



FCC/ISED - TEST REPORT

Report Number : **709502403822-00F Rev1** Date of Issue: October 31, 2024

Model : Lime-CCU23

Product Type : CCU

Applicant : Neutron Holdings, Inc.

Address : 85 2nd St, San Francisco, CA 94105 USA

Production Facility : Quectel Wireless Solutions Co., Ltd.

Address : Building 5, Shanghai Business Park Phase III (Area B), No.1016
Tianlin Road.Minhang District, Shanghai 200233, China

Test Result : ☒ **Positive** ☐ **Negative**

Total pages including
Appendices : 51



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This revised report replaced all the version issued before.



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2 Details about the Test Laboratory

Details about the Test Laboratory

Test Site 1

Company name: TÜV SÜD Certification and Testing (China) Co., Ltd. Shanghai Branch
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FCC Registration No.: 820234

FCC Designation Number: CN1183

ISED CAB identifier CN0101

IC Registration No.: 31668



3 Description of the Equipment under Test

Description of the Equipment Under Test

Product:	CCU
Model no.:	Lime-CCU23
Hardware Version Identification No. (HVIN)	Lime-CCU23
Product Marketing Name (PMN)	Lime-CCU23
FCC ID:	2APB2-LIME-CCU23
IC:	32977-LIMECCU23
Options and accessories:	NA
Rating:	DC 42V/54V
RF Transmission Frequency:	For 2.4G Wi-Fi: For 802.11b/g/n-HT20: 2412~2462 MHz For 5G Wi-Fi: 5180~5240 MHz (U-NII-1) 5260~5320 MHz (U-NII-2A) 5500~5720 MHz (U-NII-2C) 5745~5825 MHz (U-NII-3) The device shall not be capable of transmitting in the 5600-5650 MHz band. The device shall not be capable of transmitting in the 5600-5650 MHz band. For BLE (Module1): 2402~2480 MHz For EDR (Module1): 2402~2480 MHz For BLE (Module2): 2402~2480 MHz For EDR (Module2): 2402~2480 MHz
No. of Operated Channel:	For 2.4G Wi-Fi: 11 for 802.11b/802.11g/802.11n(H20) For 5G Wi-Fi:



5180~5240 MHz (U-NII-1)
5260~5320 MHz (U-NII-2A)
5500~5590, 5660~5720 MHz (U-NII-2C)
5745~5825 MHz (U-NII-3)

For BLE (Module1): 40

For EDR (Module1): 79

For BLE (Module2): 40

For EDR (Module2): 79

Modulation:

For 2.4G Wi-Fi:

Direct Sequence Spread Spectrum (DSSS) for 802.11b

Orthogonal Frequency Division Multiplexing (OFDM) for 802.11g/n

For 5G Wi-Fi:

Orthogonal Frequency Division Multiplexing (OFDM) for 802.11a/n/ac

For BLE (Module1): GFSK

For EDR (Module1): GFSK, $\pi/4$ DQPSK, 8DPSK

For BLE (Module2): GFSK

For EDR (Module2): GFSK, $\pi/4$ DQPSK, 8DPSK

Hardware Version:

EG21GGFR07A01M4G_OCPU_NCFG_QDM549_01.200.01.002

Software Version:

V1.2

Data speed:

For 2.4G Wi-Fi:

11b 1-11Mbps

11g 6-54Mbps

11n(H20) 6.5-72.2Mbps

For 5G Wi-Fi:

11a 6 ~ 54Mbps,

11n HT20 6.5 ~ 72.2Mbps,

11ac VHT20 6.5 ~ 86.7Mbps, 11ac VHT40 13.5 ~ 200Mbps,

11ac VHT80 29.3 ~ 433.3Mbps

For BLE (Module1): 1Mbps

For EDR (Module1): 1Mbps, 2Mbps, 3Mbps

For BLE (Module2): 1Mbps, 2Mbps

For EDR (Module2): 1Mbps, 2Mbps, 3Mbps

Channel list:

For 2.4G Wi-Fi:

802.11b/g/n(HT20)			
Ch	Fre(MHz)	Ch	Fre(MHz)
1	2412	7	2442
2	2417	8	2447
3	2422	9	2452
4	2427	10	2457
5	2432	11	2462
6	2437		

For 5G Wi-Fi:

Band (GHz)	Operating Channel Number	Channel center frequencies for 20MHz bandwidth (MHz)
5.15GHz~5.25GHz	36	5180
	40	5200
	44	5220
	48	5240
5.25GHz~5.35GHz	52	5260
	56	5280
	60	5300
	64	5320
5.5GHz~5.7GHz	100	5500
	104	5520
	108	5540
	112	5560
	116	5580
	132	5660
	136	5680
	140	5700
5.725GHz~5.825GHz	144	5720
	149	5745
	153	5765
	157	5785
	161	5805
	165	5825

Band (GHz)	Operating Channel Number	Channel center frequencies for 40MHz bandwidth (MHz)
5.15GHz~5.25GHz	38	5190
	46	5230
5.25GHz~5.35GHz	54	5270
	62	5310
5.5GHz~5.7GHz	102	5510



	110	5550
	118	5590
	134	5670
	142	5710
5.725GHz~5.825GHz	151	5755
	159	5795

Band (GHz)	Operating Channel Number	Channel center frequencies for 80MHz bandwidth (MHz)
5.15GHz~5.25GHz	42	5210
5.25GHz~5.35GHz	58	5290
5.5GHz~5.7GHz	106	5530
	138	5690
5.725GHz~5.825GHz	155	5775

For BLE

Ch	Fre(MHz)	Ch	Fre(MHz)	Ch	Fre(MHz)	Ch	Fre(MHz)
0	2402	10	2422	20	2442	30	2462
1	2404	11	2424	21	2444	31	2464
2	2406	12	2426	22	2446	32	2466
3	2408	13	2428	23	2448	33	2468
4	2410	14	2430	24	2450	34	2470
5	2412	15	2432	25	2452	35	2472
6	2414	16	2434	26	2454	36	2474
7	2416	17	2436	27	2456	37	2476
8	2418	18	2438	28	2458	38	2478
9	2420	19	2440	29	2460	39	2480

For EDR

Ch	Fre (MH)	Ch	Fre (MH)	Ch	Fre (MH)	Ch	Fre (MH)	Ch	Fre (MHz)
1	2402	17	2418	33	2434	49	2450	65	2466
2	2403	18	2419	34	2435	50	2451	66	2467
3	2404	19	2420	35	2436	51	2452	67	2468
4	2405	20	2421	36	2437	52	2453	68	2469
5	2406	21	2422	37	2438	53	2454	69	2470
6	2407	22	2423	38	2439	54	2455	70	2471
7	2408	23	2424	39	2440	55	2456	71	2472
8	2409	24	2425	40	2441	56	2457	72	2473
9	2410	25	2426	41	2442	57	2458	73	2474
10	2411	26	2427	42	2443	58	2459	74	2475
11	2412	27	2428	43	2444	59	2460	75	2476
12	2413	28	2429	44	2445	60	2461	76	2477
13	2414	29	2430	45	2446	61	2462	77	2478
14	2415	30	2431	46	2447	62	2463	78	2479
15	2416	31	2432	47	2448	63	2464	79	2480



16	2417	32	2433	48	2449	64	2465		
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Antenna Type: For 2.4G Wi-Fi: FPC
For 5G Wi-Fi: FPC
For BLE (Module1): FPC
For EDR (Module1): FPC
For BLE (Module2): FPC
For EDR (Module2): FPC

Antenna Gain: For 2.4G Wi-Fi: 1.96 dBi
For 5G Wi-Fi: 3.52 dBi
For BLE (Module1): 1.96 dBi
For EDR (Module1): 1.96 dBi
For BLE (Module2): 3.16 dBi
For EDR (Module2): 3.16 dBi

Description of the EUT: The Equipment Under Test (EUT) is a CCU with Wi-Fi Module, BLE/EDR Module1, BLE/EDR Module2 and LTE Module. The EUT support Wi-Fi operated at 2.4GHz and 5GHz, BLE Module1 operated 1Mbps and BLE Module2 operated 1Mbps and 2Mbps.

Test sample no.: SHA-843416-2 (Radiated sample)
SHA-843416-3 (Conducted sample)

The sample's mentioned in this report is/are submitted/ supplied/ manufactured by client. The laboratory therefore assumes no responsibility for accuracy of information on the brand name, model number, origin of manufacture, consignment, antenna gain or any information supplied.



4 Summary of Test Standards

Test Standards	
FCC Part 15 Subpart C 10-1-2023 Edition	PART 15 - RADIO FREQUENCY DEVICES Subpart C - Intentional Radiators
RSS-Gen Issue 5 April 2018 + Amendment 1 March 2019 + Amendment 2 February 2021	General Requirements for Compliance of Radio Apparatus
RSS-247 Issue 3 August 2023	Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSS) and License-Exempt Local Area Network (LE-LAN) Devices

All the test methods were according to KDB 558074 D01 15.247 Measurement Guidance v05r02 and ANSI C63.10-2013.



5 Summary of Test Results

Technical Requirements							
FCC Part 15 Subpart C & RSS-247 Issue 3/RSS-Gen Issue 5							
Test Condition			Pages	Test Site	Test Result		
					Pass	Fail	N/A
§15.207	RSS-GEN 8.8	Conducted emission AC power port	---	Site 1	☒	☐	☐
§15.247 (b) (3)	RSS-247 5.4(d)	Conducted peak output power	17-18	Site 1	☒	☐	☐
	RSS-247 5.4(d)	Equivalent Isotropic Radiated Power	17-18	Site 1	☒	☐	☐
§15.247(a)(1)	RSS-247 5.1(a) & RSS-Gen 6.7	20dB bandwidth and 99% Occupied Bandwidth	---	---	☐	☐	☒
§15.247(a)(1)	RSS-247 5.1(b)	Carrier frequency separation	---	---	☐	☐	☒
§15.247(a)(1)(iii)	RSS-247 5.1(d)	Number of hopping frequencies	---	---	☐	☐	☒
§15.247(a)(1)(iii)	RSS-247 5.1(d)	Dwell Time - Average Time of Occupancy	---	---	☐	☐	☒
§15.247(a)(2)	RSS-247 5.2(a) & RSS-GEN 6.7	6dB bandwidth and 99% Occupied Bandwidth	19-21	Site 1	☒	☐	☐
§15.247(e)	RSS-247 5.2(b)	Power spectral density	22-23	Site 1	☒	☐	☐
§15.247(d)	RSS-247 5.5	Spurious RF conducted emissions	24-27	Site 1	☒	☐	☐
§15.247(d)	RSS-247 5.5	Band edge	28-30	Site 1	☒	☐	☐
§15.247(d) & §15.209 & §15.205	RSS-247 5.5 & RSS-Gen 6.13	Spurious radiated emissions for transmitter	31-37	Site 1	☒	☐	☐
§15.203	RSS-Gen 6.8	Antenna requirement	See note 1		☒	☐	☐

Remark 1: N/A – Not Applicable.

Remark 2: The EUT only operation at 2.4G Wi-Fi and 5G Wi-Fi UNII Band (5180MHz-5240MHz, 5260~5320 MHz, 5500~5720 MHz, 5745MHz-5825MHz).

Note 1: The EUT uses a FPC antenna, which gain is 1.96 dBi for 2.4GWi-Fi, 3.52 dBi for 5GWi-Fi. In accordance to §15.203 and RSS-Gen 6.8, It is considered sufficiently to comply with the provisions of this section.



15.203 requirement: An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator, the manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. 15.247(c) (1)(i) requirement: (i) Systems operating in the 2400-2483.5 MHz band that is used exclusively for fixed. Point-to-point operations may employ transmitting antennas with directional gain greater than 6dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6dBi



6 General Remarks

Remarks

This submittal(s) (test report) is intended for FCC ID: 2APB2-LIME-CCU23, IC: 32977-LIMECCU23 complies with Section 15.207, 15.209, 15.247 of the FCC Part 15, Subpart C Rules and RSS-247, RSS-GEN.

This report is only for BLE (Module2) test report, for the 5GHz Wi-Fi test report please refer to 709502403822-00A, for the 2.4GHz Wi-Fi test report please refer to 709502403822-00C, for the BLE (Module2) test report please refer to 709502403822-00D, for the EDR (Module1) test report please refer to 709502403822-00E, for the EDR (Module2) test report please refer to 709502403822-00G.

We tested it and listed the worst data in this report.

SUMMARY:

All tests according to the regulations cited on page 10 were

■ - Performed

□ - **Not** Performed

The Equipment under Test

■ - **Fulfills** the general approval requirements.

□ - **Does not** fulfill the general approval requirements.

Sample Received Date: September 9, 2024

Testing Start Date: September 12, 2024

Testing End Date: September 20, 2024

- TÜV SÜD Certification and Testing (China) Co., Ltd. Shanghai Branch

Reviewed by:

Prepared by:

Tested by:



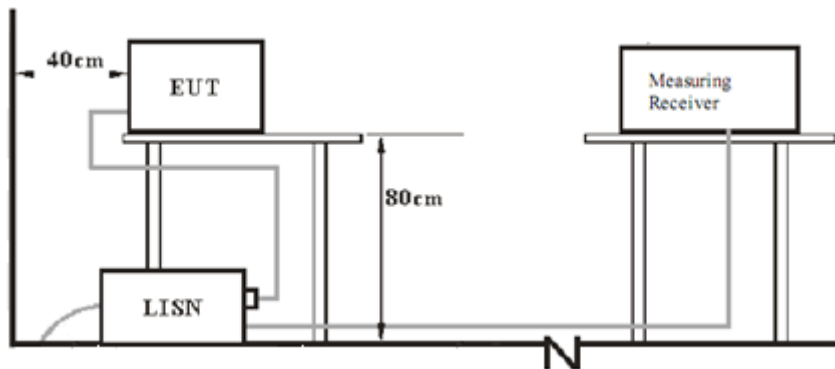
Hui TONG
Review Engineer

Wenqiang LU
Project Engineer

Chengjie GUO
Test Engineer

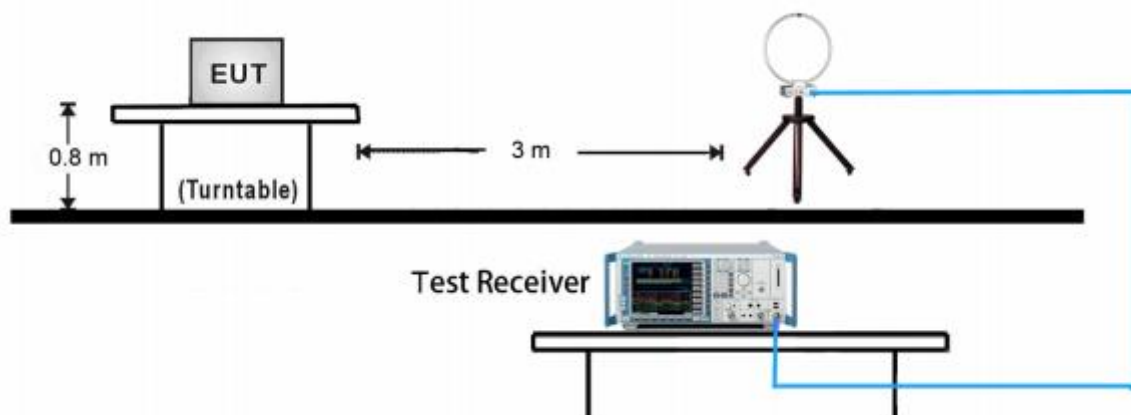
7 Test Setups

7.1 AC Power Line Conducted Emission test setups

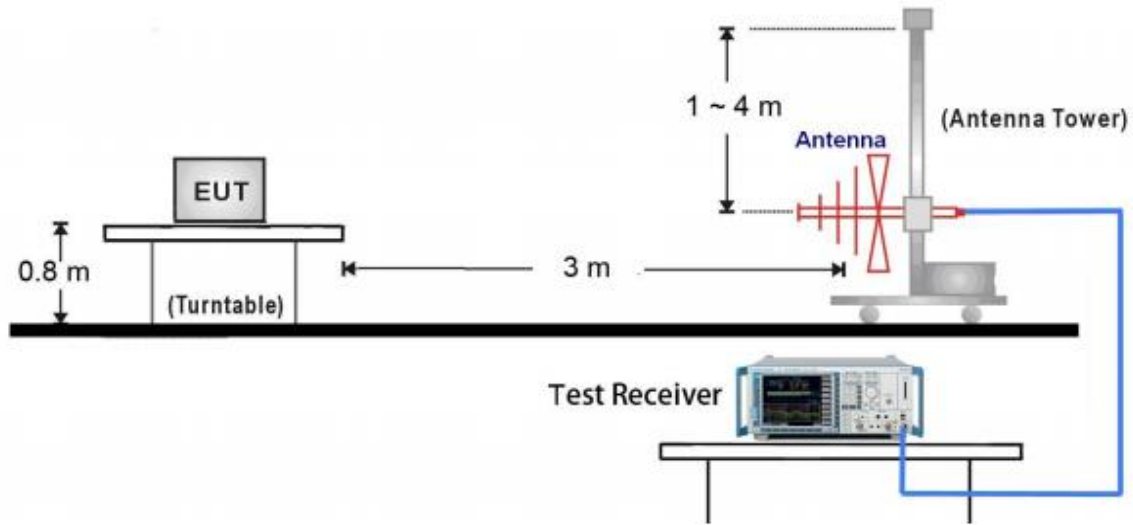


7.2 Radiated test setups

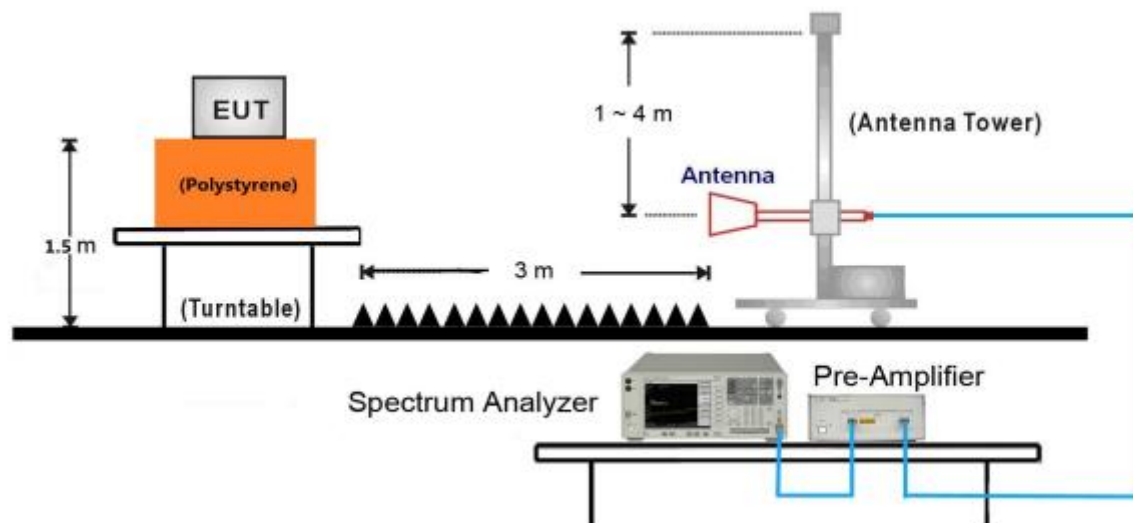
9kHz ~ 30MHz Test Setup:



30MHz ~ 1GHz Test Setup:

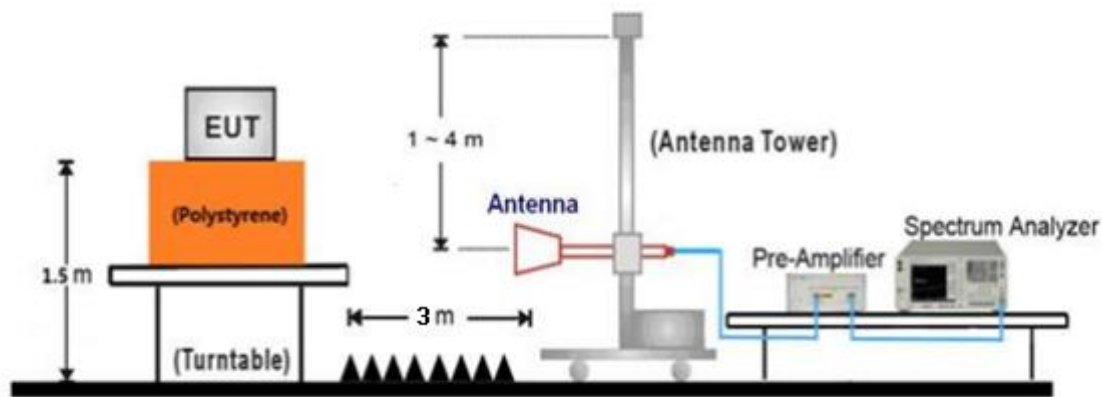


1GHz ~ 18GHz Test Setup:

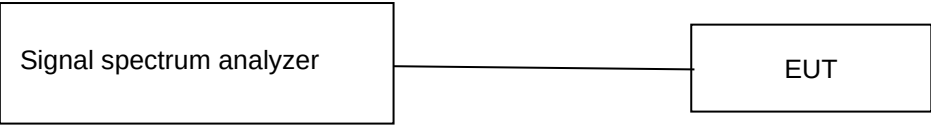




18GHz ~ 25GHz Test Setup:



7.3 Conducted RF test setups





8 Systems test configuration

Auxiliary Equipment Used during Test:

DESCRIPTION	MANUFACTURER	MODEL NO.(SHIELD)	S/N(LENGTH)
Notebook	Lenove	E470	PF-OU5TS7 17/09

Test software: SecureCRT.exe, which used to control the EUT in continues transmitting mode.

The system was configured to channel 0, 19, and 39 for the test.

Test Mode Applicability and Tested Channel Detail:

Mode	Tested Channel	Data Rate (Mbps)	Modulation	Index Value (Power level setting)
Bluetooth LE	0	1	GFSK	8
	19	1	GFSK	8
	39	1	GFSK	8

Mode	Tested Channel	Data Rate (Mbps)	Modulation	Index Value (Power level setting)
Bluetooth LE	0	2	GFSK	8
	19	2	GFSK	8
	39	2	GFSK	8

9 Technical Requirement

9.1 Conducted peak output power & EIRP

Test Method

1. Use the following spectrum analyzer settings:
RBW > the 6 dB bandwidth of the emission being measured, VBW $\geq$ 3RBW, Span $\geq$ 3RBW
Sweep = auto, Detector function = peak, Trace = max hold.
2. Add a correction factor to the display.
3. Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission. The indicated level is the peak output power.

Limits

According to §15.247 (b) (3) & RSS-247 5.4(d), conducted peak output power limit as below:

	Frequency Range	Limit	Limit
	MHz	W	dBm
Conducted peak output power	2400-2483.5	≤ 1	≤ 30
e.i.r.p.	2400-2483.5	≤ 4	≤ 36

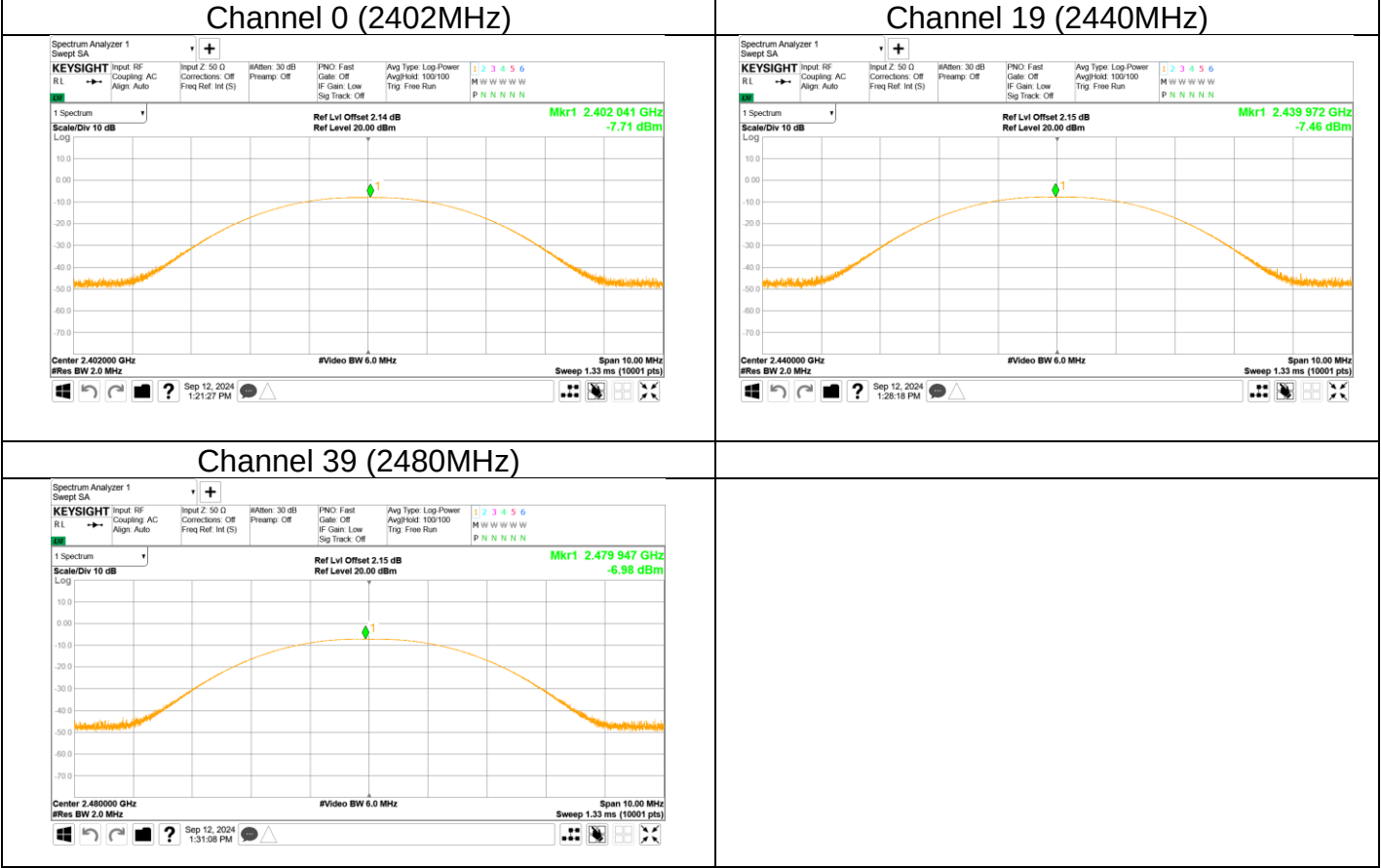
Test result as below table

Data transmission rate:1Mbps			
Frequency	Conducted Peak	E.I.R.P	Result
MHz	Output Power	dBm	
	dBm		
Low channel 2402MHz	-7.71	-4.55	Pass
Middle channel 2440MHz	-7.46	-4.3	Pass
High channel 2480MHz	-6.98	-3.82	Pass

Data transmission rate:2Mbps			
Frequency	Conducted Peak	E.I.R.P	Result
MHz	Output Power	dBm	
	dBm		
Low channel 2402MHz	-7.84	-4.68	Pass
Middle channel 2440MHz	-7.54	-4.38	Pass
High channel 2480MHz	-7.12	-3.96	Pass



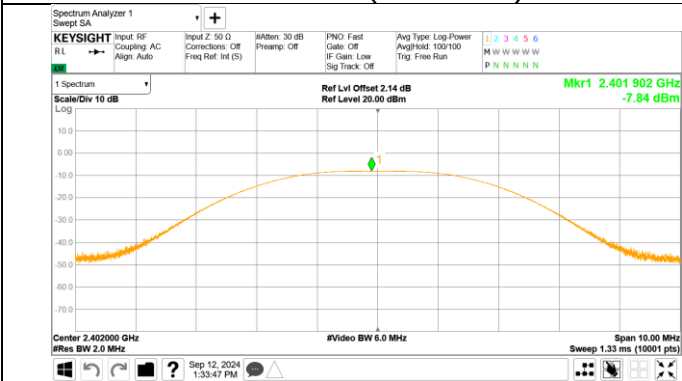
Peak output power (1Mbps)



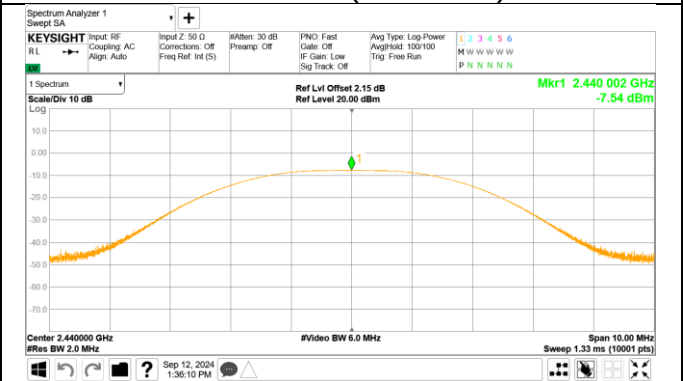


Peak output power (2Mbps)

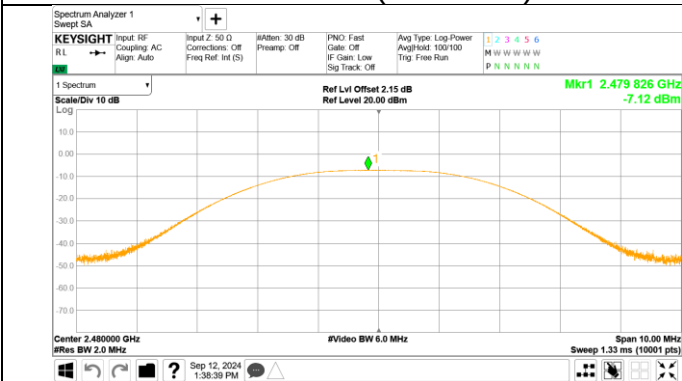
Channel 0 (2402MHz)



Channel 19 (2440MHz)



Channel 39 (2480MHz)





9.2 6dB bandwidth and 99% Occupied Bandwidth

Test Method for 6 dB Bandwidth

1. The RF output of EUT was connected to the spectrum analyzer. The path loss was compensated to the results for each measurement.
2. Set to the maximum power setting, the instrument center frequency is set to the nominal EUT channel center frequency enable the EUT transmit continuously.
3. Use the following spectrum analyzer settings:
RBW=100KHz, VBW $\geq$ 3RBW, Sweep = auto, Detector function = peak, Trace = max hold
4. Use the automatic bandwidth measurement capability of an instrument, use the X dB bandwidth mode with X set to 6 dB.
5. Allow the trace to stabilize, record the 6 dB Bandwidth value.

Test Method for 99 % Bandwidth

1. Connect EUT test port to spectrum analyzer.
Use the following spectrum analyzer settings:
RBW=1% to 5% of the actual occupied, VBW $\geq$ 3RBW, Sweep = auto,
Detector function = peak, Trace = max hold
2. Use the occupied bandwidth measurement capability of test receiver.
3. Allow the trace to stabilize, record the occupied bandwidth value.

Limit

According to §15.247(a)(2), 6dB bandwidth limit as below:

6dB bandwidth Limit [kHz]	99% bandwidth Limit [kHz]
≥ 500	--

Test result

Data transmission rate:1Mbps			
Frequency MHz	6dB bandwidth kHz	99% Bandwidth kHz	Result
Top channel 2402MHz	706	1056	Pass
Middle channel 2440MHz	699	1059	Pass
Bottom channel 2480MHz	713	1056	Pass

Data transmission rate:2Mbps			
Frequency MHz	6dB bandwidth kHz	99% Bandwidth kHz	Result
Top channel 2402MHz	1386	2074	Pass
Middle channel 2440MHz	1366	2084	Pass
Bottom channel 2480MHz	1382	2077	Pass



6dB Bandwidth







99% Occupied Bandwidth







9.3 Power spectral density

Test Method

This procedure shall be used if maximum peak conducted output power was used to demonstrate compliance:

1. The RF output of EUT was connected to the spectrum analyzer. The path loss was compensated to the results for each measurement.
2. Set to the maximum power setting, the instrument center frequency is set to the nominal EUT channel center frequency enable the EUT transmit continuously.
3. Use the following spectrum analyzer settings:
4. Set analyzer center frequency to DTS channel center frequency. RBW=3kHz, VBW≥3RBW, Span=1.5 times DTS bandwidth, Detector=Peak, Sweep=auto, Trace= max hold.
5. Allow trace to fully stabilize, use the peak marker function to determine the maximum amplitude level within the RBW.
6. Repeat above procedures until other frequencies measured were completed.

Limit

Limit [dBm/3KHz]
≤8

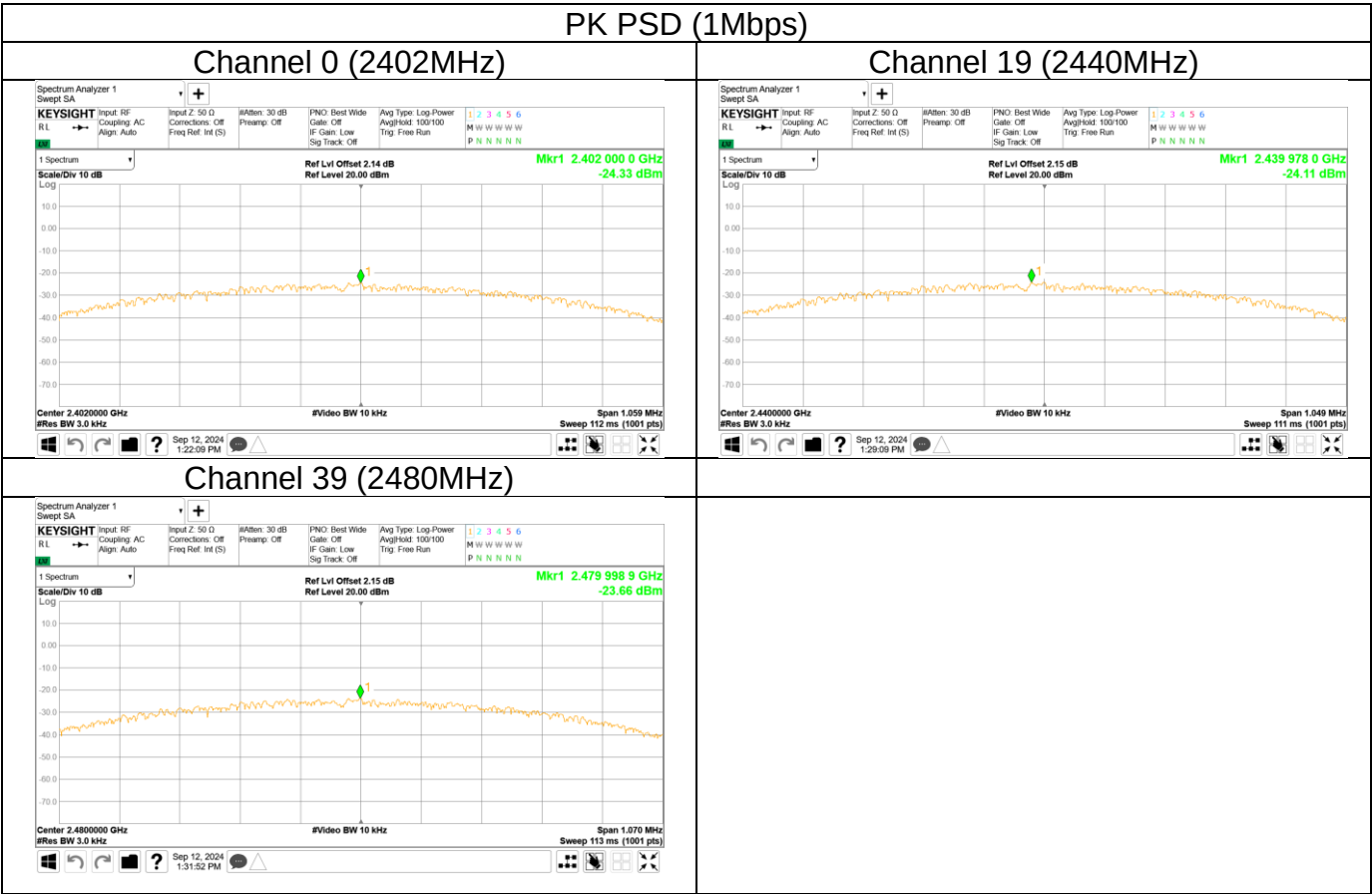
Test result

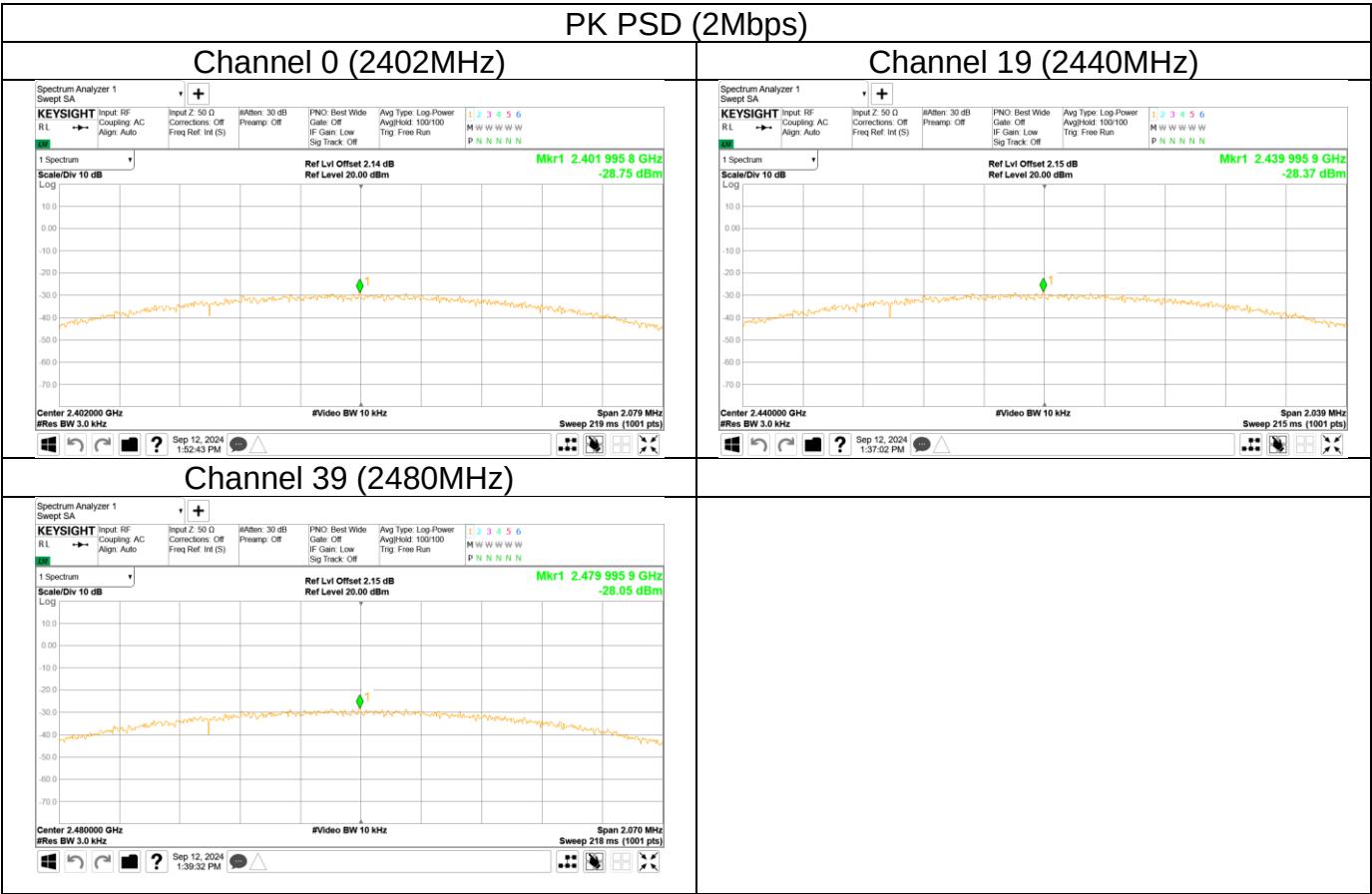
Data transmission rate:1Mbps

Frequency MHz	Power spectral density dBm/3kHz	Result
Top channel 2402MHz	-24.33	Pass
Middle channel 2440MHz	-24.11	Pass
Bottom channel 2480MHz	-23.66	Pass

Data transmission rate:2Mbps

Frequency MHz	Power spectral density dBm/3kHz	Result
Top channel 2402MHz	-28.75	Pass
Middle channel 2440MHz	-28.37	Pass
Bottom channel 2480MHz	-28.05	Pass







9.4 Spurious RF conducted emissions

Test Method

1. The RF output of EUT was connected to the spectrum analyzer by RF cable. The path loss was compensated to the results for each measurement.
2. Set to the maximum power setting, the instrument center frequency is set to the nominal EUT channel center frequency enable the EUT transmit continuously.
3. Use the following spectrum analyzer settings:
Span = wide enough to capture the peak level of the in-band emission and all spurious emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the 10th harmonic. Typically, several plots are required to cover this entire span.
RBW = 100 kHz, VBW $\geq$ 3RBW, Sweep = auto, Detector function = peak, Trace = max hold
4. Allow the trace to stabilize. Set the marker on the peak of any spurious emission recorded.
5. The level displayed must comply with the limit specified in this Section. Submit these plots.
6. Repeat above procedures until all frequencies measured were complete.

Limit

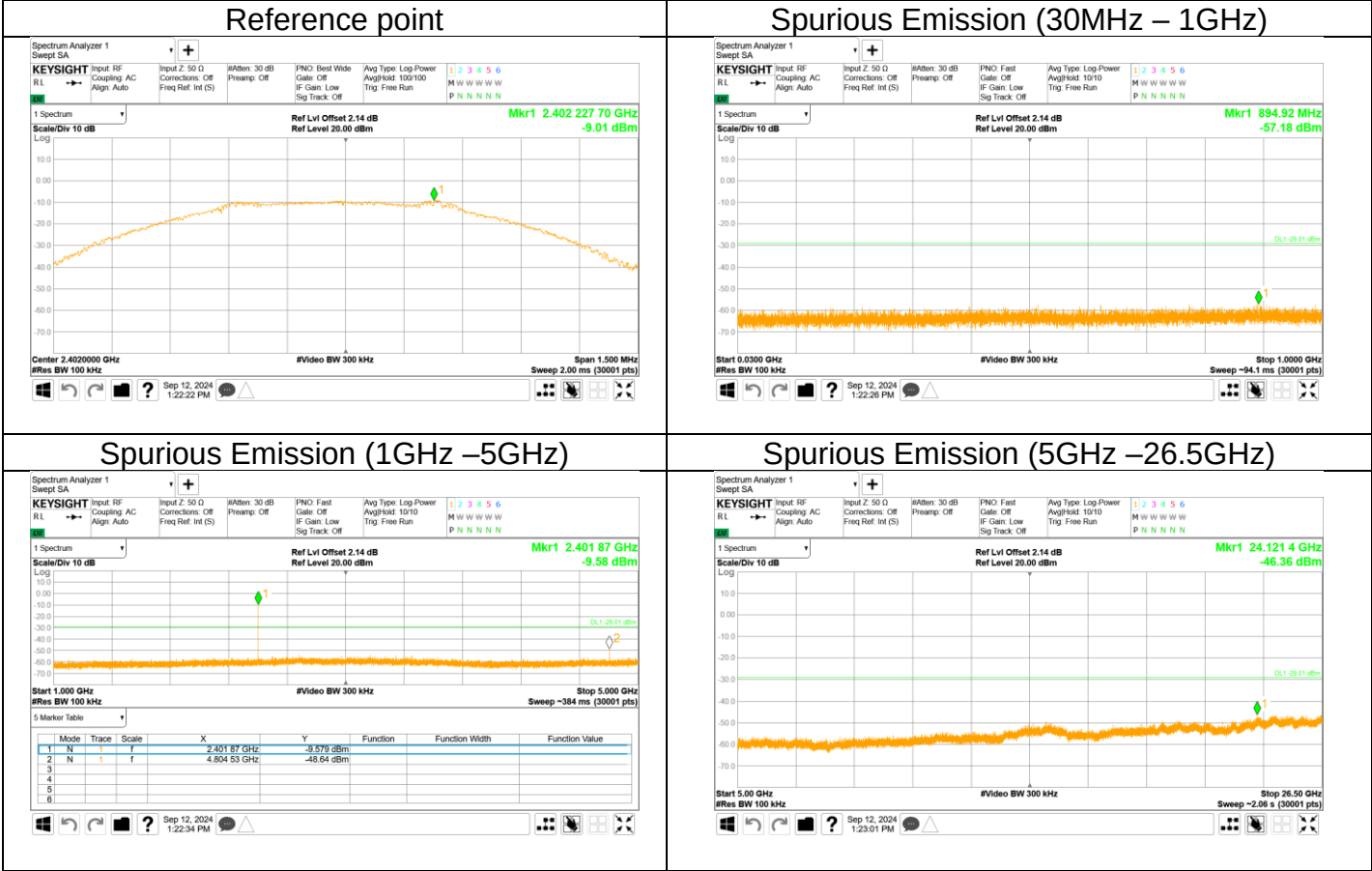
According to §15.247(d), spurious RF conducted emissions limit as below:

Frequency Range MHz	Limit (dBc)
30-25000	-20



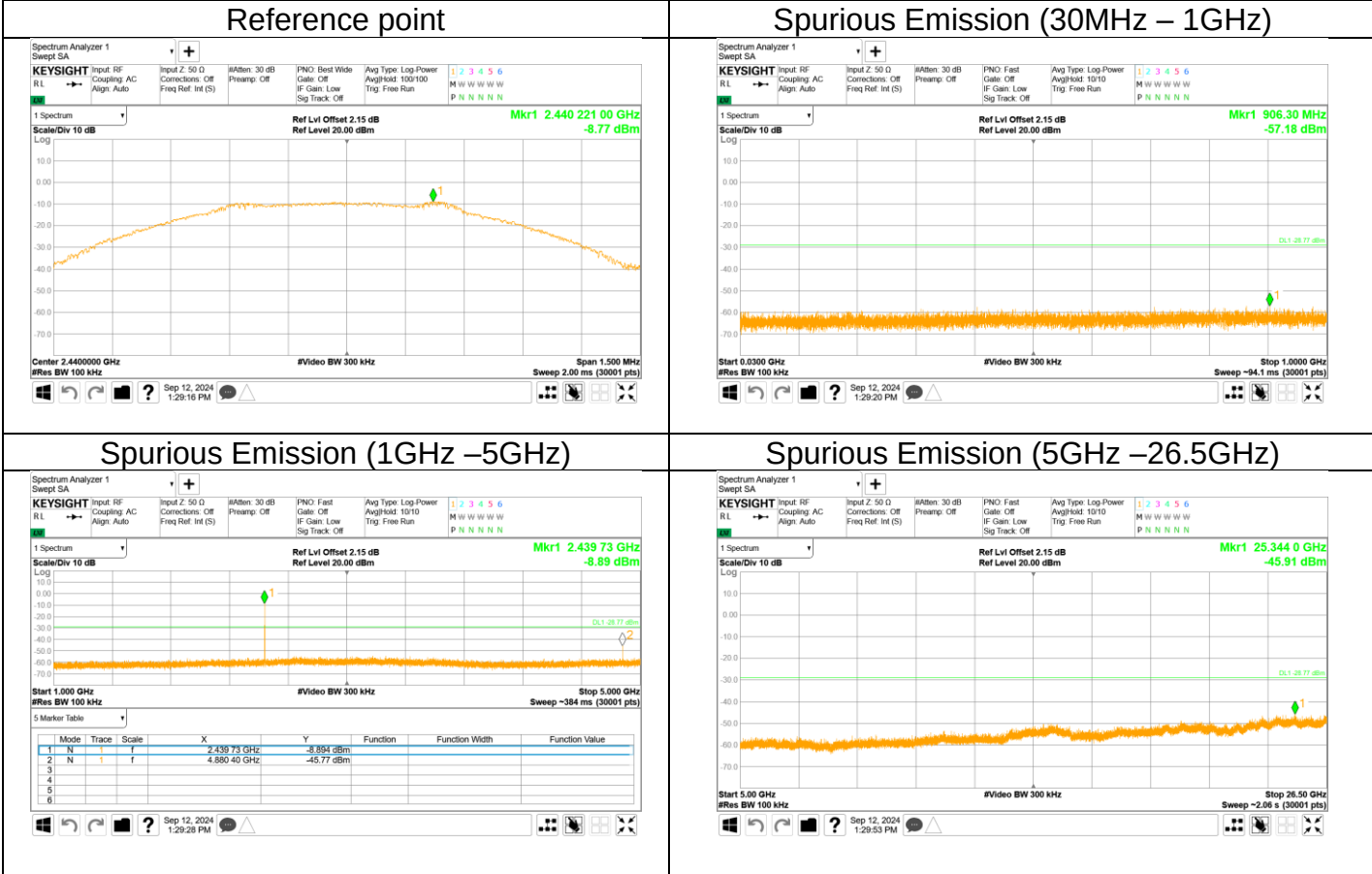
Spurious RF conducted emissions

Out-of-Band Emissions (1Mbps)
Channel 0 (2402MHz)





Out-of-Band Emissions (1Mbps)
Channel 19 (2440MHz)

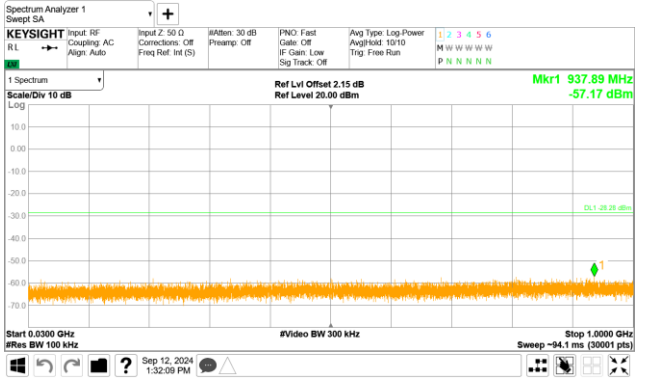
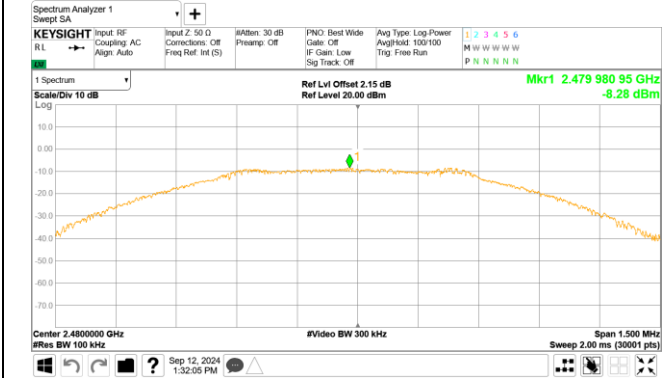




Out-of-Band Emissions (1Mbps)
Channel 39 (2480MHz)

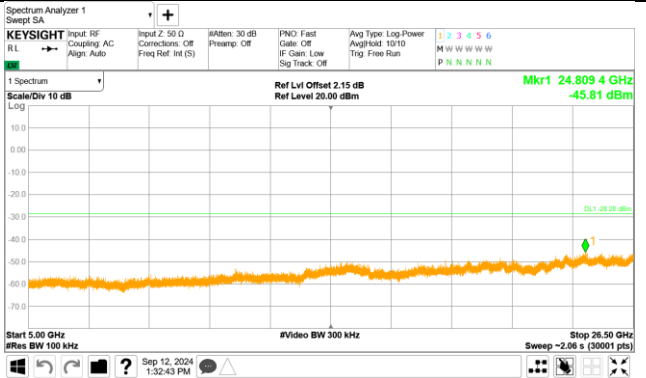
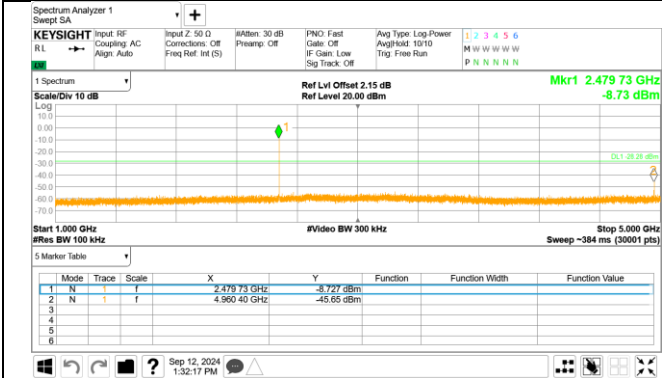
Reference point

Spurious Emission (30MHz – 1GHz)



Spurious Emission (1GHz – 5GHz)

Spurious Emission (5GHz – 26.5GHz)



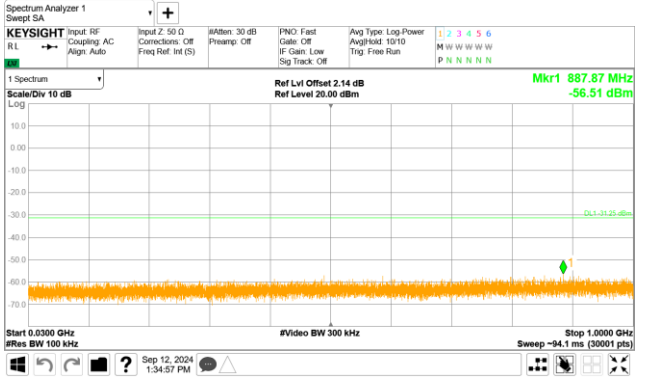
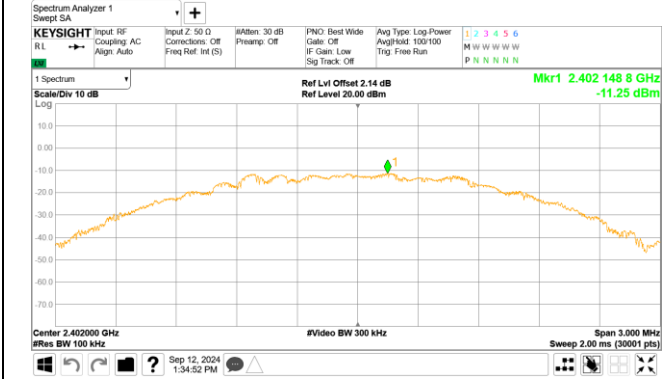


Out-of-Band Emissions (2Mbps)

Channel 0 (2402MHz)

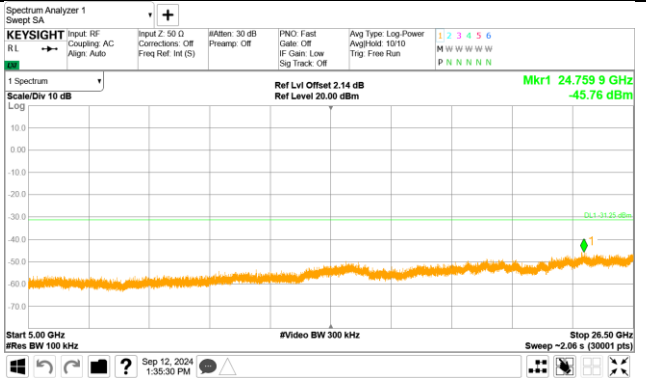
Reference point

Spurious Emission (30MHz – 1GHz)

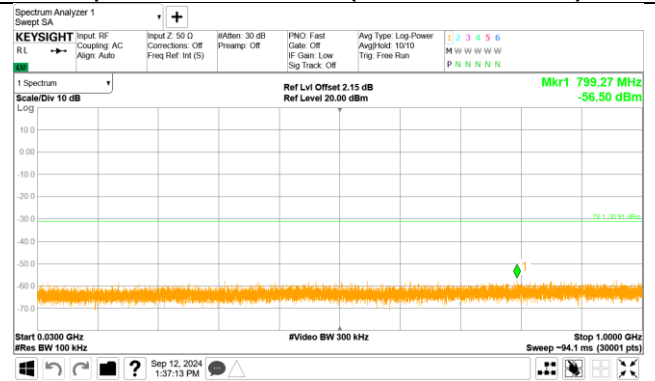


Spurious Emission (1GHz –5GHz)

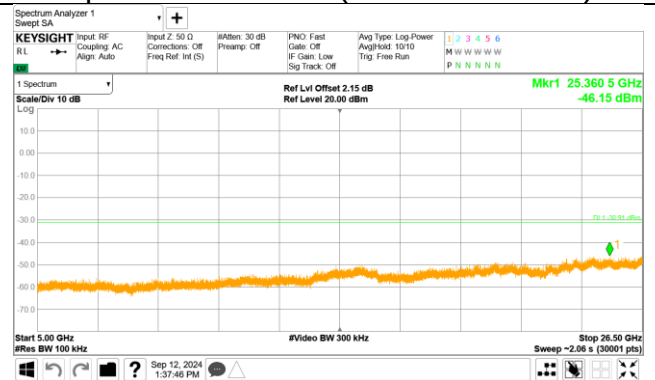
Spurious Emission (5GHz –26.5GHz)



Spurious Emission (30MHz – 1GHz)



Spurious Emission (5GHz –26.5GHz)





Out-of-Band Emissions (2Mbps)
Channel 39 (2480MHz)

