

RADIO TEST REPORT – 455174-5TRFWL

Type of assessment:

Modular transmitter integration - Partial testing

Applicant:

Roambee Corporation

Product:

BeeSense Flex

Model:

BNG 500

FCC ID:

2ALG8BEENG500

IC Registration number:

28141-BEENG500

Specifications:

- ◆ FCC 47 CFR Part 15 Subpart C, §15.247

Date of issue: February 16, 2022

Tarek Elkholy, EMC/RF Specialist

Tested by



Signature

Yong Huang, EMC/RF Specialist

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	FCC:	CA2040	CA2041	CA0101
	ISED:	2040A-4	2040G-5	24676
Website	www.nemko.com			

Limits of responsibility

Note that the results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contained in this report are within Nemko Canada's ISO/IEC 17025 accreditation.

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Section 1 Report summary

1.1 Test specifications

FCC 47 CFR Part 15, Subpart C, Clause 15.247	Operation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–585 MHz
RSS-247, Issue 2, Feb 2017, Section 5	Digital Transmission Systems (DTSSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

1.2 Test methods

KDB 996369 D04	Modular Transmitter Integration Guide Guidance for Host Product Manufacturers
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

1.3 Exclusions

The evaluation was done to ensure there are no radiated spurious emissions exceeding the applicable limits are generated in the restricted bands due to - transmission operations, and to ensure compliance with the applicable FCC/ISED rules for the transmitters operating individually. The applicant has declared that WiFi and BLE do not transmit simultaneously. This includes compliance for the summation of all spurious radiated emissions occupying the same or overlapping frequency ranges, as defined by the applicable rules. All other requirements are excluded from the scope of this report.

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was performed against all relevant requirements of the test standard except as noted in section 1.3 above. Results obtained indicate that the product under test complies In full with the requirements tested. The test results relate only to the items tested.

See “Summary of test results” for full details.

1.5 Test report revision history

Table 1.5-1: Test report revision history

Revision #	Date of issue	Details of changes made to test report
TRF	February 16, 2022	Original report issued

Section 2 Engineering considerations

2.1 Modifications incorporated in the EUT for compliance

There were no modifications performed to the EUT during this assessment.

2.2 Technical judgment

None.

2.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 3 Test conditions

3.1 Atmospheric conditions

Temperature	15 °C – 35 °C
Relative humidity	20 % – 75 %
Air pressure	86 kPa (860 mbar) – 106 kPa (1060 mbar)

When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.

3.2 Power supply range

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages $\pm 5\%$, for which the equipment was designed.

Section 4 Measurement uncertainty

4.1 Uncertainty of measurement

UKAS Lab 34 and TIA-603-B have been used as guidance for measurement uncertainty reasonable estimations with regards to previous experience and validation of data. Nemko Canada, Inc. follows these test methods in order to satisfy ISO/IEC 17025 requirements for estimation of uncertainty of measurement for wireless products.

Measurement uncertainty budgets for the tests are detailed below. Measurement uncertainty calculations assume a coverage factor of $K = 2$ with 95% certainty.

Table 4.1-1: Measurement uncertainty calculations

Test name	Measurement uncertainty, \pm dB
All antenna port measurements	0.55
Occupied bandwidth	4.45
Conducted spurious emissions	1.13
Radiated spurious emissions	3.78
AC power line conducted emissions	3.55

Section 5 Information provided by the applicant

5.1 Disclaimer

This section contains information provided by the applicant and has been utilized to support the test plan. Inaccurate information provided by the applicant can affect the validity of the results contained within this test report. Nemko accepts no responsibility for the information contained within this section and the impact it may have on the test plan and resulting measurements.

5.2 Applicant/Manufacture

Applicant name	Roambee Corporation
Applicant address	3120 De La Cruz Blvd. Suite 210, Santa Clara, California, 95054, USA.
Manufacture name	Sercomm
Manufacture address	8F, No.3-1, YuanQu St., NanKang, Taipei, 115, Taiwan.

5.3 EUT information

Product	BeeSense Flex
Model	BNG 500
Serial number	None
Power supply requirements	Battery: 1.2 V(DC)
Product description and theory of operation	IoT sensor with GNSS location tracking and cellular / Wi-Fi / BLE connectivity
Antenna information	Type: Chip PCB Antenna Manufacturer: Kyocera AVX Model: 1001013 Peak gain:2.6 dBi

5.4 EUT setup details

5.4.1 Radio exercise details

WiFi Operating conditions	The EUT preloaded with test binary was connected through custom Tag-connect cable to a laptop loaded with (EspRFTTestTool_v2.8_Manual) test software to force the EUT to transmit WiFi signals according to the table below.
BLE Operating conditions	The EUT was loaded by Nordic Radio Test Mode application, Version 1.5 (radio_test_nrf_sdk_1.5) and connected via Segger J-link Tag-connect port to a laptop loaded with J-Link RTT viewerV7.20 to force the EUT to continuously transmit at power level of 0 dBm, 2 Mbps data rate at different BLE channels.

5.4.2 EUT setup configuration

Table 5.4-1: EUT interface ports

Description	Qty.
USB service port	1

Table 5.4-2: Support equipment

Description	Brand name	Model, Part number, Serial number, Revision level
laptop	Dell	MN: Latitude E6420, DPN: VVF52 A01, SN: 28MCCS1

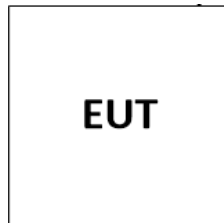


Figure 5.4-1: Radiated testing block diagram

Section 6 Summary of test results

6.1 Testing location

Test location (s)	Cambridge
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6.2 Testing period

Test start date	January 6, 2022	Test end date	January 20, 2022
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6.3 Sample information

Receipt date	December 27, 2021	Nemko sample ID number(s)	4551740003, 4551740005
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6.4 FCC Part 27, test results

Table 6.4-1: FCC requirements results

Part	Test description	Verdict
§15.247(d)	Spurious emissions	Pass
Notes:	Only radiated spurious emissions were assessed, all other specification's requirements are not applicable for this type of assessment, therefore were removed from the table.	

6.5 ISED RSS-247, test results

Table 6.5-1: ISED requirements results

Part	Test description	Verdict
RSS-247, 5.5	Unwanted emissions	Pass
Notes:	Only radiated spurious emissions were assessed, all other specification's requirements are not applicable for this type of assessment, therefore were removed from the table.	

Section 7 Test equipment

7.1 Test equipment list

Table 7.1-1: Equipment list

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
3 m EMI test chamber	TDK	SAC-3	FA003012	1 year	April 12, 2022
Flush mount turntable	SUNAR	FM2022	FA003006	—	NCR
Controller	SUNAR	SC110V	FA002976	—	NCR
Antenna mast	SUNAR	TLT2	FA003007	—	NCR
AC Power source	Chroma	0	FA003020	—	NCR
Receiver/spectrum analyzer	Rohde & Schwarz	ESR26	FA002969	1 year	November 30, 2022
Horn antenna (1–18 GHz)	ETS Lindgren	3117	FA002911	1 year	April 21, 2022
Preamplifier (1–18 GHz)	ETS Lindgren	124334	FA002956	1 year	April 5, 2022
Horn antenna (18–40 GHz)	EMCO	3116B	FA002948	1 year	January 22, 2022
Preamplifier 18-40 GHz	None	None	FA003323	1 year	April 5, 2022
Bilog antenna (30–2000 MHz)	SUNAR	JB1	FA003010	1 year	April 28, 2022
50 Ω coax cable	Huber + Suhner	None	FA003047	1 year	December 17, 2022
50 Ω coax cable	Huber + Suhner	None	FA003043	1 year	Nov 9, 2022

Notes: NCR - no calibration required

Section 8 Testing data

8.1 Spurious (out-of-band) unwanted emissions

8.1.1 References, definitions and limits

FCC §15.247:

- (d) 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. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

RSS-247, Clause 5.5:

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 root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

Table 8.1-1: FCC §15.209 and RSS-Gen – Radiated emission limits

Frequency, MHz	Field strength of emissions		Measurement distance, m
	μV/m	dBμV/m	
0.009–0.490	2400/F	$67.6 - 20 \times \log_{10}(F)$	300
0.490–1.705	24000/F	$87.6 - 20 \times \log_{10}(F)$	30
1.705–30.0	30	29.5	30
30–88	100	40.0	3
88–216	150	43.5	3
216–960	200	46.0	3
above 960	500	54.0	3

Notes: In the emission table above, the tighter limit applies at the band edges.
For frequencies above 1 GHz the limit on peak RF emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test.

References, definitions and limits, continued

Table 8.1-2: ISED restricted frequency bands

MHz	MHz	MHz	GHz
0.090–0.110	12.57675–12.57725	399.9–410	7.25–7.75
0.495–0.505	13.36–13.41	608–614	8.025–8.5
2.1735–2.1905	16.42–16.423	960–1427	9.0–9.2
3.020–3.026	16.69475–16.69525	1435–1626.5	9.3–9.5
4.125–4.128	16.80425–16.80475	1645.5–1646.5	10.6–12.7
4.17725–4.17775	25.5–25.67	1660–1710	13.25–13.4
4.20725–4.20775	37.5–38.25	1718.8–1722.2	14.47–14.5
5.677–5.683	73–74.6	2200–2300	15.35–16.2
6.215–6.218	74.8–75.2	2310–2390	17.7–21.4
6.26775–6.26825	108–138	2483.5–2500	22.01–23.12
6.31175–6.31225	149.9–150.05	2655–2900	23.6–24.0
8.291–8.294	156.52475–156.52525	3260–3267	31.2–31.8
8.362–8.366	156.7–156.9	3332–3339	36.43–36.5
8.37625–8.38675	162.0125–167.17	3345.8–3358	
8.41425–8.41475	167.72–173.2	3500–4400	Above 38.6
12.29–12.293	240–285	4500–5150	
12.51975–12.52025	322–335.4	5350–5460	

Note: Certain frequency bands listed in Table 8.1-2 and above 38.6 GHz are designated for licence-exempt applications. These frequency bands and the requirements that apply to related devices are set out in the 200 and 300 series of RSSs.

Table 8.1-3: FCC restricted frequency bands

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
0.495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2690–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	Above 38.6
13.36–13.41			

8.1.2 Test summary

Verdict	Pass		
Tested by	Tarek Elkholy	Test date	January 14, 2022

8.1.3 Observations, settings and special notes

- As part of the current assessment, the test range of 9 kHz to 10th harmonic has been fully considered and compared to the actual frequencies utilized within the EUT. Since the EUT contains a transmitter in the GHz range, the EUT has been deemed compliant without formal testing in the 9 kHz to 30 MHz test range, therefore formal test results (tabular data and/or plots) are not provided within this test report.
- EUT was set to transmit in normal operation.
- Radiated measurements were performed at a distance of 3 m, except for the range 18-26 GHz was measured at a distance of 1 m.

Spectrum analyser settings for radiated measurements within restricted bands below 1 GHz:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for peak radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	Peak
Trace mode:	Max Hold

8.1.4 Test data, WiFi, 802.11b

Table 8.1-4: Radiated field strength measurement results - 802.11b

Channel	Frequency, MHz	Peak Field strength, dBμV/m		Margin, dB	Average Field strength, dBμV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	4824.1	59.0	74.0	15.0	48.9	54.0	5.1
Low	17983.5	52.3	74.0	21.7	40.4	54.0	13.6
Mid	4884.5	59.9	74.0	14.1	49.8	54.0	4.2
Mid	7326.0	66.1	74.0	7.9	52.3	54.0	1.7
High	4924.1	61.5	74.0	12.5	51.6	54.0	2.4
High	7385.9	63.6	74.0	10.4	50.5	54.0	3.5

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

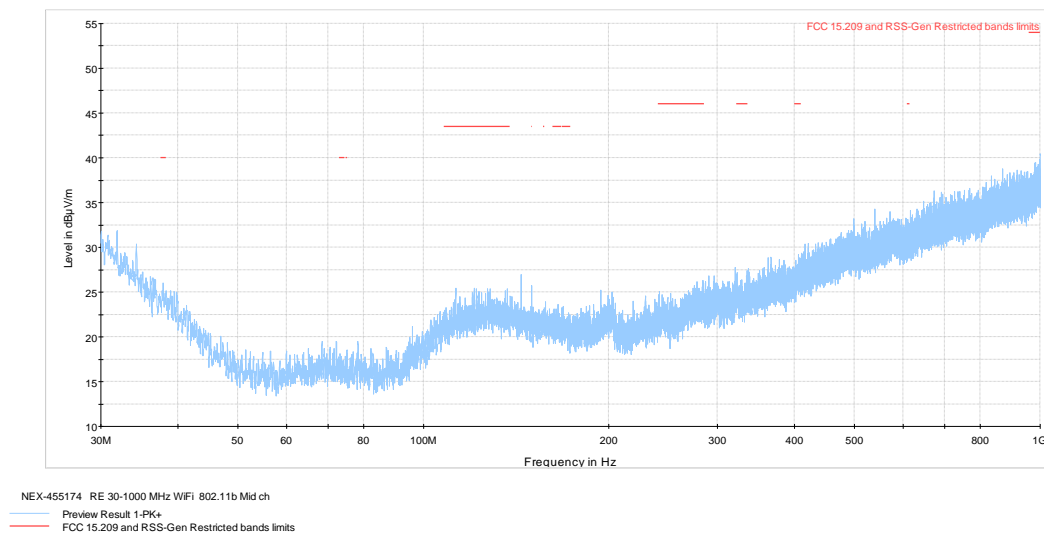


Figure 8.1-1: Radiated spurious emissions 30- 1000 MHz on Mid ch, sample plot

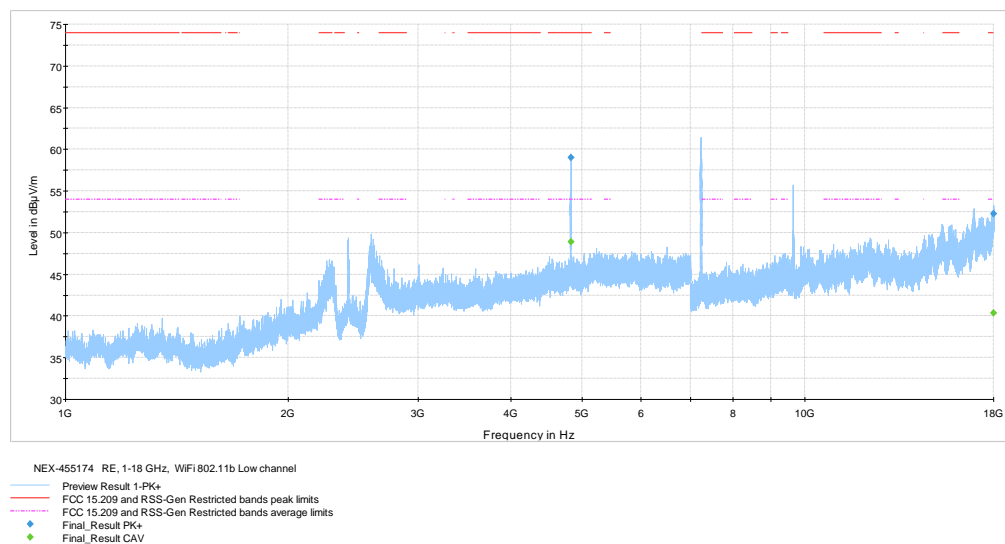


Figure 8.1-2: Radiated spurious emissions 1- 18 GHz on Low ch

Test data, WiFi, 802.11b, continued

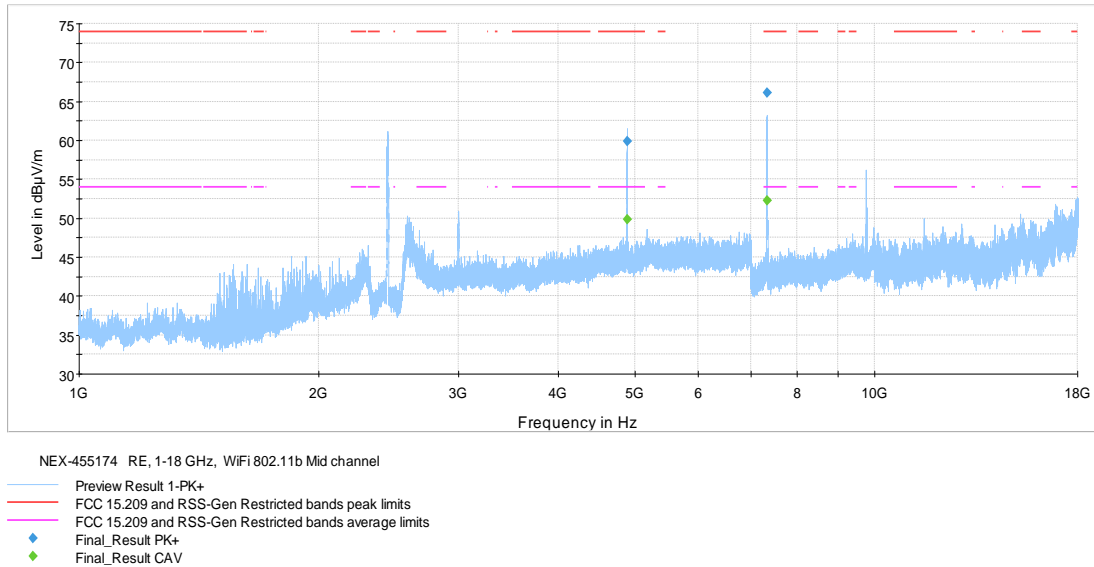


Figure 8.1-3: Radiated spurious emissions 1- 18 GHz on Mid ch

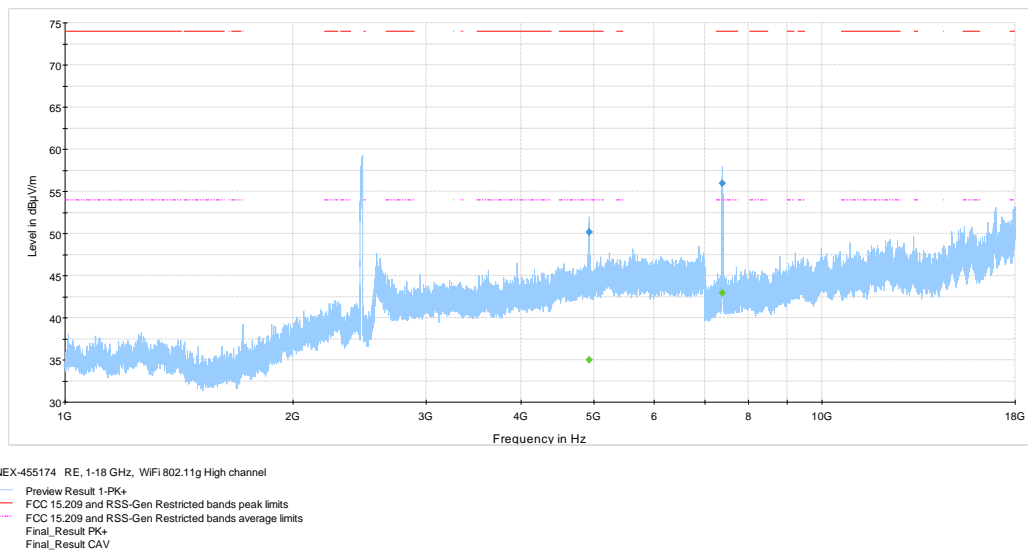


Figure 8.1-4: Radiated spurious emissions 1- 18 GHz on High ch

Test data, WiFi, 802.11b, continued

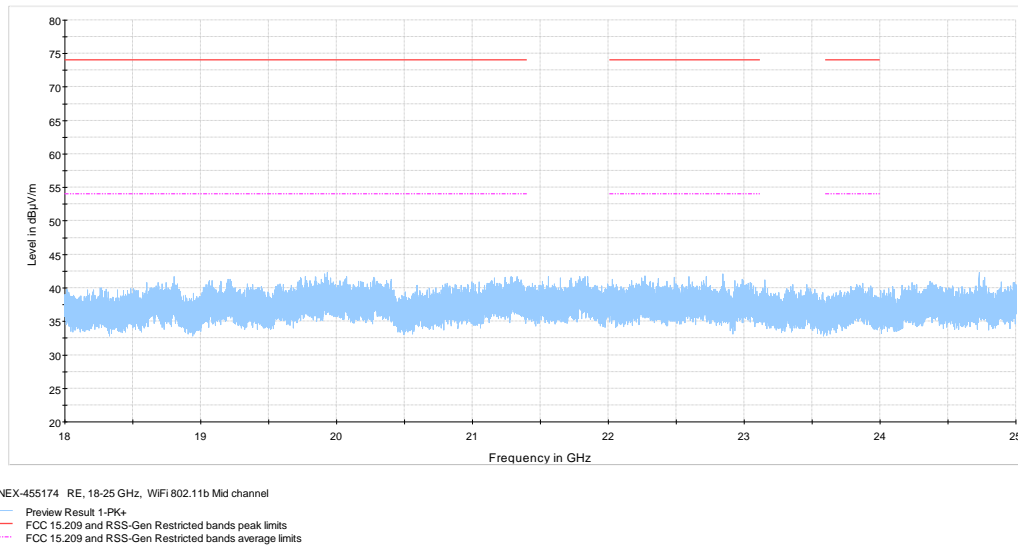


Figure 8.1-5: Radiated spurious emissions 18- 25 GHz on Mid ch, sample plot

Test data, WiFi, 802.11g

Table 8.1-5: Radiated field strength measurement results - 802.11g

Channel	Frequency, MHz	Peak Field strength, dBμV/m		Margin, dB	Average Field strength, dBμV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	4819.7	51.7	74.0	22.3	37.3	54.0	16.7
Low	7250.9	53.0	74.0	21.0	38.1	54.0	15.9
Low	17986.0	53.0	74.0	21.1	40.5	54.0	13.5
Mid	4883.8	46.3	74.0	27.7	34.1	54.0	19.9
Mid	7325.0	55.3	74.0	18.7	42.3	54.0	11.7
Mid	17980.0	54.0	74.0	20.0	40.3	54.0	13.7
High	4922.5	50.1	74.0	23.9	35.0	54.0	19.0
High	7388.4	55.9	74.0	18.1	42.9	54.0	11.1

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

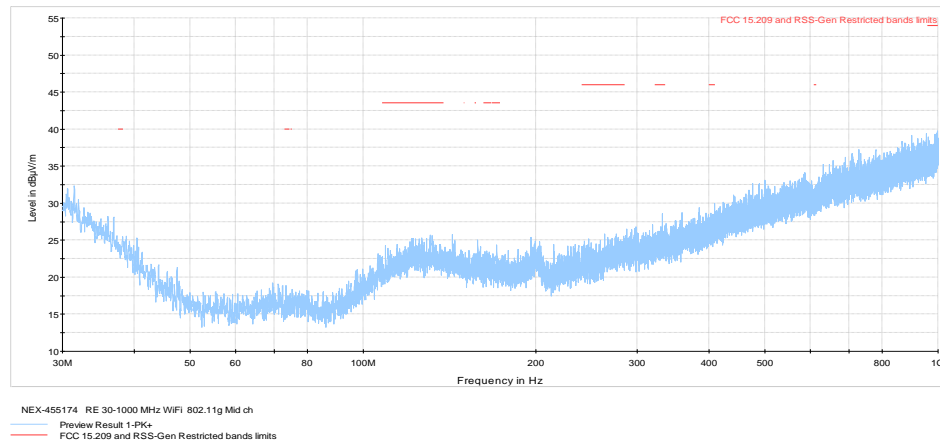


Figure 8.1-6: Radiated spurious emissions 30- 1000 MHz on Mid ch, sample plot

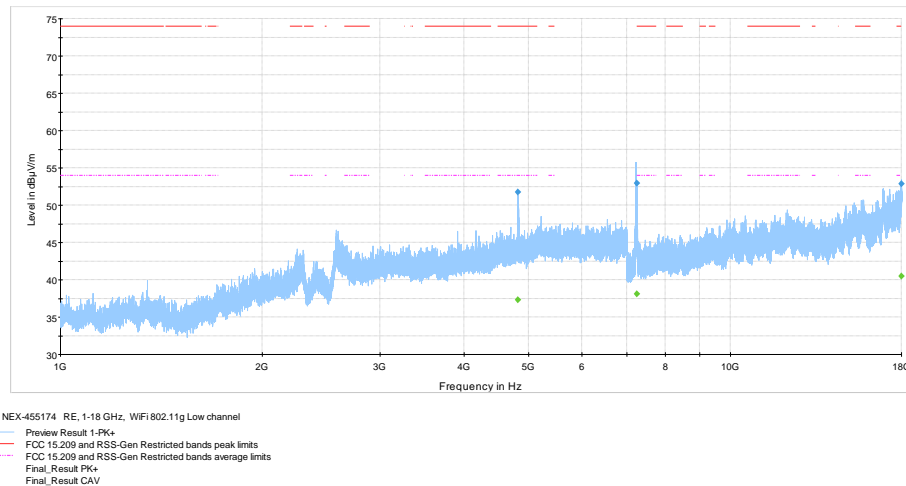


Figure 8.1-7: Radiated spurious emissions 1- 18 GHz on Low ch

Test data, WiFi, 802.11g, continued

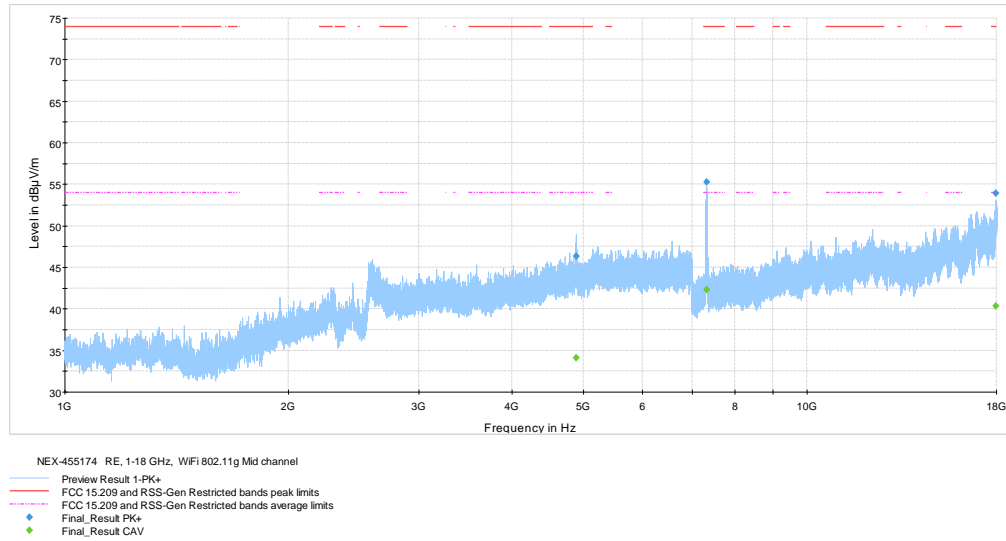


Figure 8.1-8: Radiated spurious emissions 1- 18 GHz on Mid ch

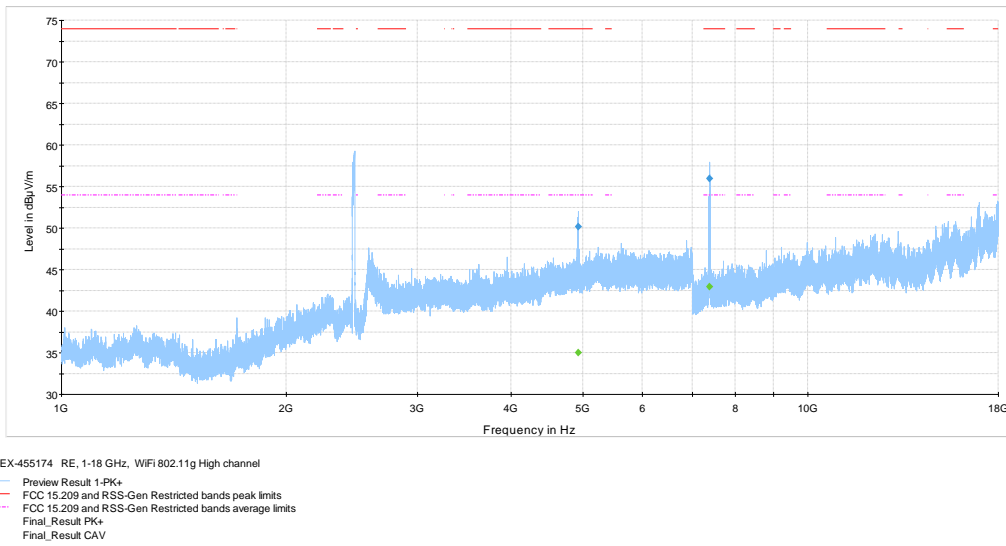
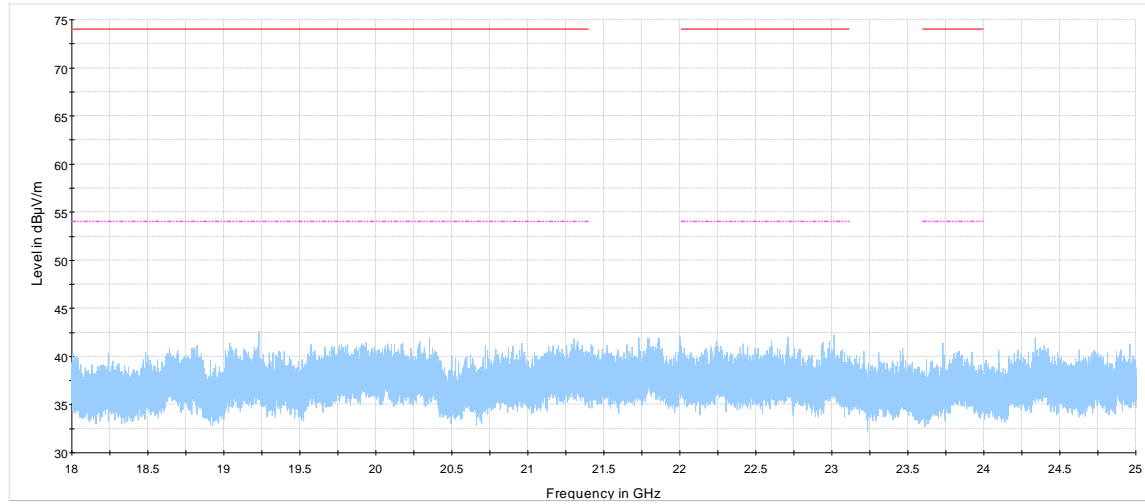


Figure 8.1-9: Radiated spurious emissions 1- 18 GHz on High ch

Test data, WiFi, 80.211g, continued



NEX-455174 RE, 18-25 GHz, WiFi 802.11g Mid channel

Preview Result 1-PK+
FCC 15.209 and RSS-Gen Restricted bands peak limits
FCC 15.209 and RSS-Gen Restricted bands average limits

Figure 8.1-10: Radiated spurious emissions 18- 25 GHz on Mid ch, sample plot

Test data, WiFi, 80.211n HT20

Table 8.1-6: Radiated field strength measurement results - 802.11n HT20

Channel	Frequency, MHz	Peak Field strength, dBμV/m		Margin, dB	Average Field strength, dBμV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	4810.5	45.5	74.0	28.5	33.5	54.0	20.5
Low	7251.8	50.2	74.0	23.8	36.6	54.0	17.4
Low	17982.0	51.6	74.0	22.4	40.1	54.0	13.9
Mid	7319.0	53.0	74.0	21.0	38.7	54.0	15.3
Mid	17980.3	53.1	74.0	20.9	40.3	54.0	13.7
High	4918.0	46.6	74.0	27.4	33.8	54.0	20.2
High	7390.6	51.5	74.0	22.5	38.8	54.0	15.2
High	17995.0	52.6	74.0	21.4	40.3	54.0	13.7

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

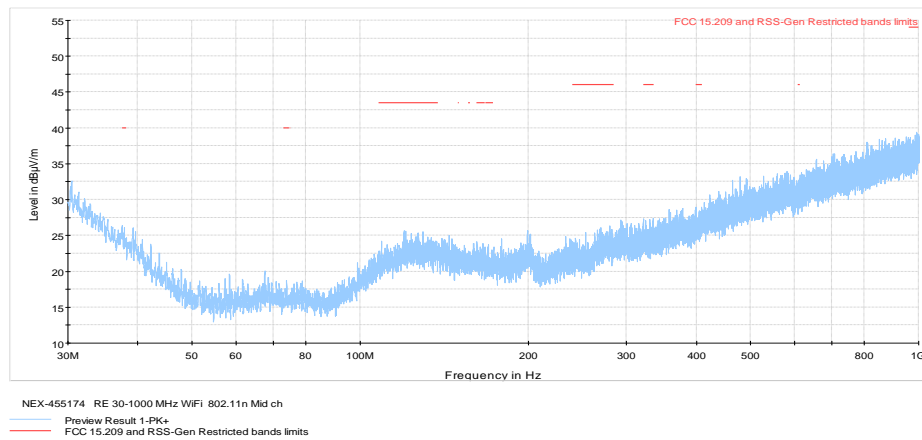


Figure 8.1-11: Radiated spurious emissions 30- 1000 MHz on Mid ch, sample plot

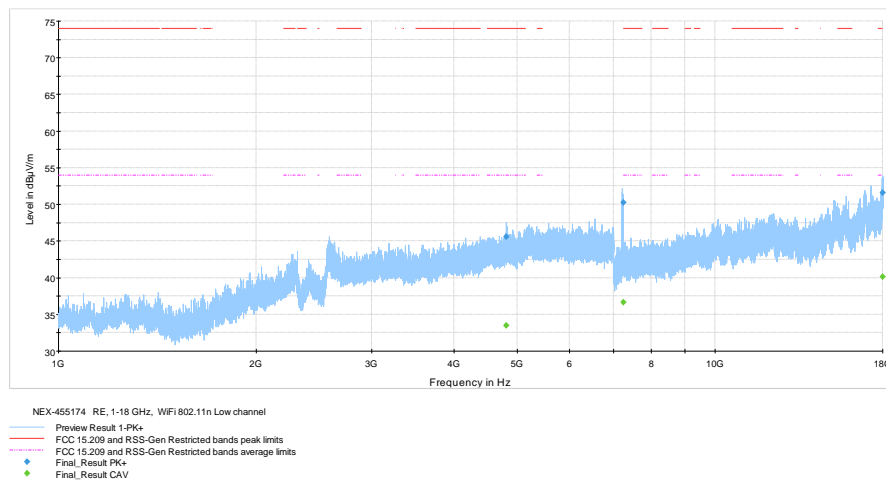


Figure 8.1-12: Radiated spurious emissions 1- 18 GHz on Low ch

Test data, WiFi, 80.211n HT20, continued

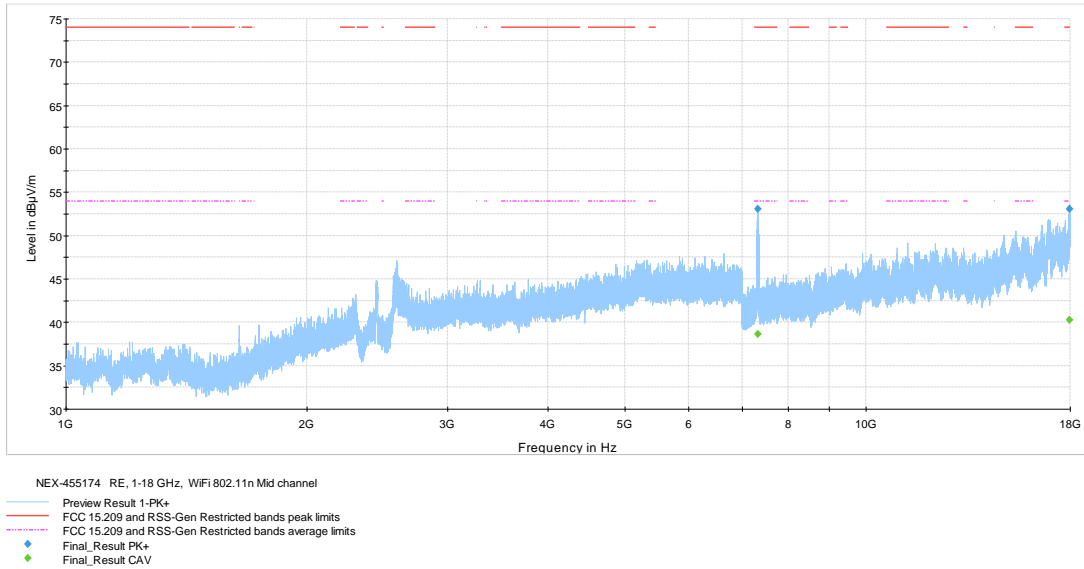


Figure 8.1-13: Radiated spurious emissions 1- 18 GHz on Mid ch

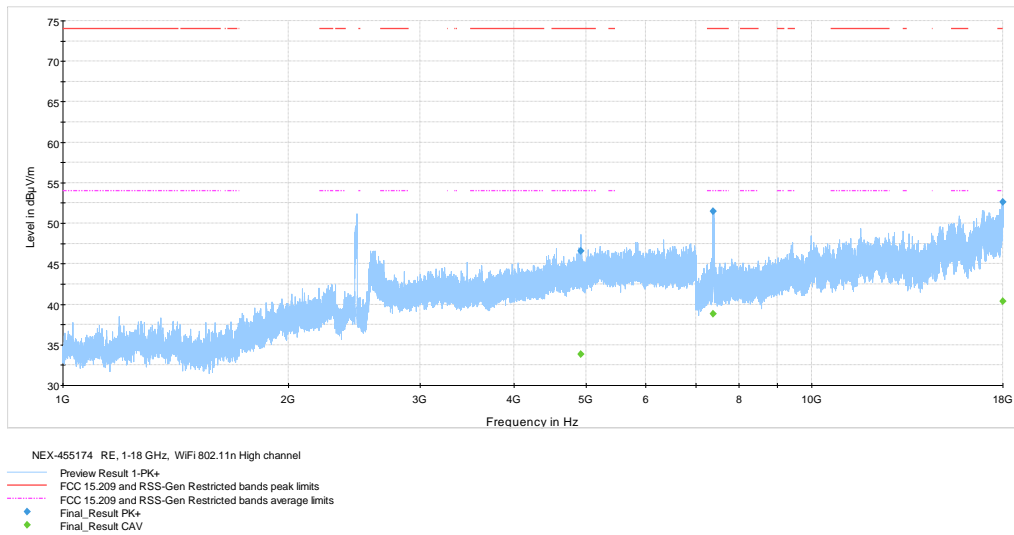


Figure 8.1-14: Radiated spurious emissions 1- 18 GHz on High ch

Test data, WiFi, 80.211n HT20, continued

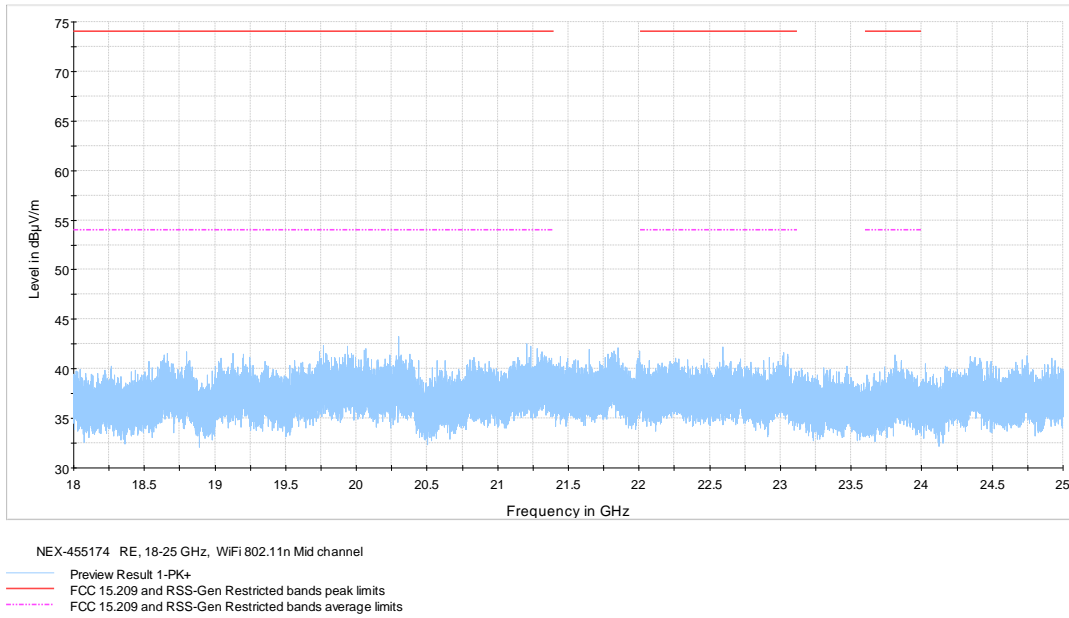


Figure 8.1-15: Radiated spurious emissions 18- 25 GHz on Mid ch, sample plot

Test data, BLE

Table 8.1-7: Radiated field strength measurement results

Channel	Frequency, MHz	Peak Field strength, dBμV/m		Margin, dB	Average Field strength, dBμV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	4803.0	50.0	74.0	24.0	39.4	54.0	14.6
Low	17947.0	51.8	74.0	22.2	39.7	54.0	14.3
Mid	4880.3.0	49.0	74.0	25.0	38.8	54.0	15.2
Mid	7321.5	58.5	74.0	15.5	49.3	54.0	4.7
Mid	17980.0	53.1	74.0	20.9	40.4	54.0	13.6
High	4959.4	48.5	74.0	25.5	38.3	54.0	15.7
High	7438.8	58.8	74.0	15.2	52.1	54.0	1.9
High	17992.5	52.9	74.0	21.1	10.4	54.0	13.4

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

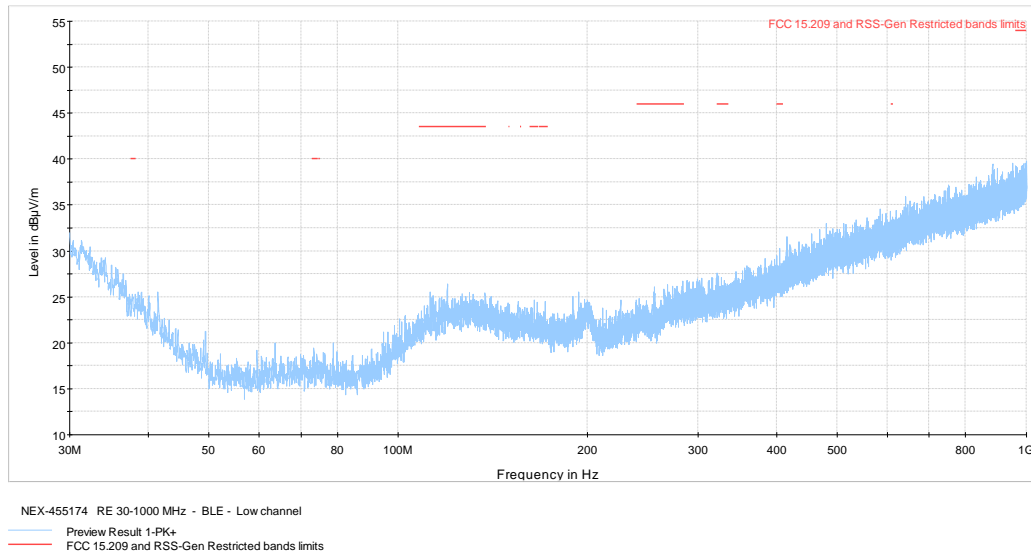


Figure 8.1-16: Radiated spurious emissions 30- 1000 MHz on Low ch

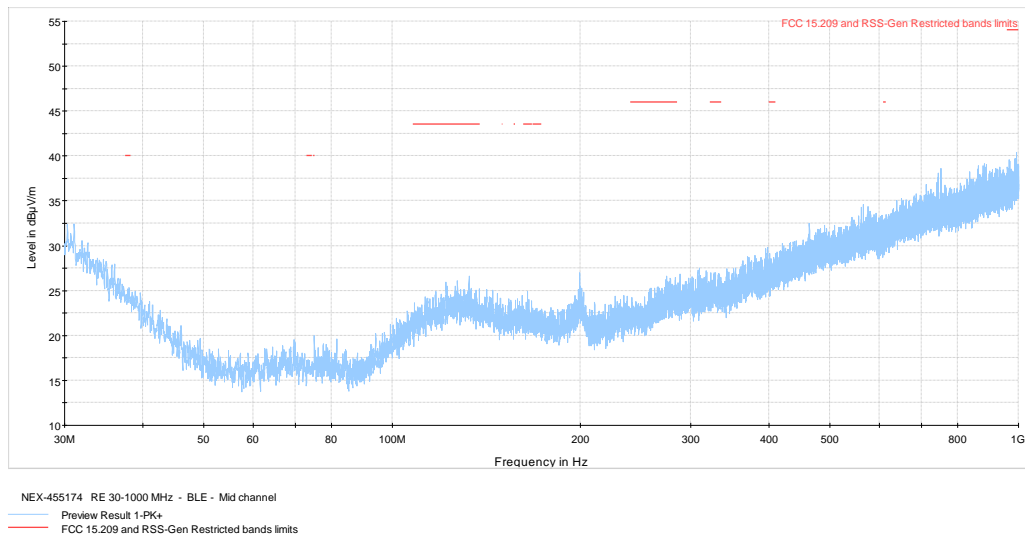


Figure 8.1-17: Radiated spurious emissions 30- 1000 MHz on Mid ch

Test data, BLE, continued

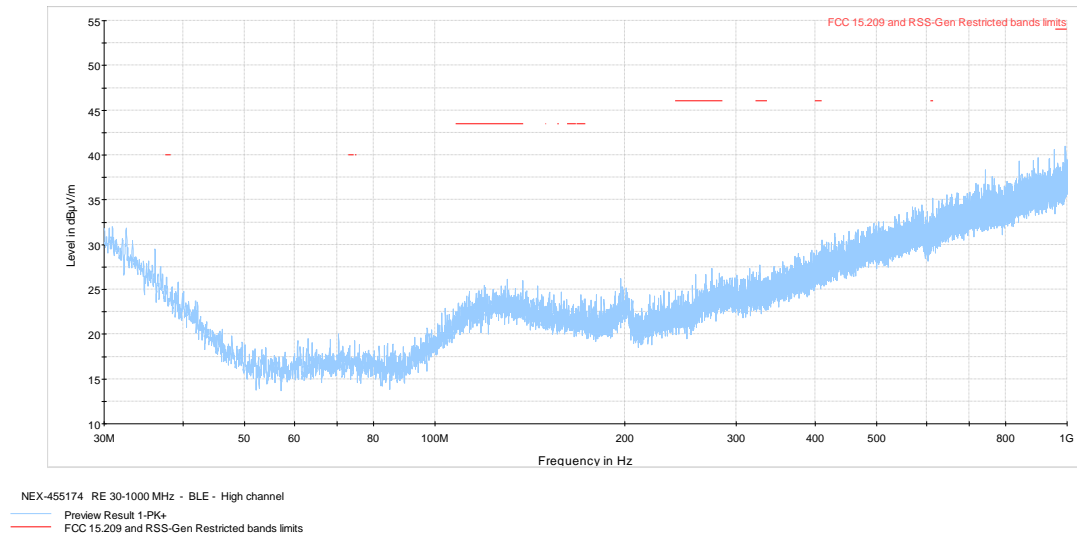


Figure 8.1-18: Radiated spurious emissions 30- 1000 MHz on High ch

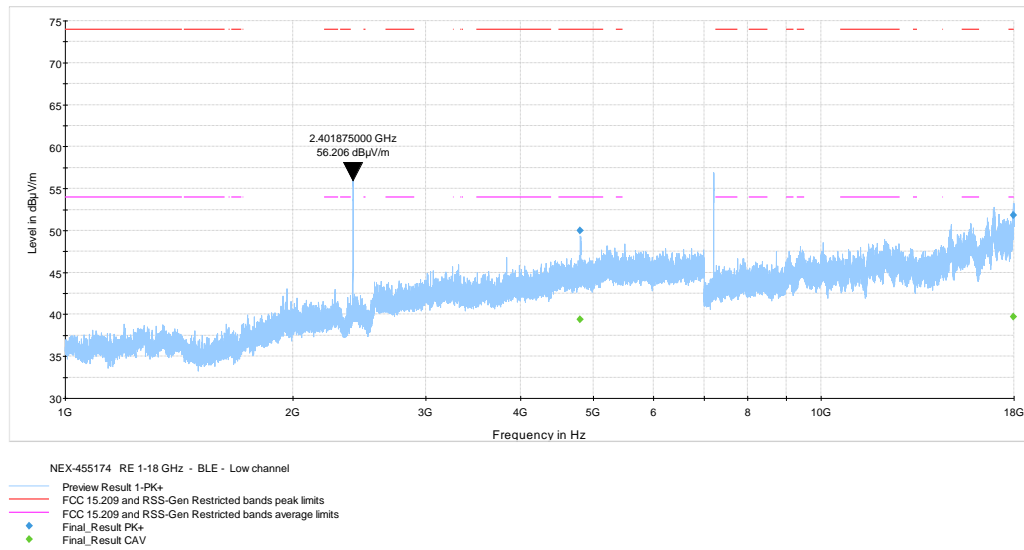


Figure 8.1-19: Radiated spurious emissions 1- 18 GHz on Low ch

Test data, BLE, continued

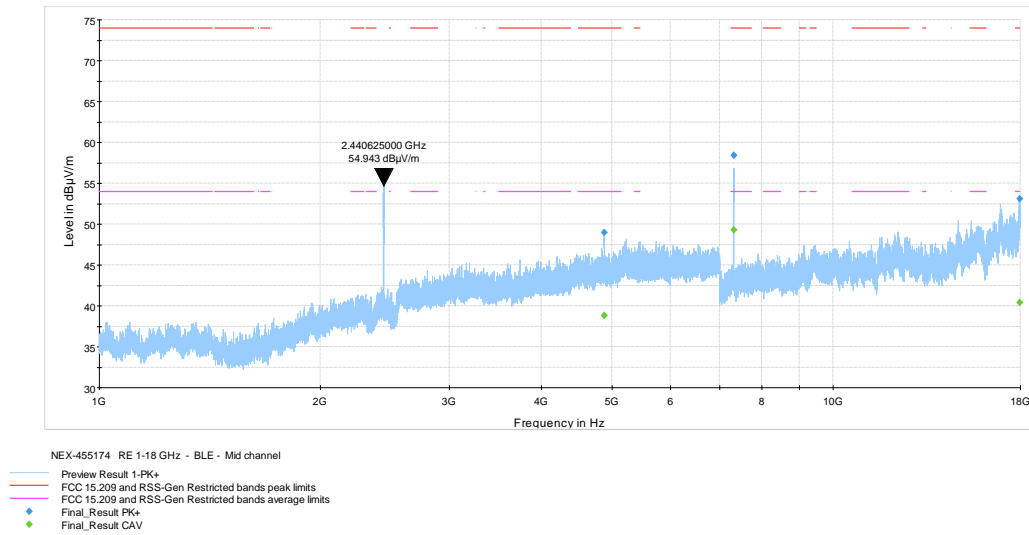


Figure 8.1-20: Radiated spurious emissions 1- 18 GHz on Mid ch

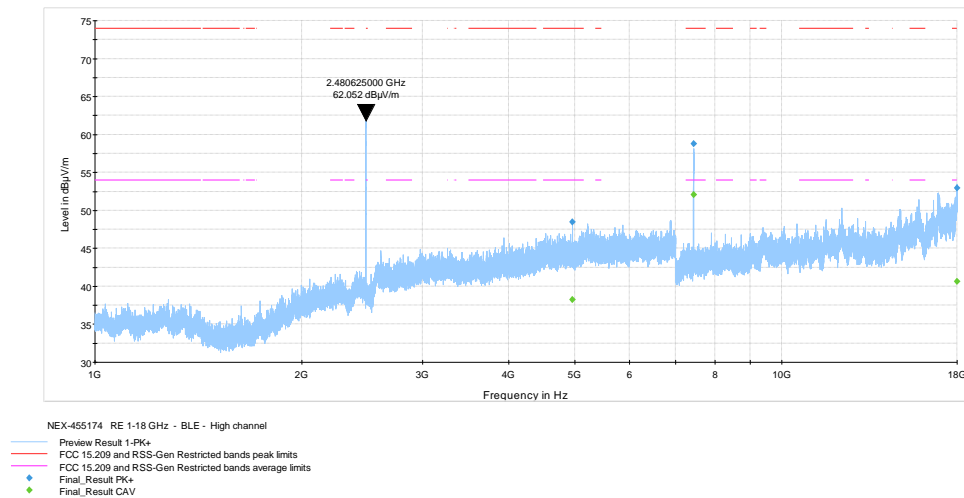


Figure 8.1-21: Radiated spurious emissions 1- 18 GHz on High ch

Test data, BLE, continued

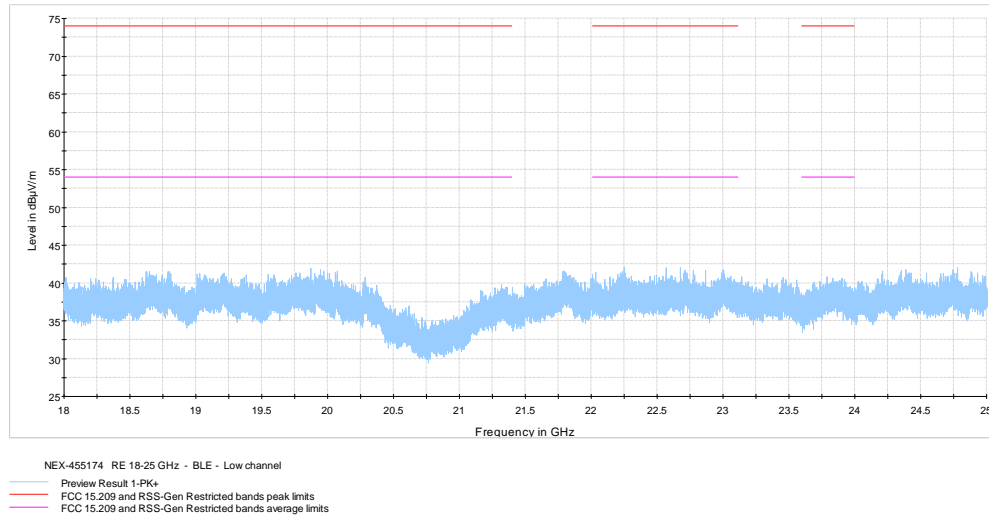


Figure 8.1-22: Radiated spurious emissions 18- 25 GHz on Low ch

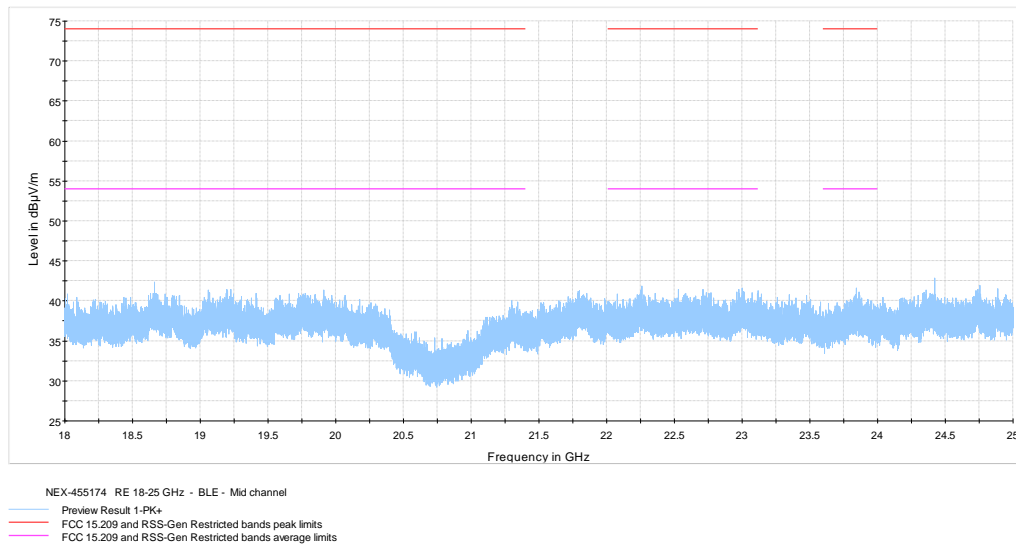


Figure 8.1-23: Radiated spurious emissions 18- 25 GHz on Mid ch

Test data, BLE, continued

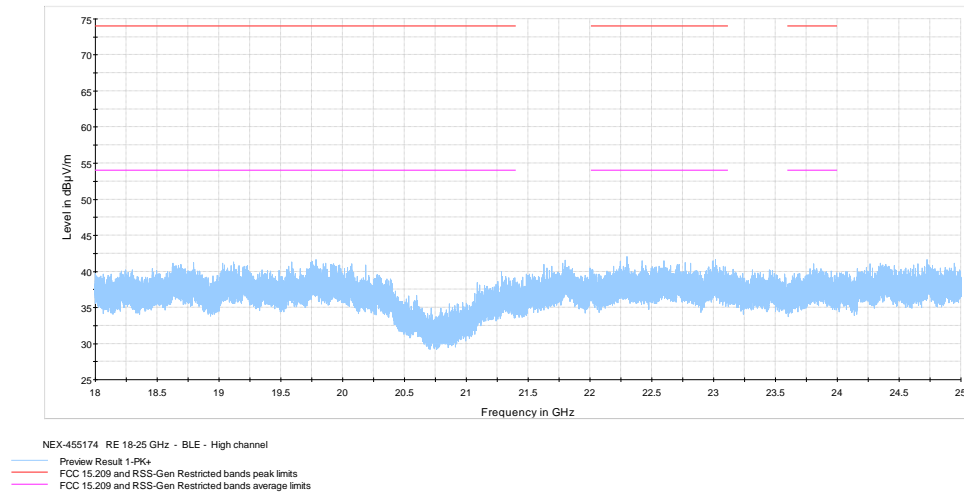


Figure 8.1-24: Radiated spurious emissions 18- 25 GHz on High ch

End of the test report