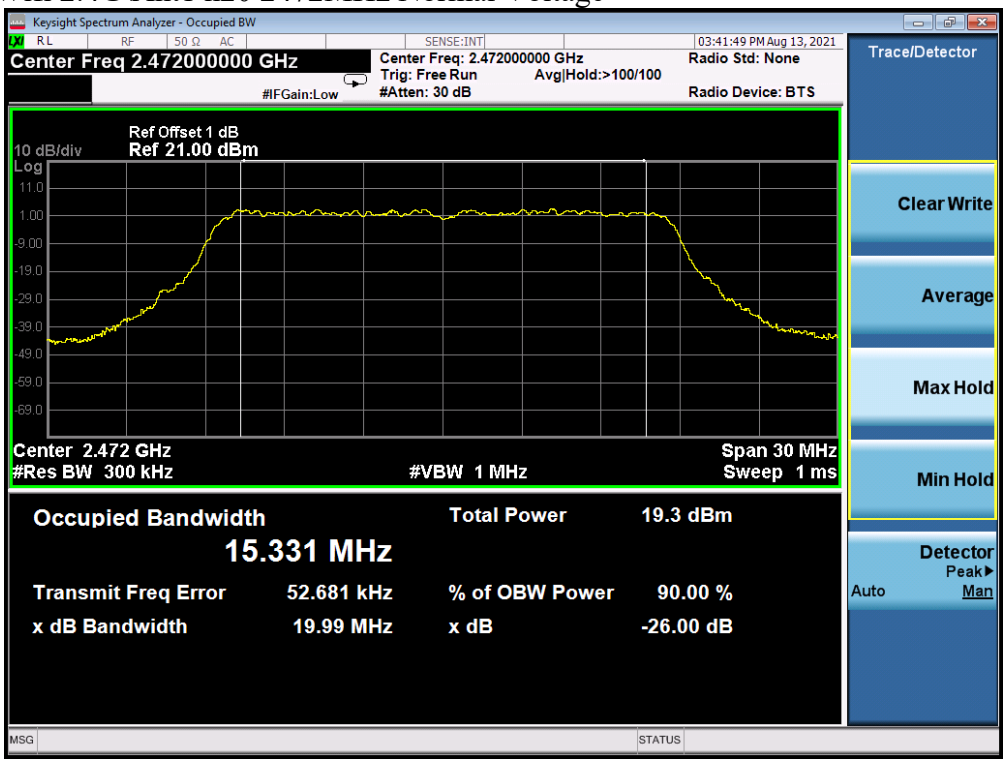
Test Data: Wifi 2.4G\Ant1 n20 2412MHz Normal Voltage



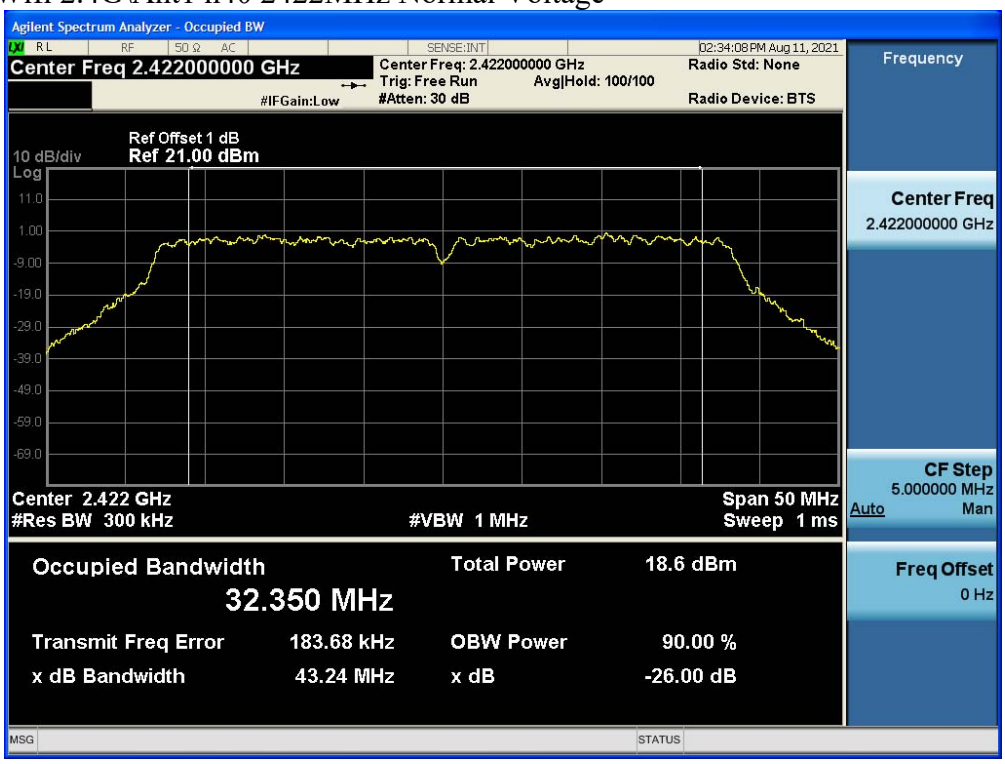
Test Data: Wifi 2.4G\Ant1 n20 2437MHz Normal Voltage



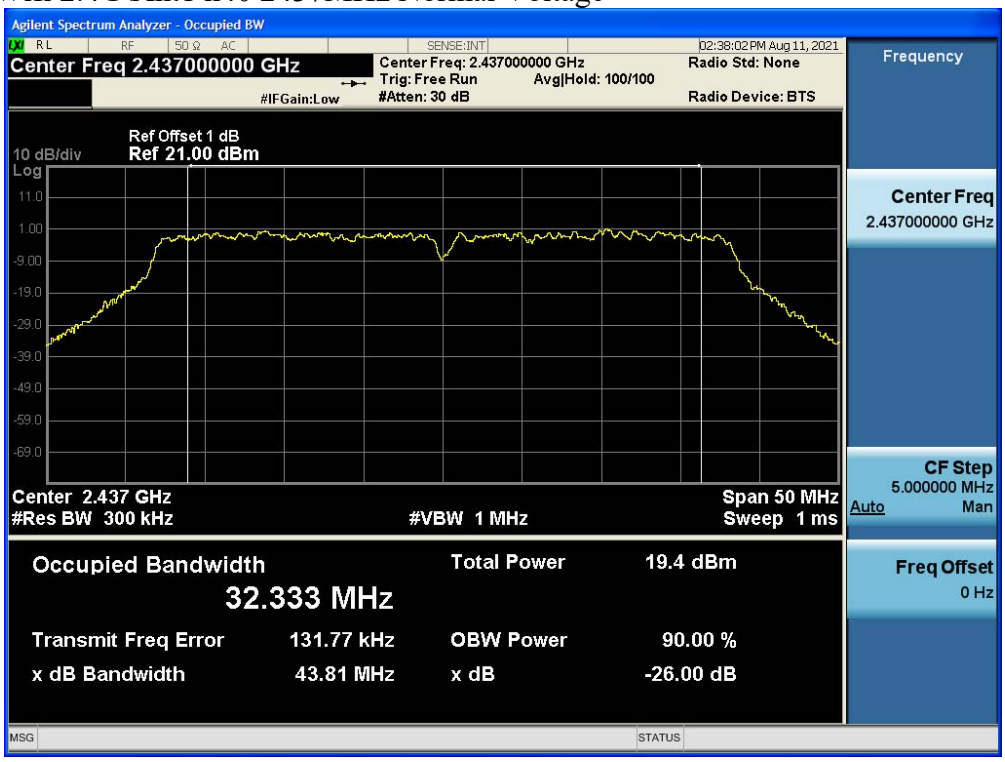
Test Data: Wifi 2.4G\Ant1 n20 2472MHz Normal Voltage



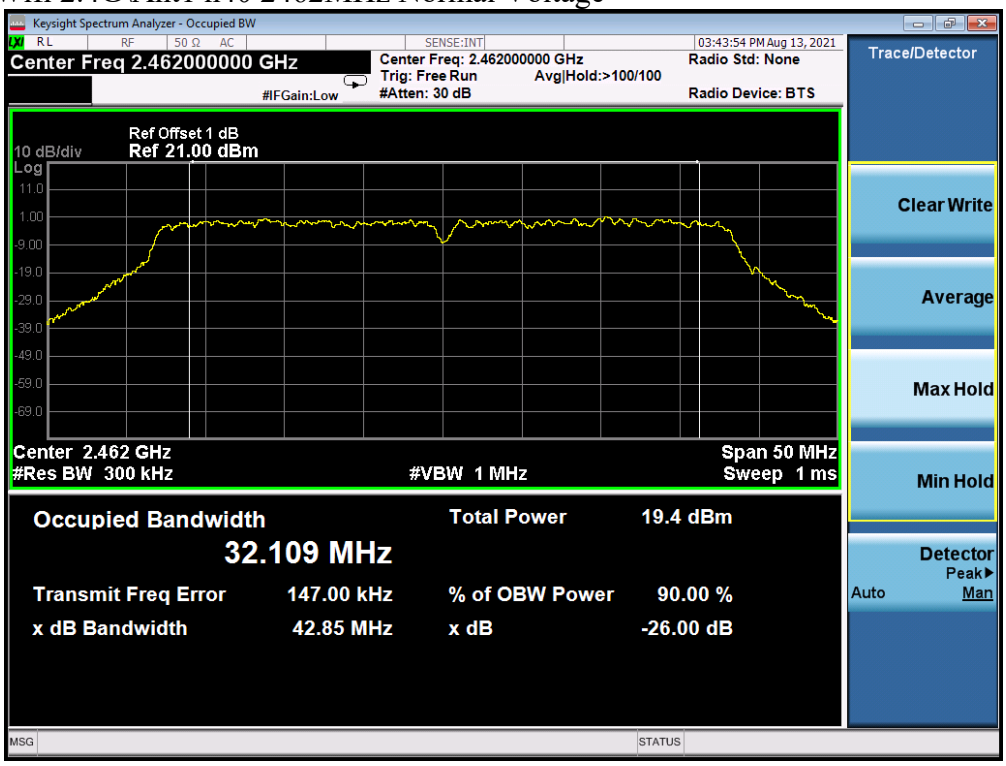
Test Data: Wifi 2.4G\Ant1 n40 2422MHz Normal Voltage



Test Data: Wifi 2.4G\Ant1 n40 2437MHz Normal Voltage



Test Data: Wifi 2.4G\Ant1 n40 2462MHz Normal Voltage



5.5 Transmitter Spurious Emissions

5.5.1 Limit

Frequency below 2.387 and above 2.4965GHz :2.5uW
Frequency between 2.387 – 2.400GHz, 2.4835-2.4965GHz: 25uW

5.5.2 Measurement Equipment Used

Refer to section Appendix A: Equipment List for detail.

5.5.3 Test Setup

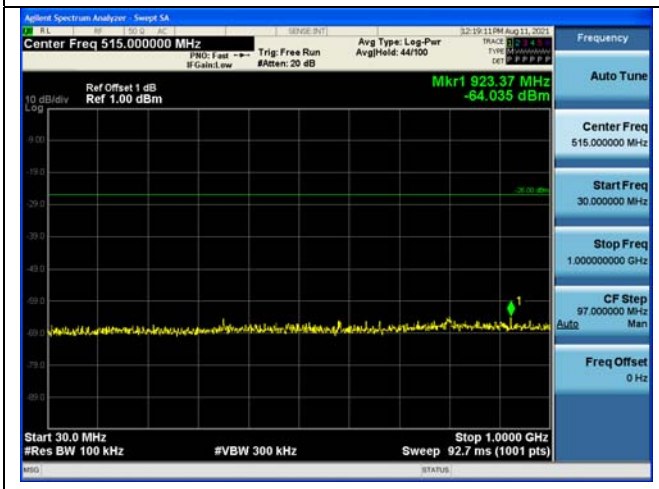
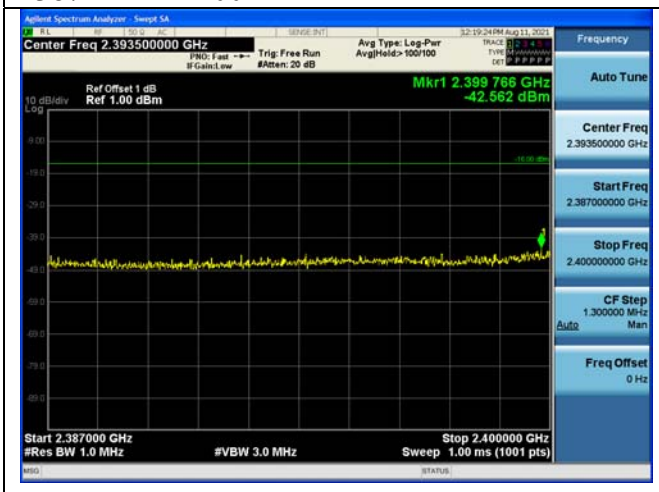
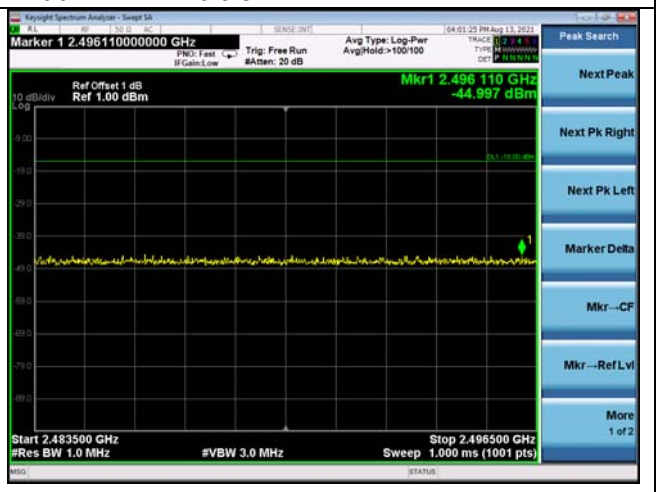
Refer to section 5.1.3 for detail.

5.5.4 Test Procedure

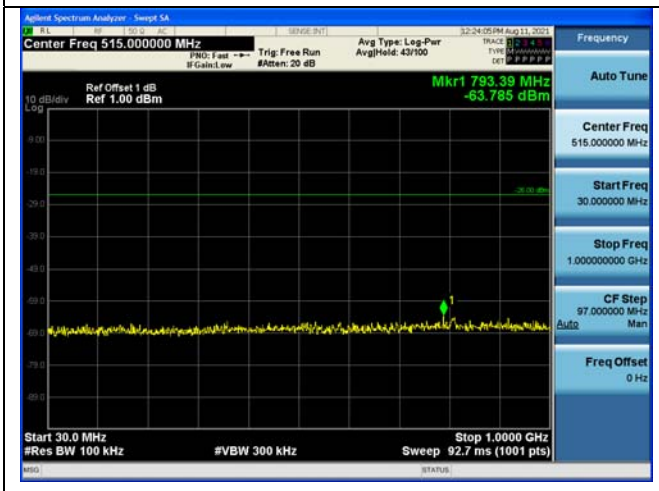
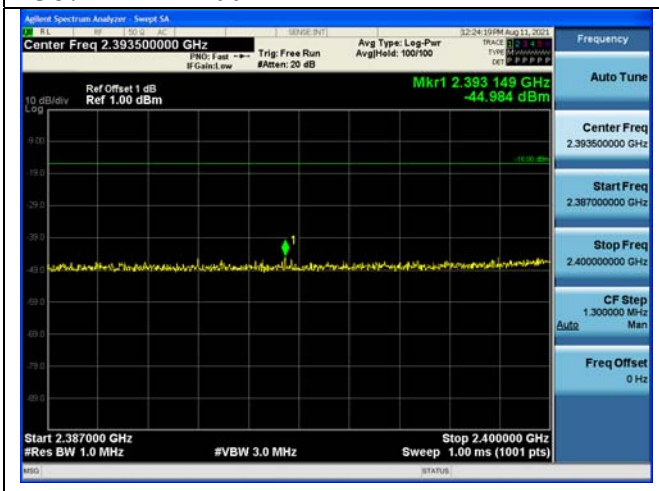
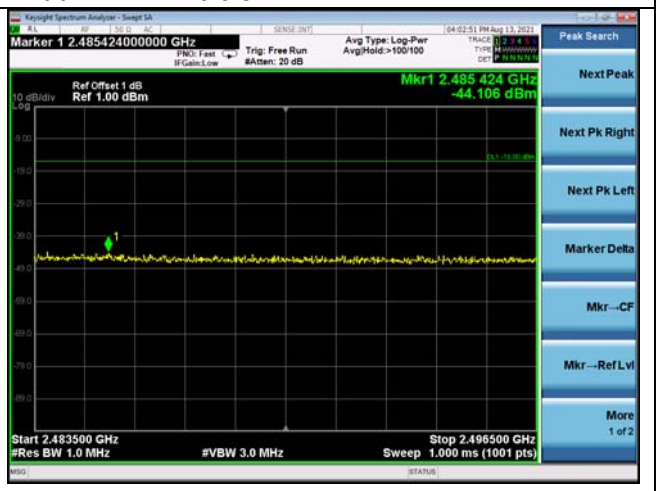
1. Set the EUT at hopping off and modulation on.
2. Set the ETU operate at channel low, mid and high and normal voltage.
3. Set the RBW=100 kHz, VBW=300 kHz for frequency below 1GHz and RBW=1MHz, VBW= 3MHz for frequency above 1GHz.
4. Measured the max. level of the following frequency range:
   10MHz – 1000MHz;
   1000MHz – 2387MHz;
   2387MHz – 2400MHz;
   2483.5MHz – 2496.5MHz;
   2496.5MHz – 26GHz.
5. Varied input voltage to + 10% and - 10% normal voltage and repeat procedure 1 to 4 again.
6. The Worst data was report.

5.5.5 Test Results

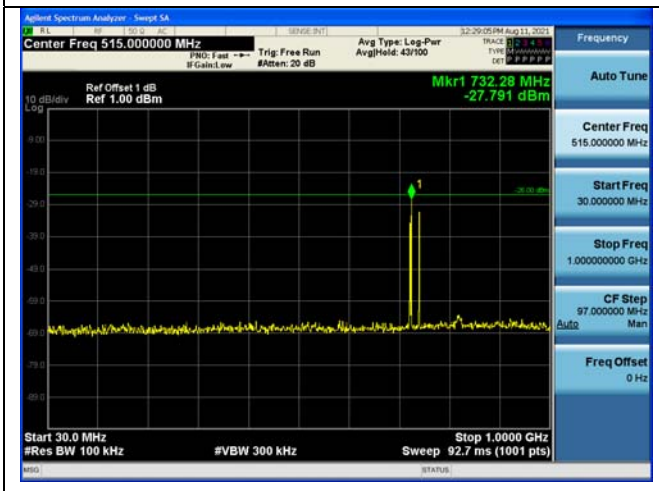
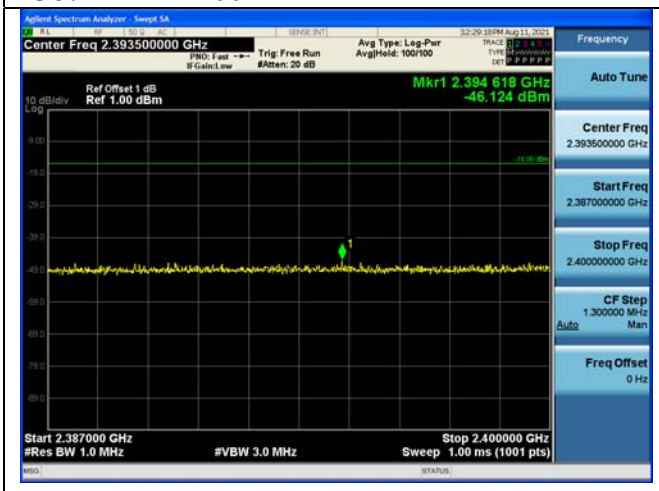
Test Data: Wifi 2.4G b 2412MHz

10MHz – 1000MHz	1000MHz – 2387MHz
	
2387MHz – 2400MHz	2400MHz – 2496.5MHz
	
2496.5MHz – 26GHz	
	

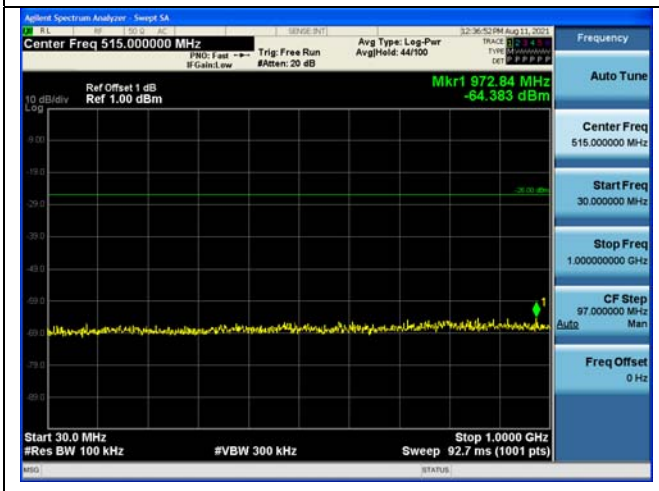
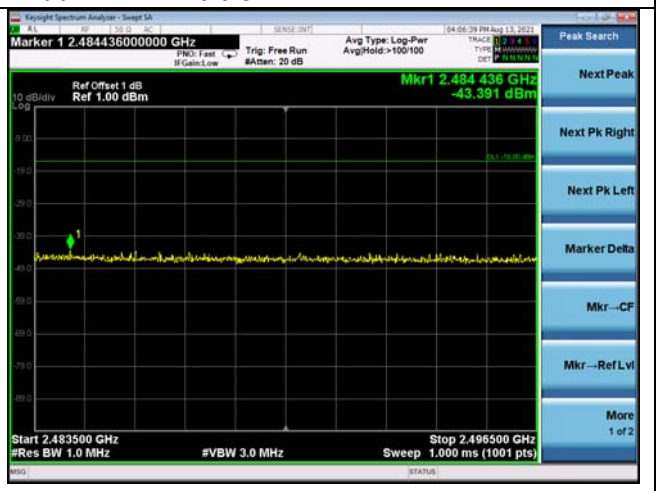
Test Data: Wifi 2.4G b 2437MHz

10MHz – 1000MHz	1000MHz – 2387MHz
	
2387MHz – 2400MHz	**2400MHz – 2496.5MHz**
	
2496.5MHz – 26GHz	
	

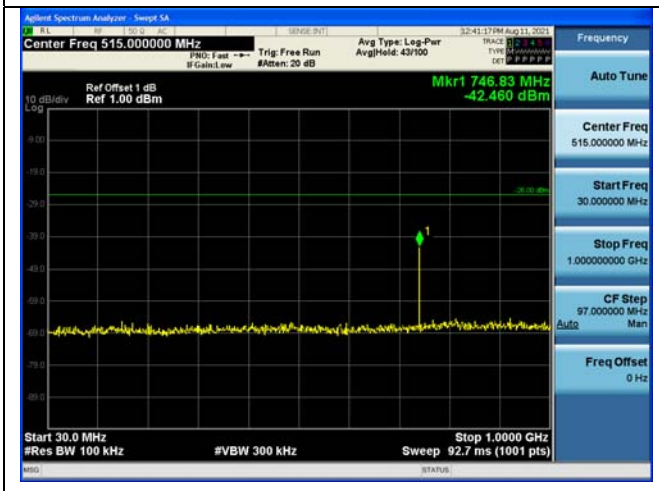
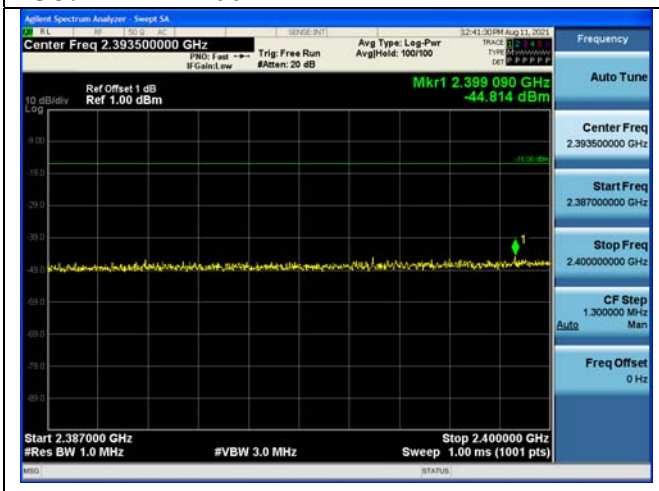
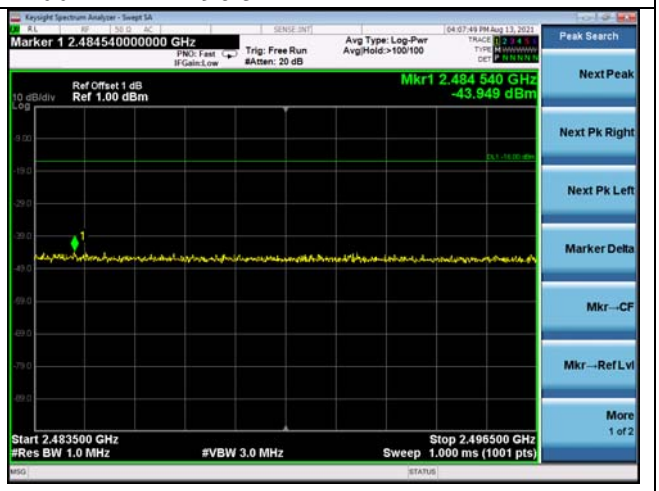
Test Data: Wifi 2.4G b 2472MHz

10MHz – 1000MHz	1000MHz – 2387MHz
	
2387MHz – 2400MHz	**2400MHz – 2496.5MHz**
	
2496.5MHz – 26GHz	
	

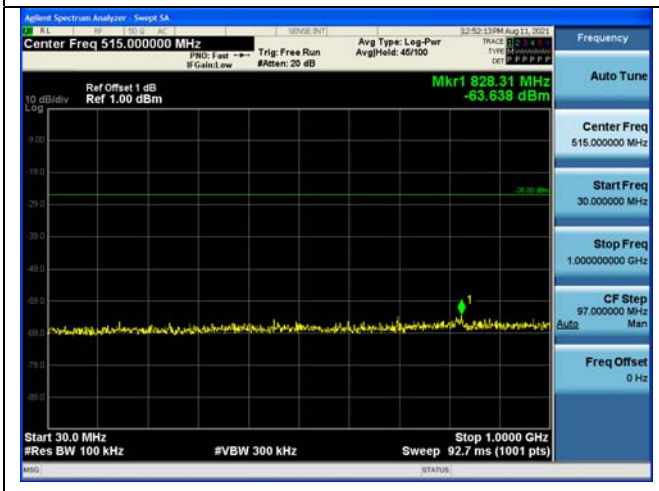
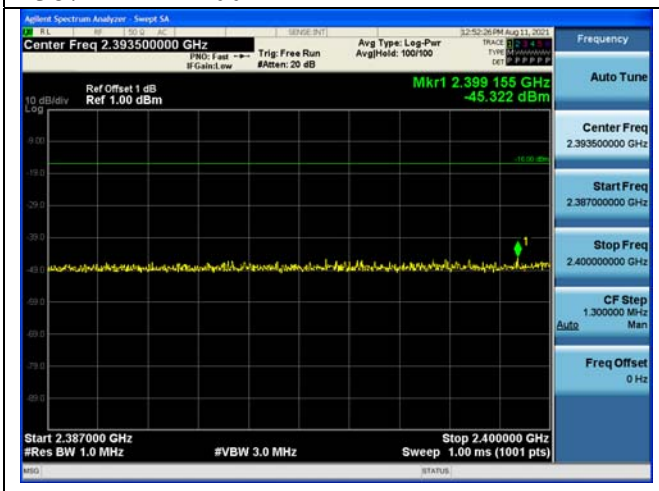
Test Data: Wifi 2.4G g 2412MHz

10MHz – 1000MHz	1000MHz – 2387MHz
	
2387MHz – 2400MHz	**2400MHz – 2496.5MHz**
	
2496.5MHz – 26GHz	
	

Test Data: Wifi 2.4G g 2437MHz

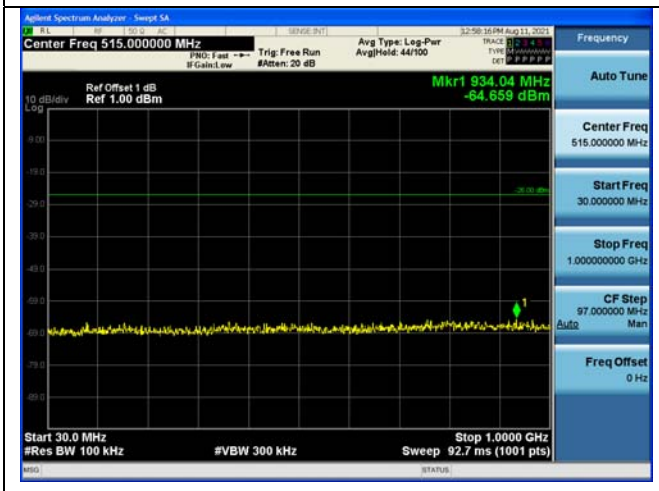
10MHz – 1000MHz	1000MHz – 2387MHz
	
2387MHz – 2400MHz	**2400MHz – 2496.5MHz**
	
2496.5MHz – 26GHz	
	

Test Data: Wifi 2.4G g 2472MHz

10MHz – 1000MHz	1000MHz – 2387MHz
	
2387MHz – 2400MHz	**2400MHz – 2496.5MHz**
	
2496.5MHz – 26GHz	
	

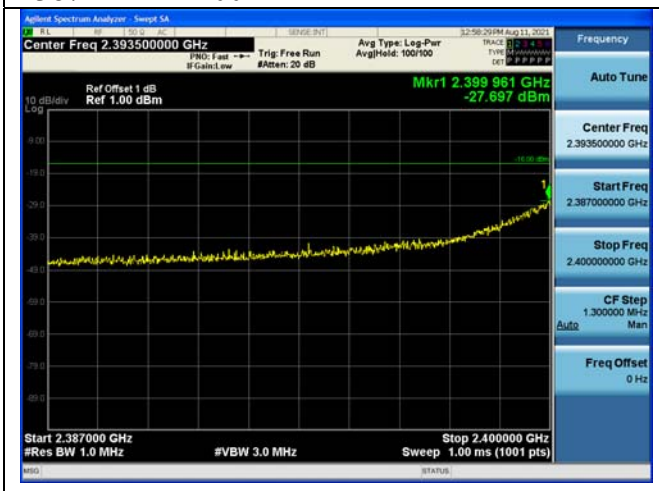
Test Data: Wifi 2.4G n20 2412MHz

10MHz – 1000MHz

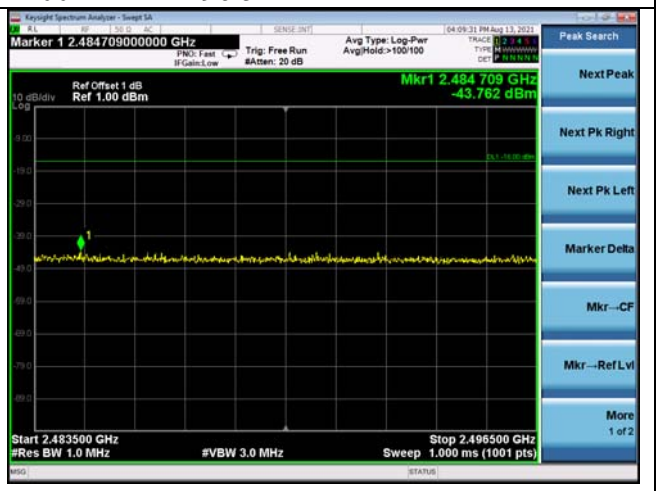


1000MHz – 2387MHz

2387MHz – 2400MHz

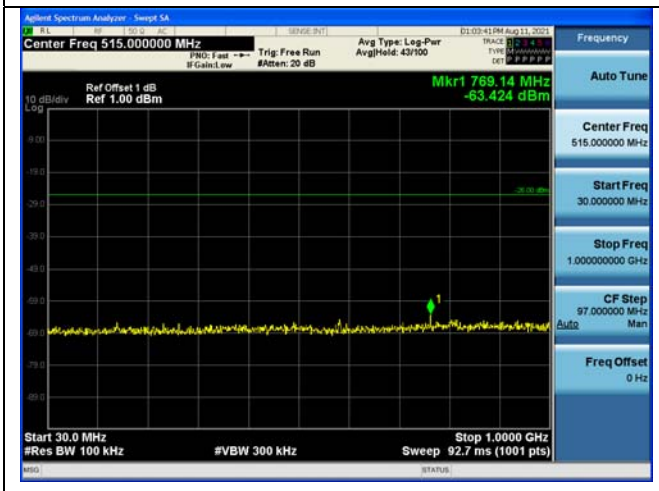
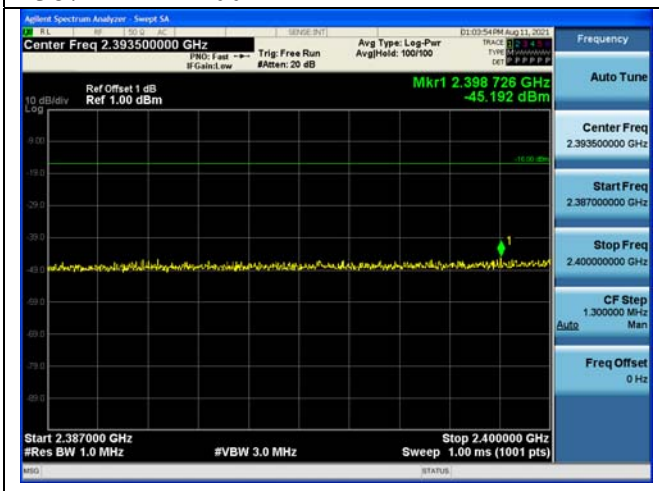
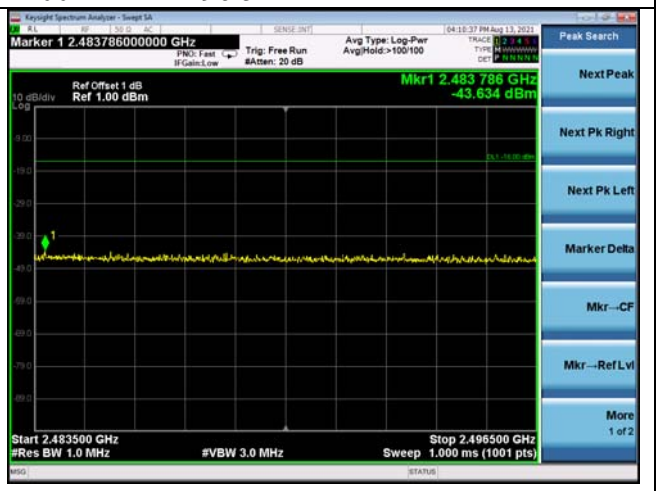


2400MHz – 2496.5MHz



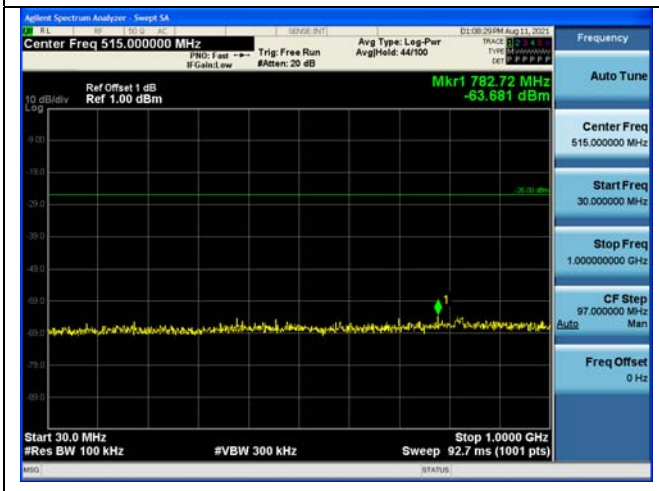
2496.5MHz – 26GHz

Test Data: Wifi 2.4G n20 2437MHz

10MHz – 1000MHz	1000MHz – 2387MHz
	
2387MHz – 2400MHz	**2400MHz – 2496.5MHz**
	
2496.5MHz – 26GHz	
	

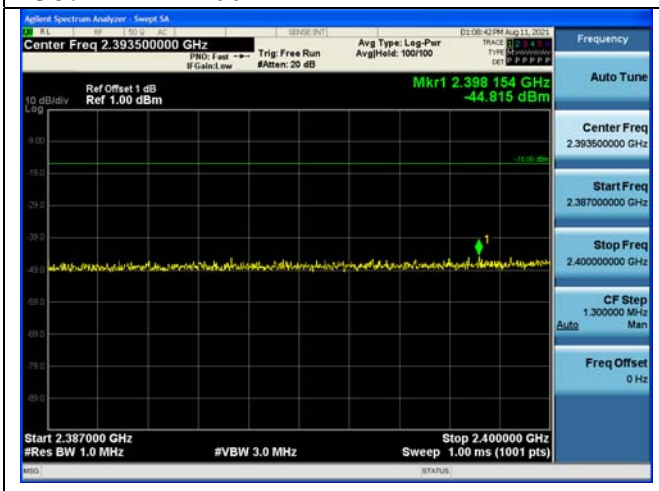
Test Data: Wifi 2.4G n20 2472MHz

10MHz – 1000MHz



1000MHz – 2387MHz

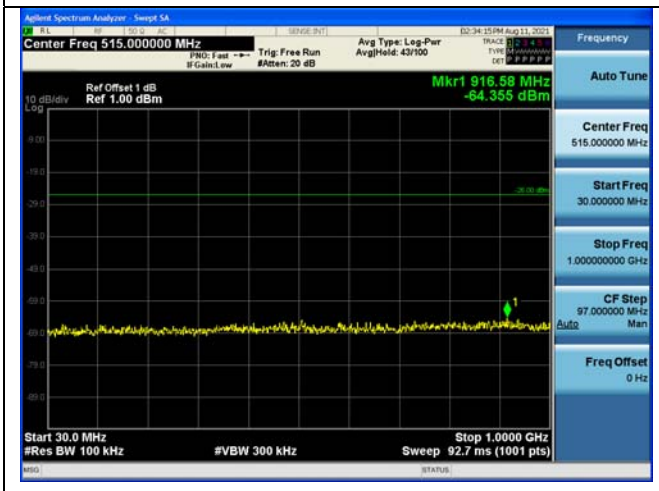
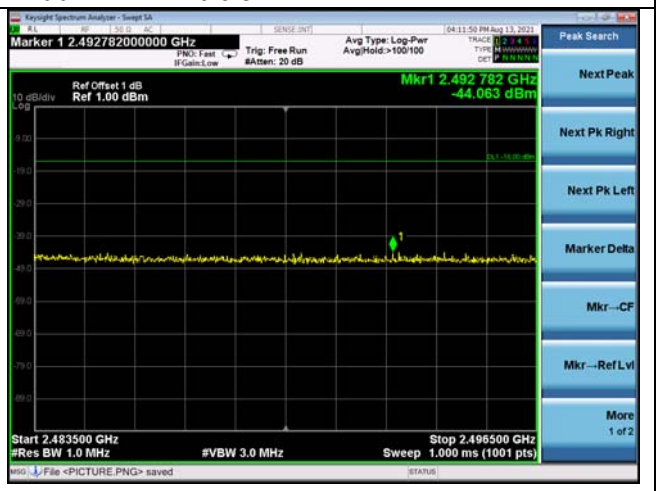
2387MHz – 2400MHz



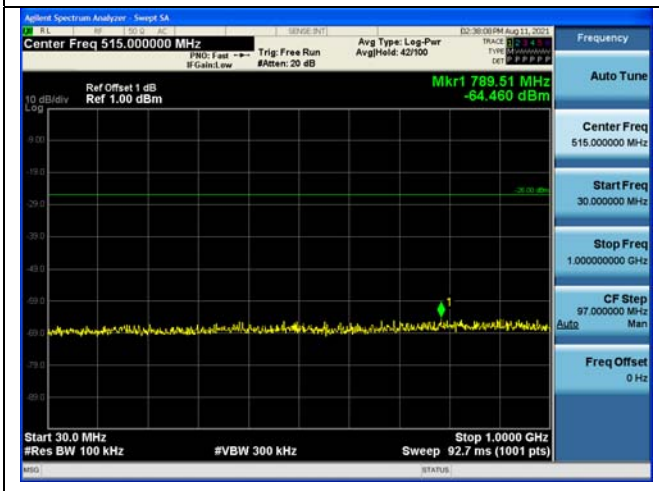
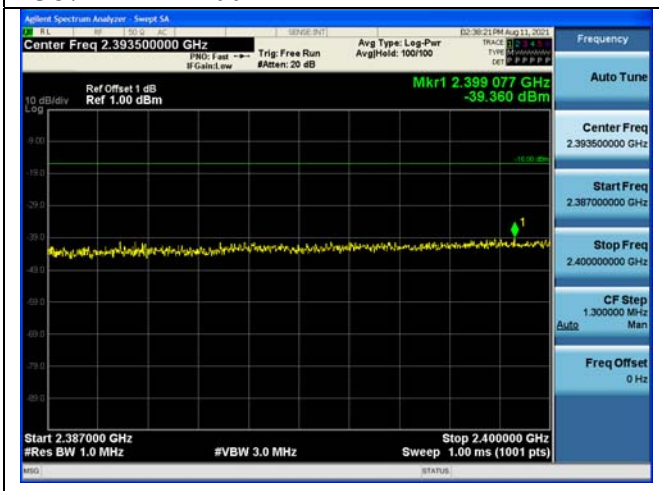
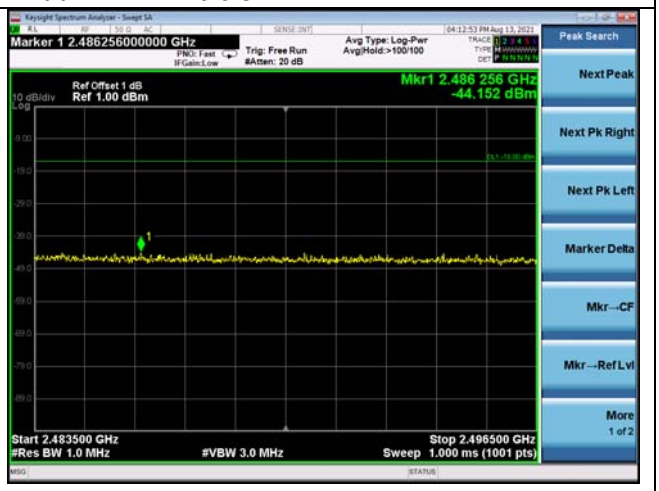
2400MHz – 2496.5MHz

2496.5MHz – 26GHz

Test Data: Wifi 2.4G n40 2422MHz

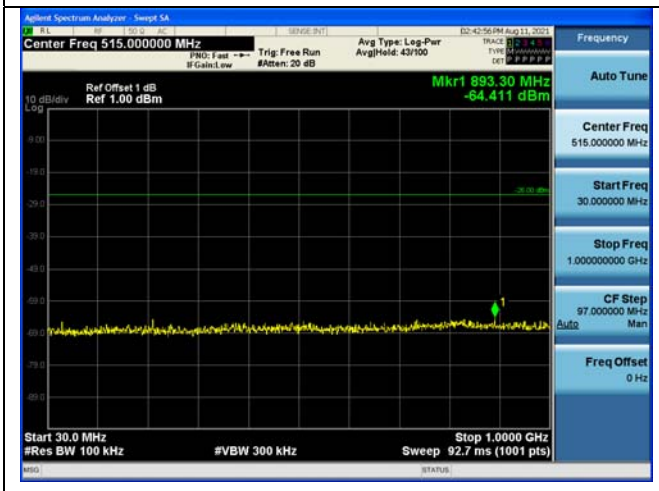
10MHz – 1000MHz	1000MHz – 2387MHz
	
2387MHz – 2400MHz	**2400MHz – 2496.5MHz**
	
2496.5MHz – 26GHz	
	

Test Data: Wifi 2.4G n40 2437MHz

10MHz – 1000MHz	1000MHz – 2387MHz
	
2387MHz – 2400MHz	**2400MHz – 2496.5MHz**
	
2496.5MHz – 26GHz	
	

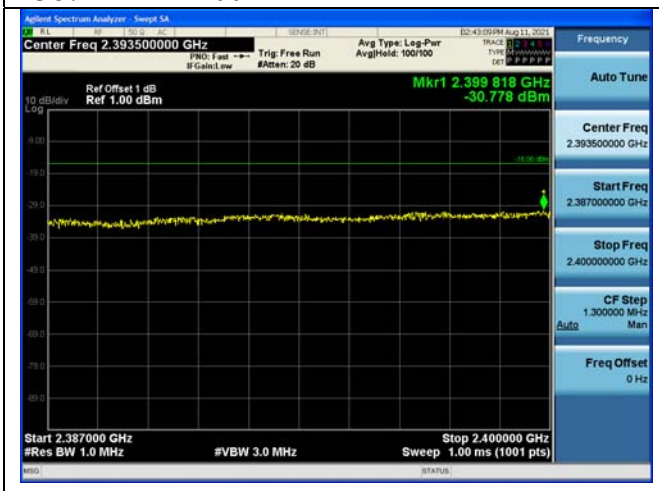
Test Data: Wifi 2.4G n40 2462MHz

10MHz – 1000MHz

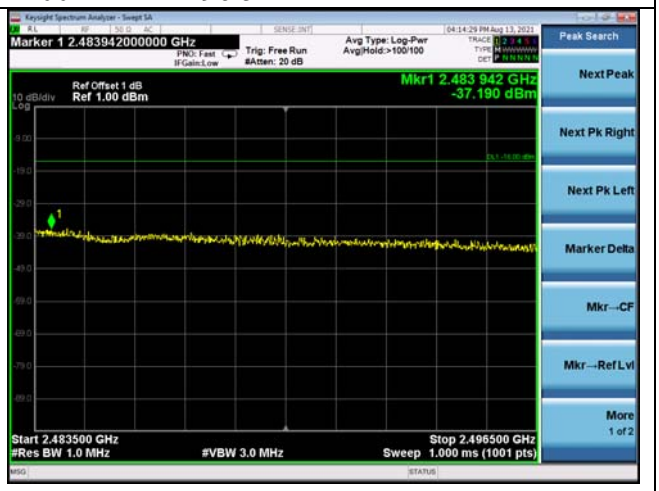


1000MHz – 2387MHz

2387MHz – 2400MHz



2400MHz – 2496.5MHz



2496.5MHz – 26GHz

5.6 Limitation of Collateral Emission of Receiver

5.6.1 Limit

Frequency below 1GHz : 4nW
Frequency above 1GHz : 20nW

5.6.2 Measurement Equipment Used

Refer to section Appendix A: Equipment List for detail.

5.6.3 Test Setup

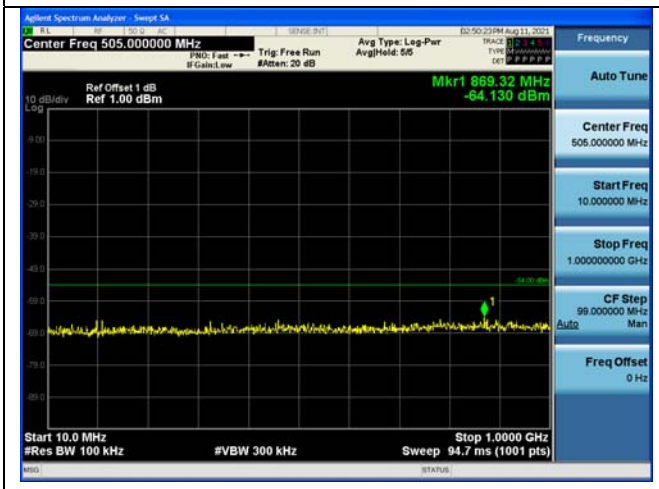
Refer to section 5.1.3 for detail.

5.6.4 Test Procedure

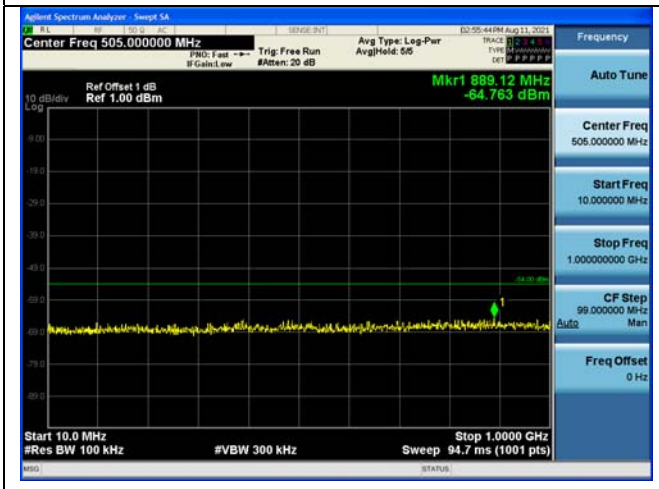
1. Setup the EUT at hopping off and modulation on.
2. Setup the ETU operate at channel low, mid and high and normal voltage.
3. Set the RBW=100kHz, VBW=300kHz, Sweep = auto, Start=10MHz, Stop=1GHz. Max hold view, mark highest level.
4. Set the RBW=1MHz, VBW=3MHz, Sweep = auto, Start=1GHz, Stop=26GHz. Max hold view, mark highest level.
5. Varied input voltage to + 10% and - 10% normal voltage and repeat procedure 1 to 4 again.
6. The Worst data was report.

5.6.5 Test Results

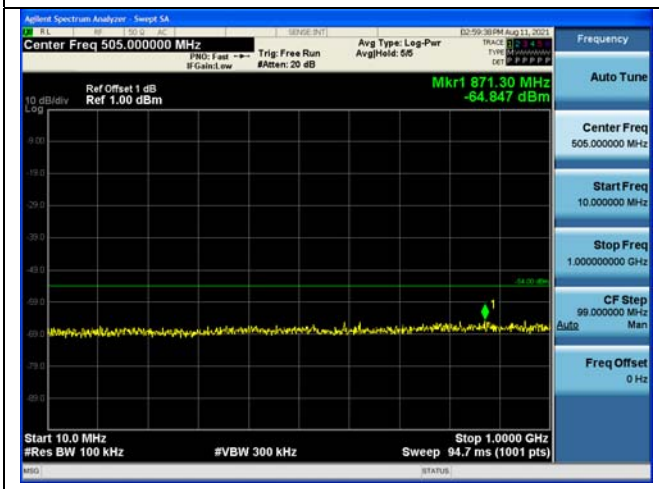
Test Data: Wifi 2.4G b 2412MHz

Below 1GHz	Above 1GHz
	

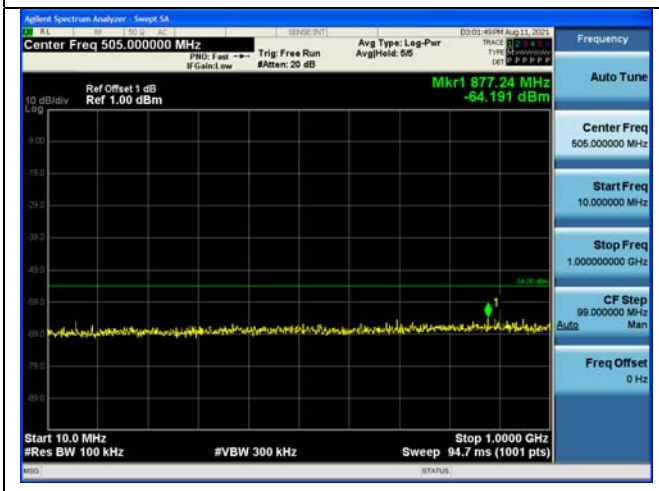
Test Data: Wifi 2.4G b 2437MHz

Below 1GHz	Above 1GHz
	

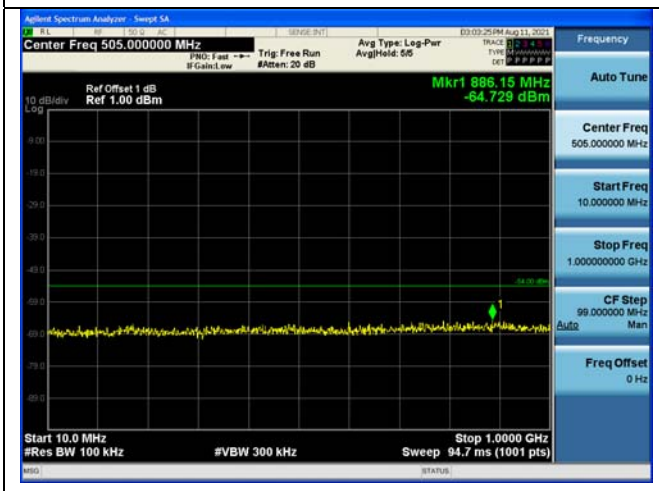
Test Data: Wifi 2.4G b 2472MHz

Below 1GHz	Above 1GHz
	

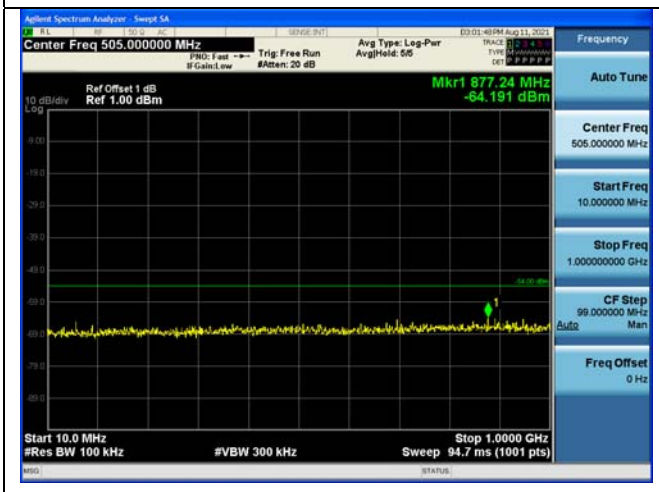
Test Data: Wifi 2.4G g 2412MHz

Below 1GHz	Above 1GHz
	

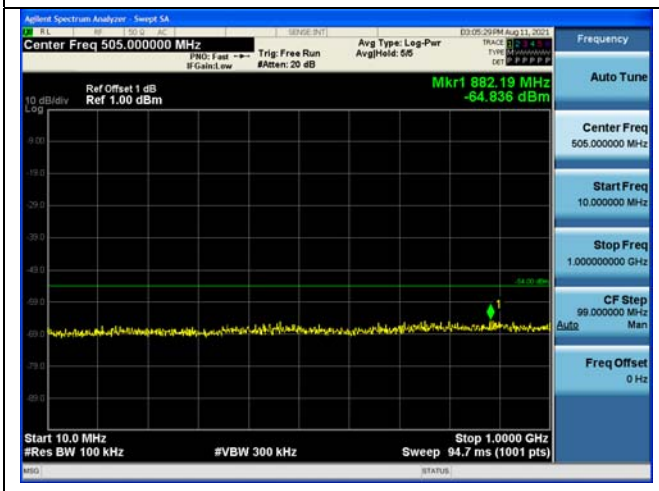
Test Data: Wifi 2.4G g 2437MHz

Below 1GHz	Above 1GHz
	

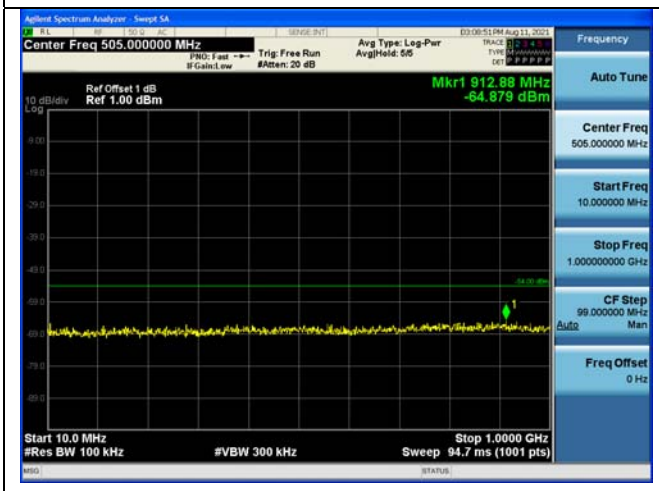
Test Data: Wifi 2.4G g 2472MHz

Below 1GHz	Above 1GHz
	

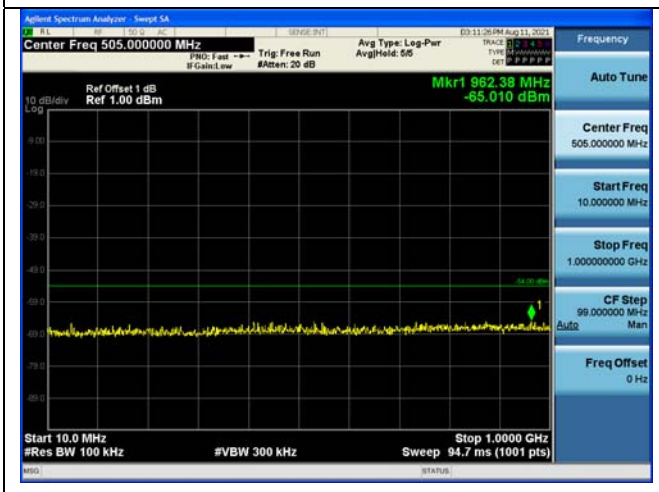
Test Data: Wifi 2.4G n20 2412MHz

Below 1GHz	Above 1GHz
	

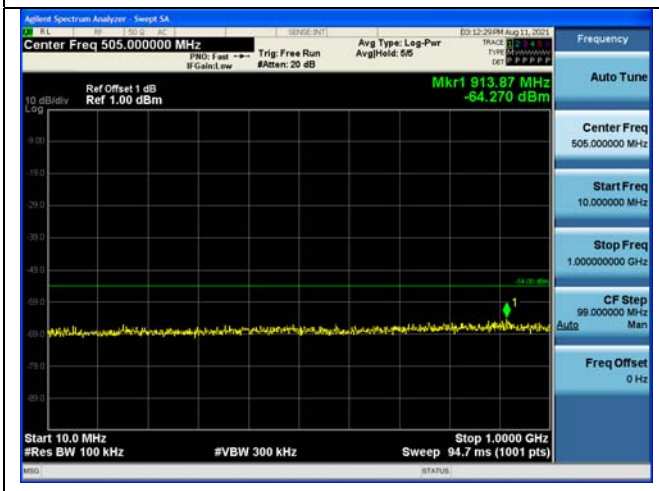
Test Data: Wifi 2.4G n20 2437MHz

Below 1GHz	Above 1GHz
	

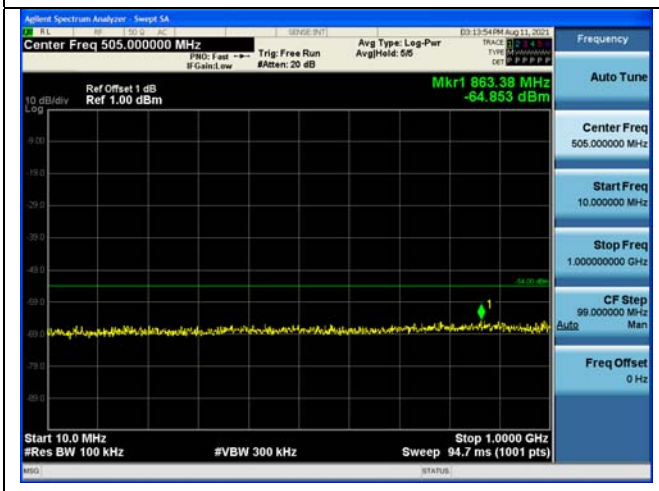
Test Data: Wifi 2.4G n20 2472MHz

Below 1GHz	Above 1GHz
	

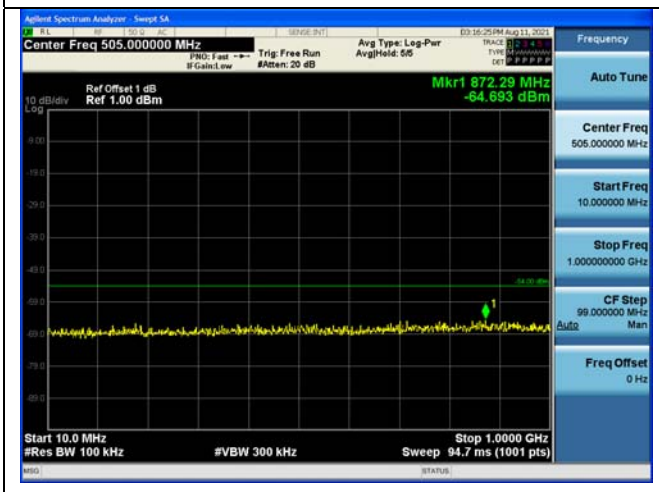
Test Data: Wifi 2.4G n40 2422MHz

Below 1GHz	Above 1GHz
	

Test Data: Wifi 2.4G n40 2437MHz

Below 1GHz	Above 1GHz
	

Test Data: Wifi 2.4G n40 2462MHz

Below 1GHz	Above 1GHz
	

5.7 Angular Width of Principal Radiation (AWPR)

The angular width of principal radiation (AWPR), which follows from the antenna pattern specifications, shall satisfy the expression 360/A degree.

To be assessed:
AWPR < 360/A (degree)
A represent the value determined by dividing equivalent isotropic radiated power by the value obtained by applying an antenna power with the mean power (3mW for BT; 10mW for Wifi/ BLE) to the transmitting antenna with its absolute gain being 2.14 dBi.

Ambient temperature: 24℃ Relative humidity: 63% Test Date: 2021/08/12

802.11b Antenna gain=2.22dBi

		CH Low	CH Mid	CH High
Normal Voltage 5 V	Conducted power (mW/MHz)	6.427	7.194	7.568
	Radiated power (dBm/MHz)	10.30	10.79	11.01
	Radiated power (mW/MHz)	10.715	11.995	12.618
	Constant A	10.715 /16.4<1	11.995 /16.4<1	12.618 /16.4<1
Upper Voltage 5.5 V	Conducted power (mW/MHz)	6.486	7.015	7.656
	Radiated power (dBm/MHz)	10.34	10.68	11.06
	Radiated power (mW/MHz)	10.814	11.695	12.764
	Constant A	10.814 /16.4<1	11.695 /16.4<1	12.764 /16.4<1
Lower Voltage 4.5 V	Conducted power (mW/MHz)	6.622	7.228	7.430
	Radiated power (dBm/MHz)	10.43	10.81	10.93
	Radiated power (mW/MHz)	11.041	12.050	12.388
	Constant A	11.041 /16.4<1	12.050 /16.4<1	12.388 /16.4<1

In these cases, according to article 49.20 (f)(2) of the Regulations the constant A should be equalized to 1. As a result AWPR, 360 degrees, which is always satisfied.

802.11g Antenna gain=2.22dBi

		CH Low	CH Mid	CH High
Normal Voltage 5 V	Conducted power (mW/MHz)	4.222	4.768	4.383
	Radiated power (dBm/MHz)	8.475	9.003	8.638
	Radiated power (mW/MHz)	7.039	7.949	7.308
	Constant A	7.039/16.4<1	7.949/16.4<1	7.308/16.4<1
Upper Voltage 5.5 V	Conducted power (mW/MHz)	4.335	5.309	4.912
	Radiated power (dBm/MHz)	8.59	9.47	9.133
	Radiated power (mW/MHz)	7.228	8.851	8.19
	Constant A	7.228/16.4<1	8.851/16.4<1	8.19/16.4<1
Lower Voltage 4.5 V	Conducted power (mW/MHz)	4.358	5.302	4.889
	Radiated power (dBm/MHz)	8.613	9.464	9.112
	Radiated power (mW/MHz)	7.266	8.839	8.151
	Constant A	7.266/16.4<1	8.839/16.4<1	8.151/16.4<1

In these cases, according to article 49.20 (f)(2) of the Regulations the constant A should be equalized to 1. As a result AWPR, 360 degrees, which is always satisfied.

802.11n HT20 Antenna gain=2.22dBi

		CH Low	CH Mid	CH High
Normal Voltage 5 V	Conducted power (mW/MHz)	4.748	5.805	4.174
	Radiated power (dBm/MHz)	8.985	9.858	8.426
	Radiated power (mW/MHz)	7.916	9.679	6.96
	Constant A	7.916/16.4<1	9.679/16.4<1	6.96/16.4<1
Upper Voltage 5.5 V	Conducted power (mW/MHz)	4.791	5.886	4.463
	Radiated power (dBm/MHz)	9.024	9.918	8.716
	Radiated power (mW/MHz)	7.988	9.813	7.44
	Constant A	7.988/16.4<1	9.813/16.4<1	7.44/16.4<1
Lower Voltage 4.5 V	Conducted power (mW/MHz)	4.761	5.836	4.172
	Radiated power (dBm/MHz)	8.997	9.881	8.423
	Radiated power (mW/MHz)	7.937	9.73	6.955
	Constant A	7.937/16.4<1	9.73/16.4<1	6.955/16.4<1

In these cases, according to article 49.20 (f)(2) of the Regulations the constant A should be equalized to 1. As a result AWPR, 360 degrees, which is always satisfied.

802.11n HT40 Antenna gain=2.22dBi

		CH Low	CH Mid	CH High
Normal Voltage 5 V	Conducted power (mW/MHz)	1.107	1.477	1.466
	Radiated power (dBm/MHz)	2.66	3.915	3.88
	Radiated power (mW/MHz)	1.845	2.463	2.443
	Constant A	1.845/16.4<1	2.463/16.4<1	2.443/16.4<1
Upper Voltage 5.5 V	Conducted power (mW/MHz)	1.217	1.477	1.452
	Radiated power (dBm/MHz)	3.073	3.915	3.84
	Radiated power (mW/MHz)	2.029	2.463	2.421
	Constant A	2.029/16.4<1	2.463/16.4<1	2.421/16.4<1
Lower Voltage 4.5 V	Conducted power (mW/MHz)	1.245	1.469	1.468
	Radiated power (dBm/MHz)	3.172	3.889	3.887
	Radiated power (mW/MHz)	2.076	2.448	2.447
	Constant A	2.076/16.4<1	2.448/16.4<1	2.447/16.4<1

In these cases, according to article 49.20 (f)(2) of the Regulations the constant A should be equalized to 1. As a result AWPR, 360 degrees, which is always satisfied.

5.8 Carrier Sense Capability

5.8.1 Limit

Shall not transmit when received signal level is above 100 mV

Automatic cessation of transmitting is required when the electric field strength is exceeding E (mV/m):
Antenna Voltage (in dBm) = 22.79 + max. antenna Gain - 20 x Log f (f in MHz)
This voltage will be generated in de direction of the max. Gain.

WIFI 2.4GHz

		Antenna Gain (dBi)		dBm
Channel Low 2412MHz:	Pcs = 22.79 +	2.22	- 20 * log (2412) =	-42.64
Channel Mid 2437MHz:	Pcs = 22.79 +	2.22	- 20 * log (2437) =	-42.73
Channel High 2472MHz:	Pcs = 22.79 +	2.22	- 20 * log (2472) =	-42.85

5.8.2 Measurement Equipment Used

Refer to section Appendix A: Equipment List for detail.

5.8.3 Test Setup

Refer to section 5.1.3 for detail.

5.8.4 Test Procedure

1. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port through splitter to spectrum.
2. Set center frequency of spectrum analyzer = operating frequency.
3. Set the spectrum analyzer as RBW, VBW=1MHz, Span = 50MHz, Sweep = Auto.
4. EUT link to device set it in normal mode.
5. Used spectrum analyzer trigger function and delta mark function.

5.8.5 Test Results

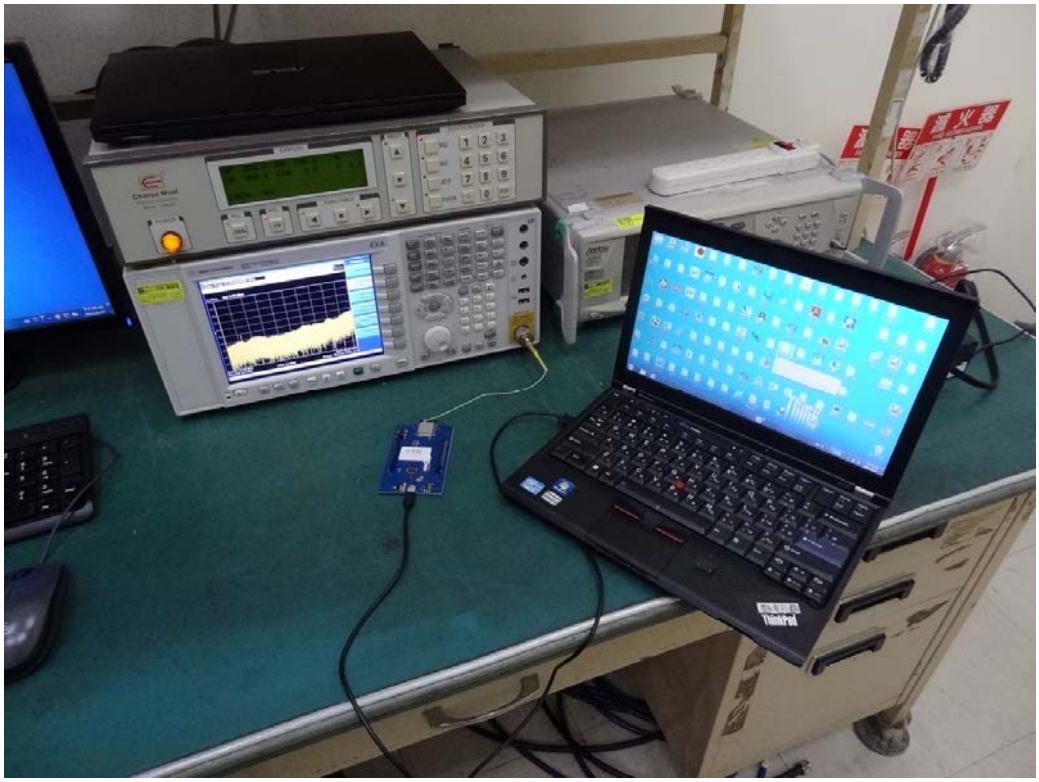
PASS

6. Appendix

6.1 Appendix A: Equipment List

Location Conducted	Equipment Name	Brand	Model	S/N	Last Cal. Date	Next Cal. Date
Conducted	Power Meter	Anritsu	ML2495A	1116010	09/25/2020	09/25/2021
Conducted	Power Sensor	Anritsu	MA2411B	34NKF50	09/25/2020	09/25/2021
Conducted	Power Sensor	DARE	RPR3006W	13I00030SNO33	01/04/2021	01/04/2022
Conducted	Power Sensor	DARE	RPR3006W	13I00030SNO34	01/04/2021	01/04/2022
Conducted	Power Sensor	DARE	RPR3006W	14I00889SNO35	06/23/2021	06/23/2022
Conducted	Power Sensor	DARE	RPR3006W	14I00889SNO36	06/23/2021	06/23/2022
Conducted	Temperature Chamber	KSON	THS-B4H100	2287	04/26/2021	04/26/2022
Conducted	DC Power supply	ABM	8185D	N/A	01/05/2021	01/05/2022
Conducted	AC Power supply	EXTECH	CFC105W	NA	N/A	N/A
Conducted	Spectrum analyzer	Keysight	N9010A	MY56070257	09/23/2020	09/23/2021
Conducted	Test Software	DARE	Radiation Ver:2013.1.23	NA	NA	NA
Conducted	Test Software	R&S	CMUGO Ver:2.0.0	N/A	N/A	N/A
Conducted	Universal Digital Radio Communication Tester	R&S	CMU200	111968	11/29/2020	11/29/2021
Conducted	Wideband Radio Communication Tester	R&S	CMW500	1201.002K50108793-JG	10/28/2020	10/28/2021
Conducted	BT Simulator	Agilent	N4010A	MY48100200	NA	NA
Conducted	GPS Simulator	Welnavigate	GS-50	701523	NA	NA
Conducted (TS8997)	Wideband Radio Communication Tester	R&S	CMW500	168811	07/19/2021	07/19/2022
Conducted (TS8997)	Signal Generator	R&S	SMB100B	101085	10/28/2020	10/28/2021
Conducted (TS8997)	Vector Signal Generator	R&S	SMBV100A	263246	10/28/2020	10/28/2021
Conducted (TS8997)	Signal analyzer 40GHz	R&S	FSV40	101884	10/20/2020	10/20/2021
Conducted (TS8997)	OSP150 extension unit CAM-BUS	R&S	OSP150	101107	04/06/2021	04/06/2022
Conducted (TS8997)	Test Software	R&S	EMC32	NA	NA	NA

6.2 Appendix B: Photographs of Setup



6.3 Appendix C: Photographs of EUT

Please refer to the File of **ISL-20LR045P**

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