



RF TEST REPORT

Applicant Quectel Wireless Solutions Co., Ltd
FCC ID XMR202102AF50T
Product Wi-Fi&BT module
Brand Quectel
Model AF50T
Report No. R2101A0024-R1V1
Issue Date July 5, 2021

TA Technology (Shanghai) Co., Ltd. tested the above equipment in accordance with the requirements in **FCC CFR47 Part 15C (2020)**. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Prepared by: Peng Tao

Approved by: Kai Xu

TA Technology (Shanghai) Co., Ltd.

No.145, Jintang Rd, Tangzhen Industry Park, Pudong Shanghai, China

TEL: +86-021-50791141/2/3

FAX: +86-021-50791141/2/3-8000



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Version	Revision description	Issue Date
Rev.0	Initial issue of report.	June 11, 2021
Rev.1	Update data in Page34	July 5, 2021
Note: This revised report (Report No. R2101A0024-R1V1) supersedes and replaces the previously issued report (Report No. R2101A0024-R1). Please discard or destroy the previously issued report and dispose of it accordingly.		

Summary of measurement results

Number	Test Case	Clause in FCC rules	Verdict
1	Maximum output power	15.247(b)(3)	PASS
2	6 dB bandwidth	15.247(a)(2)	PASS
3	Power spectral density	15.247(e)	PASS
4	Band Edge	15.247(d)	PASS
5	Spurious RF Conducted Emissions	15.247(d)	PASS
6	Unwanted Emissions	15.247(d),15.205,15.209	PASS
7	Conducted Emissions	15.207	PASS
Date of Testing: April 15, 2021~May 7, 2021			
Date of Sample Received: March 5, 2021			
Note: All indications of Pass/Fail in this report are opinions expressed by TA Technology (Shanghai) Co., Ltd. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only.			

1. Test Laboratory

1.1. Notes of the test report

This report shall not be reproduced in full or partial, without the written approval of **TA technology (shanghai) co., Ltd.** The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. Measurement Uncertainties were not taken into account and are published for informational purposes only. This report is written to support regulatory compliance of the applicable standards stated above.

1.2. Test facility

FCC (Designation number: CN1179, Test Firm Registration Number: 446626)

TA Technology (Shanghai) Co., Ltd. has been listed on the US Federal Communications Commission list of test facilities recognized to perform measurements.

A2LA (Certificate Number: 3857.01)

TA Technology (Shanghai) Co., Ltd. has been listed by American Association for Laboratory Accreditation to perform measurement.

1.3. Testing Location

Company: TA Technology (Shanghai) Co., Ltd.
Address: No.145, Jintang Rd, Tangzhen Industry Park, Pudong
City: Shanghai
Post code: 201201
Country: P. R. China
Contact: Xu Kai
Telephone: +86-021-50791141/2/3
Fax: +86-021-50791141/2/3-8000
Website: <http://www.ta-shanghai.com>
E-mail: xukai@ta-shanghai.com

2. General Description of Equipment under Test

2.1. Applicant and Manufacturer Information

Applicant	Quectel Wireless Solutions Co., Ltd
Applicant address	Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai 200233, China
Manufacturer	Quectel Wireless Solutions Co., Ltd
Manufacturer address	Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai 200233, China

2.2. General information

EUT Description	
Model	AF50T
SN:	C1A21AU25000250
Hardware Version	R1.0
Software Version	AF50TAATA
Power Supply	External power supply
Antenna Type	External Antenna
Antenna Connector	A permanently attached antenna (meet with the standard FCC Part 15.203 requirement)
Antenna Gain	Antenna 1: 3dBi Antenna 2: 3dBi
Directional gain	Power: 3dBi PSD: 6.01dBi
additional beamforming gain	NA
Test Mode	802.11b, 802.11g, 802.11n(HT20/HT40), 802.11ax(HE20/HE40) Bluetooth LE V5.2
Modulation Type	802.11b: DSSS 802.11g/n(HT20/HT40): OFDM 802.11ax(HE20/HE40): OFDM, OFDMA Bluetooth LE: GFSK
Max. Conducted Power	Wi-Fi 2.4G: 22.14dBm Bluetooth LE: 9.25 dBm
Operating Frequency Range(s)	802.11b/g/n(HT20)/ax(HE20): 2412 ~ 2462 MHz 802.11n(HT40)/ax(HE40): 2422 ~ 2452 MHz Bluetooth LE: 2402 ~2480 MHz
Note: 1. The EUT is sent from the applicant to TA and the information of the EUT is declared by the applicant.	

3. Applied Standards

According to the specifications of the manufacturer, it must comply with the requirements of the following standards:

Test standards:

FCC CFR47 Part 15C (2020) Radio Frequency Devices

ANSI C63.10 (2013)

Reference standard:

KDB 558074 D01 15.247 Meas Guidance v05r02

KDB 662911 D01 Multiple Transmitter Output v02r01

4. Test Configuration

Test Mode

The EUT has been associated with peripherals and configuration operated in a manner tended to maximize its emission characteristics in a typical application.

The radiated emission was measured in the following position: EUT stand-up position (Z axis), lie-down position (X, Y axis). The worst emission was found in lie-down position (X axis) and the loop antenna is vertical, the others are vertical and horizontal. and the worst case was recorded.

In order to find the worst case condition, Pre-tests are needed at the presence of different data rate. Preliminary tests have been done on all the configuration for confirming worst case. Data rate below means worst-case rate of each test item.

Test Mode	Data Rate		
	Antenna 1	Antenna 2	MIMO
802.11b	1 Mbps	1 Mbps	/
802.11g	6 Mbps	6 Mbps	/
802.11n HT20	MCS0	MCS0	MCS8
802.11n HT40	MCS0	MCS0	MCS8
802.11ax HE20	MCS0	MCS0	MCS0
802.11ax HE40	MCS0	MCS0	MCS0

The worst case Antenna mode for each of the following tests for Wi-Fi:

Test Cases	Antenna 1	Antenna 2	MIMO
Maximum conducted output power	O	O	802.11n HT20 802.11n HT40 802.11ax HE20 802.11ax HE40
6dB Bandwidth	802.11b/g	--	802.11n HT20 802.11n HT40 802.11ax HE20 802.11ax HE40
Band Edge	802.11b/g	--	802.11n HT20 802.11n HT40 802.11ax HE20 802.11ax HE40
Power Spectral Density	O	O	802.11n HT20 802.11n HT40 802.11ax HE20 802.11ax HE40
Spurious RF Conducted Emissions	802.11b/g	--	802.11n HT20 802.11n HT40 802.11ax HE20 802.11ax HE40
Unwanted Emissions	802.11b/g	--	802.11n HT20 802.11n HT40 802.11ax HE20 802.11ax HE40
Conducted Emission	802.11b/g	--	802.11n HT20 802.11n HT40 802.11ax HE20 802.11ax HE40
Note: "O": test all bands			

According to RF Output power results in chapter 5.1, MIMO was selected as the worst antenna for 802.11n HT20/ HT40, 802.11ax HE20/HE40. SISO Antenna 1 was selected as the worst SISO antenna for 802.11b/g.

5. Test Case Results

5.1. Maximum output power

Ambient condition

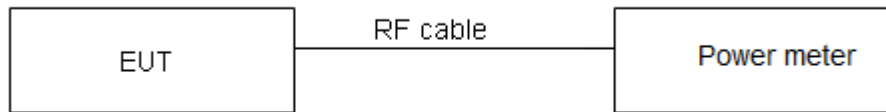
Temperature	Relative humidity	Pressure
23°C ~25°C	45%~50%	101.5kPa

Methods of Measurement

During the process of the testing, The EUT was connected to Power meter with a known loss. The EUT is max power transmission with proper modulation.

The conducted Power is measured at each antenna port. The measured results at the various antenna ports are then summed mathematically.

Test Setup



Limits

Rule Part 15.247 (b) (3) specifies that " For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz: 1 Watt."

Average Output Power	$\leq 1\text{W}$ (30dBm)
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Measurement Uncertainty

The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor $k = 2$, $U = 0.44$ dB.

Test Results

SISO Antenna 1/2 Power Index							
Channel	802.11b	802.11g	802.11n HT20	802.11ax HE20	Channel	802.11n HT40	802.11ax HE40
CH1	20	19	19	19	CH3	19	19
CH6	20	19	19	19	CH6	19	19
CH11	20	19	19	19	CH9	19	19

MIMO Antenna 1/2 Power Index					
Channel	802.11n HT20	802.11ax HE20	Channel	802.11n HT40	802.11ax HE40
CH1	19	19	CH3	19	19
CH6	19	19	CH6	19	19
CH11	19	19	CH9	19	19

Test Mode	T _{on} (ms)	T _(on+off) (ms)	Duty cycle	Duty cycle correction Factor(dB)
802.11b	6.69	7.56	0.88	0.53
802.11g	0.24	0.26	0.93	0.33
802.11n HT20	10.26	11.00	0.93	0.30
802.11n HT40	4.06	5.10	0.80	0.99
802.11ax HE20	11.54	12.22	0.94	0.25
802.11ax HE40	3.26	4.10	0.80	1.00
Bluetooth LE (125K)	0.39	0.62	0.619	2.086
Bluetooth LE (500K)	1.07	1.88	0.567	2.465
Bluetooth LE (1M)	0.39	0.62	0.619	2.086
Bluetooth LE (2M)	0.20	0.62	0.324	4.898
Note: when Duty cycle ≥ 0.98 , Duty cycle correction Factor not required.				

Test Mode	Carrier frequency (MHz)	Average Power Measured (dBm)	Average Power with duty factor (dBm)	Limit (dBm)	Conclusion
Bluetooth (Low Energy) (125K)	2402	6.53	8.62	30	PASS
	2440	7.16	9.25	30	PASS
	2480	4.56	6.65	30	PASS
Bluetooth (Low Energy) (500K)	2402	4.59	7.06	30	PASS
	2440	5.80	8.27	30	PASS
	2480	2.93	5.40	30	PASS
Bluetooth (Low Energy) (1M)	2402	5.06	7.15	30	PASS
	2440	6.00	8.09	30	PASS
	2480	3.43	5.52	30	PASS
Bluetooth (Low Energy) (2M)	2402	2.32	7.22	30	PASS
	2440	3.33	8.23	30	PASS
	2480	0.76	5.66	30	PASS

Note: Average Power with duty factor = Average Power Measured +Duty cycle correction factor

SISO Antenna 1

Test Mode	Carrier frequency (MHz)	Average Power Measured (dBm)	Average Power with duty factor (dBm)	Limit (dBm)	Conclusion
802.11b	2412	19.44	19.97	30	PASS
	2437	18.61	19.14	30	PASS
	2462	17.92	18.45	30	PASS
802.11g	2412	19.38	19.71	30	PASS
	2437	18.78	19.11	30	PASS
	2462	18.16	18.49	30	PASS
802.11n HT20	2412	18.91	19.21	30	PASS
	2437	18.41	18.71	30	PASS
	2462	17.82	18.12	30	PASS
802.11n HT40	2422	18.81	19.80	30	PASS
	2437	18.03	19.02	30	PASS
	2452	17.68	18.67	30	PASS
802.11ax HE20	2412	18.97	19.22	30	PASS
	2437	18.49	18.74	30	PASS
	2462	17.89	18.14	30	PASS
802.11ax HE40	2422	18.28	19.28	30	PASS
	2437	17.91	18.91	30	PASS
	2452	17.62	18.62	30	PASS

Note: Average Power with duty factor = Average Power Measured +Duty cycle correction factor

**SISO Antenna 2**

Test Mode	Carrier frequency (MHz)	Average Power Measured (dBm)	Average Power with duty factor (dBm)	Limit (dBm)	Conclusion
802.11b	2412	19.21	19.74	30	PASS
	2437	19.16	19.69	30	PASS
	2462	18.92	19.45	30	PASS
802.11g	2412	19.14	19.47	30	PASS
	2437	19.16	19.49	30	PASS
	2462	19.05	19.38	30	PASS
802.11n HT20	2412	18.71	19.01	30	PASS
	2437	18.76	19.06	30	PASS
	2462	18.68	18.98	30	PASS
802.11n HT40	2422	18.07	19.06	30	PASS
	2437	18.35	19.34	30	PASS
	2452	17.93	18.92	30	PASS
802.11ax HE20	2412	18.75	19.00	30	PASS
	2437	18.86	19.11	30	PASS
	2462	18.73	18.98	30	PASS
802.11ax HE40	2422	18.10	19.10	30	PASS
	2437	18.36	19.36	30	PASS
	2452	18.04	19.04	30	PASS

Note: Average Power with duty factor = Average Power Measured +Duty cycle correction factor

MIMO

Test Mode	Carrier frequency (MHz)	MIMO Antenna 1		MIMO Antenna 2		Total Power (dBm)	Limit (dBm)	Conclusion
		Average Power Measured (dBm)	Average Power with duty factor (dBm)	Average Power Measured (dBm)	Average Power with duty factor (dBm)			
802.11n HT20	2412	18.22	18.52	17.92	18.22	21.39	30	PASS
	2437	17.72	18.02	18.07	18.37	21.21	30	PASS
	2462	17.12	17.42	17.91	18.21	20.85	30	PASS
802.11n HT40	2422	17.63	18.62	17.44	18.43	21.54	30	PASS
	2437	17.37	18.36	17.66	18.65	21.52	30	PASS
	2452	16.97	17.96	17.31	18.30	21.14	30	PASS
802.11ax HE20	2412	18.59	18.84	18.31	18.56	21.71	30	PASS
	2437	18.11	18.36	18.46	18.71	21.55	30	PASS
	2462	17.52	17.77	18.33	18.58	21.20	30	PASS
802.11ax HE40	2422	18.22	19.22	18.03	19.03	22.13	30	PASS
	2437	17.94	18.94	18.32	19.32	22.14	30	PASS
	2452	17.61	18.61	17.97	18.97	21.80	30	PASS

Note: 1. Average Power with duty factor = Average Power Measured + Duty cycle correction factor
2. For Total Power, according to KDB 662911 D01 Multiple Transmitter Output v02r01 1),
The Total Power = $10\log(10^{(\text{Power antenna1 in dBm}/10)} + 10^{(\text{Power antenna2 in dBm}/10)})$.
3. The manufacturer declared the transmitter output signals is CDD mode. And $N_{ss}=1$. According to KDB 662911 D01 Multiple Transmitter Output v02r01 2)f)(i): If all antennas have the same gain,
Directional gain = $G_{ANT} + \text{Array Gain}$,
For power measurements on IEEE 802.11 devices,
Array Gain = 0 dB (i.e., no array gain) for $N_{ANT} \leq 4$;
Array Gain = 0 dB (i.e., no array gain) for channel widths ≥ 40 MHz for any N_{ANT} ;
Array Gain = $5 \log(N_{ANT}/N_{ss})$ dB or 3 dB, whichever is less, for 20-MHz channel widths with $N_{ANT} \geq 5$.
So directional gain = $G_{ANT} + \text{Array Gain} = 3 + 0 = 3 \text{ dB} < 6 \text{ dB}$. So the power limit is 30dBm

5.2. 99% Bandwidth and 6dB Bandwidth

Ambient condition

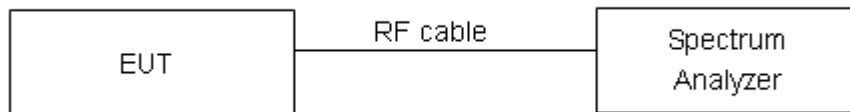
Temperature	Relative humidity	Pressure
23°C ~25°C	45%~50%	101.5kPa

Method of Measurement

The EUT was connected to the spectrum analyzer through an external attenuator (20dB) and a known loss cable. RBW is set to 100 kHz; VBW is set to 300 kHz on spectrum analyzer.
Dector=Peak, Trace mode=max hold.

The EUT was connected to the spectrum analyzer through a known loss cable. The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / x dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value.

Test Setup



Limits

Rule Part 15.247 (a) (2) specifies that “Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.”

minimum 6 dB bandwidth	≥ 500 kHz
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Measurement Uncertainty

The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor $k = 2$, $U = 936$ Hz.

Test Results:

Test Mode	Carrier frequency (MHz)	99% bandwidth (MHz)	Minimum 6 dB bandwidth (MHz)	Limit (kHz)	Conclusion
802.11b	2412	12.9160	8.092	500	PASS
	2437	13.2820	8.089	500	PASS
	2462	13.3300	8.081	500	PASS
802.11g	2412	12.2640	15.730	500	PASS
	2437	16.3710	16.280	500	PASS
	2462	16.3500	16.330	500	PASS
802.11n HT20	2412	17.4410	16.930	500	PASS
	2437	17.5880	17.580	500	PASS
	2462	17.5320	17.590	500	PASS
802.11n HT40	2422	35.8480	35.350	500	PASS
	2437	36.0050	36.310	500	PASS
	2452	35.8420	35.200	500	PASS
802.11ax HE20	2412	18.8410	18.310	500	PASS
	2437	18.9510	18.790	500	PASS
	2462	18.9290	18.860	500	PASS
802.11ax HE40	2422	37.5470	35.330	500	PASS
	2437	37.7550	37.680	500	PASS
	2452	37.6360	36.380	500	PASS
Bluetooth (Low Energy) (125K)	2402	1.0474	0.689	500	PASS
	2440	1.0487	0.682	500	PASS
	2480	1.0516	0.682	500	PASS
Bluetooth (Low Energy) (500K)	2402	1.0095	0.669	500	PASS
	2440	1.0116	0.665	500	PASS
	2480	1.0105	0.660	500	PASS
Bluetooth (Low Energy)	2402	1.0271	0.672	500	PASS
	2440	1.0249	0.669	500	PASS



(1M)	2480	1.0275	0.670	500	PASS
Bluetooth (Low Energy) (2M)	2402	2.0129	1.154	500	PASS
	2440	2.0120	1.151	500	PASS
	2480	2.0102	1.161	500	PASS

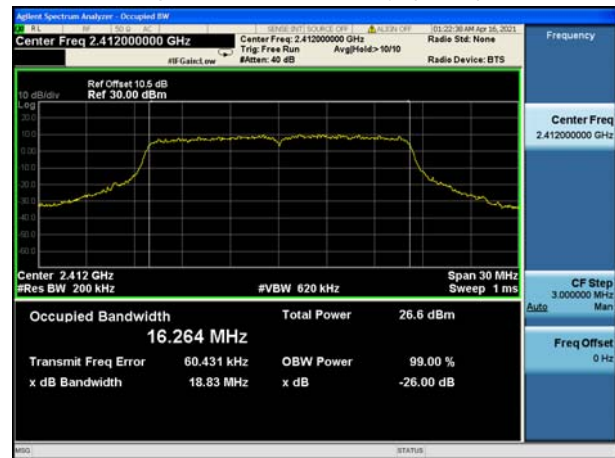


99%bandwidth

802.11b, Carrier frequency (MHz): 2412



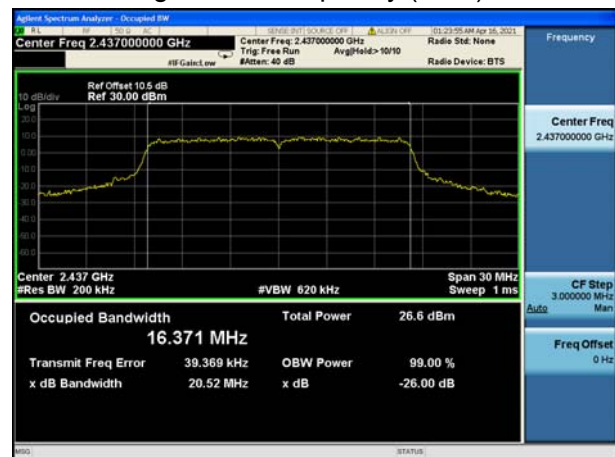
802.11g, Carrier frequency (MHz): 2412



802.11b, Carrier frequency (MHz): 2437



802.11g, Carrier frequency (MHz): 2437



802.11b, Carrier frequency (MHz): 2462



802.11g, Carrier frequency (MHz): 2462



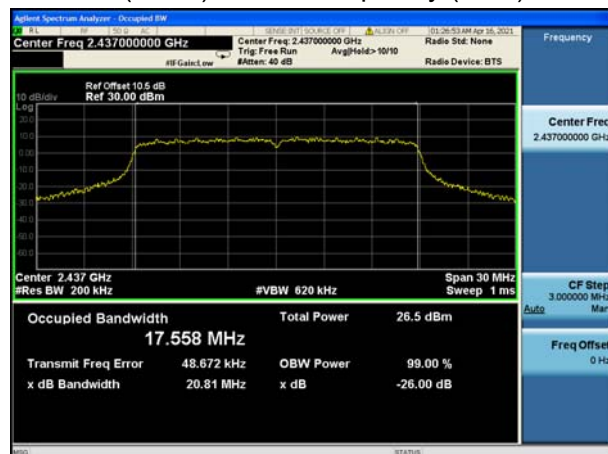
802.11n(HT20), Carrier frequency (MHz): 2412



802.11n(HT40), Carrier frequency (MHz): 2422



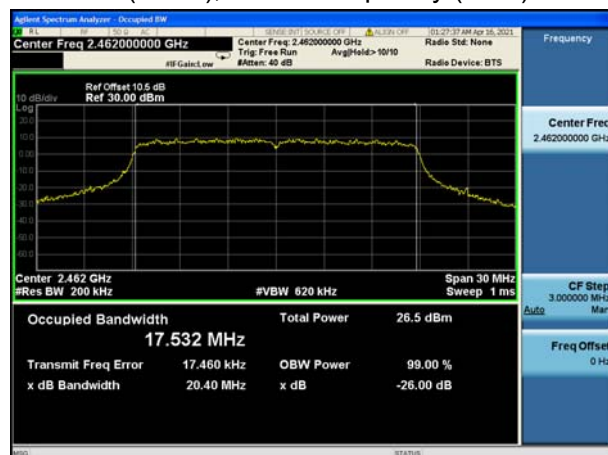
802.11n(HT20), Carrier frequency (MHz): 2437



802.11n(HT40), Carrier frequency (MHz): 2437



802.11n(HT20), Carrier frequency (MHz): 2462



802.11n(HT40), Carrier frequency (MHz): 2452



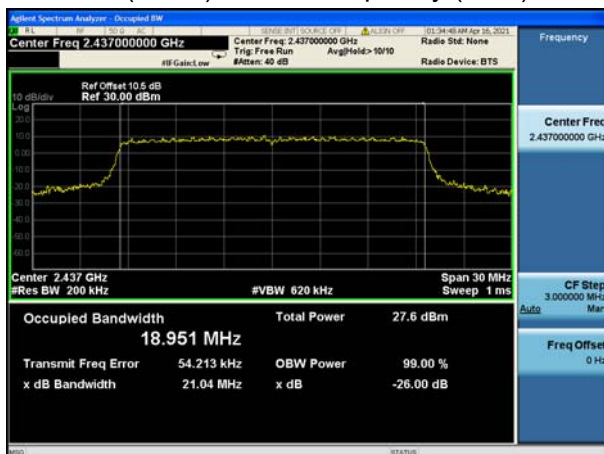
802.11ax(HE20), Carrier frequency (MHz): 2412



802.11ax(HE40), Carrier frequency (MHz): 2422



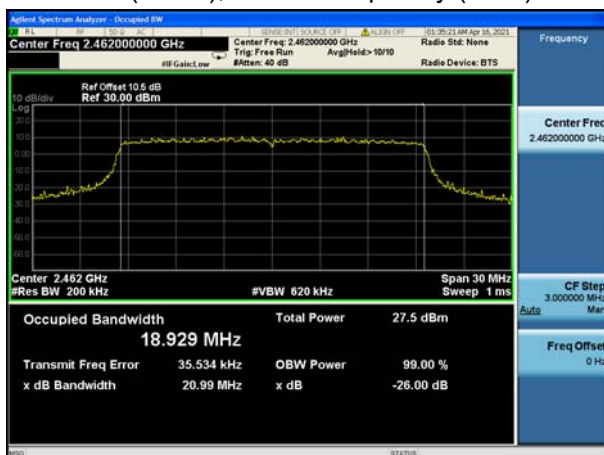
802.11ax(HE20), Carrier frequency (MHz): 2437



802.11ax(HE40), Carrier frequency (MHz): 2437



802.11ax(HE20), Carrier frequency (MHz): 2462



802.11ax(HE40), Carrier frequency (MHz): 2452



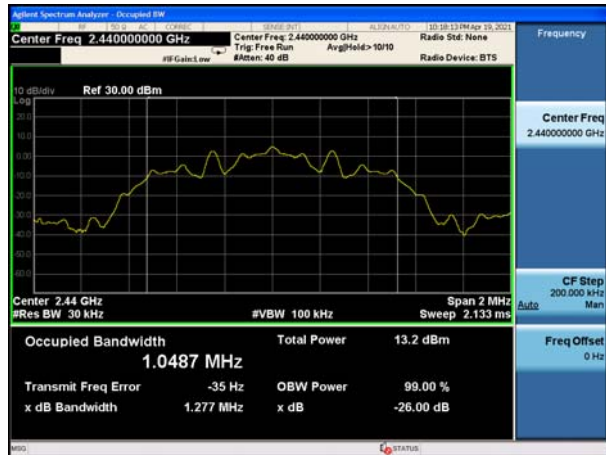
Bluetooth LE (125K) Carrier frequency (MHz):
2402



Bluetooth LE (500K) Carrier frequency (MHz):
2402



Bluetooth LE (125K) Carrier frequency (MHz):
2440



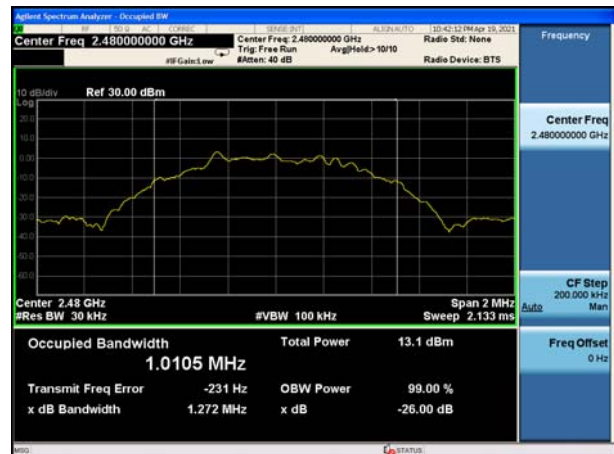
Bluetooth LE (500K) Carrier frequency (MHz):
2440



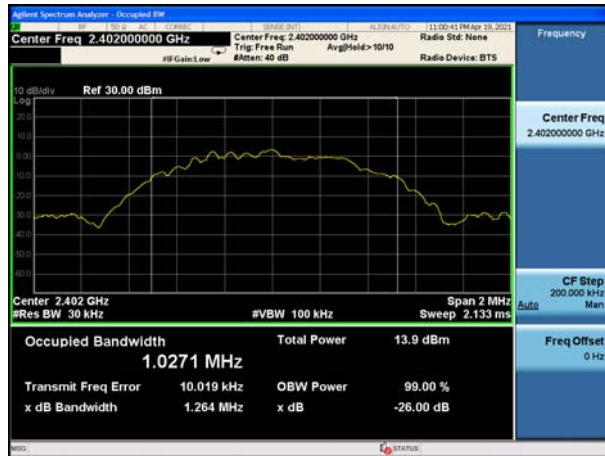
Bluetooth LE (125K) Carrier frequency (MHz):
2480



Bluetooth LE (500K) Carrier frequency (MHz):
2480



Bluetooth LE (1M) Carrier frequency (MHz): 2402



Bluetooth LE (2M) Carrier frequency (MHz): 2402



Bluetooth LE (1M) Carrier frequency (MHz): 2440



Bluetooth LE (2M) Carrier frequency (MHz): 2440



Bluetooth LE (1M) Carrier frequency (MHz): 2480



Bluetooth LE (2M) Carrier frequency (MHz): 2480





6 dB bandwidth

802.11b, Carrier frequency (MHz): 2412



802.11g, Carrier frequency (MHz): 2412



802.11b, Carrier frequency (MHz): 2437



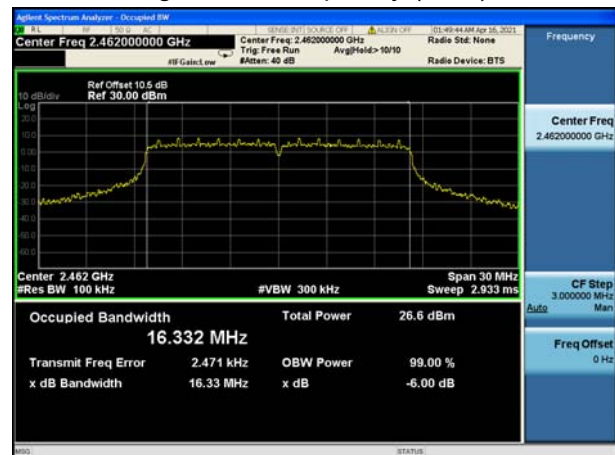
802.11g, Carrier frequency (MHz): 2437



802.11b, Carrier frequency (MHz): 2462



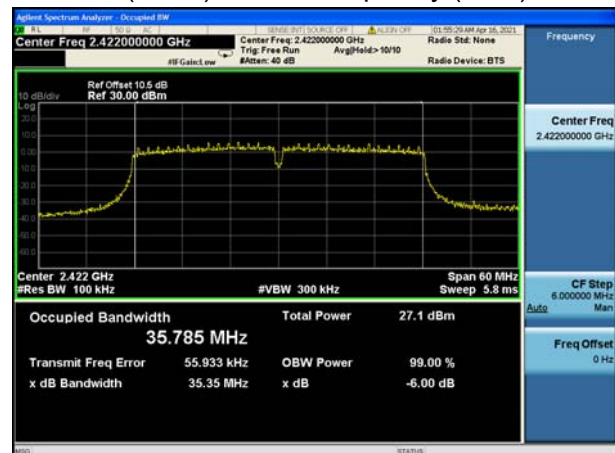
802.11g, Carrier frequency (MHz): 2462



802.11n(HT20), Carrier frequency (MHz): 2412



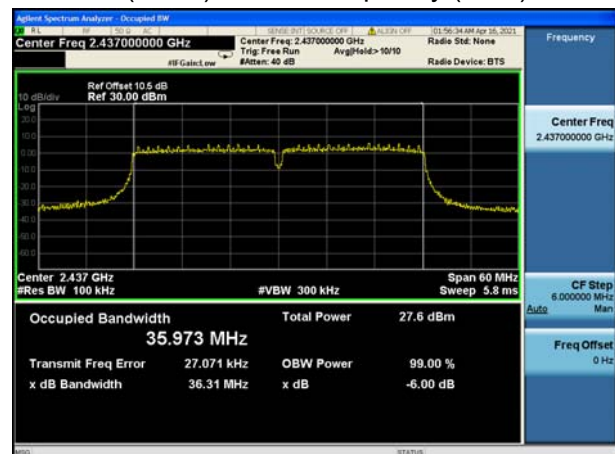
802.11n(HT40), Carrier frequency (MHz): 2422



802.11n(HT20), Carrier frequency (MHz): 2437



802.11n(HT40), Carrier frequency (MHz): 2437



802.11n(HT20), Carrier frequency (MHz): 2462



802.11n(HT40), Carrier frequency (MHz): 2452



802.11ax(HE20), Carrier frequency (MHz): 2412



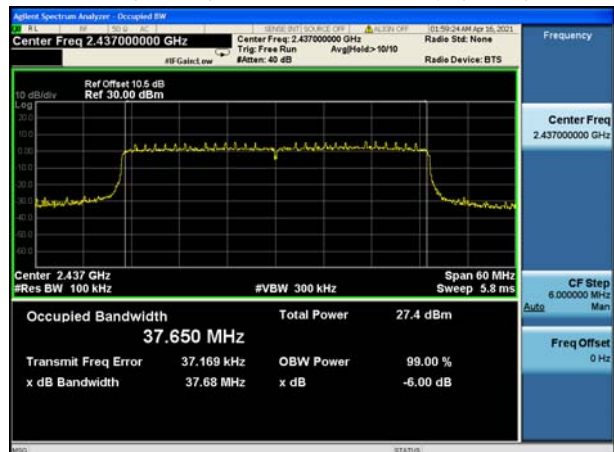
802.11ax(HE40), Carrier frequency (MHz): 2422



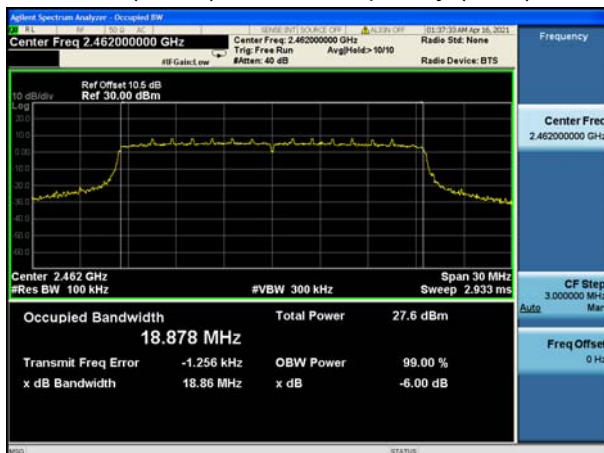
802.11ax(HE20), Carrier frequency (MHz): 2437



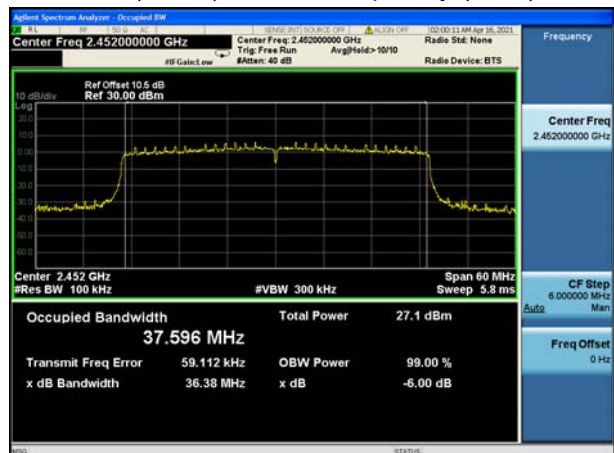
802.11ax(HE40), Carrier frequency (MHz): 2437



802.11ax(HE20), Carrier frequency (MHz): 2462



802.11ax(HE40), Carrier frequency (MHz): 2452



Bluetooth LE (125K) Carrier frequency (MHz): 2402



Bluetooth LE (500K) Carrier frequency (MHz): 2402



Bluetooth LE (125K) Carrier frequency (MHz): 2440



Bluetooth LE (500K) Carrier frequency (MHz): 2440



Bluetooth LE (125K) Carrier frequency (MHz): 2480



Bluetooth LE (500K) Carrier frequency (MHz): 2480



Bluetooth LE (1M) Carrier frequency (MHz): 2402



Bluetooth LE (2M) Carrier frequency (MHz): 2402



Bluetooth LE (1M) Carrier frequency (MHz): 2440



Bluetooth LE (2M) Carrier frequency (MHz): 2440



Bluetooth LE (1M) Carrier frequency (MHz): 2480



Bluetooth LE (2M) Carrier frequency (MHz): 2480



5.3. Band Edge

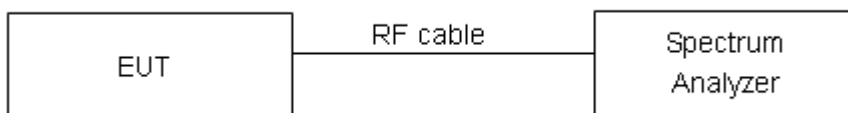
Ambient condition

Temperature	Relative humidity	Pressure
23°C ~25°C	45%~50%	101.5kPa

Method of Measurement

The EUT was connected to the spectrum analyzer through an external attenuator (20dB) and a known loss cable the band edge of the lowest and highest channels were measured. The peak detector is used and RBW is set to 100 kHz and VBW is set to 300 kHz on spectrum analyzer. Spectrum analyzer plots are included on the following pages.

Test Setup



Limits

Rule Part 15.247(d) specifies that “In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.” If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.”

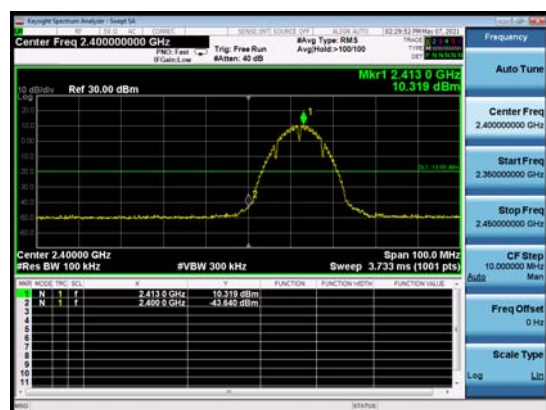
Measurement Uncertainty

The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor $k = 1.96$.

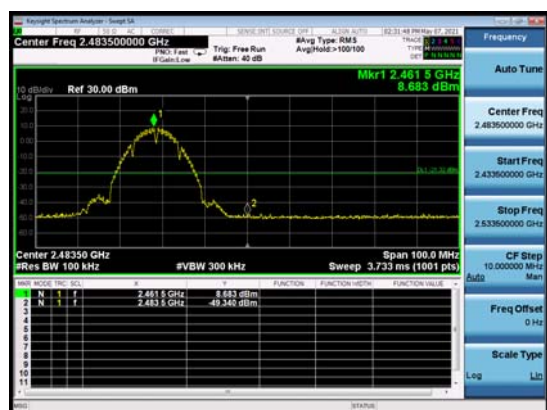
Frequency	Uncertainty
2GHz-3GHz	1.407 dB

Test Results: PASS

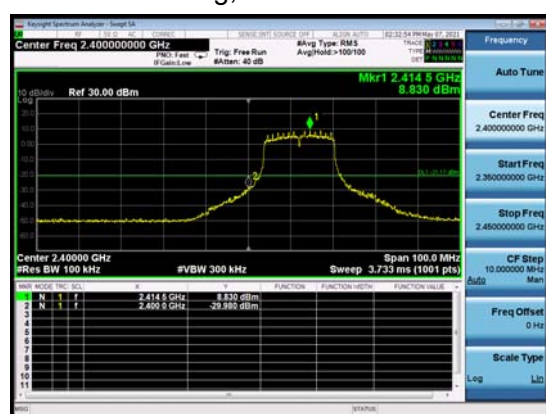
802.11b, Channel No.: 1



802.11b, Channel No.: 11



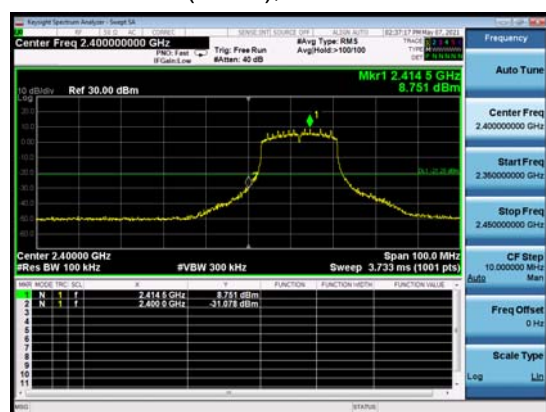
802.11g, Channel No.: 1



802.11g, Channel No.: 11



802.11n(HT20), Channel No.: 1



802.11n(HT20), Channel No.: 11



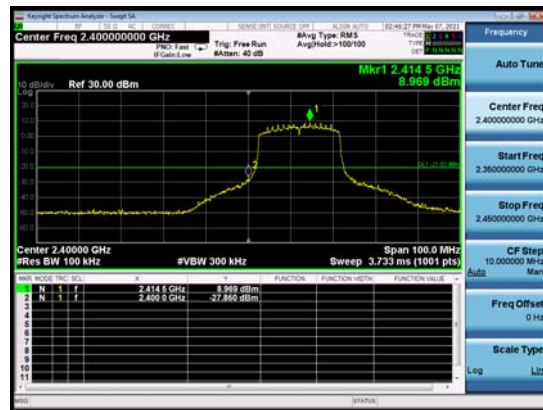
802.11n(HT40), Channel No.: 3



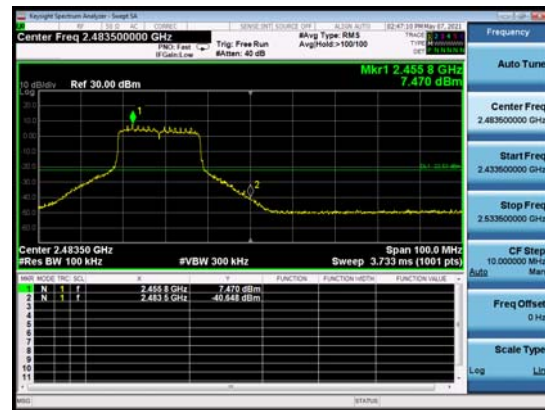
802.11n(HT40), Channel No.: 9



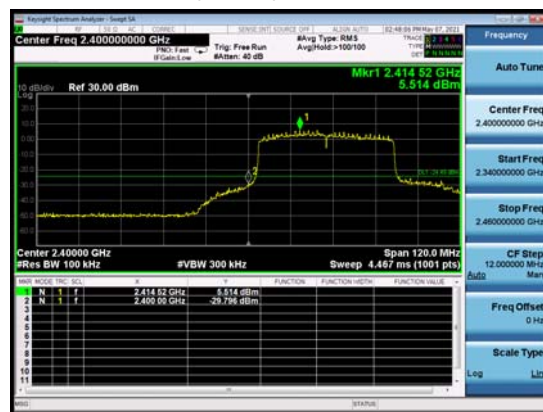
802.11ax(HE20), Channel No.: 1



802.11ax(HE20), Channel No.: 11



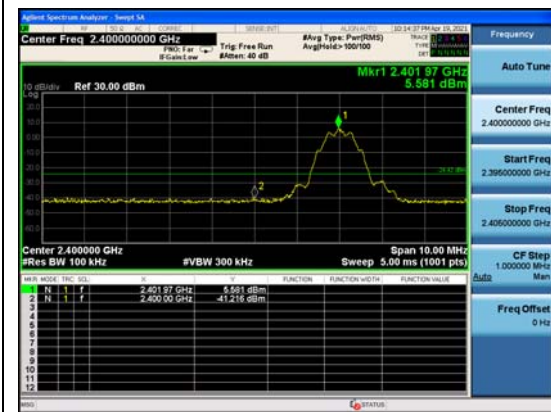
802.11ax(HE40), Channel No.: 3



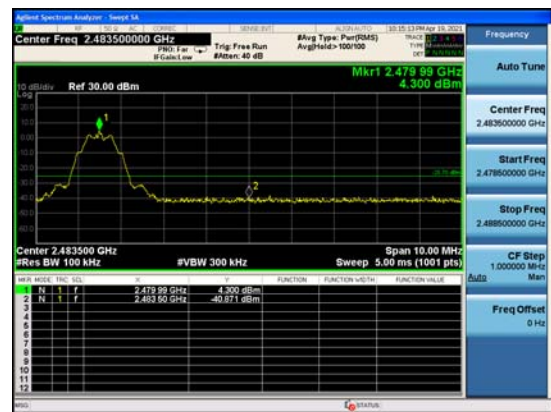
802.11ax(HE40), Channel No.: 9



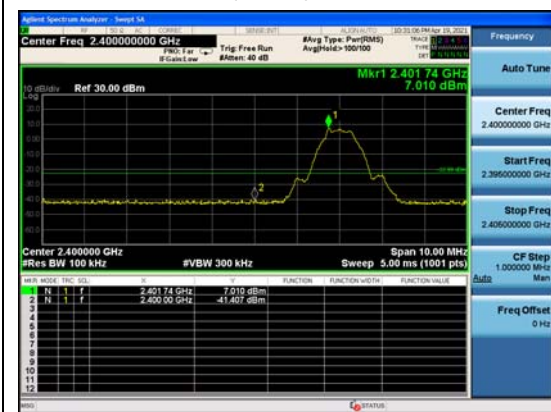
Bluetooth LE (125K), Channel No.: 0



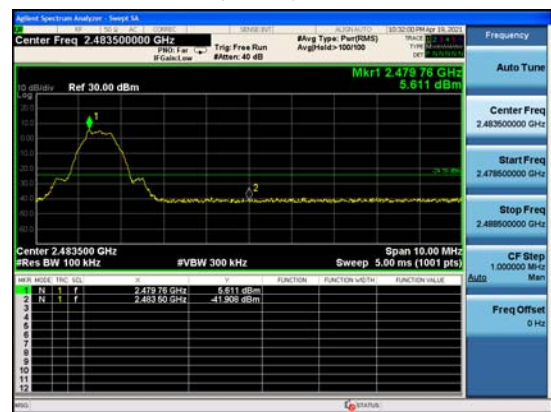
Bluetooth LE (125K), Channel No.: 39



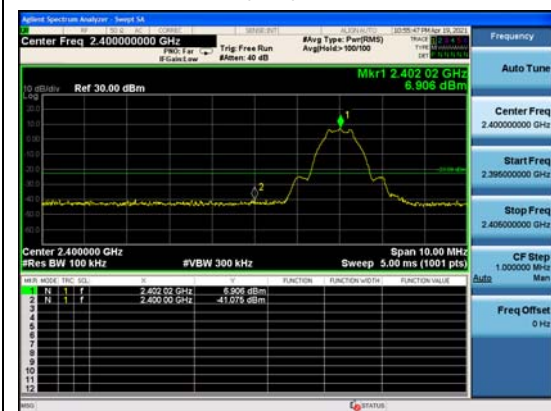
Bluetooth LE (500K), Channel No.: 0



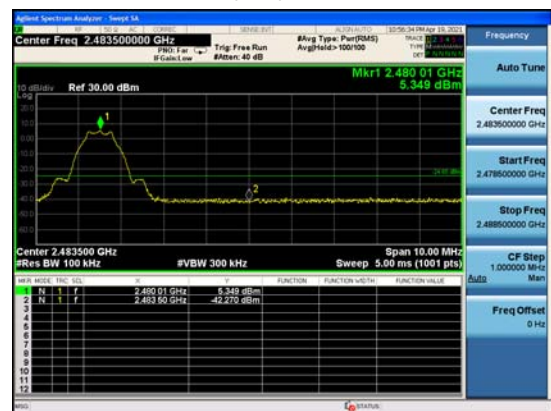
Bluetooth LE (500K), Channel No.: 39



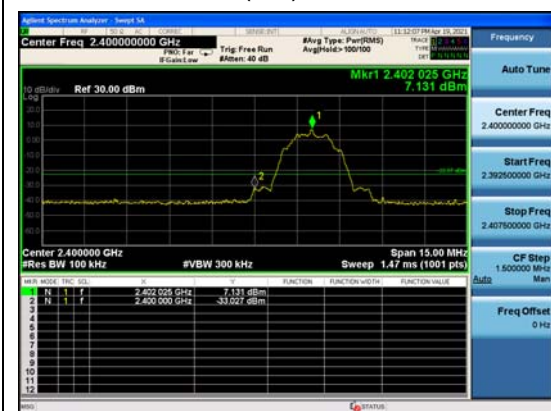
Bluetooth LE (1M), Channel No.: 0



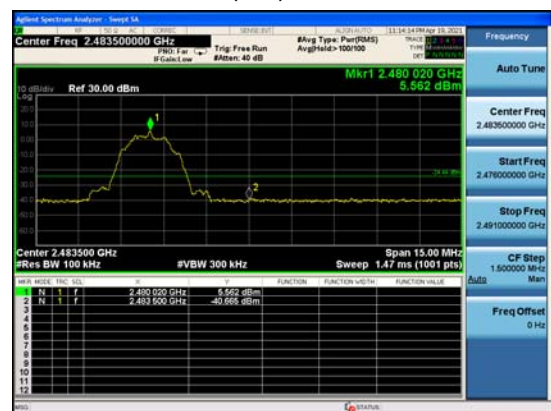
Bluetooth LE (1M), Channel No.: 39



Bluetooth LE (2M), Channel No.: 0



Bluetooth LE (2M), Channel No.: 39



5.4. Power Spectral Density

Ambient condition

Temperature	Relative humidity	Pressure
23°C ~25°C	45%~50%	101.5kPa

Method of Measurement

During the process of the testing, The EUT was connected to Spectrum Analyzer with a known loss.

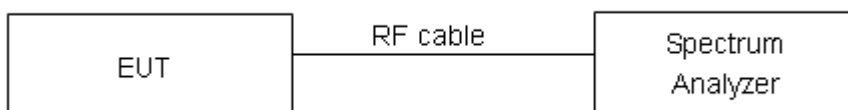
The EUT is max power transmission with proper modulation.

Method AVGPS-2 was used for this test.

- Measure the duty cycle(D)of the transmitter output signal as described in 11.6
- Set instrument center frequency to DTS channel center frequency
- Set span to at least 1.5 times the OBW
- Set RBW to: $3\text{kHz} \leq \text{RBW} \leq 100\text{Kh}$
- Set VBW $\geq [3 \times \text{RBW}]$
- Detector= power averaging(rms) or sample detector (when rms not available)
- Ensure that the number of measurement points in the sweep $2[2 \times \text{span}/\text{RBW}]$
- Sweep time =auto couple
- Do not use sweep triggering; allow sweep to "free run"
- Employ trace averaging(rms) mode over a minimum of 100 traces
- Use the peak marker function to determine the maximum amplitude level
- Add $[10 \log(1/ D)]$, where D is the duty cycle measured in step a), to the measured PSD to compute the average PSD during the actual transmission time
- If measured value exceeds requirement specified by regulatory agency then reduce RBW(but o less than 3 kHz) and repeat(note that this may require zooming in on the emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced)

The conducted Power is measured at each antenna port. The measured results at the various antenna ports are then summed mathematically.

Test setup



Limits

Rule Part 15.247(e) specifies that "For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. "

Limits	$\leq 8 \text{ dBm} / 3\text{kHz}$
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Measurement Uncertainty

The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor $k = 2$, $U = 0.75\text{dB}$.

Test Results:

Test Mode	Channel Number	Read Value (dBm / 3kHz)	Power Spectral Density (dBm / 3kHz)	Limit (dBm / 3kHz)	Conclusion
Bluetooth (Low Energy) (125K)	0	-0.52	1.57	8	PASS
	19	0.41	2.49	8	PASS
	39	-2.65	-0.57	8	PASS
Bluetooth (Low Energy) (500K)	0	-7.11	-4.64	8	PASS
	19	-6.26	-3.79	8	PASS
	39	-8.62	-6.16	8	PASS
Bluetooth (Low Energy) (1M)	0	-12.01	-9.92	8	PASS
	19	-10.78	-8.69	8	PASS
	39	-13.55	-11.46	8	PASS
Bluetooth (Low Energy) (2M)	0	-16.48	-11.58	8	PASS
	19	-15.28	-10.38	8	PASS
	39	-17.98	-13.08	8	PASS

Note: Power Spectral Density =Read Value+Duty cycle correction factor

SISO Antenna 1

Test Mode	Channel Number	Read Value (dBm / 3kHz)	Power Spectral Density (dBm / 3kHz)	Limit (dBm / 3kHz)	Conclusion
802.11b	1	-11.41	-10.88	8	PASS
	6	-12.27	-11.74	8	PASS
	11	-12.94	-12.41	8	PASS
802.11g	1	-14.25	-13.92	8	PASS
	6	-14.96	-14.63	8	PASS
	11	-15.39	-15.06	8	PASS
802.11n HT20	1	-15.42	-15.12	8	PASS
	6	-16.56	-16.26	8	PASS
	11	-17.01	-16.71	8	PASS
802.11n HT40	3	-19.28	-18.28	8	PASS
	6	-19.67	-18.68	8	PASS
	9	-19.54	-18.55	8	PASS
802.11ax HE20	1	-16.91	-16.66	8	PASS
	6	-17.30	-17.05	8	PASS
	11	-18.37	-18.12	8	PASS
802.11ax HE40	3	-21.54	-20.55	8	PASS
	6	-20.49	-19.50	8	PASS
	9	-20.61	-19.61	8	PASS

Note: Power Spectral Density =Read Value+Duty cycle correction factor

SISO Antenna 2

Test Mode	Channel Number	Read Value (dBm / 3kHz)	Power Spectral Density (dBm / 3kHz)	Limit (dBm / 3kHz)	Conclusion
802.11b	1	-11.09	-10.56	8	PASS
	6	-11.52	-10.99	8	PASS
	11	-12.96	-12.42	8	PASS
802.11g	1	-13.96	-13.63	8	PASS
	6	-15.22	-14.88	8	PASS
	11	-16.26	-15.93	8	PASS
802.11n HT20	1	-14.69	-14.39	8	PASS
	6	-15.99	-15.68	8	PASS
	11	-17.15	-16.85	8	PASS
802.11n HT40	3	-18.29	-17.30	8	PASS
	6	-19.52	-18.53	8	PASS
	9	-19.50	-18.51	8	PASS
802.11ax HE20	1	-15.40	-15.15	8	PASS
	6	-16.86	-16.61	8	PASS
	11	-17.84	-17.60	8	PASS
802.11ax HE40	3	-19.56	-18.57	8	PASS
	6	-20.56	-19.57	8	PASS
	9	-21.05	-20.06	8	PASS
Note: Power Spectral Density =Read Value+Duty cycle correction factor					

MIMO

Test Mode	Channel Number	Power Spectral Density				Total PSD	Limit (dBm / 3kHz)	Conclusion
		Antenna 1		Antenna 2				
		Read Value (dBm / 3kHz)	Power Spectral Density (dBm / 3kHz)	Read Value (dBm / 3kHz)	Power Spectral Density (dBm / 3kHz)	(dBm / 3kHz)		
802.11n HT20	1	-16.70	-16.40	-15.46	-15.16	-12.72	7.99	PASS
	6	-16.90	-16.60	-15.88	-15.58	-13.05	7.99	PASS
	11	-17.69	-17.39	-17.67	-17.37	-14.37	7.99	PASS
802.11n HT40	3	-19.23	-18.23	-18.45	-17.46	-14.82	7.99	PASS
	6	-19.89	-18.90	-19.14	-18.15	-15.49	7.99	PASS
	9	-19.33	-18.34	-19.37	-18.38	-15.35	7.99	PASS
802.11ax HE20	1	-16.47	-16.22	-15.66	-15.41	-12.79	7.99	PASS
	6	-17.75	-17.50	-16.91	-16.66	-14.05	7.99	PASS
	11	-18.22	-17.97	-18.77	-18.52	-15.22	7.99	PASS
802.11ax HE40	3	-20.79	-19.79	-19.22	-18.22	-15.93	7.99	PASS
	6	-20.37	-19.37	-20.23	-19.23	-16.29	7.99	PASS
	9	-20.62	-19.62	-20.28	-19.28	-16.44	7.99	PASS

Note: 1.Power Spectral Density =Read Value+Duty cycle correction factor
2. For Total PSD, according to KDB 662911 D01 Multiple Transmitter Output v02r01 2)a),the power spectral density= $10\log(10^{(\text{PSD antenna1 in dBm}/10)}+10^{(\text{PSD antenna2 in dBm}/10)})$
3. The manufacturer declared the transmitter output signals is CDD mode. And $N_{ss}=1$. According to KDB 662911 D01 Multiple Transmitter Output v02r01 2)f)(i): If all antennas have the same gain, Directional gain = $G_{ANT} + \text{Array Gain}$. For PSD measurements on all devices, Array Gain= $10\log(N_{ant}/N_{ss})\text{dB}$, so directional gain= $G_{ANT}+\text{Array Gain}=3+10\log(2/1)=6.01 >6\text{dBi}$. So the power limit is $8+6-\text{MAX}(6,B7)\text{dBm}=7.99 \text{ dBm}$

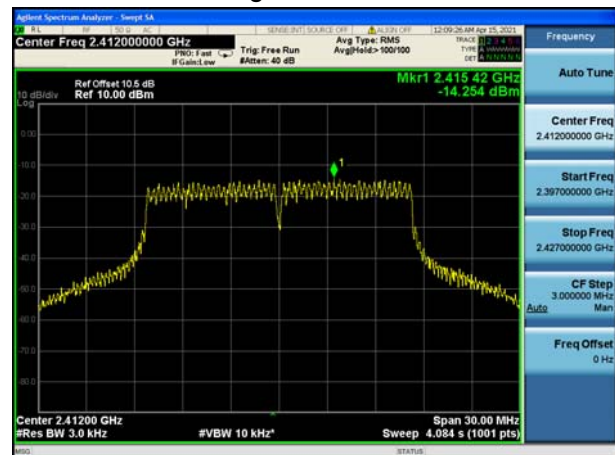


SISO Antenna 1

802.11b, Channel No.: 1



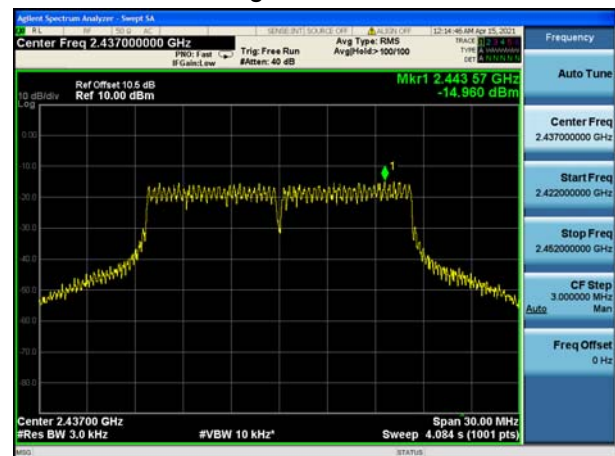
802.11g, Channel No.: 1



802.11b, Channel No.: 6



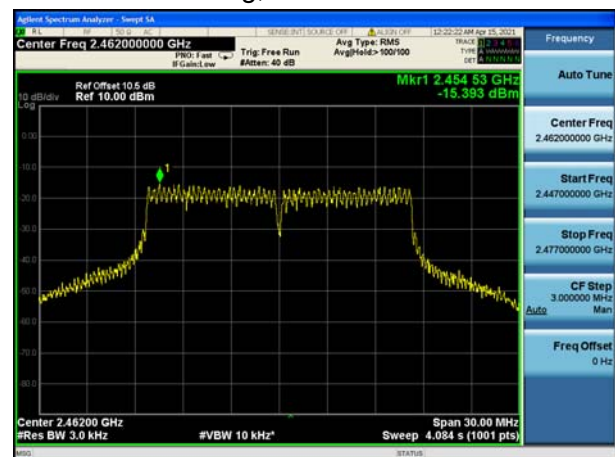
802.11g, Channel No.: 6



802.11b, Channel No.: 11



802.11g, Channel No.: 11



802.11n(HT20), Channel No. 1



802.11n(HT40), Channel No. 3



802.11n(HT20), Channel No. 6



802.11n(HT40), Channel No. 6



802.11n(HT20), Channel No. 11



802.11n(HT40), Channel No. 9



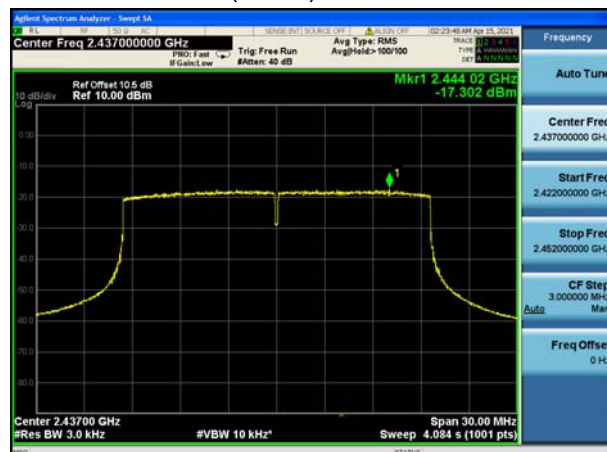
802.11ax(HE20), Channel No. 1



802.11ax(HE40), Channel No. 3



802.11ax(HE20), Channel No. 6



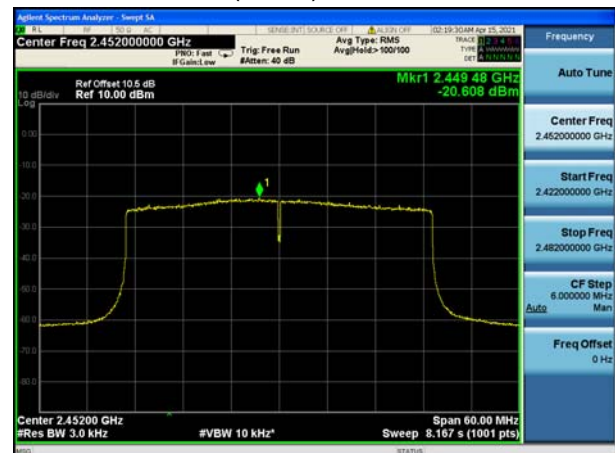
802.11ax(HE40), Channel No. 6



802.11ax(HE20), Channel No. 11



802.11ax(HE40), Channel No. 9





SISO Antenna 2

802.11b, Channel No.: 1



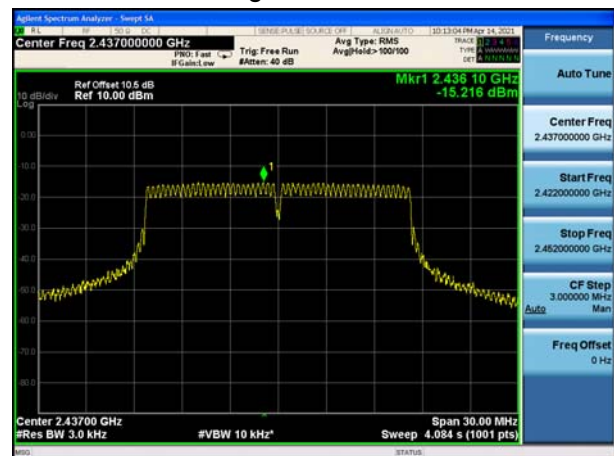
802.11g, Channel No.: 1



802.11b, Channel No.: 6



802.11g, Channel No.: 6



802.11b, Channel No.: 11



802.11g, Channel No.: 11

