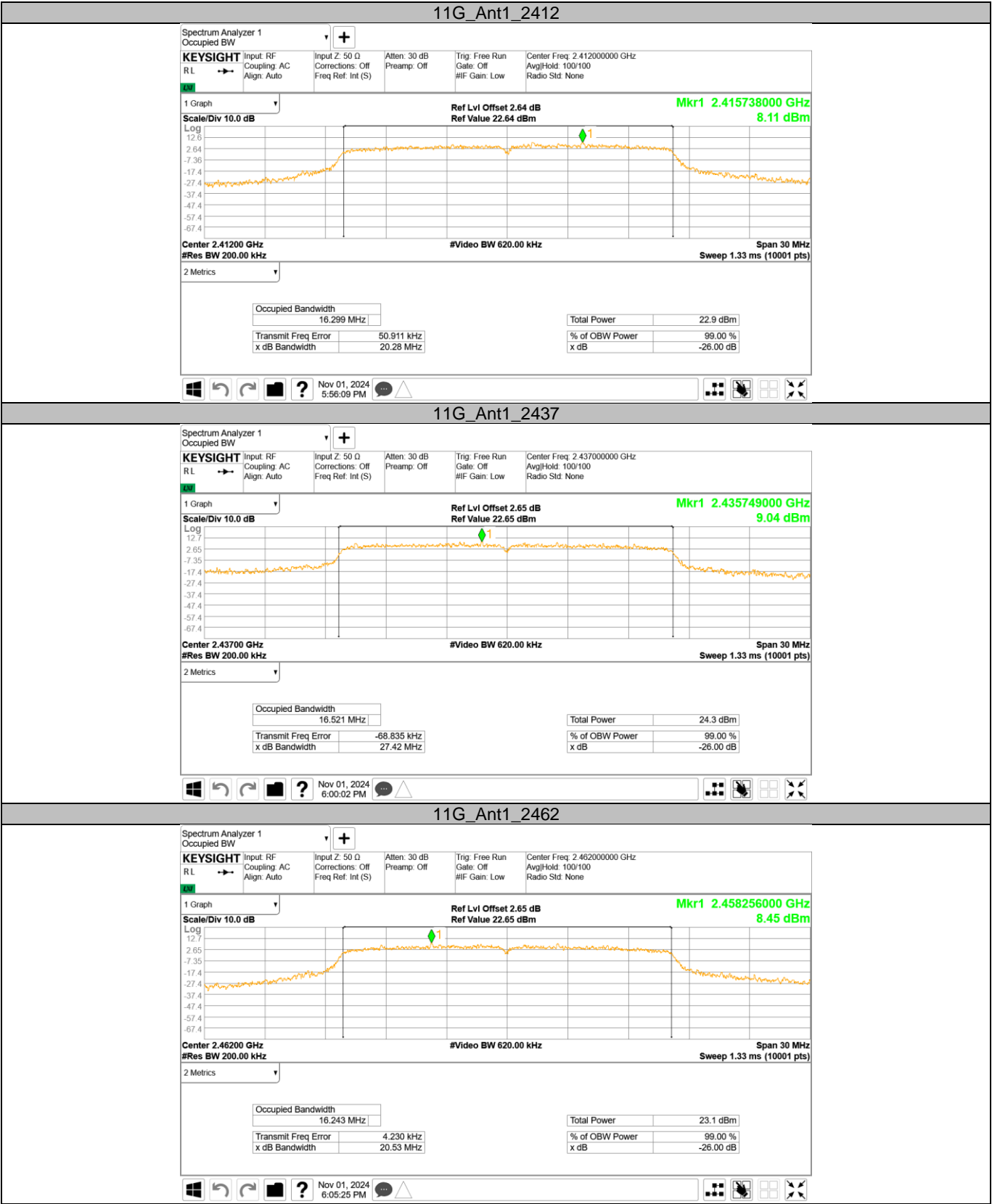






99% Occupied Bandwidth









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 \geq 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
802.11 B

Frequency MHz	Power spectral density dBm/3kHz	Result
Low channel 2412MHz	-8.81	Pass
Middle channel 2437MHz	4.47	Pass
High channel 2462MHz	-5.25	Pass

802.11 G

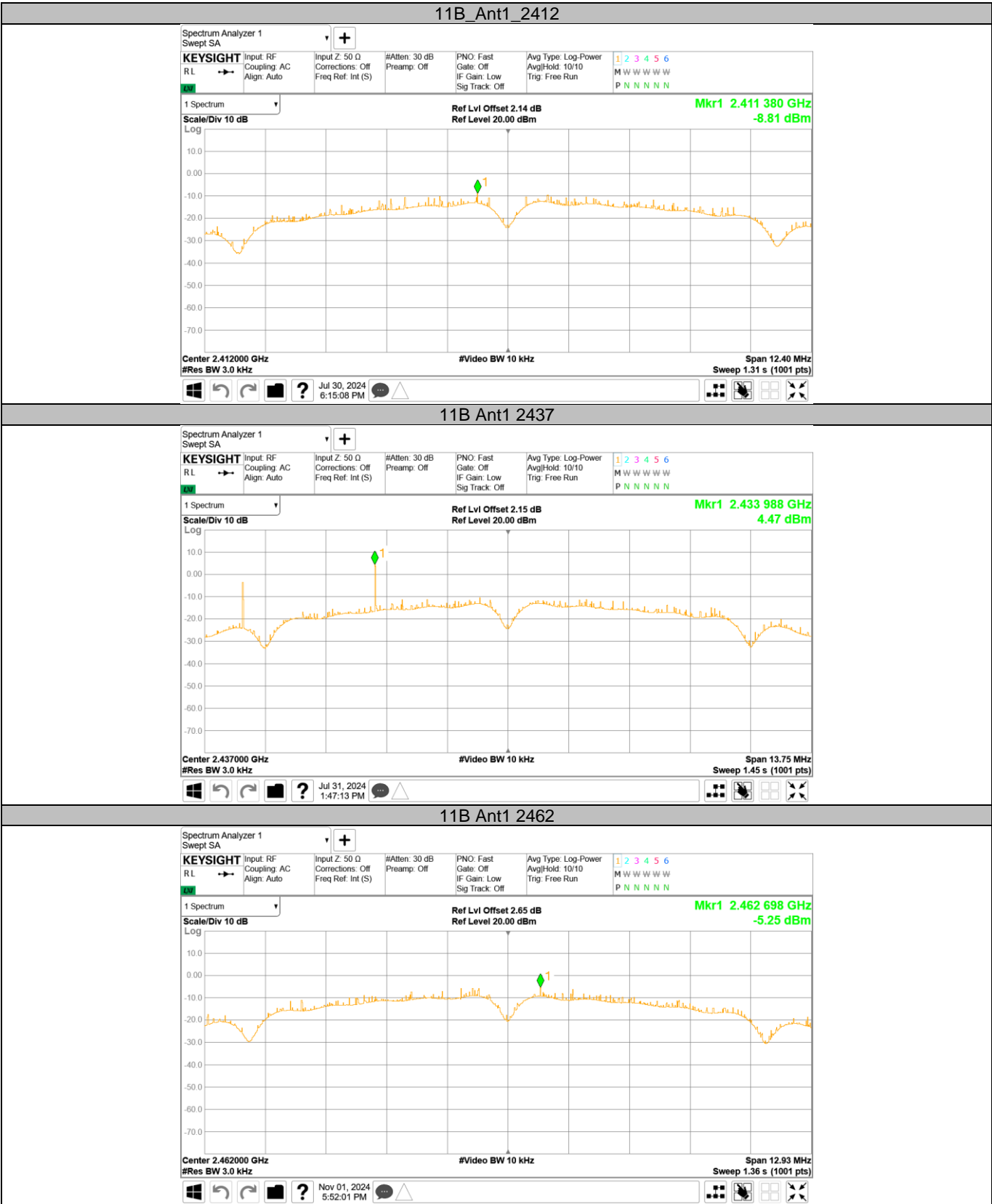
Frequency MHz	Power spectral density dBm/3kHz	Result
Low channel 2412MHz	-9.53	Pass
Middle channel 2437MHz	-7.09	Pass
High channel 2462MHz	-8.76	Pass

802.11 N20

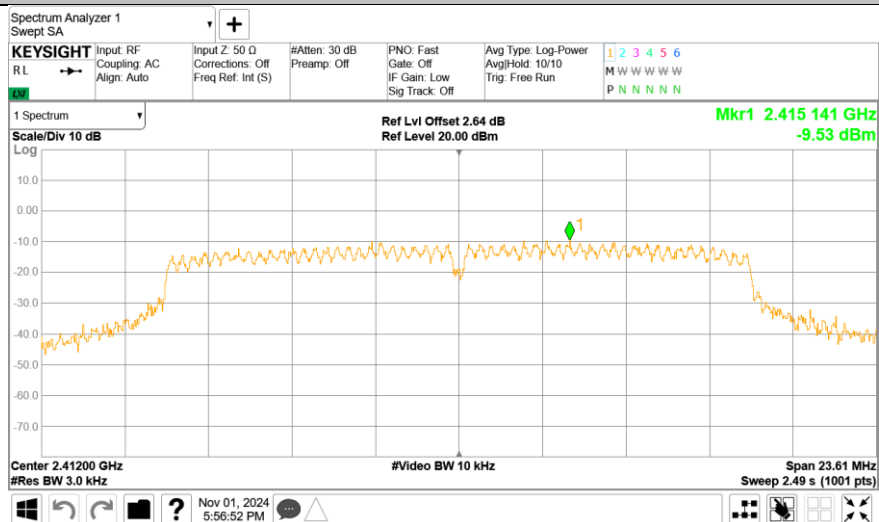
Frequency MHz	Power spectral density dBm/3kHz	Result
Low channel 2412MHz	-11.07	Pass
Middle channel 2437MHz	-8.68	Pass
High channel 2462MHz	-9.32	Pass



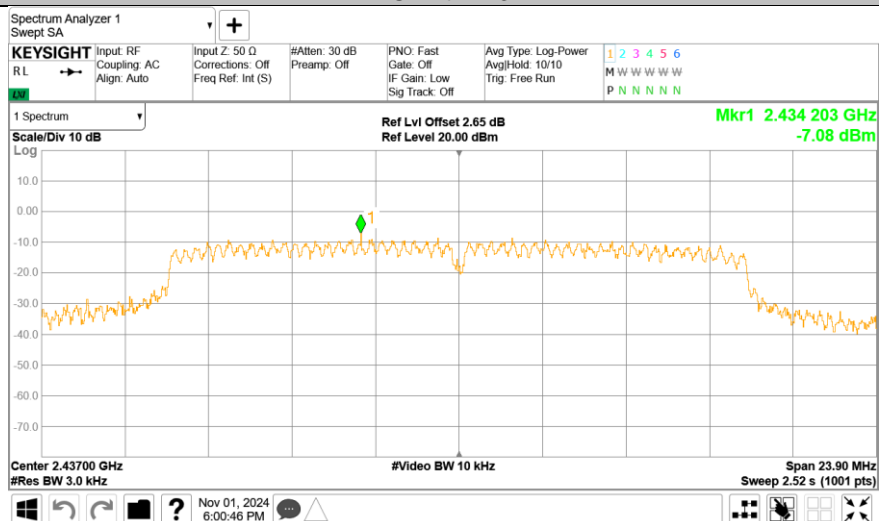
Power spectral density



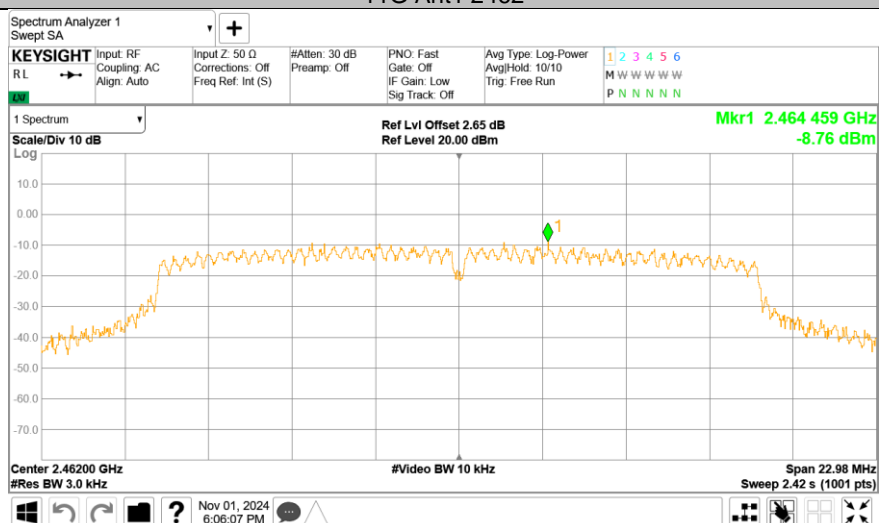
11G Ant1 2412

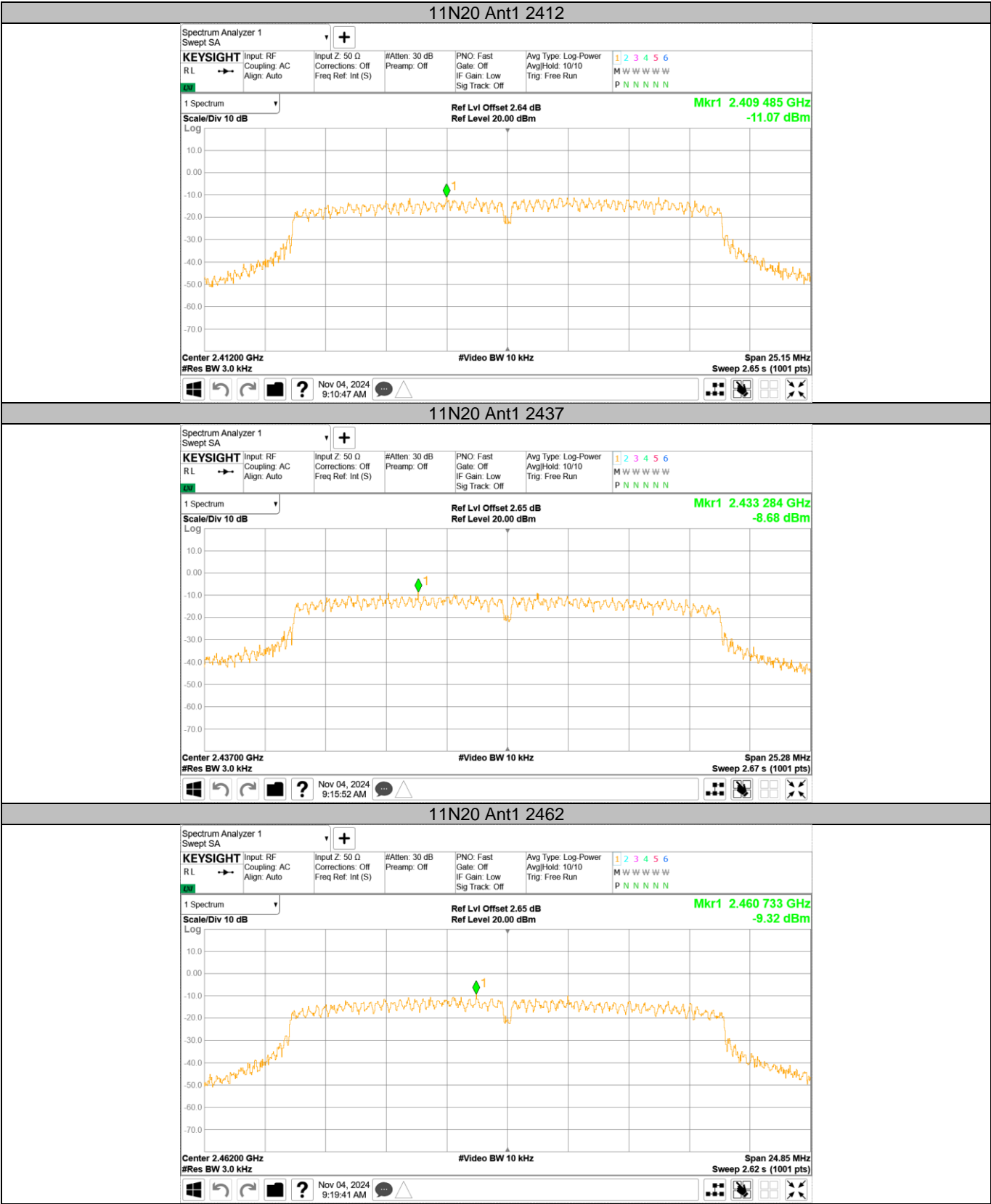


11G Ant1 2437



11G Ant1 2462







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

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



Spurious RF conducted emissions

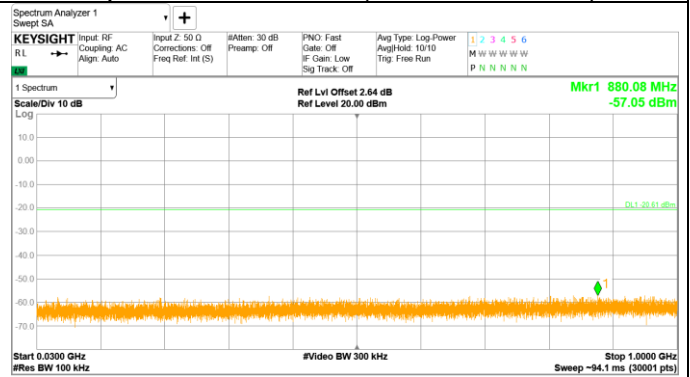
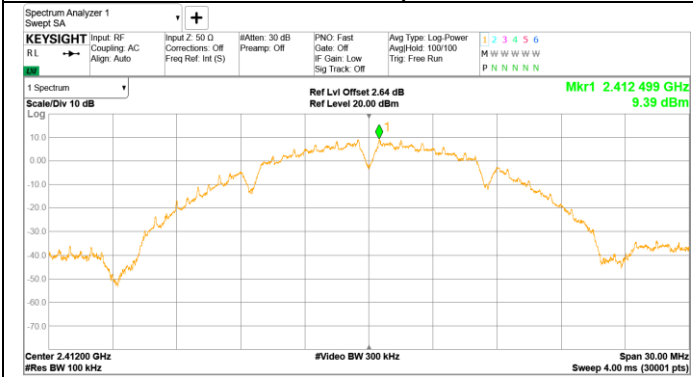
802.11 B Ant1

Out-of-Band Emissions

Channel 1 (2412MHz)

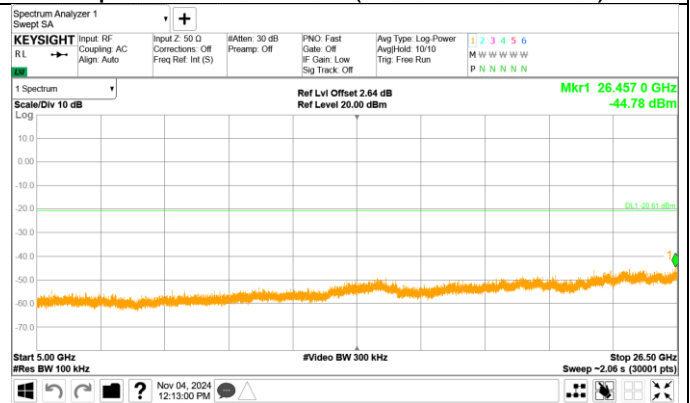
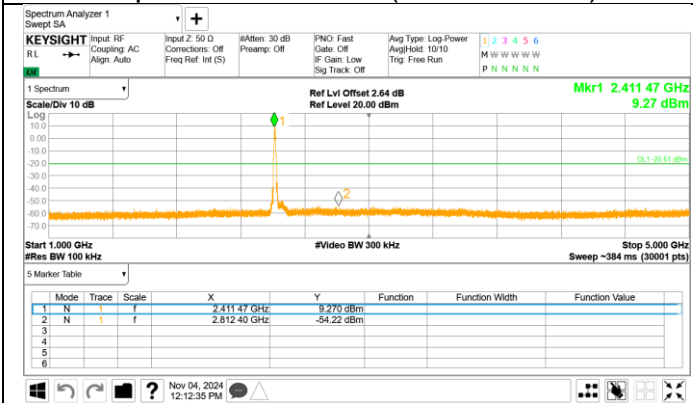
Reference point

Spurious Emission (30MHz – 1GHz)



Spurious Emission (1GHz –5GHz)

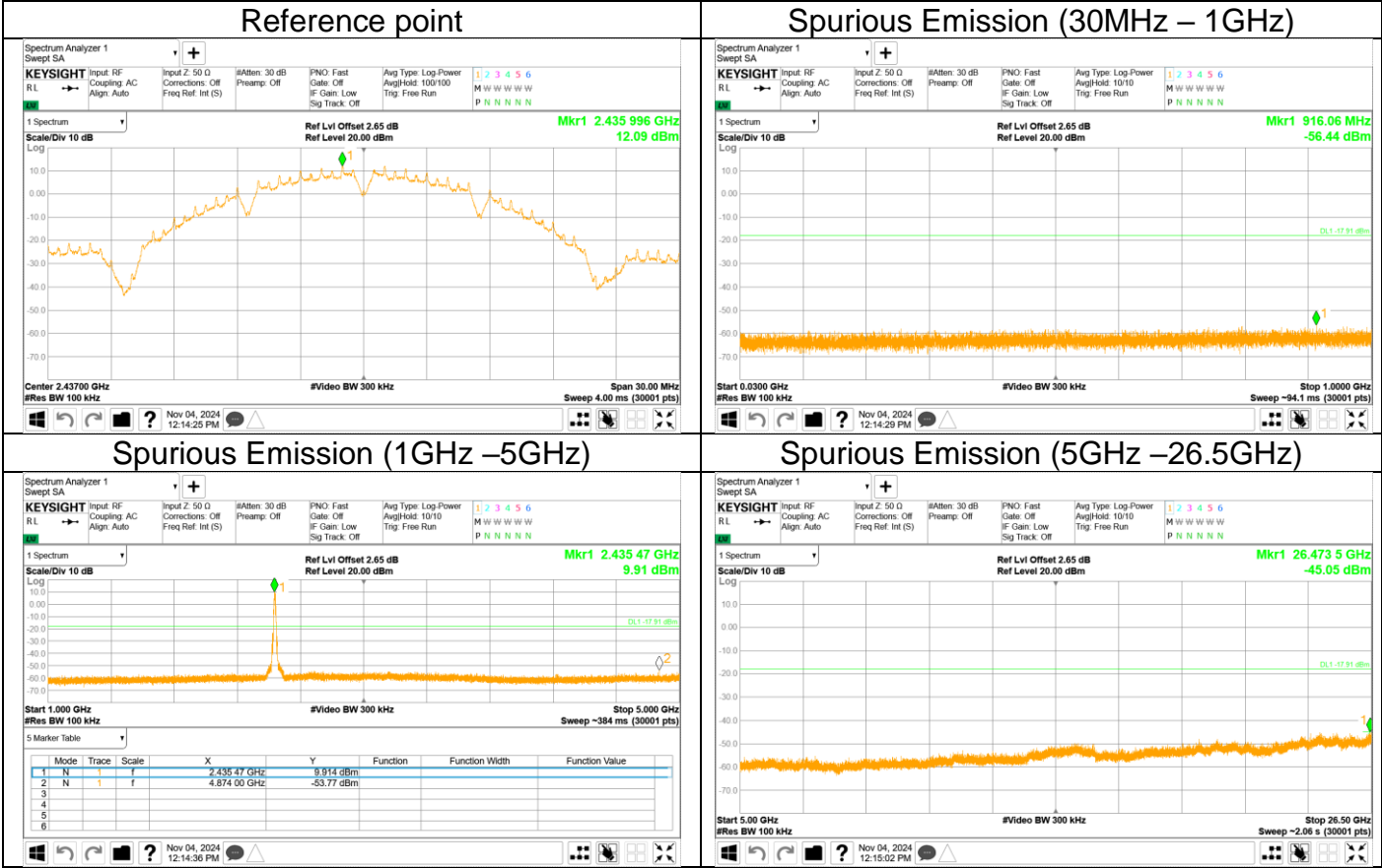
Spurious Emission (5GHz –26.5GHz)



Note: The emission which exceed the limit is the fundamental.



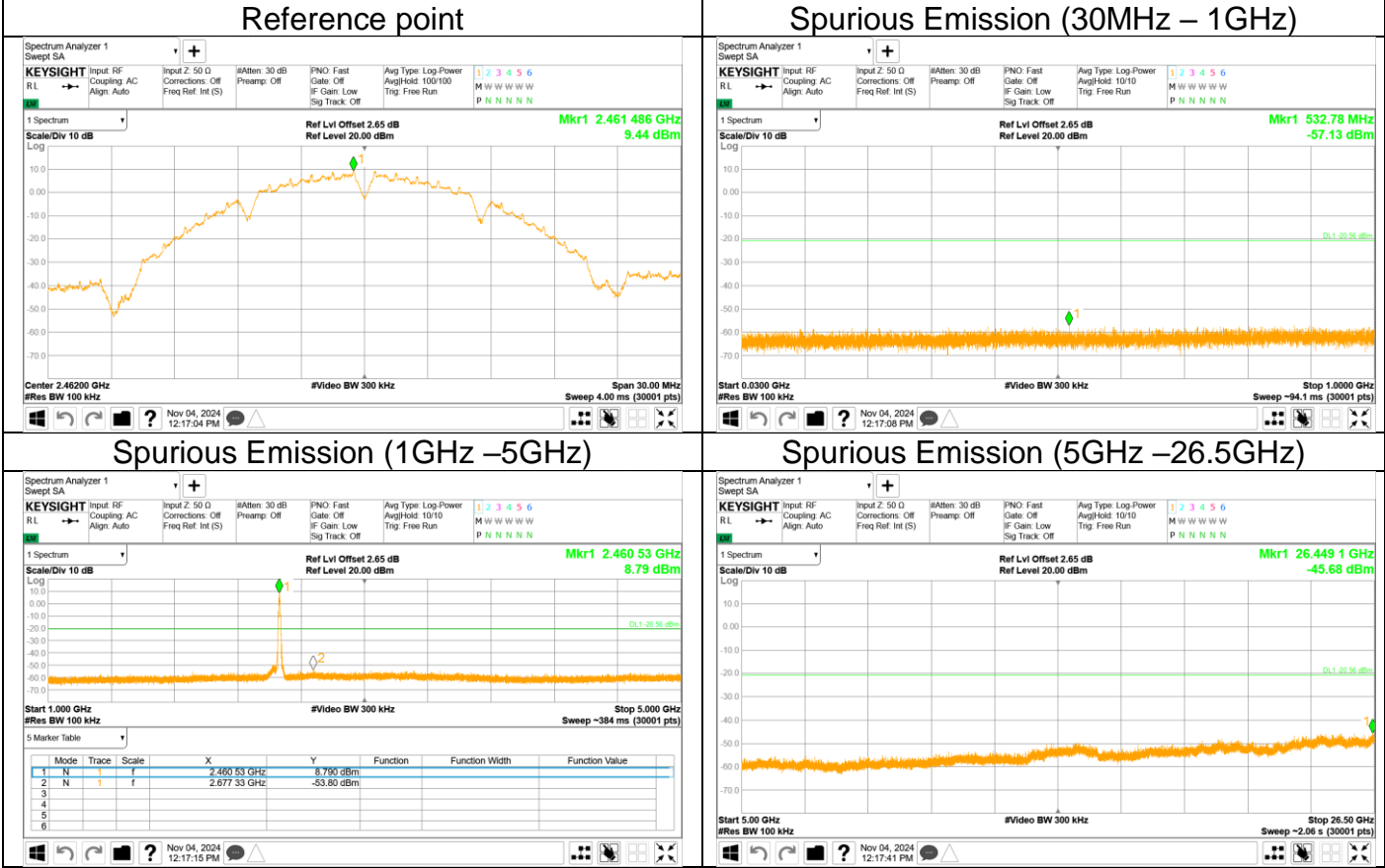
Out-of-Band Emissions
Channel 6 (2437MHz)



Note: The emission which exceed the limit is the fundamental.



Out-of-Band Emissions
Channel 11 (2462MHz)



Note: The emission which exceed the limit is the fundamental.

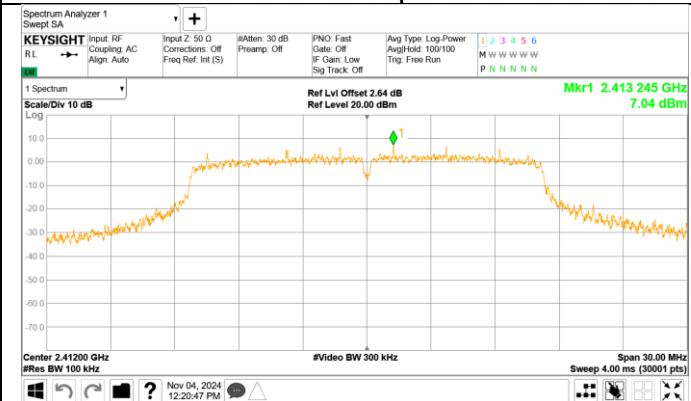


802.11 G Ant1

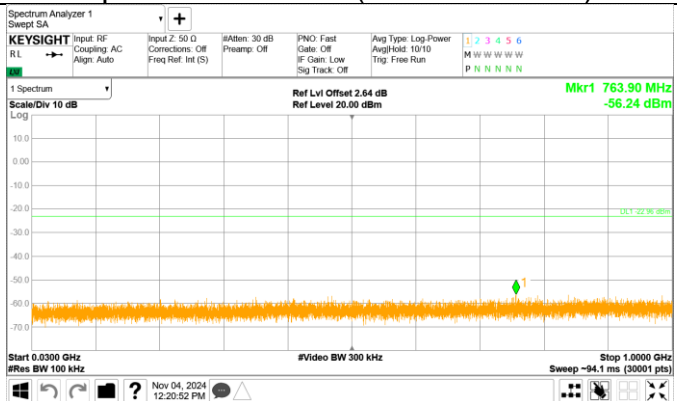
Out-of-Band Emissions

Channel 1 (2412MHz)

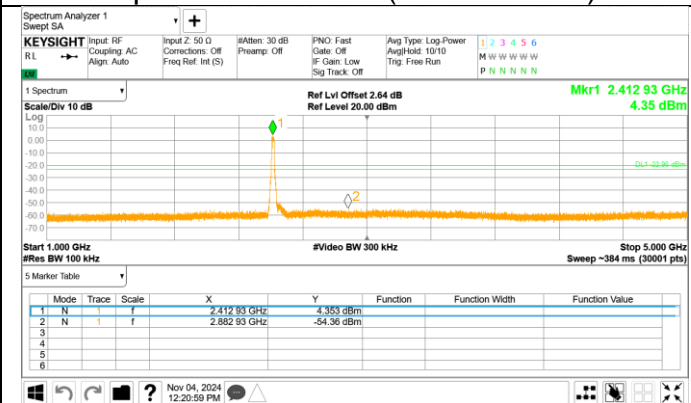
Reference point



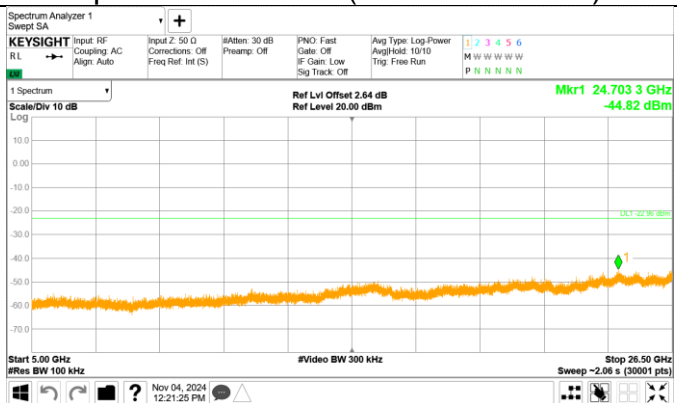
Spurious Emission (30MHz – 1GHz)



Spurious Emission (1GHz –5GHz)



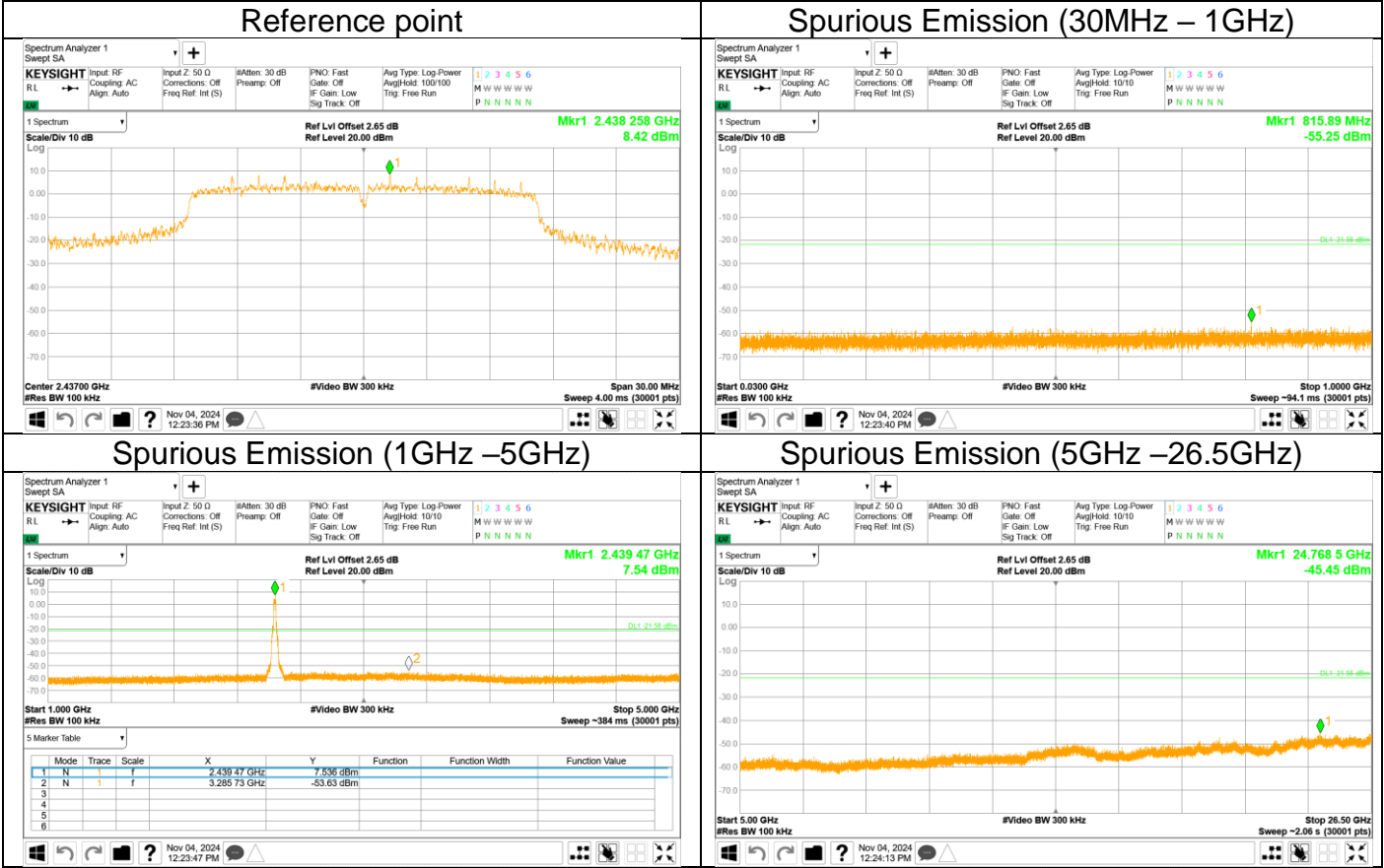
Spurious Emission (5GHz –26.5GHz)



Note: The emission which exceed the limit is the fundamental.



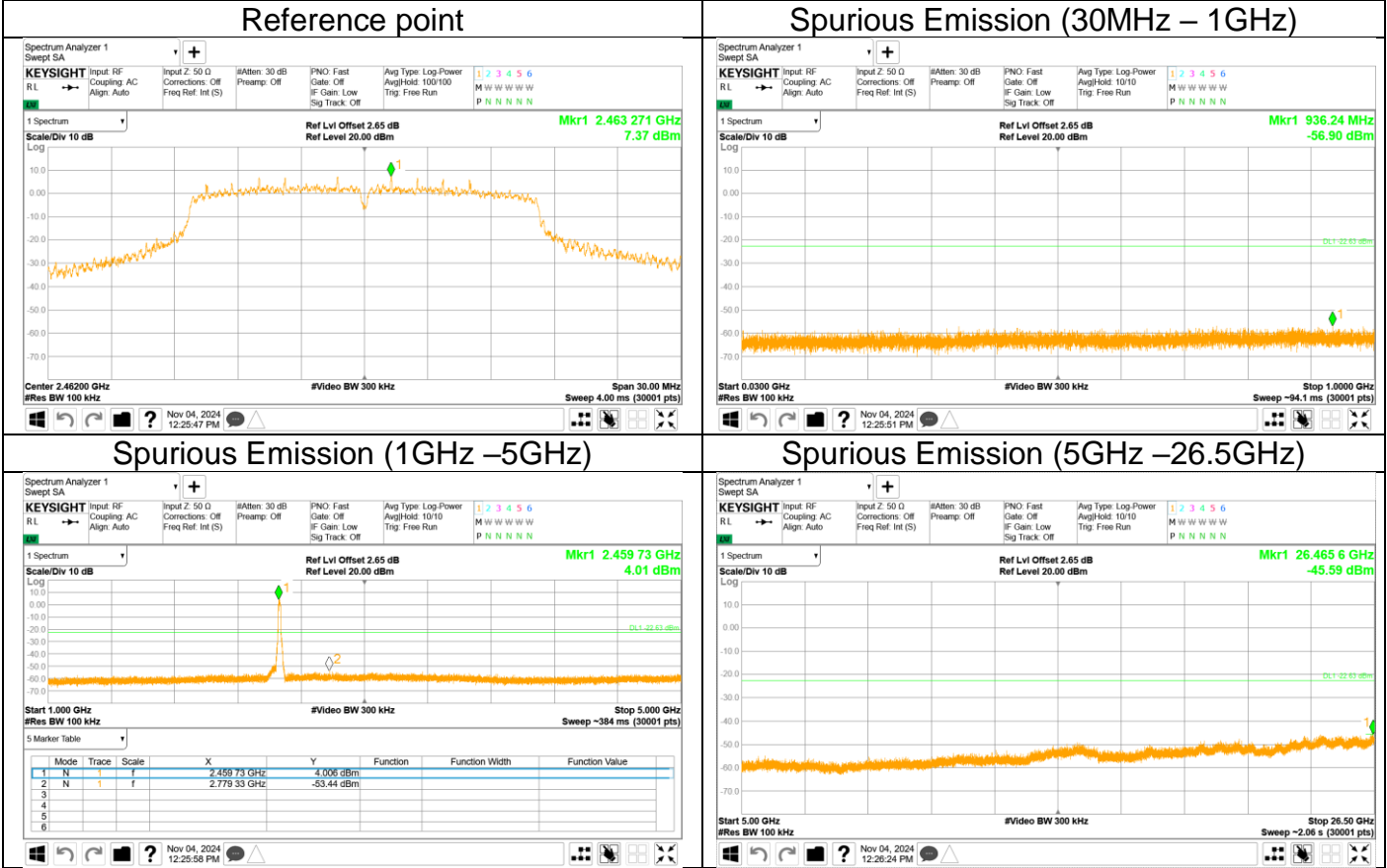
Out-of-Band Emissions
Channel 6 (2437MHz)



Note: The emission which exceed the limit is the fundamental.



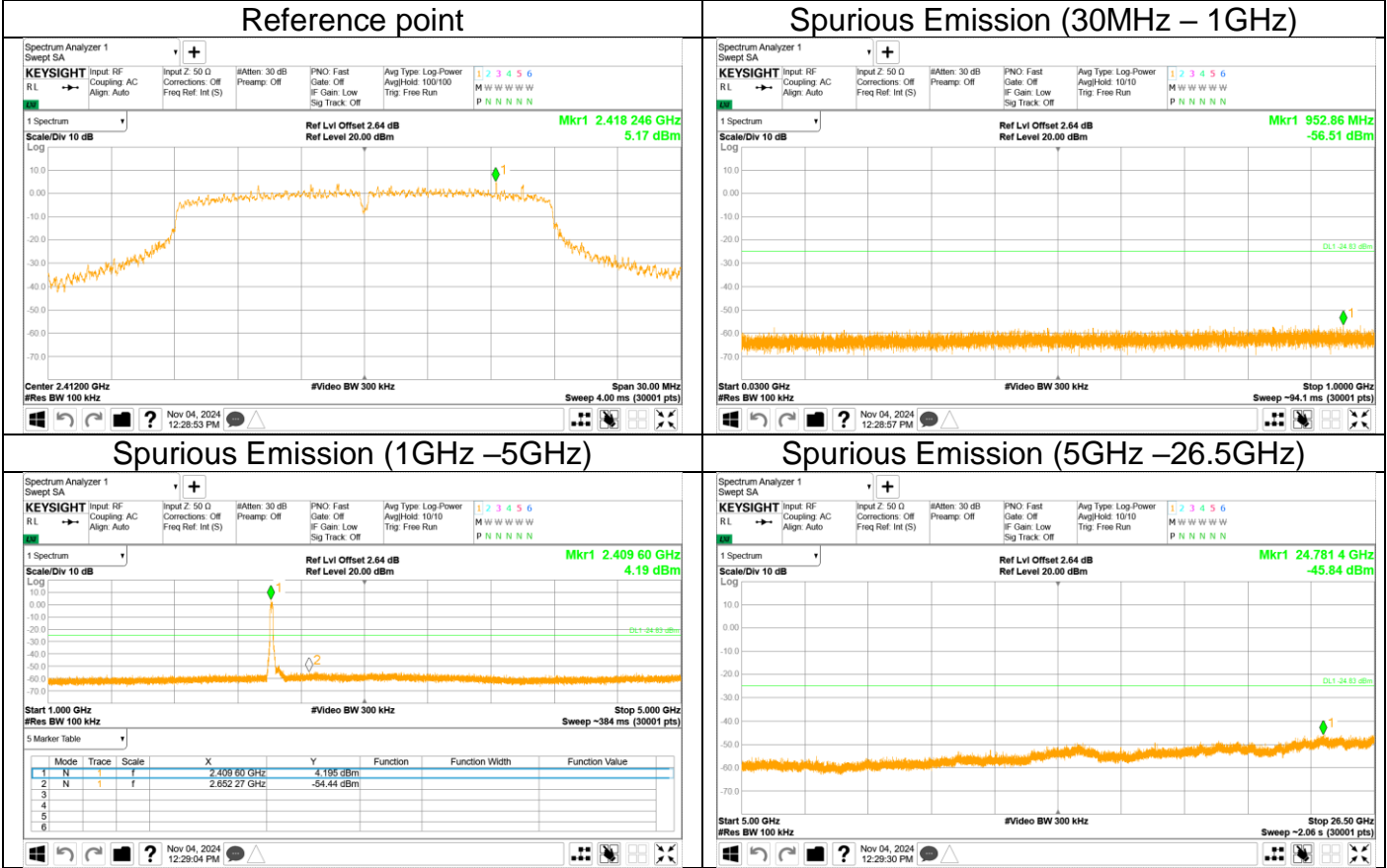
Out-of-Band Emissions
Channel 11 (2462MHz)



Note: The emission which exceed the limit is the fundamental.



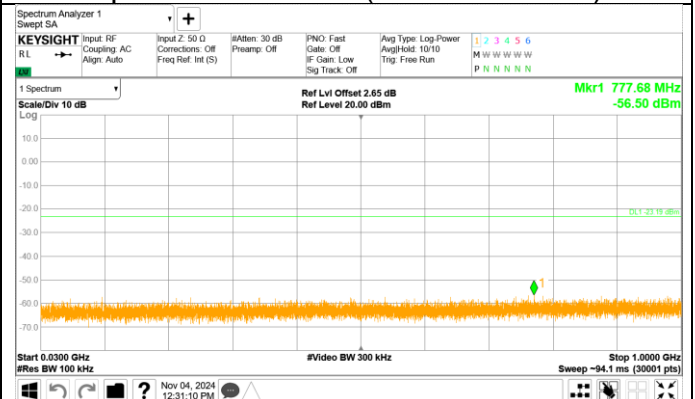
802.11 N20 Ant1
Out-of-Band Emissions
Channel 1 (2412MHz)



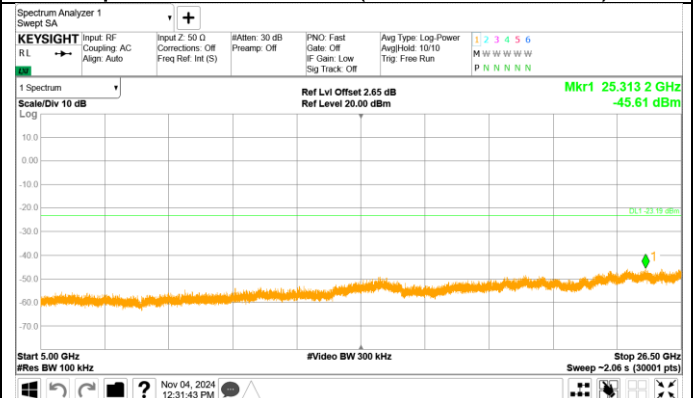
Note: The emission which exceed the limit is the fundamental.

Channel 6 (2437MHz)

Spurious Emission (30MHz – 1GHz)



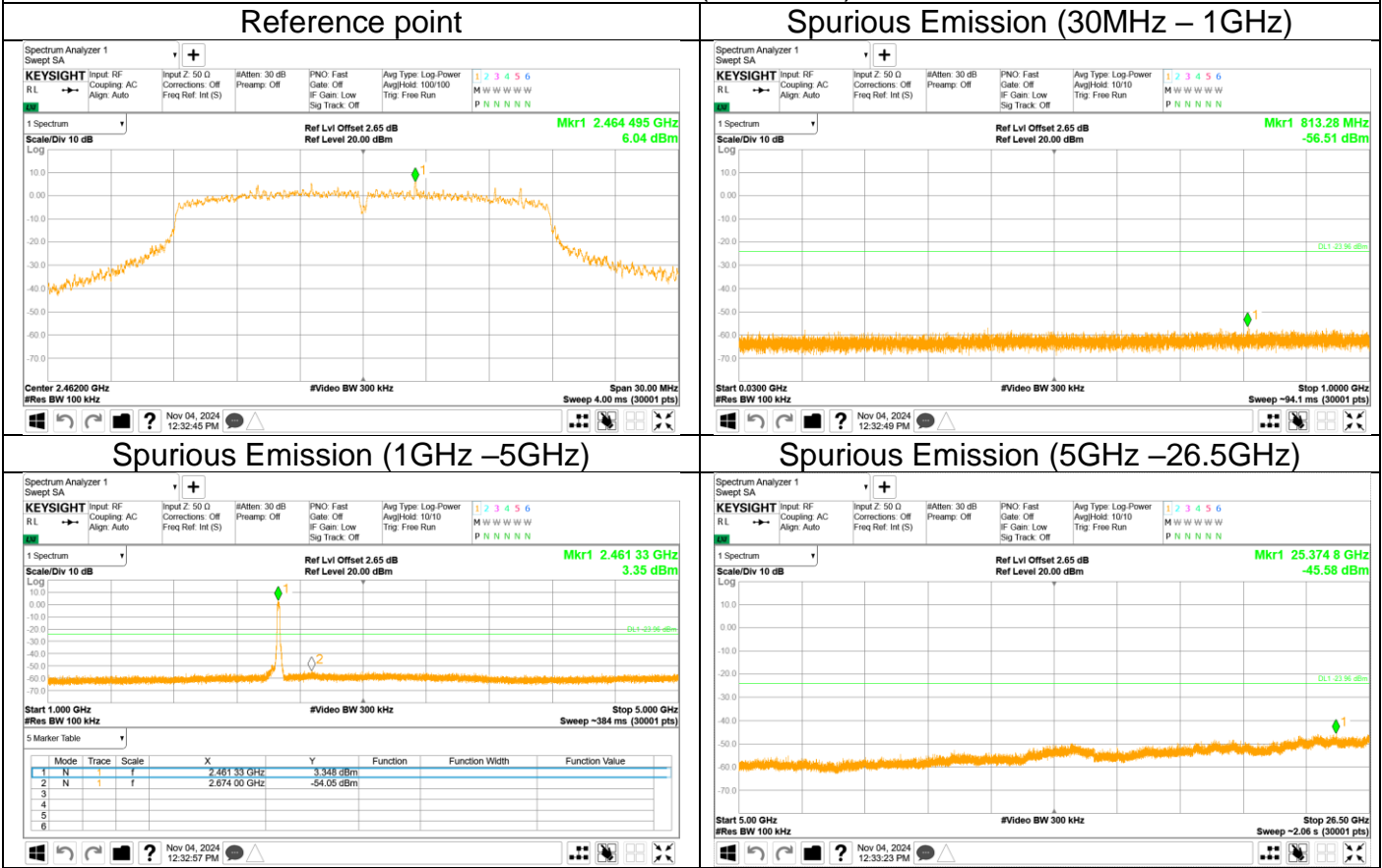
Spurious Emission (5GHz –26.5GHz)



EMC SHA F R 02.04E



Out-of-Band Emissions
Channel 11 (2462MHz)



Note: The emission which exceed the limit is the fundamental.



9.5 Band edge

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
RBW = 100 kHz, VBW \geq 3RBW, Sweep = auto, Detector function = peak, Trace = max hold
4. Allow the trace to stabilize, use the peak and delta measurement to record the result.
5. The level displayed must comply with the limit specified in this Section.
6. Repeat above procedures until all frequencies measured were complete and submit all the plots.

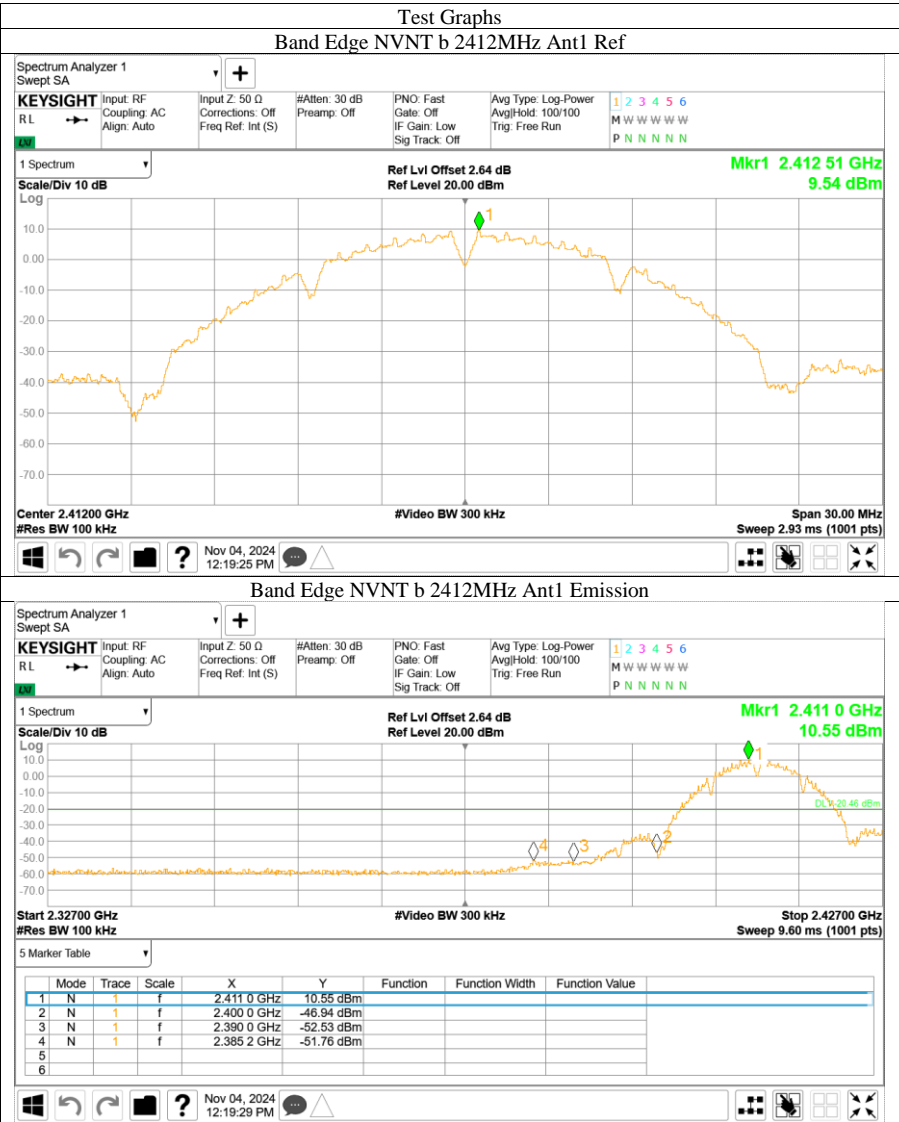
Limit:

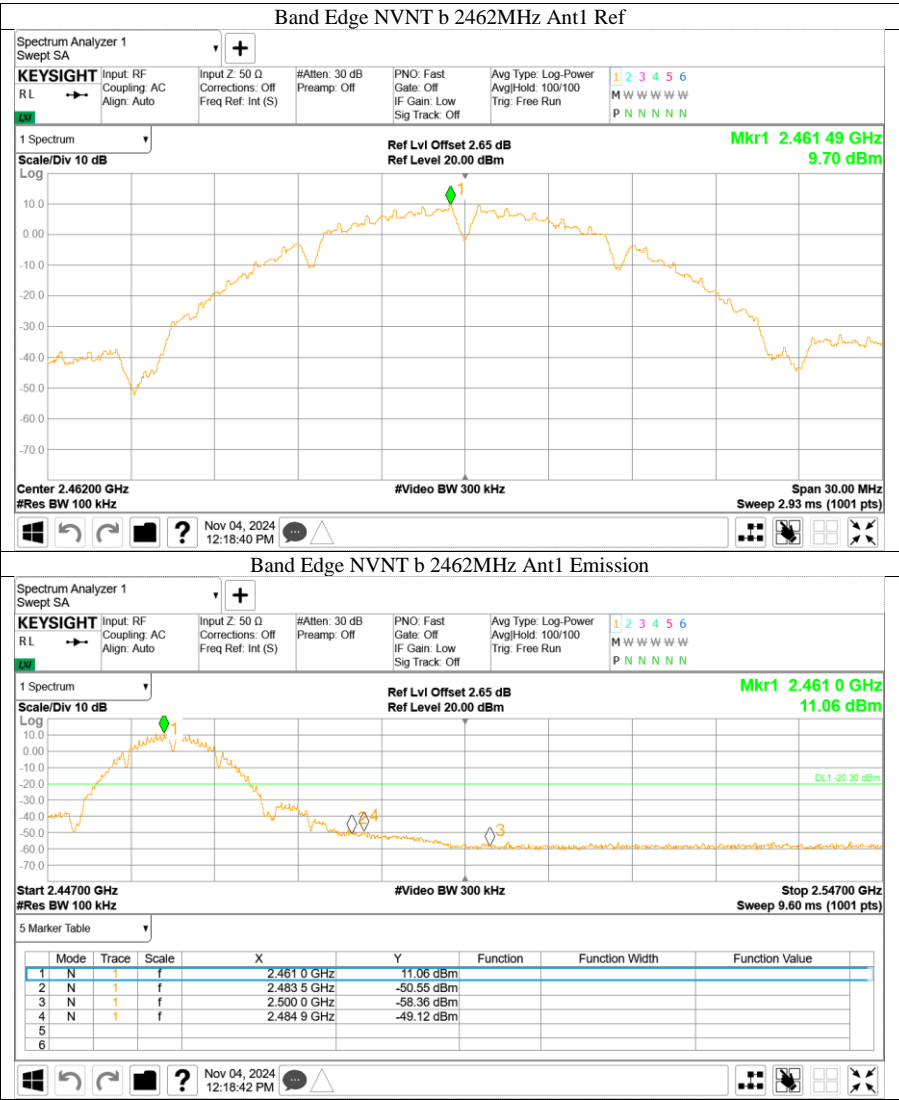
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that 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 § 15.247(b)(3) and RSS-247 section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB.

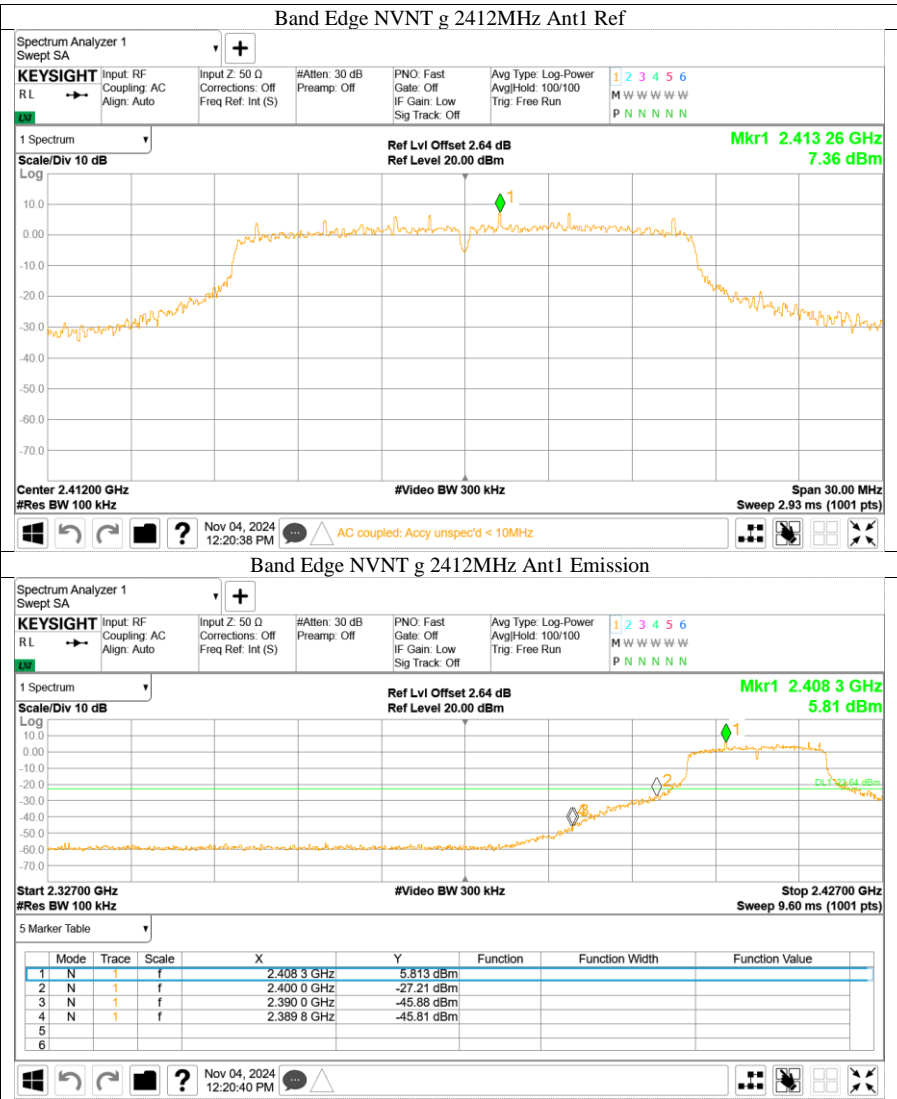
Frequency Range MHz	Limit (dBc)
30-25000	-30

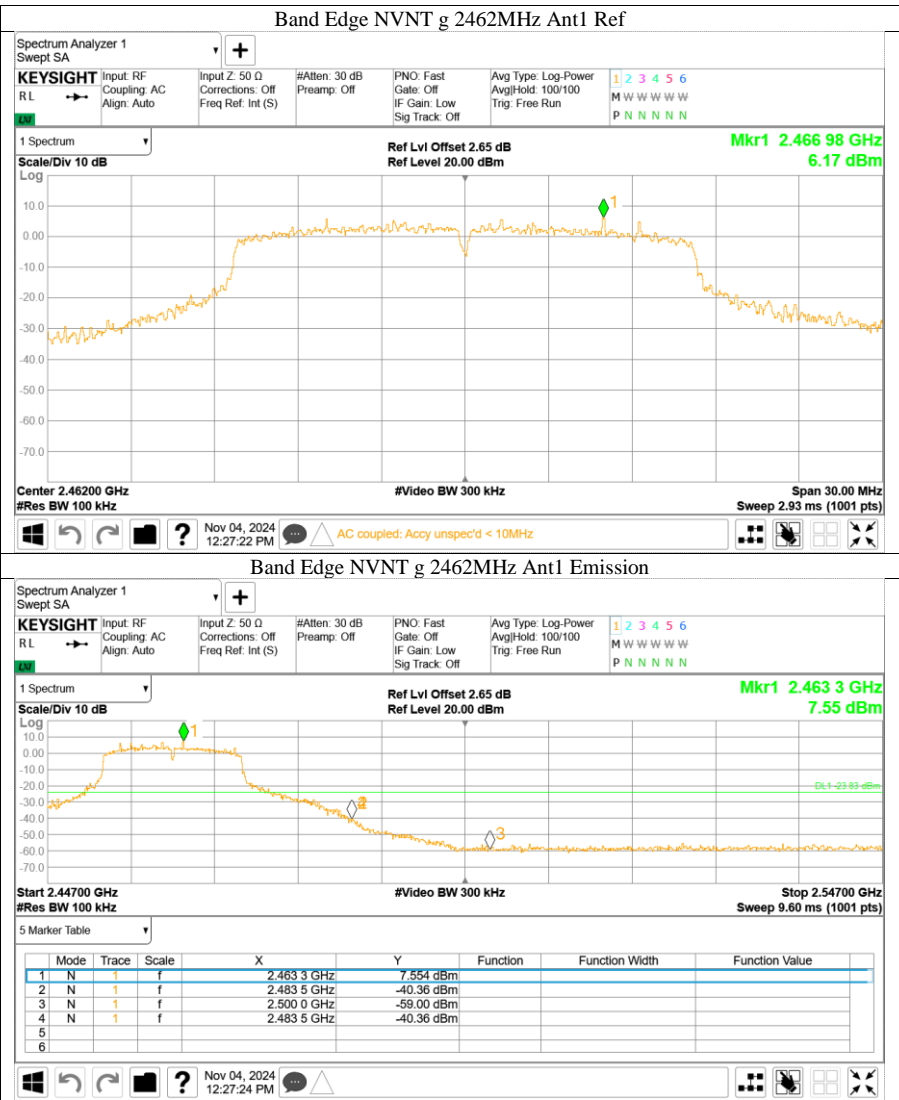


Test result

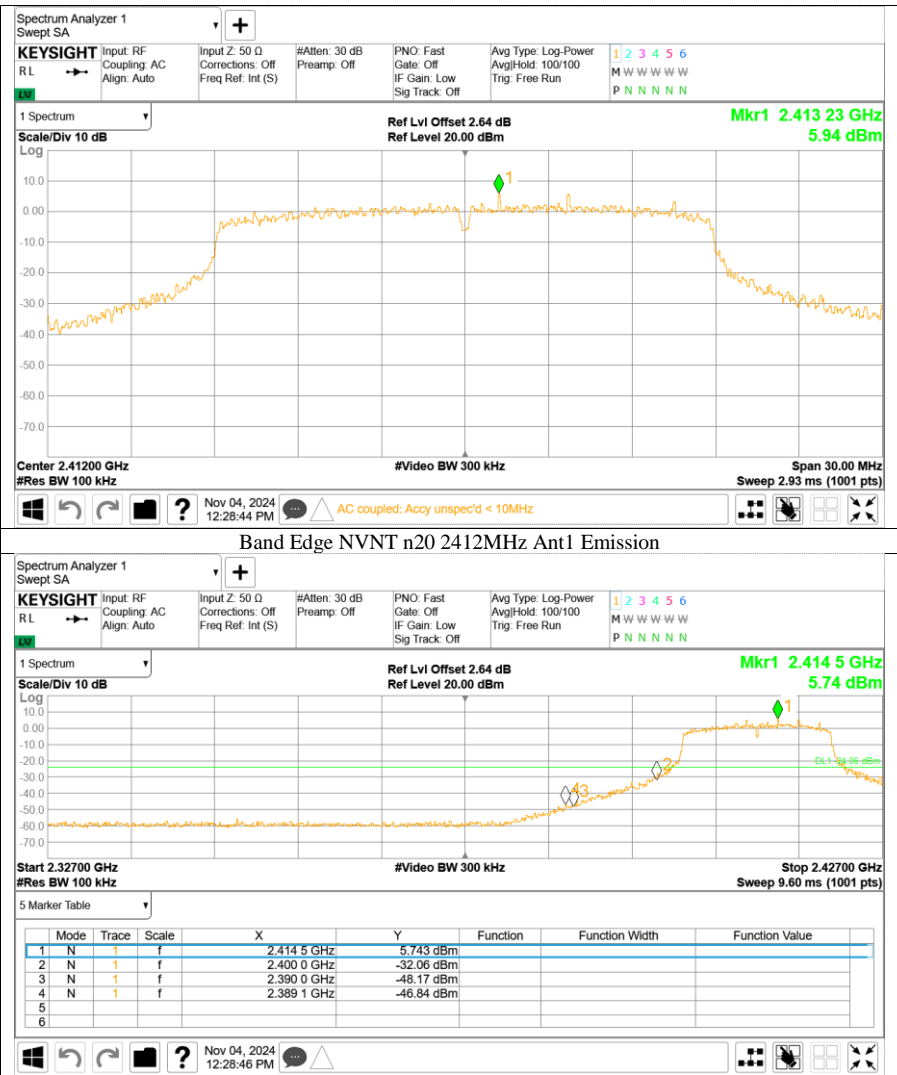


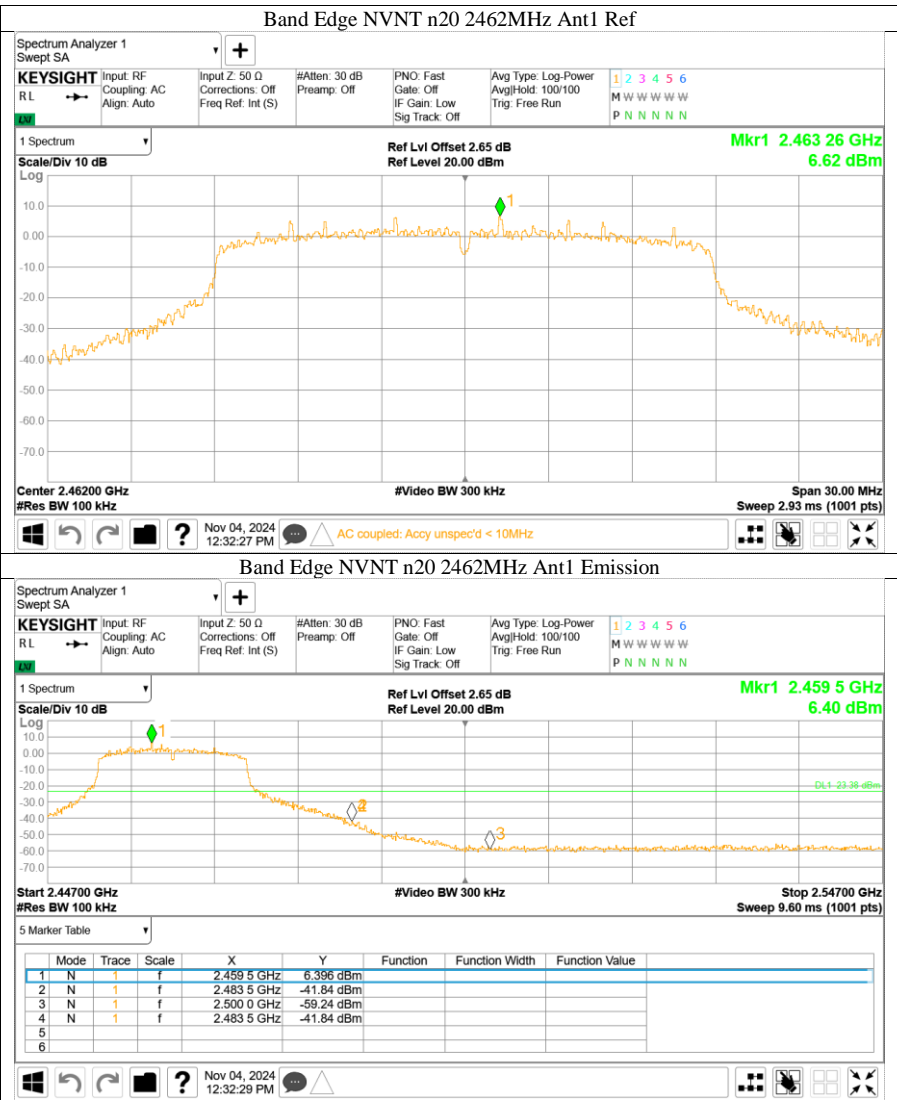






Band Edge NVNT n20 2412MHz Ant1 Ref







9.6 Spurious radiated emissions for transmitter

Test Method

1. The EUT was placed on a turn table which is 1.5m above ground plane for above 1GHz and 0.8m above ground for below 1GHz at 3 meter chamber room for test. The table was rotated 360 degrees to determine the position of the highest radiation.
2. The EUT was set 3 meters away from the interference – receiving antenna, which was mounted on the top of a variable – height antenna tower.
3. The height of antenna is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
4. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
5. Use the following spectrum analyzer settings According to C63.10
 - 1) Procedure for Unwanted Emissions Measurements Below 1000 MHz
Span = wide enough to capture the peak level of the in-band emission and all spurious
RBW = 100 kHz to 120kHz, VBW ≥ RBW for peak measurement, Sweep = auto, Detector function = peak, Trace = max hold.
 - 2) For Peak unwanted emissions Above 1GHz:
Span = wide enough to capture the peak level of the in-band emission and all spurious
RBW = 1MHz, VBW ≥ RBW for peak measurement, Sweep = auto, Detector function = peak, Trace = max hold.
Procedures for average unwanted emissions measurements above 1GHz
 - a) RBW = 1MHz.
 - b) $VBW \setminus [3 \times RBW]$.
 - c) Detector = RMS (power averaging), if $[span / (\# \text{ of points in sweep})] \setminus RBW / 2$.
Satisfying this condition can require increasing the number of points in the sweep or reducing the span. If the condition is not satisfied, then the detector mode shall be set to peak.
 - d) Averaging type = power (i.e., rms) (As an alternative, the detector and averaging type may be set for linear voltage averaging. Some instruments require linear display mode to use linear voltage averaging. Log or dB averaging shall not be used.)
 - e) Sweep time = auto.
 - f) Perform a trace average of at least 100 traces if the transmission is continuous. If the transmission is not continuous, then the number of traces shall be increased by a factor of $1 / D$, where D is the duty cycle. For example, with 50% duty cycle, at least 200 traces shall be averaged. (If a specific emission is demonstrated to be continuous—i.e., 100% duty cycle—then rather than turning ON and OFF with the transmit cycle, at least 100 traces shall be averaged.)
 - g) If tests are performed with the EUT transmitting at a duty cycle less than 98%, then a correction factor shall be added to the measurement results prior to comparing with the emission limit, to compute the emission level that would have been measured had the test been performed at 100% duty cycle. The correction factor is computed as follows:
 - 1) If power averaging (rms) mode was used in the preceding step e), then the correction factor is $[10 \log (1 / D)]$, where D is the duty cycle. For example, if the transmit duty cycle was 50%, then 3 dB shall be added to the measured emission levels.
 - 2) If linear voltage averaging mode was used in the preceding step e), then the correction



factor is $[20 \log (1 / D)]$, where D is the duty cycle. For example, if the transmit duty cycle was 50%, then 6 dB shall be added to the measured emission levels.

3) If a specific emission is demonstrated to be continuous (100% duty cycle) rather than turning ON and OFF with the transmit cycle, then no duty cycle correction is required for that emission (AV) at frequency above 1GHz.

Limit

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that 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 § 15.247(b)(3) and RSS 247 section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in § 15.209(a) and RSS-Gen is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a) and RSS-Gen section 8.9, must also comply with the radiated emission limits specified in § 15.209(a) and RSS-Gen section 8.10.

Frequency MHz	Field Strength μV/m	Field Strength dBμV/m	Detector	Measurement distance meters
0.009-0.490	2400/F(kHz)	48.5-13.8	AV	300
0.490-1.705	24000/F(kHz)	33.8-23.0	QP	30
1.705-30	30	29.5	QP	30
30-88	100	40	QP	3
88-216	150	43.5	QP	3
216-960	200	46	QP	3
960-1000	500	54	QP	3
Above 1000	500	54	AV	3
Above 1000	5000	74	PK	3

Note 1: Limit 3m(dBμV/m)=Limit 300m(dBμV/m)+40Log(300m/3m) (Below 30MHz)

Note 2: Limit 3m(dBμV/m)=Limit 30m(dBμV/m)+40Log(30m/3m) (Below 30MHz)

Spurious Radiated Emissions for Transmitter

According to C63.10, if the peak (or quasi-peak) measured value complies with the average limit, it is unnecessary to perform an average measurement, so AV emission value did not show in below table if the peak value complies with average limit.

Data of measurement within frequency range 9kHz-30MHz is the noise floor or attenuated more than 20dB below the permissible limits or the field strength is too small to be measured, so test data does not present in this report.



Above 1GHz Transmitting spurious emission test result as below:

802.11 b
2412MHz

Frequency MHz	Emission Level dBuV/m	Polarization	Limit dBuV/m	Detector	Margin dBuV/m	Result
2390.03	51.19	Horizontal	74	Peak	22.81	pass
2390.03	46.50	Horizontal	54	AV	7.5	pass
4823.93	49.96	Horizontal	74	Peak	24.04	pass
7237.40	47.95	Horizontal	74	Peak	26.05	pass
2390.47	46.78	Vertical	74	Peak	27.22	pass
4823.93	49.80	Vertical	74	Peak	24.2	pass

2437MHz

Frequency MHz	Emission Level dBuV/m	Polarization	Limit dBuV/m	Detector	Margin dBuV/m	Result
4873.87	48.13	Horizontal	74	Peak	25.87	pass
7309.65	47.31	Horizontal	74	Peak	26.69	pass
4873.87	47.00	Vertical	74	Peak	27	pass

2462MHz

Frequency MHz	Emission Level dBuV/m	Polarization	Limit dBuV/m	Detector	Margin dBuV/m	Result
2483.51	48.56	Horizontal	74	Peak	25.44	pass
4923.81	43.75	Horizontal	74	Peak	30.25	pass
2483.50	49.50	Vertical	74	Peak	24.5	pass
4923.81	46.92	Vertical	74	Peak	27.08	pass



802.11 g
2412MHz

Frequency MHz	Emission Level dBuV/m	Polarization	Limit dBuV/m	Detector	Margin dBuV/m	Result
2390.11	62.71	Horizontal	74	Peak	11.29	pass
2390.11	52.20	Horizontal	54	AV	1.8	pass
4825.00	46.56	Horizontal	74	Peak	27.44	pass
7232.62	50.63	Horizontal	74	Peak	23.37	pass
2389.92	57.55	Vertical	74	Peak	16.45	pass
2389.92	44.60	Vertical	54	AV	9.4	pass
4823.41	45.78	Vertical	74	Peak	28.22	pass
7242.18	50.89	Vertical	74	Peak	23.11	pass

2437MHz

Frequency MHz	Emission Level dBuV/m	Polarization	Limit dBuV/m	Detector	Margin dBuV/m	Result
4879.71	45.09	Horizontal	74	Peak	28.91	pass
7309.65	47.12	Horizontal	74	Peak	26.88	pass
4871.21	44.29	Vertical	74	Peak	29.71	pass
5987.91	49.29	Vertical	74	Peak	24.71	pass

2462MHz

Frequency MHz	Emission Level dBuV/m	Polarization	Limit dBuV/m	Detector	Margin dBuV/m	Result
2483.62	62.36	Horizontal	74	Peak	11.64	pass
2483.62	51.10	Horizontal	54	AV	2.9	pass
4925.41	40.93	Horizontal	74	Peak	33.07	pass
2483.59	57.99	Vertical	74	Peak	16.01	pass
2483.59	48.00	Vertical	54	AV	6	pass
4247.00	46.50	Vertical	74	Peak	27.5	pass
5993.75	50.78	Vertical	74	Peak	23.22	pass



802.11 n20
2412MHz

Frequency	Emission Level	Polarization	Limit	Detector	Margin	Result
MHz	dBuV/m		dBuV/m		dBuV/m	
2390.06	41.93	Horizontal	74	Peak	32.07	pass
4824.46	41.39	Horizontal	74	Peak	32.61	pass
2390.31	40.01	Vertical	74	Peak	33.99	pass
4825.00	41.38	Vertical	74	Peak	32.62	pass
5973.03	48.57	Vertical	74	Peak	25.43	pass

2437MHz

Frequency	Emission Level	Polarization	Limit	Detector	Margin	Result
MHz	dBuV/m		dBuV/m		dBuV/m	
4873.87	41.09	Horizontal	74	Peak	32.91	pass
4874.40	39.46	Vertical	74	Peak	34.54	pass

2462MHz

Frequency	Emission Level	Polarization	Limit	Detector	Margin	Result
MHz	dBuV/m		dBuV/m		dBuV/m	
2483.51	44.93	Horizontal	74	Peak	29.07	pass
4924.87	40.65	Horizontal	74	Peak	33.35	pass
2483.49	44.76	Vertical	74	Peak	29.24	pass
4924.34	41.51	Vertical	74	Peak	32.49	pass

Remark:

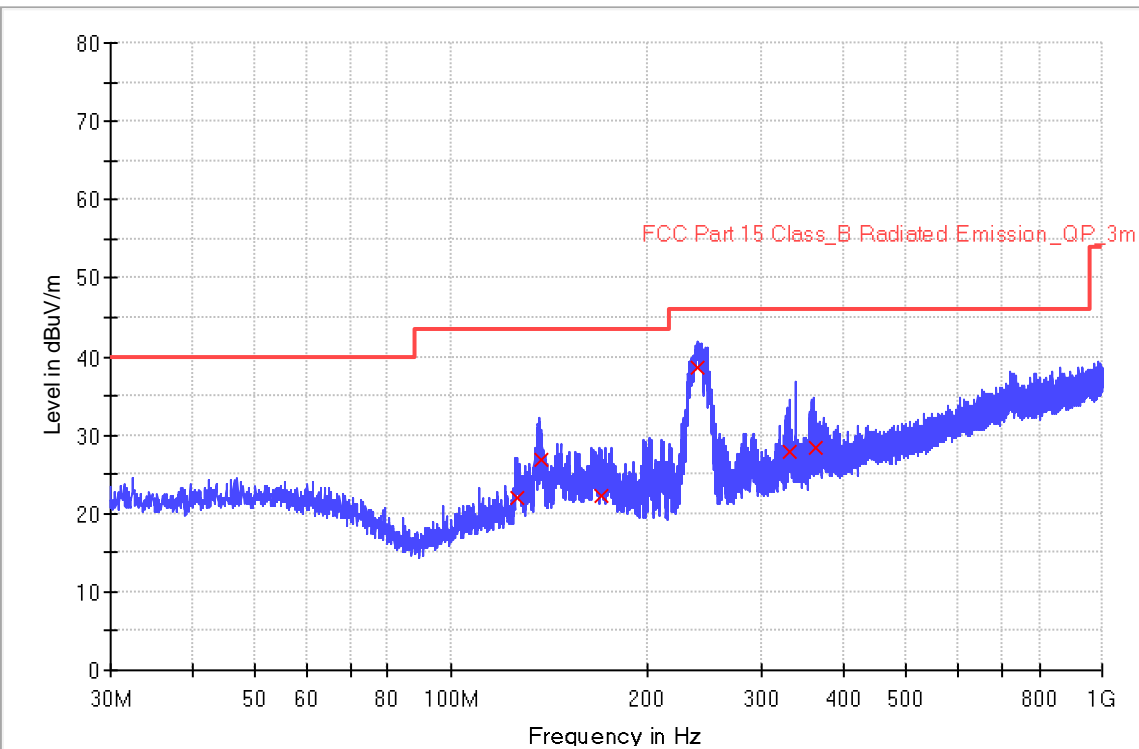
- (1) Emission level= Original Receiver Reading + Correct Factor
- (2) Correct Factor = Antenna Factor + Cable Loss -Amplifier gain
- (3) Margin = limit – Corrected Reading



The worst case of Radiated Emission below 1GHz:

Site: 3 meter chamber	Time: 2024/06/25 - 08:45
Limit: FCC_Part15.209_RE(3m)	Engineer: Wenqiang LU
Probe: VULB9168	Polarity: Horizontal
EUT: CCU, Model no: Lime-CCU23	Power: DC 20V
Note: Transmit by at channel 2437MHz for 802.11g (worst case).	

RE_VULB9168_pre_Cont_30-1000



Limit and Margin

Frequency (MHz)	QuasiPeak (dBuV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)	Margin - QPK (dB)	Limit - QPK (dBuV/m)
126.480000	22.0	1000.0	120.000	132.0	H	122.0	18.7	21.5	43.5
137.120000	26.9	1000.0	120.000	124.0	H	112.0	20.1	16.6	43.5
170.000000	22.3	1000.0	120.000	122.0	H	175.0	20.3	21.2	43.5
238.400000	38.5	1000.0	120.000	121.0	H	123.0	19.4	7.5	46.0
330.160000	27.8	1000.0	120.000	187.0	H	211.0	22.6	18.2	46.0
362.280000	28.3	1000.0	120.000	132.0	H	122.0	23.1	17.7	46.0

Note 1: Measure Level (dBuV/m) = Reading Level (dBuV) + Factor (dB)

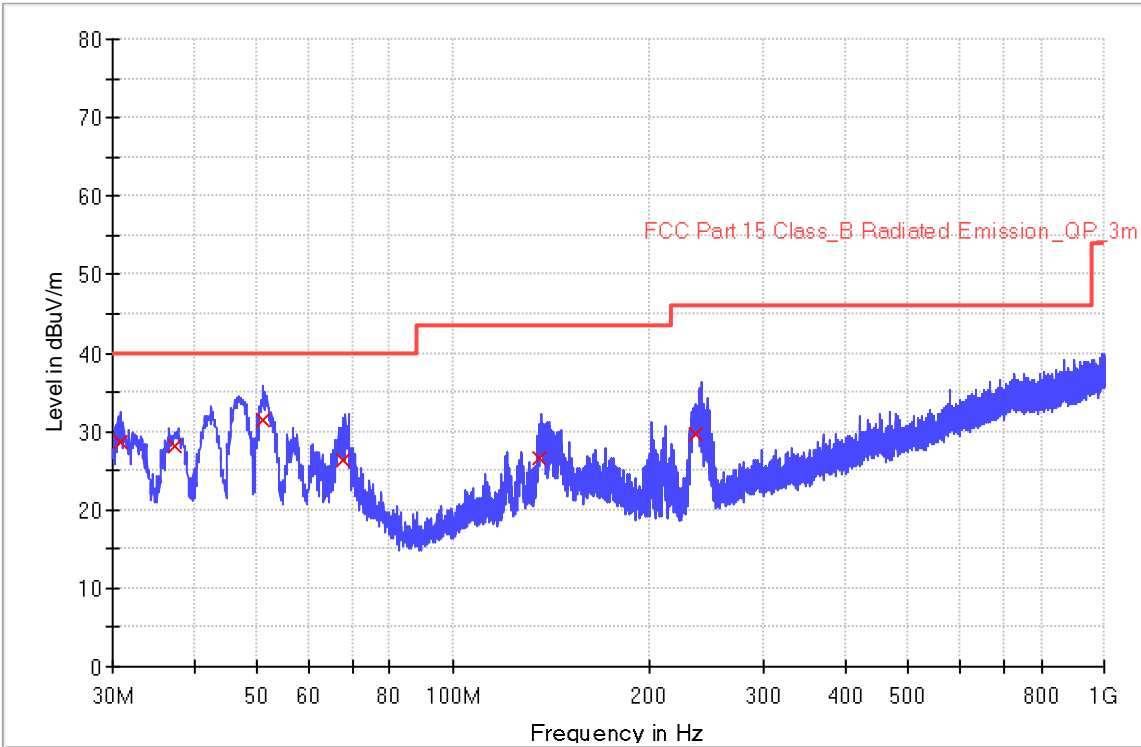
Factor (dB) = Cable Loss (dB) + Antenna Factor (dB/m)

Note 2: The test trace is same as the ambient noise and the amplitude of the emissions are attenuated more than 20dB below the permissible (the test frequency range: 9kHz ~ 30MHz, 18GHz ~ 25GHz), therefore no data appear in the report



Site: 3 meter chamber	Time: 2024/06/25 - 9:31
Limit: FCC_Part15.209_RE(3m)	Engineer: Wenqiang LU
Probe: VULB9168	Polarity: Vertical
EUT: CCU, Model no: Lime-CCU23	Power: DC 20V
Note: Transmit by at channel 2437MHz for 802.11g (worst case).	

RE_VULB9168_pre_Cont_30-1000



Limit and Margin

Frequency (MHz)	QuasiPeak (dBuV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)	Margin - QPK (dB)	Limit - QPK (dBuV/m)
30.880000	28.7	1000.0	120.000	143.0	V	123.0	19.3	11.3	40.0
37.360000	28.2	1000.0	120.000	187.0	V	123.0	19.7	11.8	40.0
51.000000	31.4	1000.0	120.000	197.0	V	126.0	20.6	8.6	40.0
67.960000	26.3	1000.0	120.000	132.0	V	221.0	19.0	13.7	40.0
135.660000	26.6	1000.0	120.000	186.0	V	13.0	19.8	16.9	43.5
235.840000	29.7	1000.0	120.000	102.0	V	286.0	19.0	16.3	46.0

Note 1: Measure Level (dBuV/m) = Reading Level (dBuV) + Factor (dB)

Factor (dB) = Cable Loss (dB) + Antenna Factor (dB/m)

Note 2: The test trace is same as the ambient noise and the amplitude of the emissions are attenuated more than 20dB below the permissible (the test frequency range: 9kHz ~ 30MHz, 18GHz ~ 25GHz), therefore no data appear in the report.



10 Test Equipment List

List of Test Instruments
Test Site1

	DESCRIPTION	MANUFACTURER	MODEL NO.	SERIAL NO.	CAL. DATE	CAL. DUE DATE
C	Signal spectrum analyzer	Agilent	N9020B	MY59050168	2024-2-19	2025-2-18
	Wideband power sensor	Rohde & Schwarz	NRP-Z81	105903	2024-2-19	2025-2-18
	10dB Attenuator	Aeroflex Weinschel	CG-4689	93459	2024-2-19	2025-2-18
RE	EMI Test Receiver	Rohde & Schwarz	ESR3	101906	2024-8-1	2025-7-31
	Signal Analyzer	Rohde & Schwarz	FSV40	101091	2024-8-1	2025-7-31
	Trilog Super Broadband Test Antenna	Schwarzbeck	VULB 9168	961	2021-9-23	2024-9-22
	Double-ridged waveguide horn antenna	Rohde & Schwarz	HF907	102393	2024-4-14	2027-4-13
	Pre-amplifier	Shenzhen HzEMC	HPA-081843	HYP A23026	2024-4-16	2025-4-15
	Loop antenna	Rohde & Schwarz	HFH2-Z2	100443	2024-6-26	2025-6-25
	Double Ridged Horn Antenna	ETS-Lindgren	3116C	00246076	2023-7-7	2026-7-6
	3m Semi-anechoic chamber	TDK	9X6X6	----	2024-5-8	2027-5-7

Measurement Software Information			
Test Item	Software	Manufacturer	Version
C	MTS 8310	MWRFtest	3.0.0.0
	Power Viewer	Rohde & Schwarz	V 11.0
RE	EMC 32	Rohde & Schwarz	V10.50.40

C - Conducted RF tests

- Conducted peak output power
- 6dB bandwidth and 99% Occupied Bandwidth
- Power spectral density*
- Spurious RF conducted emissions
- Band edge



11 System Measurement Uncertainty

For a 95% confidence level, the measurement expanded uncertainties for defined systems, in accordance with the recommendations of ISO 17025 were:

Items	Extended Uncertainty
Radiated Disturbance	9kHz to 30MHz, 3.52dB 30MHz to 1GHz, 5.03dB (Horizontal) 5.12dB (Vertical) 1GHz to 18GHz, 5.49dB 18GHz to 40GHz, 5.63dB
RF Conducted Measurement	Power related: 1.16dB Frequency related: 6.00×10^{-8}

Measurement Uncertainty Decision Rule:

Determination of conformity with the specification limits is based on the decision rule according to IEC Guide 115: 2023, clause 4.3.3.



12 Photographs of Test Set-ups

Refer to the < Test Setup photos >.



13 Photographs of EUT

Refer to the < External Photos > & < Internal Photos >.

-----End of Test Report-----