

RADIO TEST REPORT – 444710–8TRFWL

Type of assessment:

Modular transmitter integration

Applicant:

Technologies HumanWare Inc.

Product:

BT + WIFI module

Model:

PCBA-0131-A1.0

FCC ID:

XT5-0131

IC Registration number:

8670A-0131

Specifications:

- ◆ FCC 47 CFR Part 15 Subpart C, §15.247, Subpart E, §15.407
- ◆ RSS-247, Issue 2, Feb 2017, Section 5 and 6

Date of issue: October 6, 2021

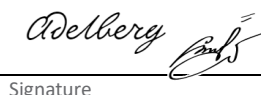
Yong Huang, EMC/RF Specialist

Tested by


Signature

Andrey Adelberg, Senior EMC/RF Specialist

Reviewed by


Signature

Nemko Canada Inc., a testing laboratory, is accredited by the Standards Council of Canada.
The tests included in this report are within the scope of this accreditation

Lab locations

Company name	Nemko Canada Inc.			
Facilities	<i>Ottawa site:</i> 303 River Road Ottawa, Ontario Canada K1V 1H2 Tel: +1 613 737 9680 Fax: +1 613 737 9691	<i>Montréal site:</i> 292 Labrosse Avenue Pointe-Claire, Québec Canada H9R 5L8 Tel: +1 514 694 2684 Fax: +1 514 694 3528	<i>Cambridge site:</i> 1-130 Saltsman Drive Cambridge, Ontario Canada N3E 0B2 Tel: +1 519 650 4811	<i>Almonte site:</i> 1500 Peter Robinson Road West Carleton, Ontario Canada K0A 1L0 Tel: +1 613 256-9117
Test site identifier	Organization FCC: ISED:	Ottawa/Almonte CA2040 2040A-4	Montreal CA2041 2040G-5	Cambridge CA0101 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.

Copyright notification

Nemko Canada Inc. authorizes the applicant to reproduce this report provided it is reproduced in its entirety and for use by the company's employees only. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties.

Nemko Canada Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

© Nemko Canada Inc.

Table of Contents

Table of Contents	3
Section 1 Report summary	4
1.1 Test specifications	4
1.2 Test methods	4
1.3 Exclusions	4
1.4 Statement of compliance.....	4
1.5 Test report revision history.....	4
Section 2 Engineering considerations	5
2.1 Modifications incorporated in the EUT for compliance	5
2.2 Technical judgment	5
2.3 Deviations from laboratory tests procedures	5
Section 3 Test conditions	6
3.1 Atmospheric conditions	6
3.2 Power supply range	6
Section 4 Measurement uncertainty	7
4.1 Uncertainty of measurement	7
Section 5 Information provided by the applicant	8
5.1 Disclaimer	8
5.2 Applicant/Manufacture	8
5.3 EUT information	8
5.4 Radio technical information.....	9
5.5 EUT setup details	9
Section 6 Summary of test results	13
6.1 Testing location	13
6.2 Testing period.....	13
6.3 Sample information	13
6.4 FCC Part 15 Subpart A and C, general requirements test results	13
6.5 FCC Part §15.247 test results	13
6.6 ISED RSS-Gen, Issue 5, test results	14
6.7 ISED RSS-247, Issue 2, test results	14
Section 7 Test equipment.....	15
7.1 Test equipment list	15
Section 8 Testing data	16
8.1 AC power line conducted emissions limits.....	16
8.2 Spurious (out-of-band) unwanted emissions.....	19
Section 9 EUT photos	62
9.1 External photos.....	62

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
FCC 47 CFR Part 15, Subpart E, Clause 15.407	Unlicensed National Information Infrastructure Devices operating in the 5.15–5.35 GHz, 5.47–5.725 GHz, 5.725–5.85 GHz, and 5.925–7.125 GHz bands.
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

558074 D01 15.247 Meas Guidance v05r02 (April 2, 2019)	Guidance for compliance measurements on digital transmission system, frequency hopping spread spectrum system, and hybrid system devices operating under section 15.247 of the FCC rules.
789033 D02 General U-NII Test Procedures New Rules v02r01 (December 14, 2017)	Guidelines for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices Part 15, Subpart E
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
RSS-102, Issue 5, March 19, 2015	Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)

1.3 Exclusions

Partial testing was performed on the product with the transmitter operating to confirm that the host product meets the FCC requirements. This investigation of the final product was done by spot checking emissions from the device while operating the host as a composite system. This testing was performed with the host product configured in typical operational modes to check the spurious emissions for compliance with all the applicable rules.

The evaluation was done to ensure there are no additional radiated spurious emissions generated due to simultaneous-transmission operations compared to single transmitter operations testing, and to ensure compliance with the applicable FCC/ISED rules for the transmitters operating individually and simultaneously. This includes compliance for the summation of all emissions from all outputs 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	October 6, 2021	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	Technologies HumanWare Inc.
Applicant address	1800, Jean-Berchmans-Michaud street Drummondville, (Quebec), Canada J2C 7G7
Manufacture name	Same as applicant
Manufacture address	Same as applicant

5.3 EUT information

Product	BT + WIFI module
Model	PCBA-0131-A1.0
Host Model	DA2
Model variant(s)	None
Serial number	None
Part number	PCBA-0131
Power supply requirements	3.0 to 3.6 Vdc, 300 mA , From host AC: 120 V, 50/60 Hz power cord
Product description and theory of operation	The PCBA-0131 RF module integrates a PCB antenna. The module allows the host to connect to Wifi networks via a SDIO interface. It also allows the host to use the Bluetooth protocol via a UART interface.

5.4 Radio technical information

Category of Wideband Data Transmission equipment	☐ Frequency Hopping Spread Spectrum (FHSS) equipment ☒ Other types of Wideband Data Transmission equipment (e.g. DSSS, OFDM, etc.).
Frequency band	2.4 GHz band and 5 GHz bands
Type of modulation	802.11b: DSSS (CCK, DQPSK, DBPSK) 802.11g/n(HT20): OFDM (QPSK, BPSK, 16-QAM, 64-QAM) BLE (GFSK) 802.11a/n/ac: OFDM (QPSK, BPSK, 16-QAM, 64-QAM)
Emission classification	F1D, W7D
Antenna information	Molex 211964 2.4GHz/5GHz Ceramic SMT antenna, max peak gain: 2.1 dBi at 2.4 GHz band and 2.2 dBi at 5 GHz band.
Firmware/Software information	8821cs-txpowerlimits-addition to wifi-bt-continuous-2021-06-29

5.5 EUT setup details

5.5.1 Radio exercise details

Operating conditions	The EUT is soldered on Humanware Digital Talking Book Machine Main PCB, the DA2. The DA2 provides 3.1Vdc power to the EUT. The DA2 also interfaces to the EUT with a digital interface (SDIO and UART). The DA2 runs on Linux and has the appropriate drivers to control the EUT. In order to control the EUT in the appropriate mode, the DA2 is connected to a laptop with a serial to USB communication adapter. The operator uses a terminal interface on the laptop to communicate with the DA2. The DA2 has a special build for this purpose, the "certification-rtwpriv-wifi-bt-continuous-2021-06-10"
Transmitter state	Transmitter set in to continuous mode.

IEEE 802.11b Mode : CCK

Frequency	Channel	Tested Data rate
2412	1	1Mbps
2437	6	1Mbps
2462	11	1Mbps

IEEE 802.11g Mode : OFDM

Frequency	Channel	Tested Data rate
2412	1	6Mbps
2437	6	6Mbps
2462	11	6Mbps

IEEE 802.11n , HT20, Mode : OFDM

Frequency	Channel	Tested Data rate
2412	1	6,5Mbps
2437	6	6,5Mbps
2462	11	6,5Mbps

IEEE 802.11n , HT40, Mode : OFDM

Frequency	Channel	Tested Data rate
2422	3	13.5Mbps
2437	6	13.5Mbps
2452	9	13.5Mbps

5.5.1 EUT setup configuration

Test Channel for 802.11a/n(HT20)/ac(VHT20)

Band	Channel	Frequency
U-NII Band I		
Low	36	5180MHz
Mid	40	5200MHz
High	48	5240MHz
U-NII Band II-A		
Low	52	5260MHz
Mid	60	5300MHz
High	64	5320MHz
U-NII Band II-C		
Low	100	5500MHz
Mid	116	5580MHz
High	140	5700MHz
U-NII Band III		
Low	149	5745MHz
Mid	157	5785MHz
High	165	5825MHz

Test Channel for 802.11n(HT40)/ac(VHT40)

Band	Channel	Frequency
U-NII Band I		
Low	38	5190MHz
High	46	5230MHz
U-NII Band II-A		
Low	54	5270MHz
High	62	5310MHz
U-NII Band II-C		
Low	102	5510MHz
Mid	110	5550MHz
High	134	5670MHz
U-NII Band III		
Low	151	5755MHz
High	159	5795MHz

5.5.2 EUT setup configuration

Test Channel for 802.11ac(VHT80)

Band	Channel	Frequency
U-NII Band I		
Only	42	5210MHz
U-NII Band II-A		
Only	58	5290MHz
U-NII Band II-C		
Low	106	5530MHz
High	122	5610MHz
U-NII Band III		
Only	155	5775MHz

Test Mode:

Mode	Data rate
802.11a	6 Mbps
802.11n(HT20) / 802.11ac(VHT20)	6.5 Mbps
802.11n(HT40) / 802.11ac(VHT40)	13.5 Mbps
802.11ac(VHT80)	29.3 Mbps

5.5.3 EUT setup configuration

Table 5.5-1: EUT sub assemblies

Description	Brand name	Model, Part number, Serial number, Revision level
Digital Talking Book Machine	Humanware	MN: DA2 SN: ALPHA-COND-1 PN: ASSY-1100
BT + WIFI module	Humanware	MN: PCBA-0131-A1.0, PN: PCBA-0131 Rev: A1.0

Table 5.5-2: Support equipment

Description	Brand name	Model, Part number, Serial number, Revision level
Serial communication board	Humanware	PN: PCBA-0097B Rev: P2
AC power adapter	InnoVision	MN: GW18W-050300UV

EUT setup configuration, continued

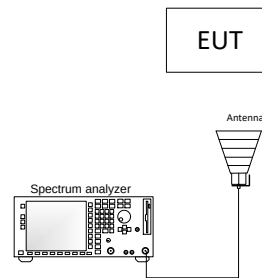


Figure 5.5-1: Radiated testing block diagram

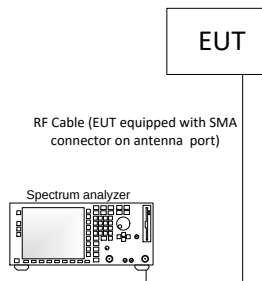


Figure 5.5-2: Antenna port testing block diagram

Section 6 Summary of test results

6.1 Testing location

Test location (s)	Montreal
-------------------	----------

6.2 Testing period

Test start date	June 10, 2021	Test end date	July 31, 2021
-----------------	---------------	---------------	---------------

6.3 Sample information

Receipt date	June 10, 2021	Nemko sample ID number(s)	2
--------------	---------------	---------------------------	---

6.4 FCC Part 15 Subpart A and C, general requirements test results

Table 6.4-1: FCC general requirements results

Part	Test description	Verdict
§15.207(a)	Conducted limits	Pass
Notes: EUT is an AC powered device.		

6.5 FCC Part §15.247 test results

Table 6.5-1: FCC requirements results

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

Table 6.5-2: FCC §15.407 requirements results

Part	Test description	Verdict
§15.407(b)(1)	Undesirable emission limits for 5.15–5.25 GHz band	Pass
§15.407(b)(2)	Undesirable emission limits for 5.25–5.35 GHz band	Pass
§15.407(b)(3)	Undesirable emission limits for 5.47–5.725 GHz bands	Pass
§15.407(b)(4)	Undesirable emission limits for 5.725–5.85 GHz band	Pass
Notes: None		

6.6 ISED RSS-Gen, Issue 5, test results

Table 6.6-1: RSS-Gen requirements results

Part	Test description	Verdict
7.3	Receiver radiated emission limits	Not applicable
7.4	Receiver conducted emission limits	Not applicable
8.8	AC power-line conducted emissions limits	Pass

Notes: ¹According to sections 5.2 and 5.3 of RSS-Gen, Issue 5 the EUT does not have a stand-alone receiver neither scanner receiver, therefore exempt from receiver requirements.
EUT is an AC powered device.

6.7 ISED RSS-247, Issue 2, test results

Table 6.7-1: ISED requirements results

Part	Test description	Verdict
5.5	Unwanted emissions	Pass

Notes: All other specification's requirements are not applicable for this type of assessment, therefore were removed from the table.

Table 6.7-2: ISED RSS-247 requirements results

Section	Test description	Verdict
6.2.1.2	Unwanted emission limits for 5150–5250 MHz band	Pass
6.2.2.2	Unwanted emission limits for 5250–5350 MHz band	Pass
6.2.3.	Unwanted emission limits for 5470–5600 MHz and 5650–5725 MHz bands	Pass
6.2.4.2	Unwanted emission limits for 5725–5850 MHz band	Pass

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 (Emissions)	TDK	SAC-3	FA002532e	2 year	February 25, 2022
Flush mount turntable	Sunol	FM2022	FA002550	—	NCR
Controller	Sunol	SC104V	FA002551	—	NCR
Antenna mast	Sunol	TLT2	FA002552	—	NCR
3 Phase AC Power Supply	apc AC Power	AFC-33045T	FA002677	—	VOU
Power Meter	HIOKI	PW3337	FA002727	1 year	March 15, 2022
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 40	FA002071	1 year	March 16, 2022
Bilog antenna (20–2000 MHz)	Sunol	JB1	FA002517	1 year	March 3, 2022
Horn antenna (1–18 GHz)	EMCO	3115	FA001451	1 year	February 16, 2022
Horn antenna (18–40 GHz)	EMCO	3116	FA002487	2 year	March 4, 2023
Pre-amplifier (0.5–18 GHz)	Com-Power	PAM-118A	FA002561	1 year	September 22, 2021
Pre-amplifier (18–40 GHz)	Com-Power	PAM-840	FA002508	1 year	September 24, 2021
2.4 GHz band Notch Filter	Microwave Circuits	N0324413	FA002693	—	VOU
Spectrum analyzer	Rohde & Schwarz	FSV 40	FA002731	1 year	March 23, 2022
Temperature chamber	Thermotron	S-4	FA002534	1 year	July 13, 2022
LISN	Rohde & Schwarz	ENV216	FA002514	1 year	January 29, 2022
50 Ω coax cable	C.C.A.	None	FA002605	—	VOU
50 Ω coax cable	C.C.A.	None	FA002831	—	VOU

Notes: NCR - no calibration required, VOU - verify on use

Section 8 Testing data

8.1 AC power line conducted emissions limits

8.1.1 References, definitions and limits

FCC §15.207:

- (a) Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/50 Ω line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

ANSI C63.10, Clause 6.2:

If the EUT normally receives power from another device that in turn connects to the public utility ac power lines, measurements shall be made on that device with the EUT in operation to demonstrate that the device continues to comply with the appropriate limits while providing the EUT with power. If the EUT is operated only from internal or dedicated batteries, with no provisions for connection to the public utility ac power lines (600 VAC or less) to operate the EUT (such as an adapter), then ac power-line conducted measurements are not required.

For direct current (dc) powered devices where the ac power adapter is not supplied with the device, an “off-the-shelf” unmodified ac power adapter shall be used. If the device is supposed to be installed in a host (e.g., the device is a module or PC card), then it is tested in a typical compliant host.

RSS-Gen, Clause 8.8:

A radio apparatus that is designed to be connected to the public utility (AC) power line shall ensure that the radio frequency voltage, which is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz, shall not exceed the limits in table below.

Unless the requirements applicable to a given device state otherwise, for any radio apparatus equipped to operate from the public utility AC power supply either directly or indirectly (such as with a battery charger), the radio frequency voltage of emissions conducted back onto the AC power lines in the frequency range of 0.15 MHz to 30 MHz shall not exceed the limits shown in table below. The more stringent limit applies at the frequency range boundaries.

Table 8.1-1: Conducted emissions limit

Frequency of emission, MHz	Conducted emissions limit, dB μ V	
	Quasi-peak	Average**
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

Notes: * - The level decreases linearly with the logarithm of the frequency.

 ** - A linear average detector is required.

8.1.2 Test summary

8.1.3 Test summary

Verdict	Pass		
Tested by	Yong Huang	Test date	June 10, 2021

8.1.4 Observations, settings and special notes

Port under test – Coupling device	AC input of host – Artificial Mains Network (AMN)
EUT power input during test	120 V _{AC} , 60 Hz;
EUT setup configuration	Table top
Measurement details	A preview measurement was generated with the receiver in continuous scan mode. Emissions detected within 10 dB or above the limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement.
Additional notes:	– The EUT was set up as tabletop configuration per ANSI C63.10-2013 measurement procedure. – The spectral scan has been corrected with transducer factors (i.e. cable loss, LISN factors, and attenuators) for determination of compliance. Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + attenuator (dB) – Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded.

Receiver settings:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Peak and Average (Preview), Quasi-peak and CAverage (Final)
Trace mode	Max Hold
Measurement time	100 ms (Preview), 160 ms (Final)

8.1.5 Test data

Table 8.1-2: Conducted emissions results on phase line

Frequency, MHz	Quasi-Peak result, dBμV	Quasi-Peak limit, dBμV	Quasi-Peak margin, dB	Correction factor, dB
0.580	43.2	56.0	12.8	10.0
0.859	44.0	56.0	12.0	9.9
1.430	43.6	56.0	12.4	9.9

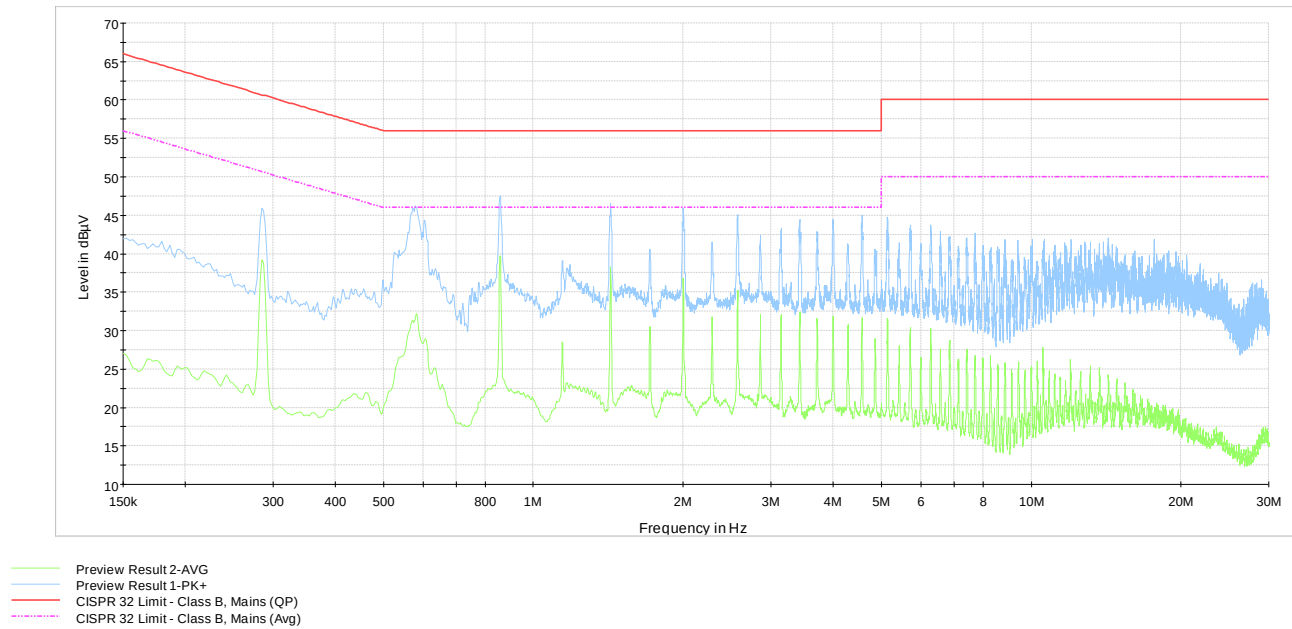
Frequency, MHz	CAverage result, dBμV	CAverage limit, dBμV	CAverage margin, dB	Correction factor, dB
0.857	38.0	46.0	8.0	9.9
1.428	36.9	46.0	9.1	9.9
2.573	34.6	46.0	11.4	9.9

Table 8.1-3: Conducted emissions results on neutral line

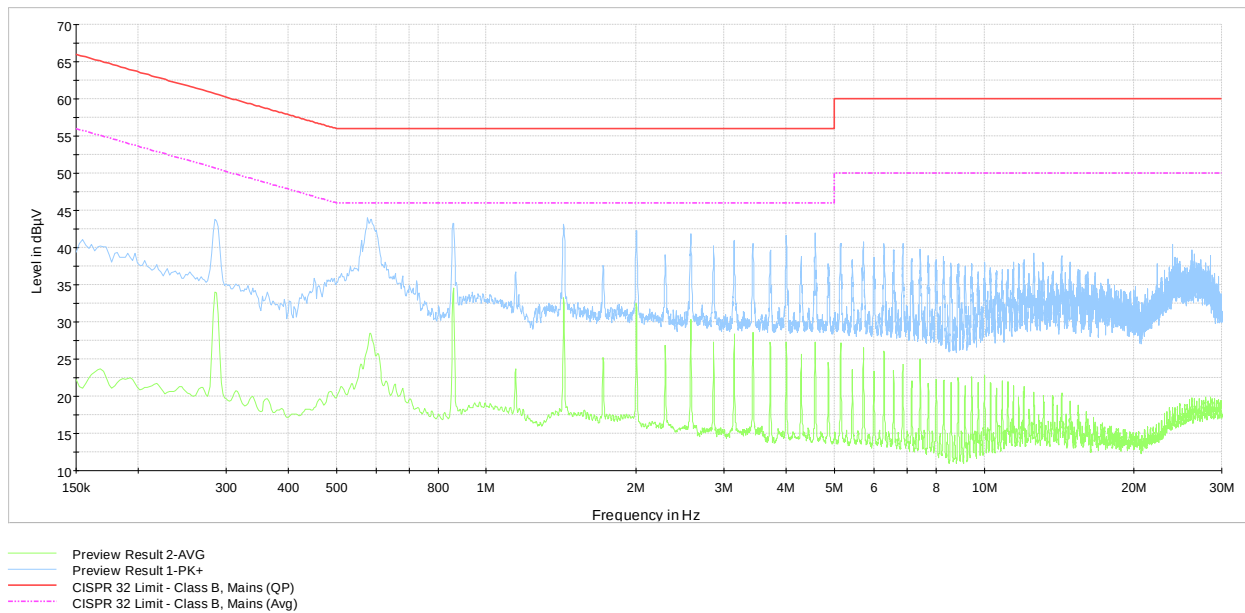
Frequency, MHz	Quasi-Peak result, dBμV	Quasi-Peak limit, dBμV	Quasi-Peak margin, dB	Correction factor, dB
0.578	38.7	56.0	17.3	10.0
0.857	40.5	56.0	15.5	9.9
1.430	40.0	56.0	16.0	9.9

Frequency, MHz	CAverage result, dBμV	CAverage limit, dBμV	CAverage margin, dB	Correction factor, dB
0.859	34.4	46.0	11.6	9.9
1.430	31.5	46.0	14.5	9.9
2.002	30.3	46.0	15.7	9.9

Test data, continued



Plot 8.1-1: Conducted emissions on phase line



Plot 8.1-2: Conducted emissions on neutral line

8.2 Spurious (out-of-band) unwanted emissions

8.2.1 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)).

FCC §15.407:

- (b) Undesirable emission limits.
- Except as shown in paragraph (b)(7) of this section, the maximum emissions outside of the frequency bands of operation shall be attenuated in accordance with the following limits:
- (1) For transmitters operating in the 5.15–5.25 GHz band: All emissions outside of the 5.15–5.35 GHz band shall not exceed an e.i.r.p. of –27 dBm/MHz.
 - (2) For transmitters operating in the 5.25–5.35 GHz band: All emissions outside of the 5.15–5.35 GHz band shall not exceed an e.i.r.p. of –27 dBm/MHz.
 - (3) For transmitters operating in the 5.47–5.725 GHz band: All emissions outside of the 5.47–5.725 GHz band shall not exceed an e.i.r.p. of –27 dBm/MHz.
 - (4) For transmitters operating in the 5.725–5.85 GHz band:
 - (i) All emissions shall be limited to a level of –27 dBm/MHz at 75 MHz or more above or below the band edge increasing linearly to 10 dBm/MHz at 25 MHz above or below the band edge, and from 25 MHz above or below the band edge increasing linearly to a level of 15.6 dBm/MHz at 5 MHz above or below the band edge, and from 5 MHz above or below the band edge increasing linearly to a level of 27 dBm/MHz at the band edge.
 - (7) The emission measurements shall be performed using a minimum resolution bandwidth of 1 MHz. A lower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 1 MHz.
 - (8) Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in § 15.209. Further, any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in § 15.207.
 - (9) The provisions of § 15.205 apply to intentional radiators operating under this section.
 - (10) When measuring the emission limits, the nominal carrier frequency shall be adjusted as close to the upper and lower frequency band edges as the design of the equipment permits.

References, definitions and limits, continued

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.

RSS-247, Clause 6.2:

Power and unwanted emissions limits

The power and e.i.r.p. of the equipment unwanted emission shall be measured in peak value. However, the equipment is required to comply with the provisions in RSS-Gen with respect to emissions falling within restricted frequency bands which are listed in the same standard.

If the transmission is in bursts, the provisions of RSS-Gen for pulsed operation shall apply.

The outermost carrier frequencies or channels shall be used when measuring unwanted emissions. Such carrier or channel centre frequencies are to be indicated in the test report.

6.2.1.2 Unwanted emission limits

For transmitters with operating frequencies in the band 5150–5250 MHz, all emissions outside the band 5150–5350 MHz shall not exceed –27 dBm/MHz e.i.r.p. Any unwanted emissions that fall into the band 5250–5350 MHz shall be attenuated below the channel power by at least 26 dB, when measured using a resolution bandwidth between 1 and 5% of the occupied bandwidth (i.e. 99% bandwidth), above 5250 MHz. The 26 dB bandwidth may fall into the 5250–5350 MHz band; however, if the occupied bandwidth also falls within the 5250–5350 MHz band, the transmission is considered as intentional and the devices shall comply with all requirements in the band 5250–5350 MHz including implementing dynamic frequency selection (DFS) and TPC, on the portion of the emission that resides in the 5250–5350 MHz band.

6.2.2.2 Unwanted emission limits

Devices shall comply with the following:

- a. All emissions outside the band 5250–5350 MHz shall not exceed –27 dBm/MHz e.i.r.p.; or
- b. All emissions outside the band 5150–5350 MHz shall not exceed –27 dBm/MHz e.i.r.p. and its power shall comply with the spectral power density for operation within the band 5150–5250 MHz. The device, except devices installed in vehicles, shall be labelled or include in the user manual the following text “for indoor use only.”

6.2.3.2 Unwanted emission limits

Emissions outside the band 5470–5725 MHz shall not exceed –27 dBm/MHz e.i.r.p. However, devices with bandwidth overlapping the band edge of 5725 MHz can meet the emission limit of –27 dBm/MHz e.i.r.p. at 5850 MHz instead of 5725 MHz.

6.2.4.2 Unwanted emission limits

Devices operating in the band 5725–5850 MHz shall have e.i.r.p. of unwanted emissions comply with the following:

- a. 27 dBm/MHz at frequencies from the band edges decreasing linearly to 15.6 dBm/MHz at 5 MHz above or below the band edges;
- b. 15.6 dBm/MHz at 5 MHz above or below the band edges decreasing linearly to 10 dBm/MHz at 25 MHz above or below the band edges;
- c. 10 dBm/MHz at 25 MHz above or below the band edges decreasing linearly to –27 dBm/MHz at 75 MHz above or below the band edges; and
- d. –27 dBm/MHz at frequencies more than 75 MHz above or below the band edges.

References, definitions and limits, continued

Table 8.2-1: 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.

Table 8.2-2: ISSED 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	
12.29–12.293	240–285	4500–5150	Above 38.6
12.51975–12.52025	322–335.4	5350–5460	

Note: Certain frequency bands listed in Table 8.2-2 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.

References, definitions and limits, continued

Table 8.2-3: 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			

8.2.2 Test summary

Verdict	Pass		
Tested by	Yong Huang	Test start date	June 16, 2021

8.2.3 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 with 100 % duty cycle.
- Radiated measurements were performed at a distance of 3 m below 18 GHz, and 1 m above 18 GHz.
- DTS emissions in non-restricted frequency bands test was performed as per KDB 558074, section 8.5 with reference to ANSI C63.10 subclause 11.11.
- Since fundamental power was tested using the maximum peak conducted output power procedure to demonstrate compliance, the spurious emissions limit is –20 dBc/100 kHz.
- DTS emissions in restricted frequency bands test was performed as per KDB 558074, section 8.6 with reference to ANSI C63.10 subclause 11.12.
- DTS band-edge emission measurements test was performed as per KDB 558074, section 8.7 with reference to ANSI C63.10 subclause 11.13.

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

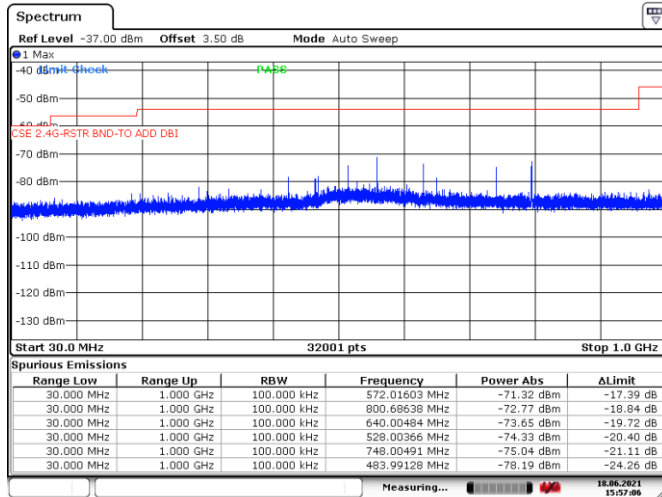
Spectrum analyser settings for average radiated measurements within restricted bands above 1 GHz:

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

Spectrum analyser settings for conducted spurious emissions measurements:

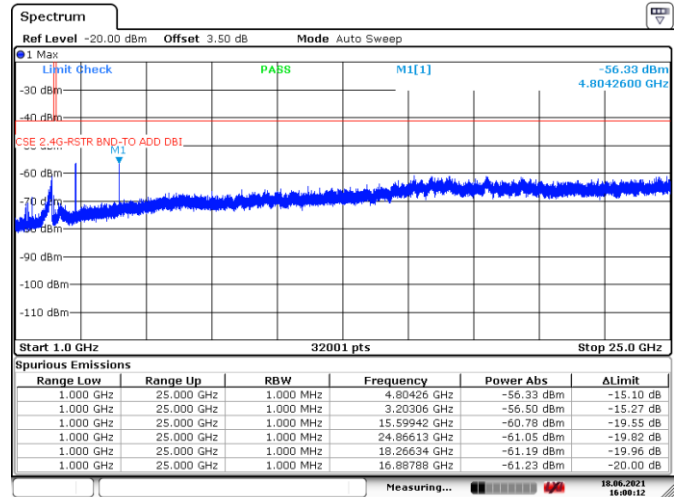
Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

8.2.4 Test data



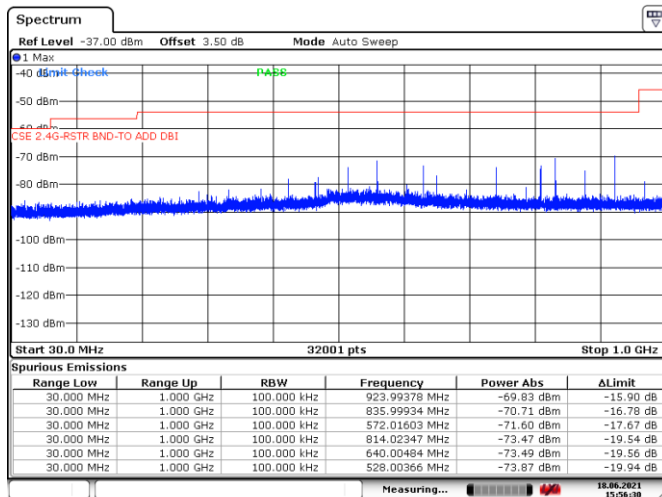
Date: 18 JUN 2021 15:57:07

Figure 8.2-1: Conducted spurious emission within restricted band 30 MHz to 1 GHz, Bluetooth TX on low channel



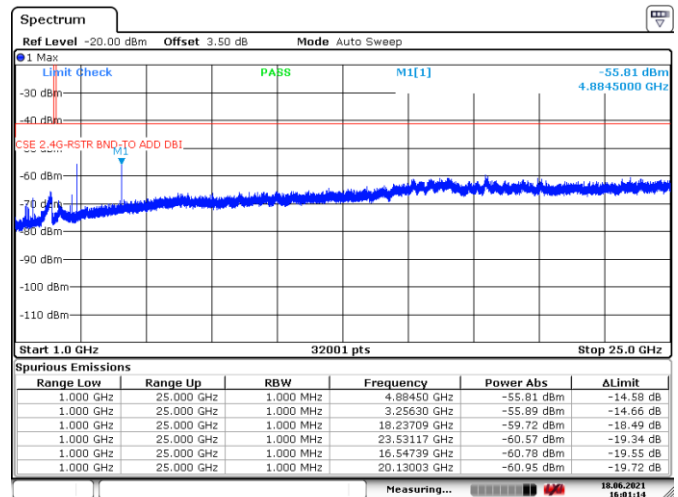
Date: 18 JUN 2021 16:00:12

Figure 8.2-2: Conducted spurious emission within restricted band above 1 GHz, Bluetooth TX on low channel



Date: 18 JUN 2021 15:56:29

Figure 8.2-3: Conducted spurious emission within restricted band 30 MHz to 1 GHz, Bluetooth TX on mid channel



Date: 18 JUN 2021 16:01:13

Figure 8.2-4: Conducted spurious emission within restricted band above 1 GHz, Bluetooth TX on mid channel

Note: Peak limit EIRP equivalent: 74 dBμV/m – 95.23 dB = -21.23 dBm
Average limit EIRP equivalent: 54 dBμV/m – 95.23 dB = -41.23 dBm

Test data, continued

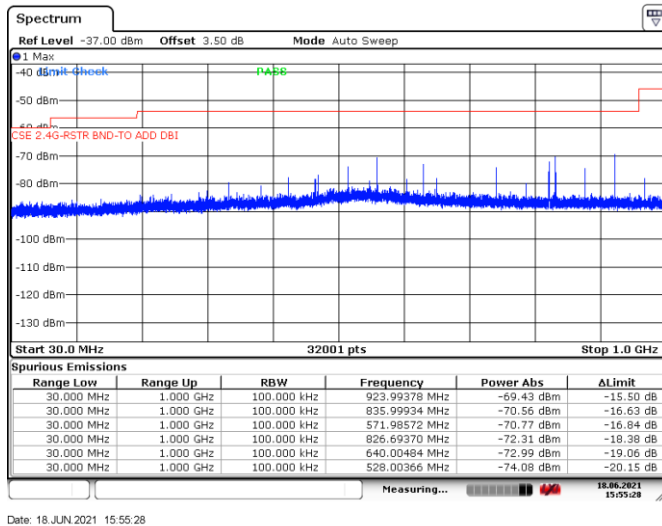


Figure 8.2-5: Conducted spurious emission within restricted band 30 MHz to 1 GHz, Bluetooth TX on high channel

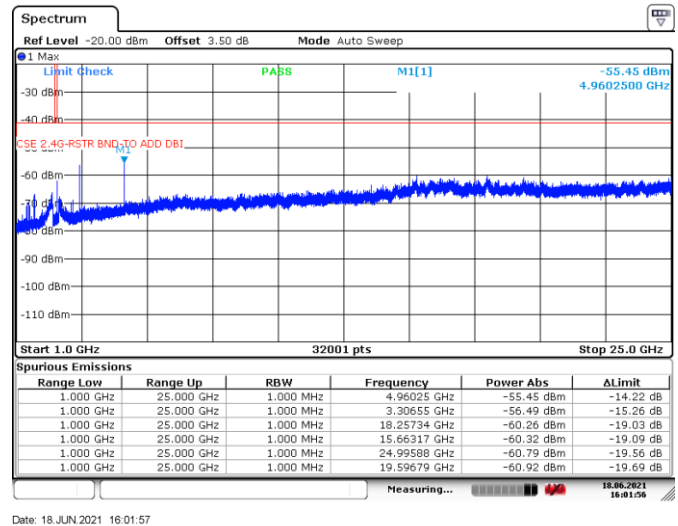


Figure 8.2-6: Conducted spurious emission within restricted band above 1 GHz, Bluetooth TX on high channel

Note: Peak limit EIRP equivalent: $74 \text{ dB}\mu\text{V/m} - 95.23 \text{ dB} = -21.23 \text{ dBm}$
 Average limit EIRP equivalent: $54 \text{ dB}\mu\text{V/m} - 95.23 \text{ dB} = -41.23 \text{ dBm}$

Test data, continued

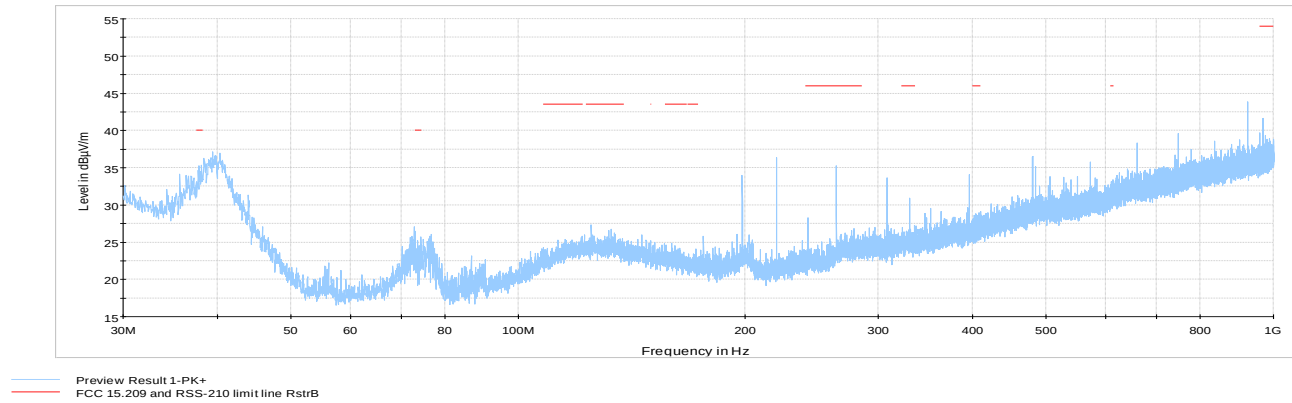


Figure 8.2-7: Cabinet Radiated spurious emissions 30 MHz to 1 GHz, Bluetooth Low channel

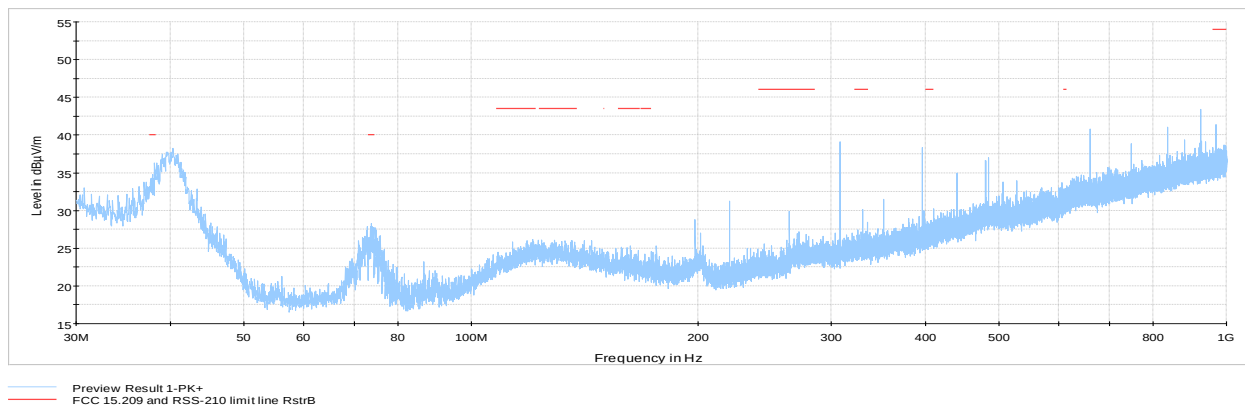


Figure 8.2-8: Cabinet Radiated spurious emissions 30 MHz to 1 GHz, Bluetooth mid channel

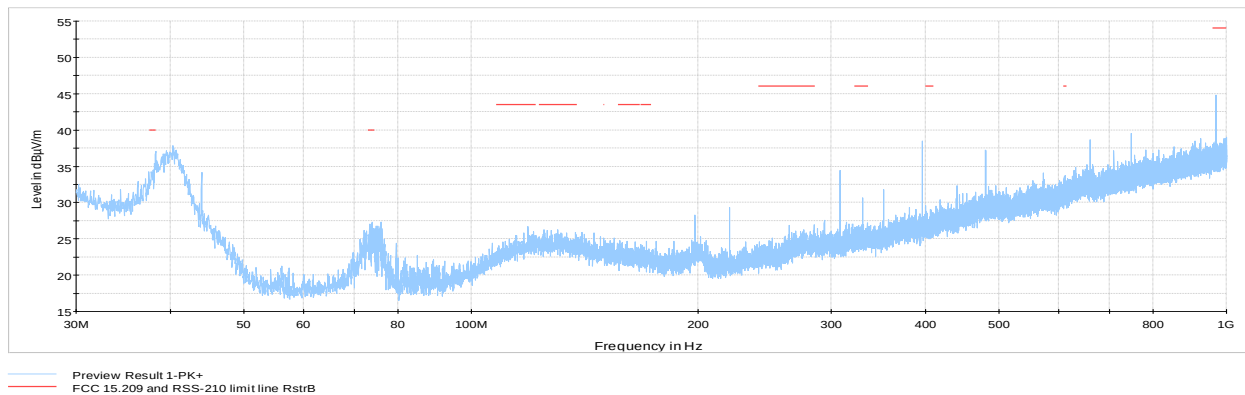


Figure 8.2-9: Cabinet Radiated spurious emissions 30 MHz to 1 GHz, Bluetooth High channel

Test data, continued

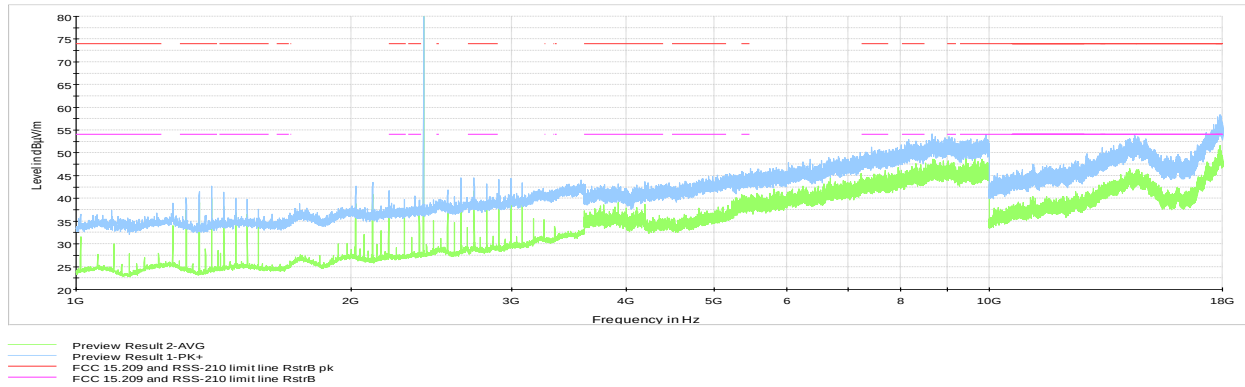


Figure 8.2-10: Cabinet Radiated spurious emissions 1 to 18 GHz, Bluetooth Low channel

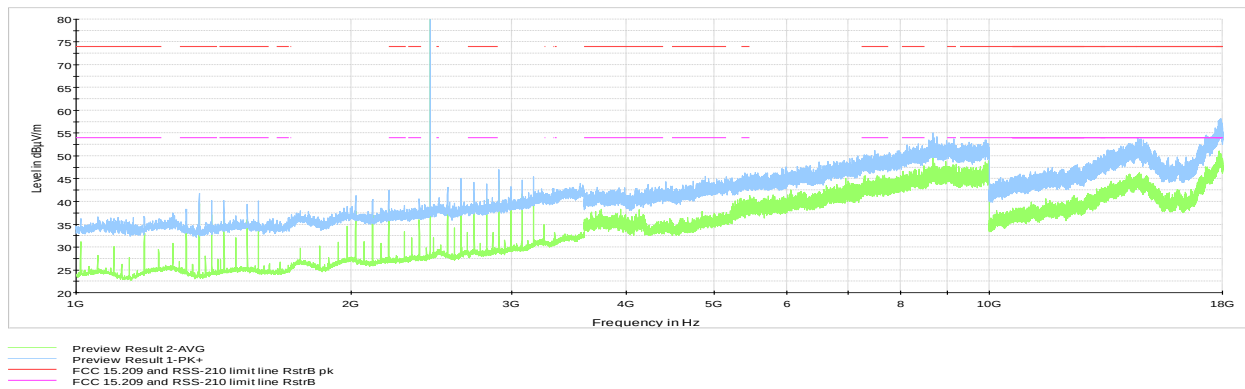


Figure 8.2-11: Cabinet Radiated spurious emissions 1 to 18 GHz, Bluetooth mid channel

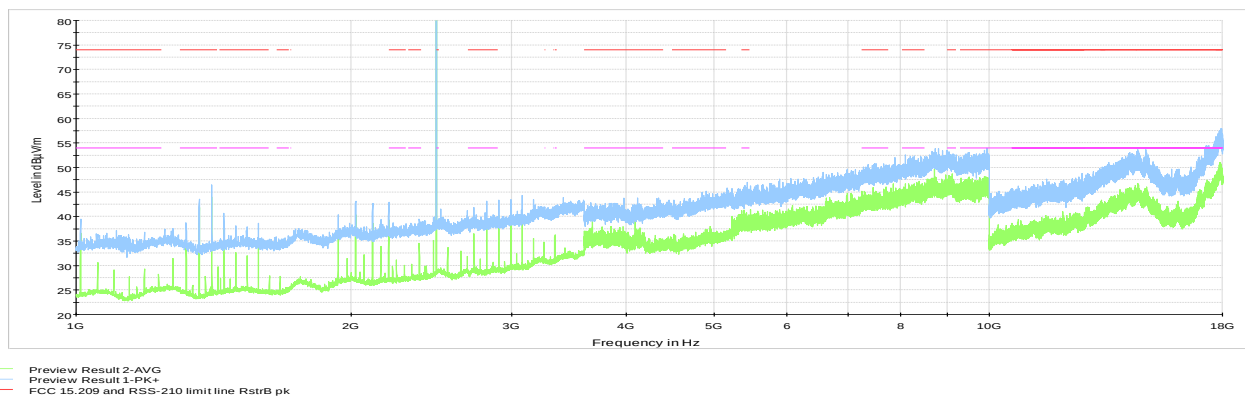
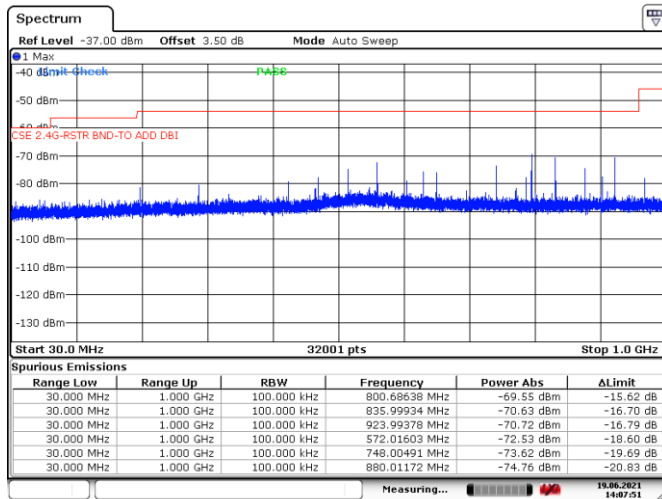


Figure 8.2-12: Cabinet Radiated spurious emissions 1 to 18 GHz, Bluetooth High channel

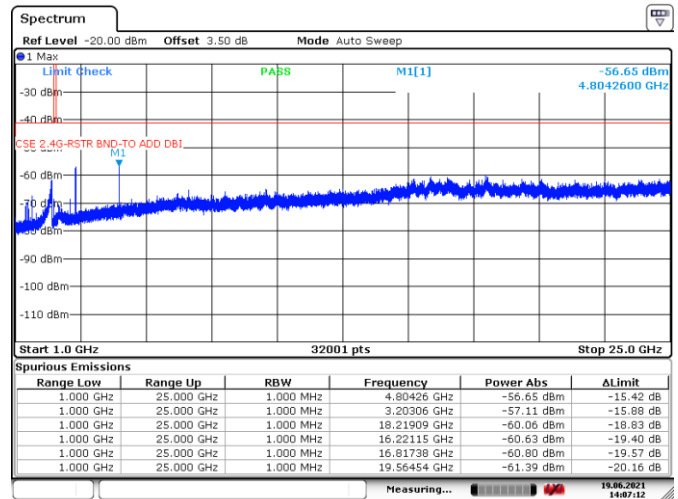
Note: Spectrum was investigated from 30 MHz to 25 GHz. Above 18 GHz, no emission related to RF portion were detected within 6 dB below the limit

Test data, continued



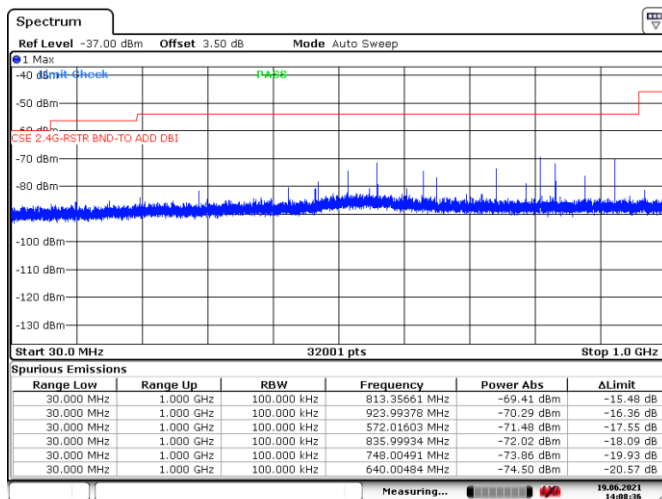
Date: 19 JUN 2021 14:07:51

Figure 8.2-13: Conducted spurious emission within restricted band 30 MHz to 1 GHz, BLE TX on low channel



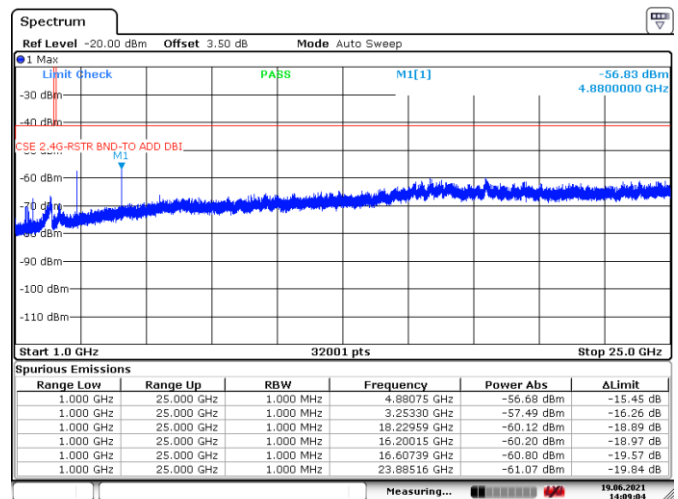
Date: 19 JUN 2021 14:07:12

Figure 8.2-14: Conducted spurious emission within restricted band above 1 GHz, BLE TX on low channel



Date: 19 JUN 2021 14:08:36

Figure 8.2-15: Conducted spurious emission within restricted band 30 MHz to 1 GHz, BLE TX on mid channel



Date: 19 JUN 2021 14:09:04

Figure 8.2-16: Conducted spurious emission within restricted band above 1 GHz, BLE TX on mid channel

Note: Peak limit EIRP equivalent: 74 dBμV/m – 95.23 dB = -21.23 dBm
Average limit EIRP equivalent: 54 dBμV/m – 95.23 dB = -41.23 dBm

Test data, continued

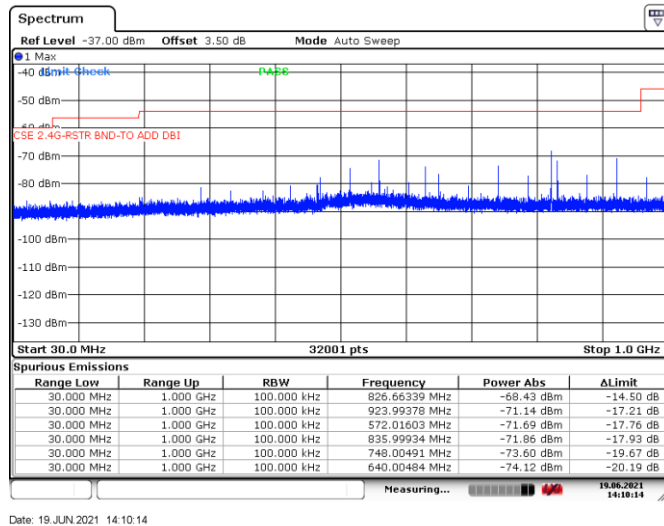


Figure 8.2-17: Conducted spurious emission within restricted band 30 MHz to 1 GHz, BLE TX on high channel

Note: Peak limit EIRP equivalent: $74 \text{ dB}\mu\text{V/m} - 95.23 \text{ dB} = -21.23 \text{ dBm}$
Average limit EIRP equivalent: $54 \text{ dB}\mu\text{V/m} - 95.23 \text{ dB} = -41.23 \text{ dBm}$

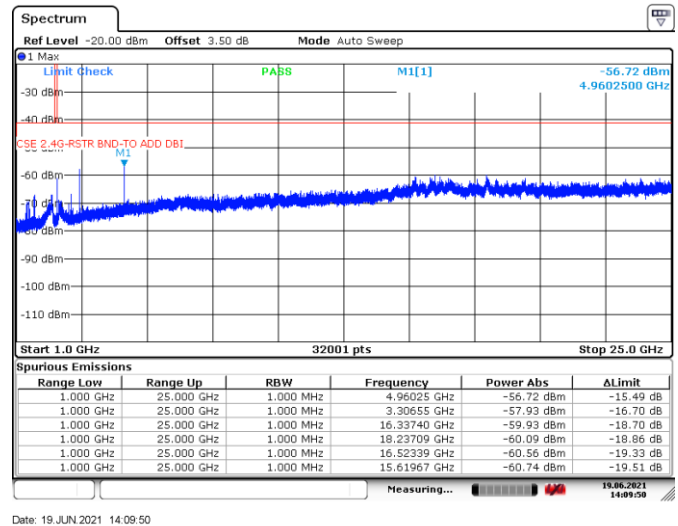


Figure 8.2-18: Conducted spurious emission within restricted band above 1 GHz, BLE TX on high channel

Test data, continued

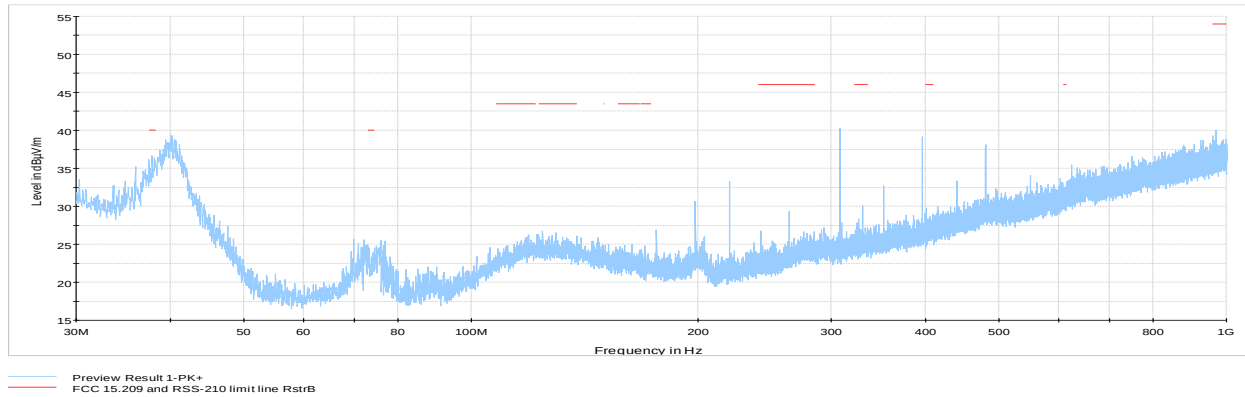


Figure 8.2-19: Cabinet Radiated spurious emissions 30 MHz to 1 GHz, BLE on Low channel

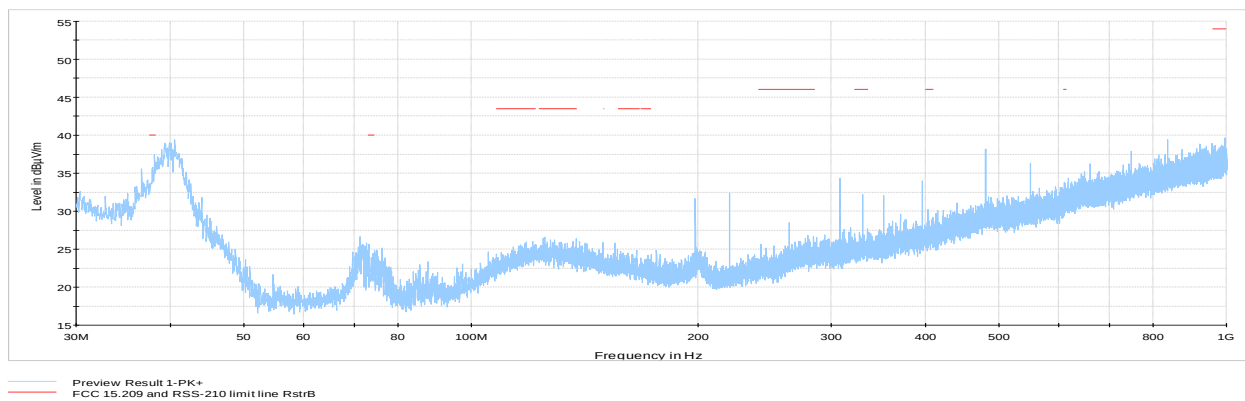


Figure 8.2-20: Cabinet Radiated spurious emissions 30 MHz to 1 GHz, BLE on mid channel

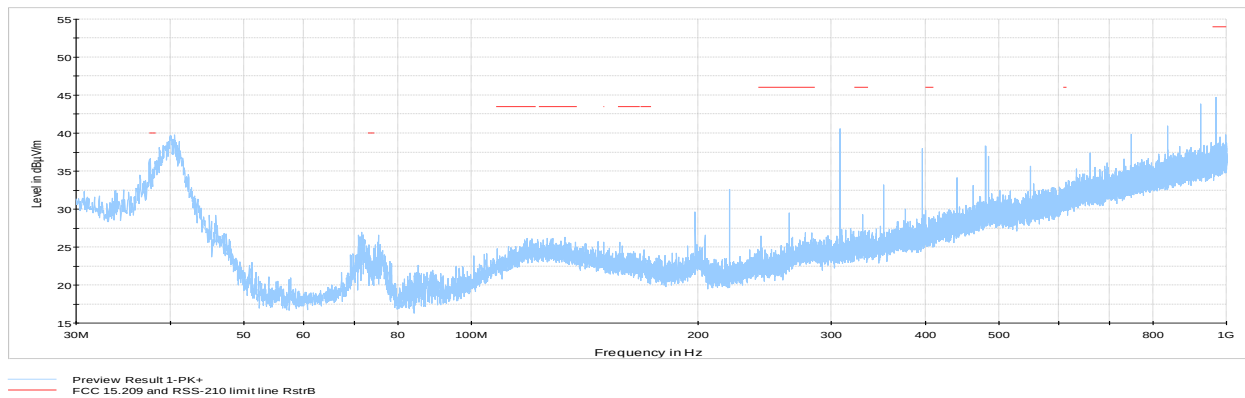


Figure 8.2-21: Cabinet Radiated spurious emissions 30 MHz to 1 GHz, BLE on High channel

Test data, continued

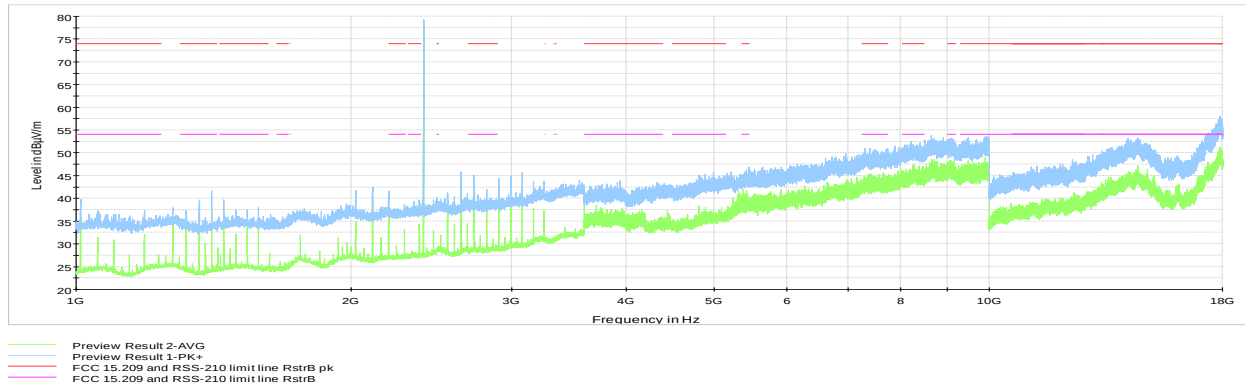


Figure 8.2-22: Cabinet Radiated spurious emissions 1 to 18 GHz, BLE on Low channel

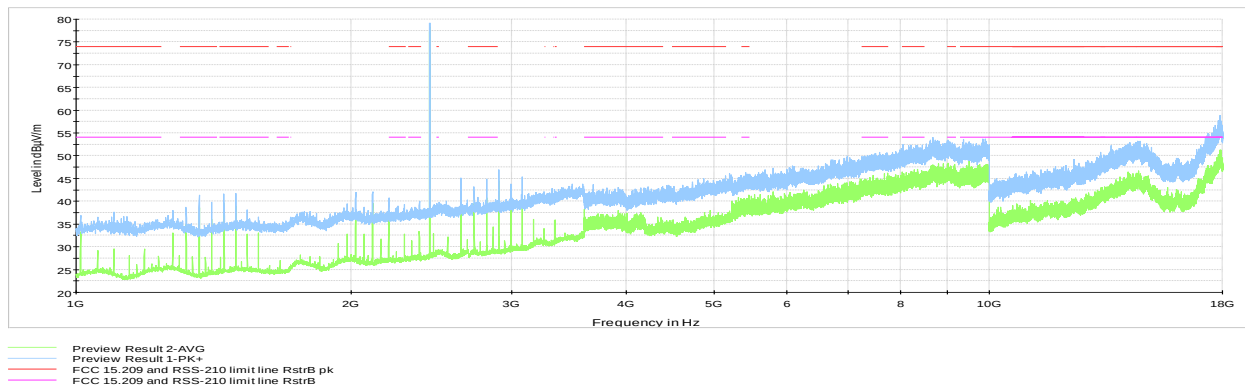


Figure 8.2-23: Cabinet Radiated spurious emissions 1 to 18 GHz, BLE on mid channel

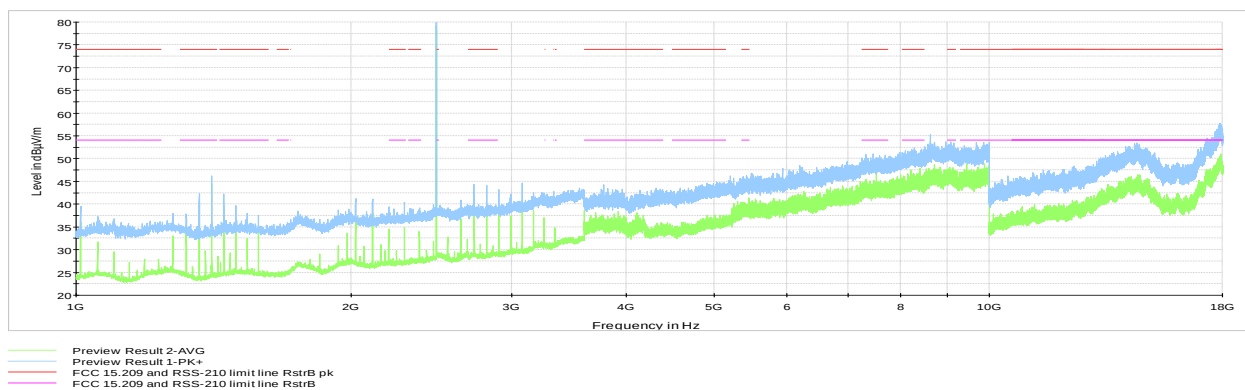
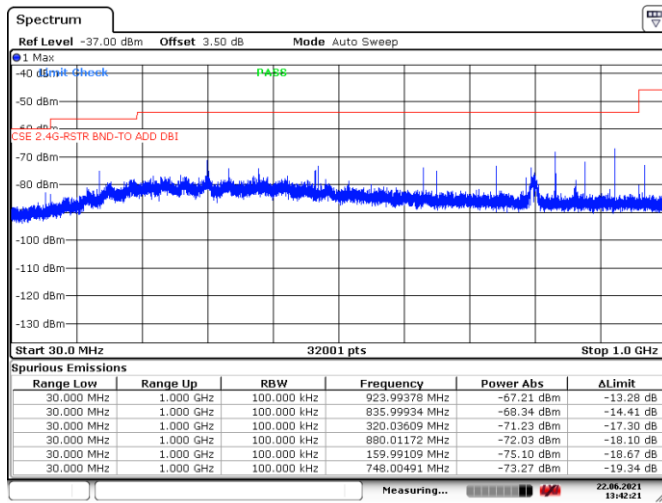


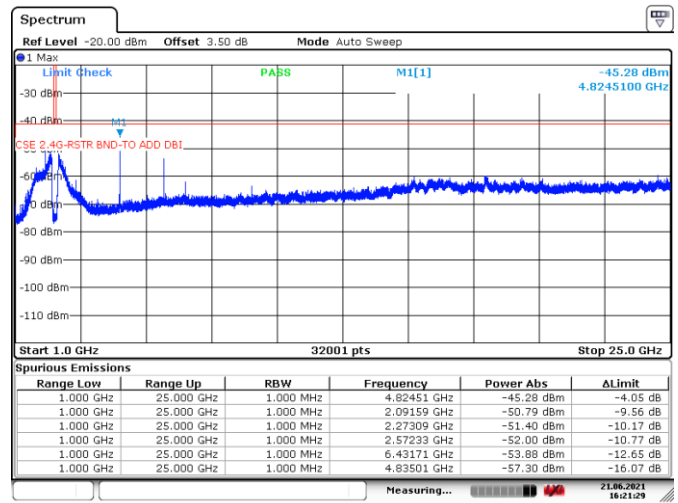
Figure 8.2-24: Cabinet Radiated spurious emissions 1 to 18 GHz, BLE on High channel

Note: Spectrum was investigated from 30 MHz to 25 GHz. Above 18 GHz, no emission related to RF portion were detected within 6 dB below the limit



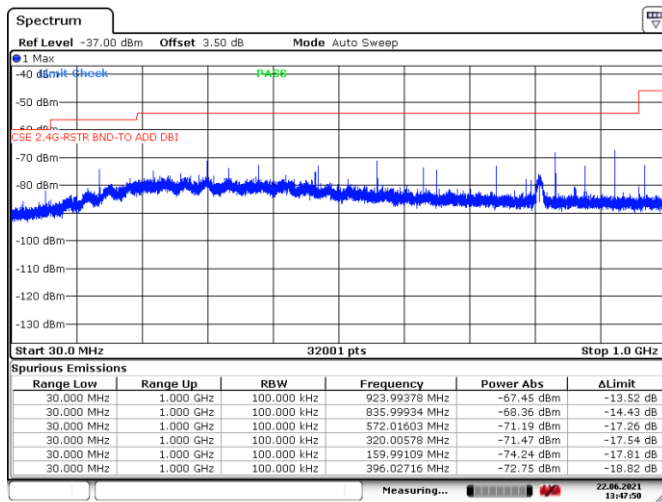
Date: 22 JUN 2021 13:42:20

Figure 8.2-25: Conducted spurious emission within restricted band 30 MHz to 1 GHz, 2.4GHz WIFI TX on 802.11b low channel



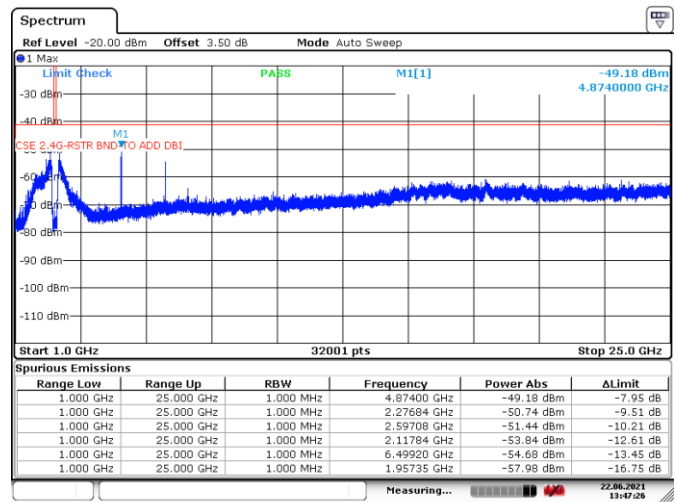
Date: 21 JUN 2021 16:21:29

Figure 8.2-26: Conducted spurious emission within restricted band above 1 GHz, 2.4GHz WIFI TX on 802.11b low channel



Date: 22 JUN 2021 13:47:50

Figure 8.2-27: Conducted spurious emission within restricted band 30 MHz to 1 GHz, 2.4GHz WIFI TX on 802.11b mid channel

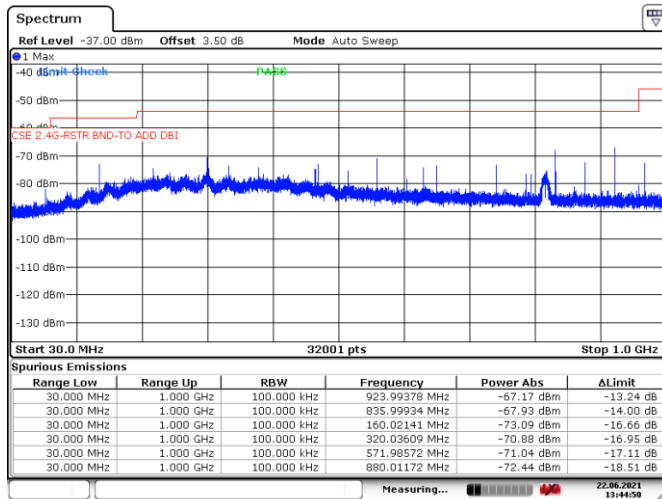


Date: 22 JUN 2021 13:47:26

Figure 8.2-28: Conducted spurious emission within restricted band above 1 GHz, 2.4GHz WIFI TX on 802.11b mid channel

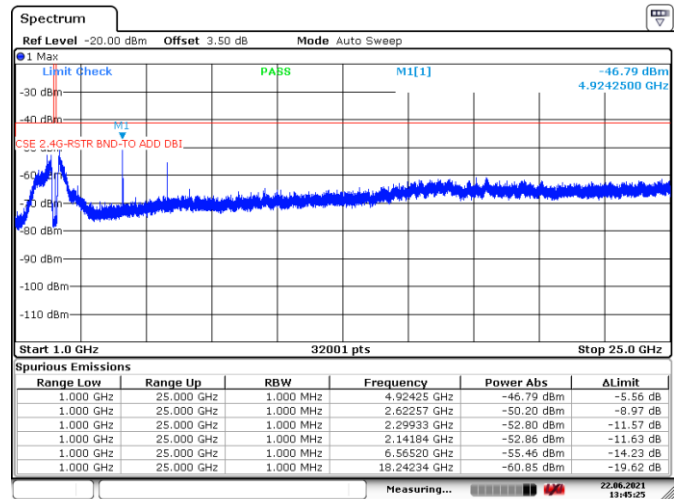
Note: Peak limit EIRP equivalent: 74 dBμV/m – 95.23 dB = –21.23 dBm
Average limit EIRP equivalent: 54 dBμV/m – 95.23 dB = –41.23 dBm

Test data, continued



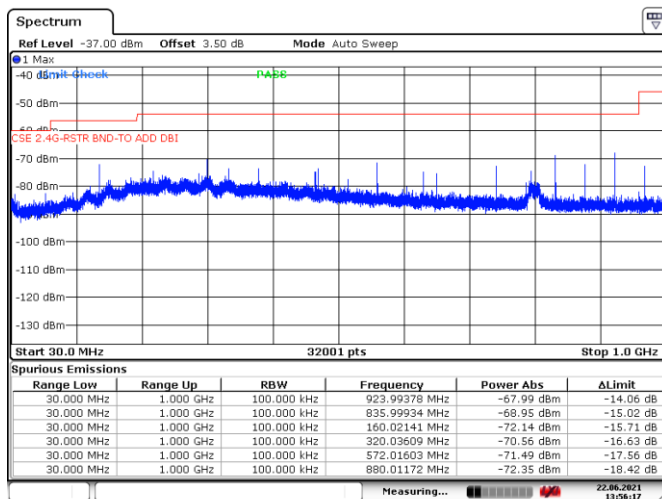
Date: 22 JUN 2021 13:44:49

Figure 8.2-29: Conducted spurious emission within restricted band 30 MHz to 1 GHz, 2.4GHz WIFI TX on 802.11b high channel



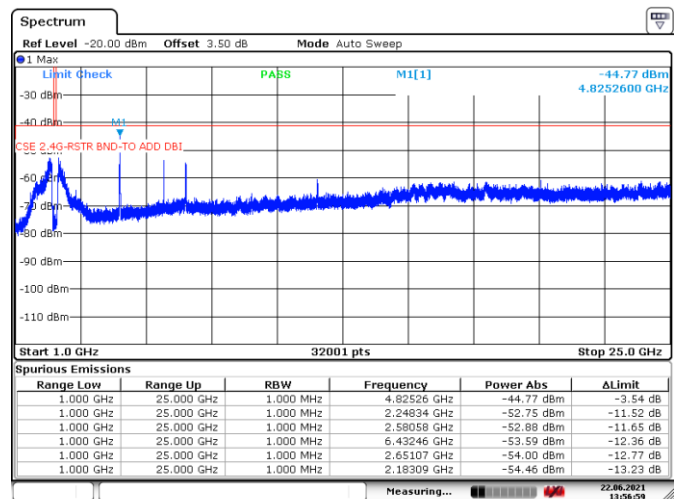
Date: 22 JUN 2021 13:45:26

Figure 8.2-30: Conducted spurious emission within restricted band above 1 GHz, 2.4GHz WIFI TX on 802.11b high channel



Date: 22 JUN 2021 13:56:17

Figure 8.2-31: Conducted spurious emission within restricted band 30 MHz to 1 GHz, 2.4GHz WIFI TX on 802.11g low channel

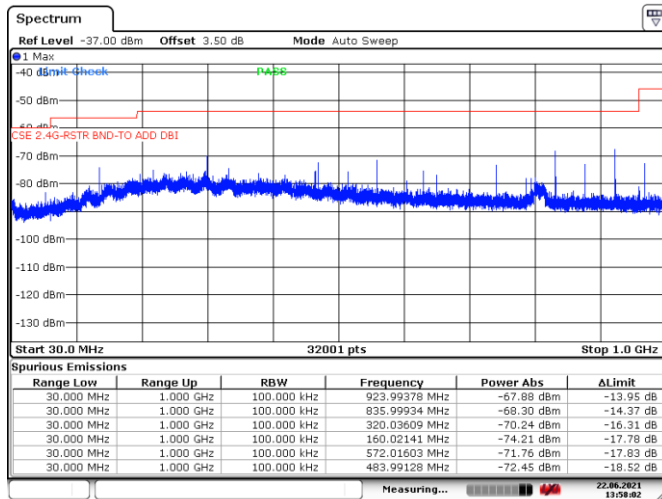


Date: 22 JUN 2021 13:57:00

Figure 8.2-32: Conducted spurious emission within restricted band above 1 GHz, 2.4GHz WIFI TX on 802.11g low channel

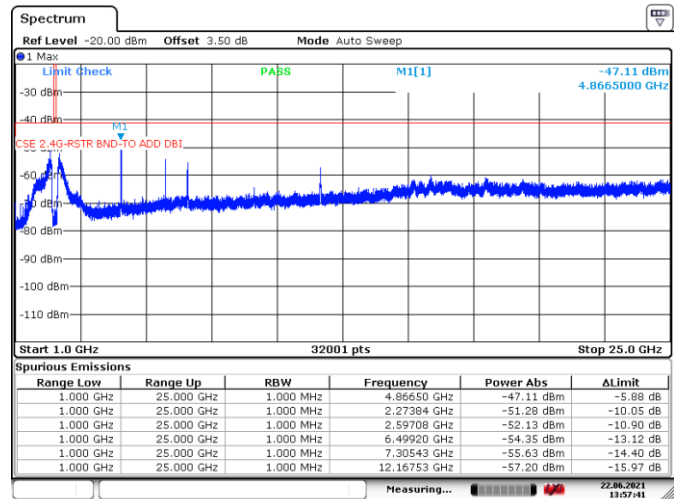
Note: Peak limit EIRP equivalent: 74 dBμV/m – 95.23 dB = -21.23 dBm
Average limit EIRP equivalent: 54 dBμV/m – 95.23 dB = -41.23 dBm

Test data, continued



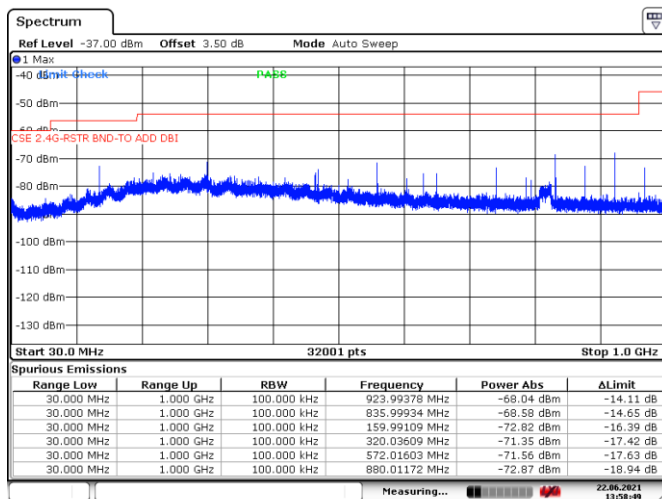
Date: 22 JUN 2021 13:58:02

Figure 8.2-33: Conducted spurious emission within restricted band 30 MHz to 1 GHz, 2.4GHz WIFI TX on 802.11g mid channel



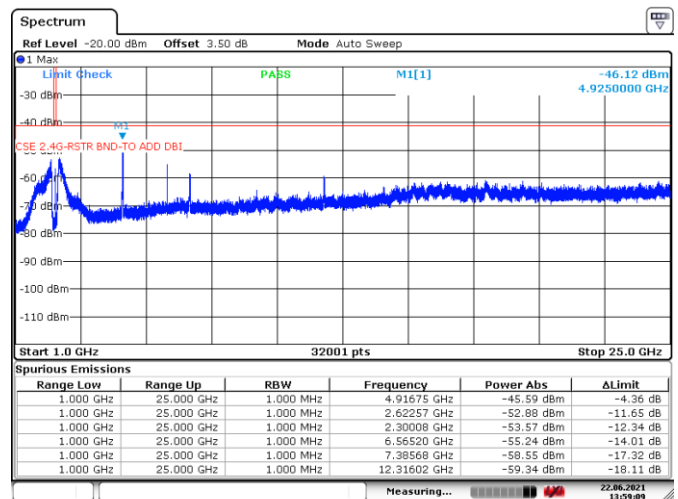
Date: 22 JUN 2021 13:57:41

Figure 8.2-34: Conducted spurious emission within restricted band above 1 GHz, 2.4GHz WIFI TX on 802.11g mid channel



Date: 22 JUN 2021 13:58:49

Figure 8.2-35: Conducted spurious emission within restricted band 30 MHz to 1 GHz, 2.4GHz WIFI TX on 802.11g high channel

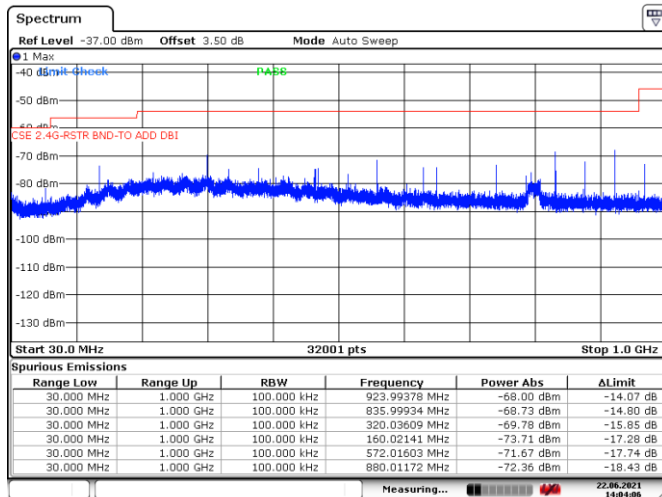


Date: 22 JUN 2021 13:59:10

Figure 8.2-36: Conducted spurious emission within restricted band above 1 GHz, 2.4GHz WIFI TX on 802.11g high channel

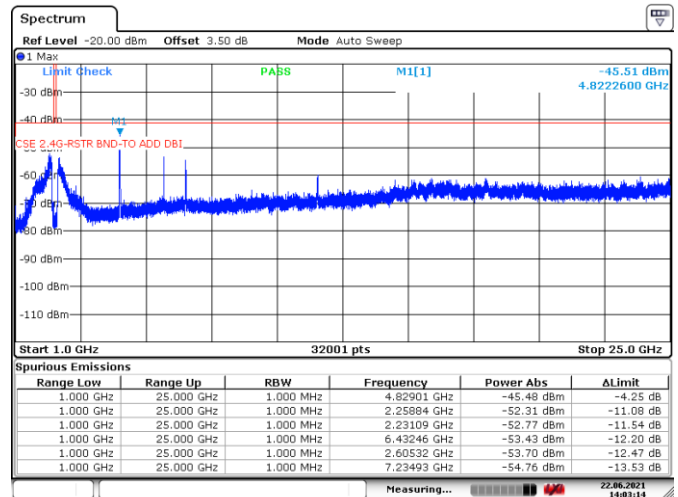
Note: Peak limit EIRP equivalent: 74 dBμV/m – 95.23 dB = –21.23 dBm
Average limit EIRP equivalent: 54 dBμV/m – 95.23 dB = –41.23 dBm

Test data, continued



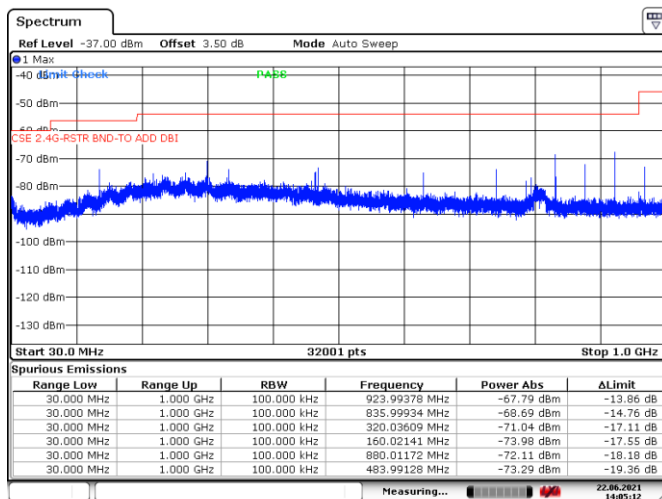
Date: 22 JUN 2021 14:04:07

Figure 8.2-37: Conducted spurious emission within restricted band 30 MHz to 1 GHz, 2.4GHz WIFI TX on 802.11n HT20 low channel



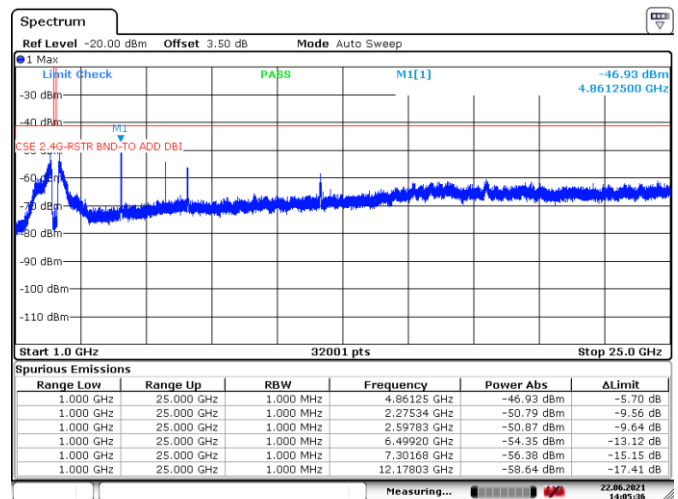
Date: 22 JUN 2021 14:03:13

Figure 8.2-38: Conducted spurious emission within restricted band above 1 GHz, 2.4GHz WIFI TX on 802.11n HT20 low channel



Date: 22 JUN 2021 14:05:13

Figure 8.2-39: Conducted spurious emission within restricted band 30 MHz to 1 GHz, 2.4GHz WIFI TX on 802.11n HT20 mid channel

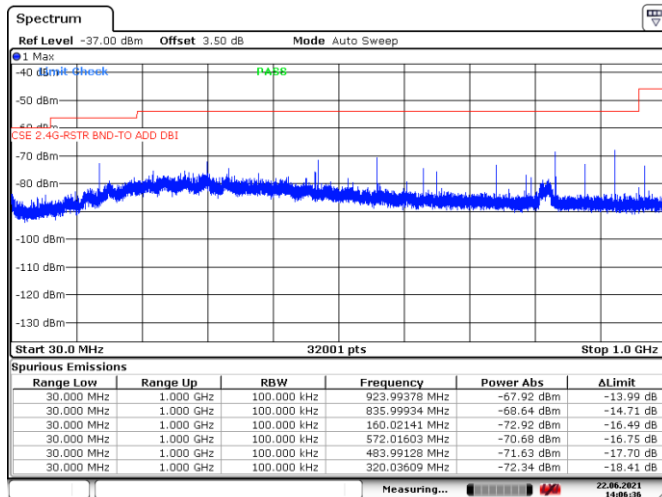


Date: 22 JUN 2021 14:05:36

Figure 8.2-40: Conducted spurious emission within restricted band above 1 GHz, 2.4GHz WIFI TX on 802.11n HT20 mid channel

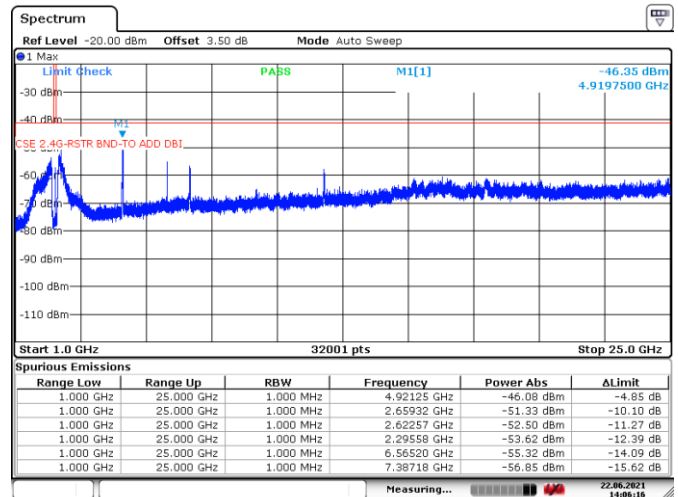
Note: Peak limit EIRP equivalent: 74 dBμV/m – 95.23 dB = –21.23 dBm
Average limit EIRP equivalent: 54 dBμV/m – 95.23 dB = –41.23 dBm

Test data, continued



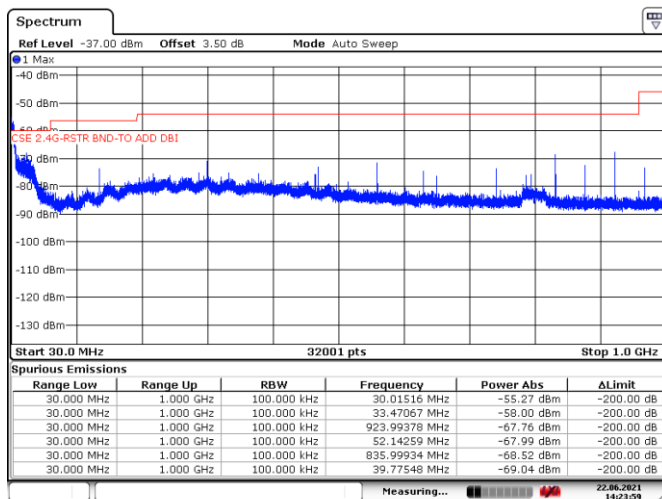
Date: 22 JUN 2021 14:06:36

Figure 8.2-41: Conducted spurious emission within restricted band 30 MHz to 1 GHz, 2.4GHz WIFI TX on 802. 11n HT20 high channel



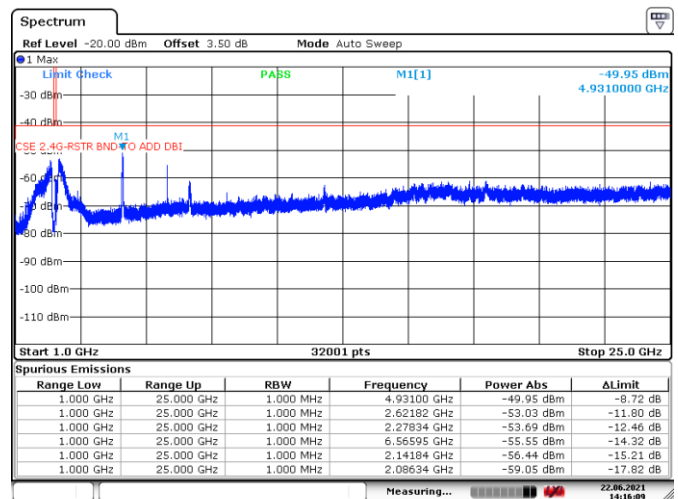
Date: 22 JUN 2021 14:06:16

Figure 8.2-42: Conducted spurious emission within restricted band above 1 GHz, 2.4GHz WIFI TX on 802. 11n HT20 channel



Date: 22 JUN 2021 14:23:59

Figure 8.2-43: Conducted spurious emission within restricted band 30 MHz to 1 GHz, 2.4GHz WIFI TX on 802. 11n HT40 channel

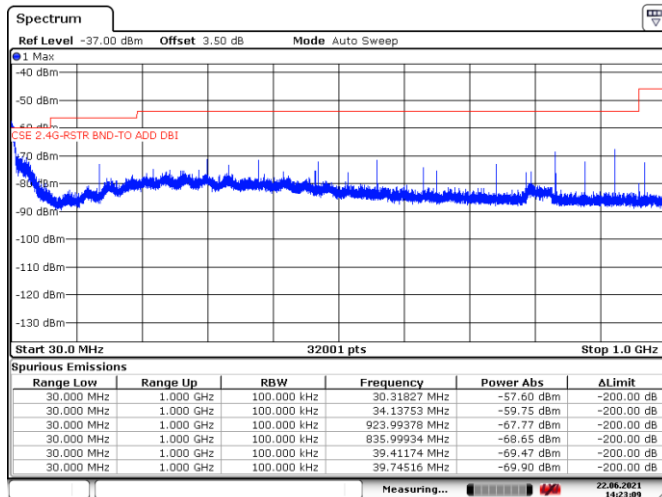


Date: 22 JUN 2021 14:16:09

Figure 8.2-44: Conducted spurious emission within restricted band above 1 GHz, 2.4GHz WIFI TX on 802. 11n HT40 low channel

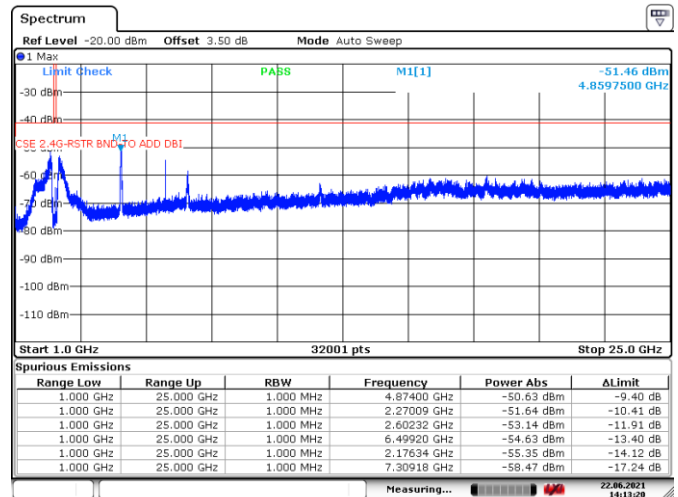
Note: Peak limit EIRP equivalent: 74 dBμV/m – 95.23 dB = -21.23 dBm
Average limit EIRP equivalent: 54 dBμV/m – 95.23 dB = -41.23 dBm
Emission from 30 MHz to 35 MHz are outside of restricted bands.

Test data, continued



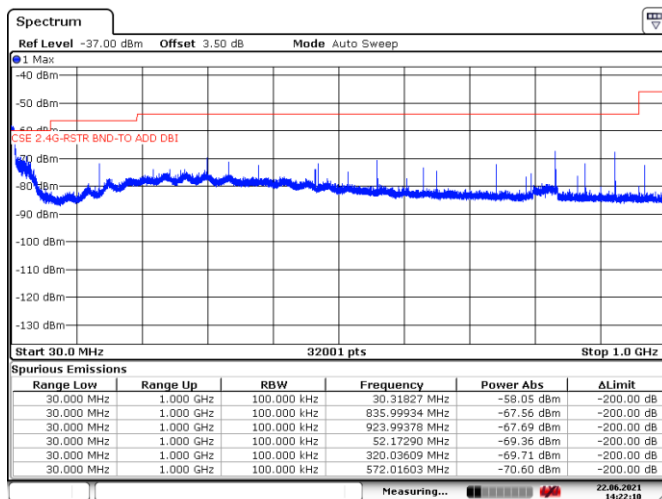
Date: 22 JUN 2021 14:23:09

Figure 8.2-45: Conducted spurious emission within restricted band 30 MHz to 1 GHz, 2.4GHz WIFI TX on 802. 11n HT40 mid channel



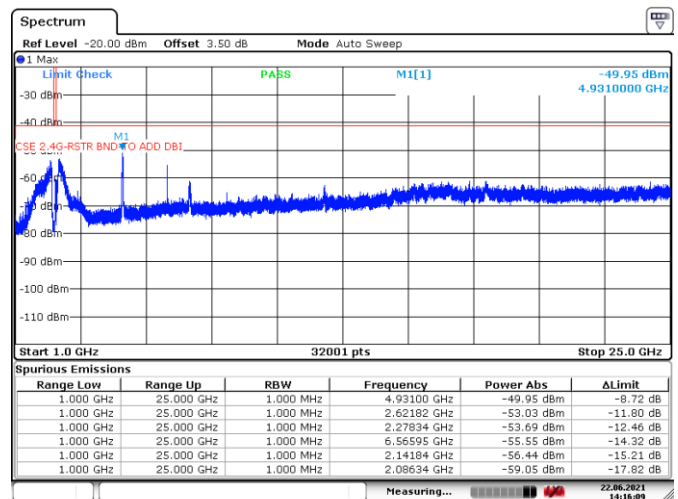
Date: 22 JUN 2021 14:13:20

Figure 8.2-46: Conducted spurious emission within restricted band above 1 GHz, 2.4GHz WIFI TX on 802. 11n HT40 mid channel



Date: 22 JUN 2021 14:22:09

Figure 8.2-47: Conducted spurious emission within restricted band 30 MHz to 1 GHz, 2.4GHz WIFI TX on 802. 11n HT40 high channel



Date: 22 JUN 2021 14:16:09

Figure 8.2-48: Conducted spurious emission within restricted band above 1 GHz, 2.4GHz WIFI TX on 802. 11n HT40 high channel

Note: Peak limit EIRP equivalent: 74 dBμV/m – 95.23 dB = -21.23 dBm
Average limit EIRP equivalent: 54 dBμV/m – 95.23 dB = -41.23 dBm

Test data, continued

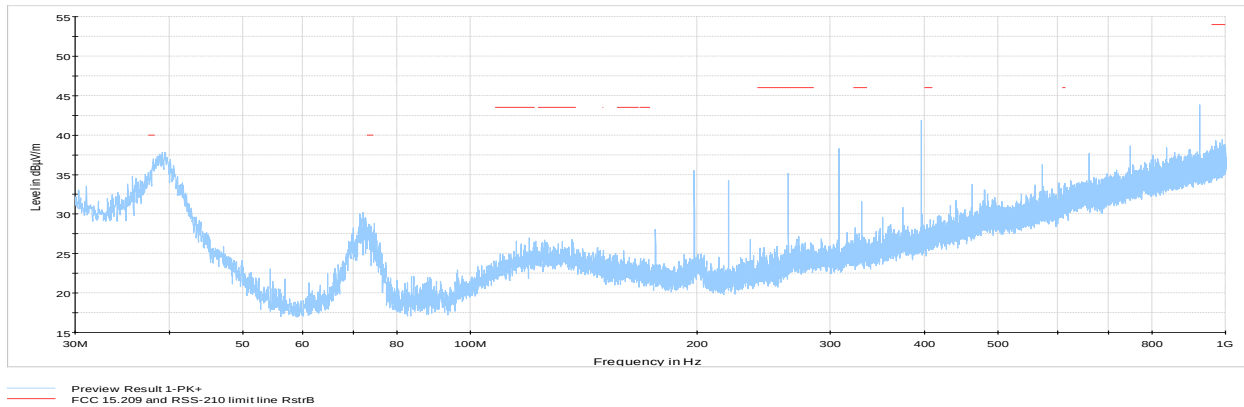


Figure 8.2-49: Cabinet Radiated spurious emissions 30 MHz to 1 GHz, 2.4 GHz WIFI on Low channel

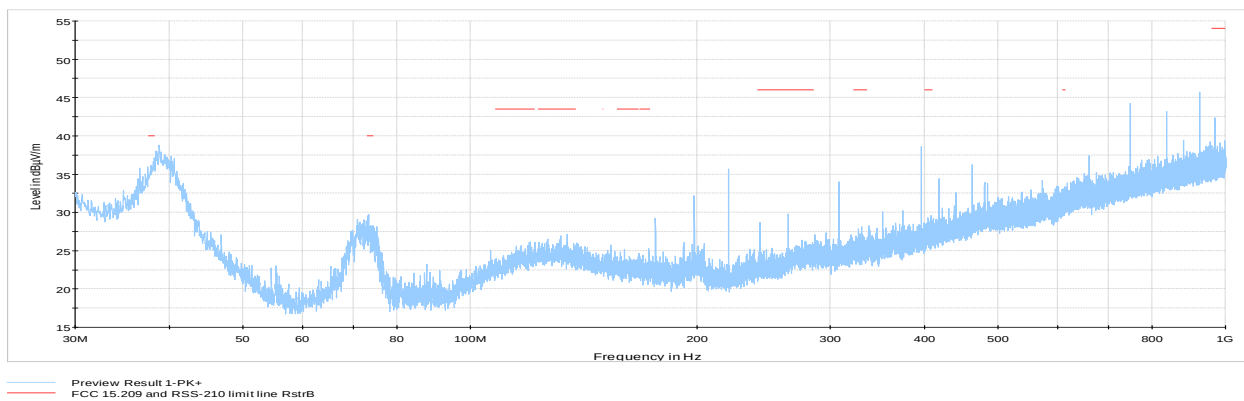


Figure 8.2-50: Cabinet Radiated spurious emissions 30 MHz to 1 GHz, 2.4 GHz WIFI on mid channel

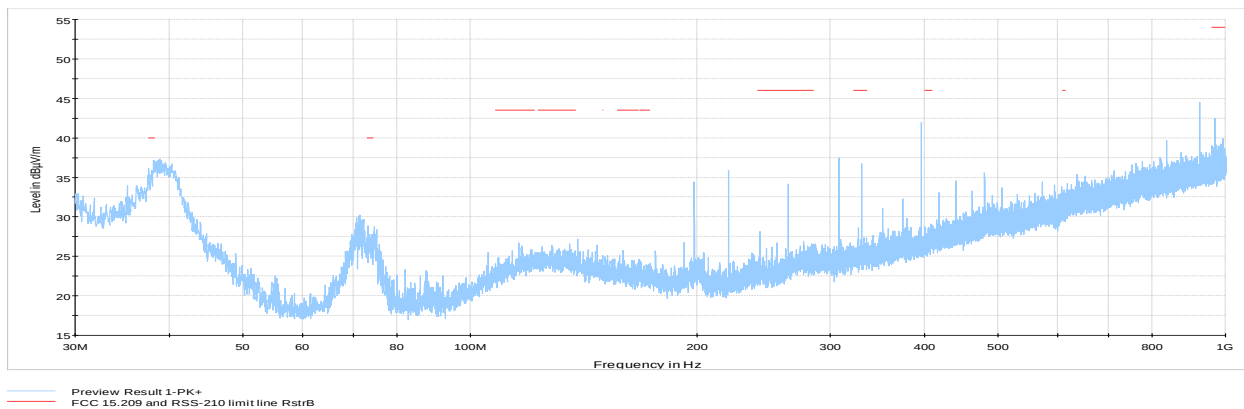


Figure 8.2-51: Cabinet Radiated spurious emissions 30 MHz to 1 GHz, 2.4 GHz WIFI on High channel

Test data, continued

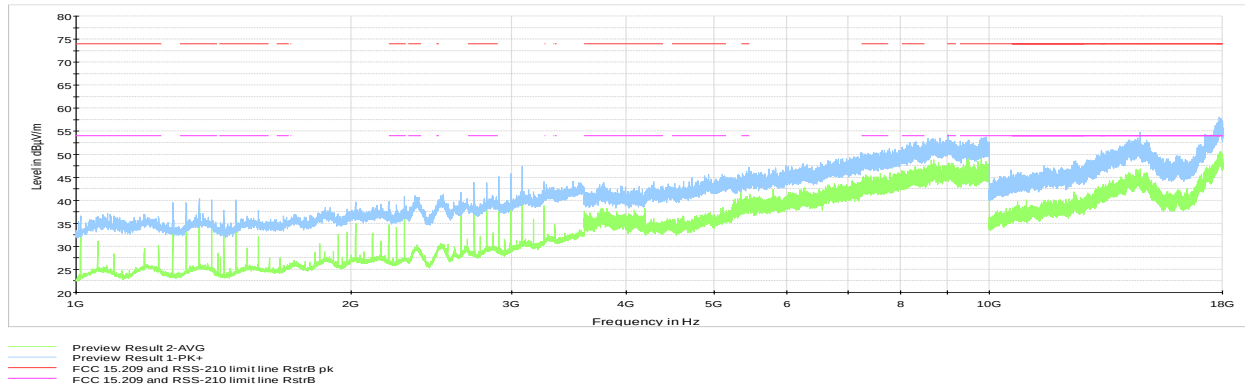


Figure 8.2-52: Cabinet Radiated spurious emissions 1 to 18 GHz, 2.4 GHz WIFI on Low channel

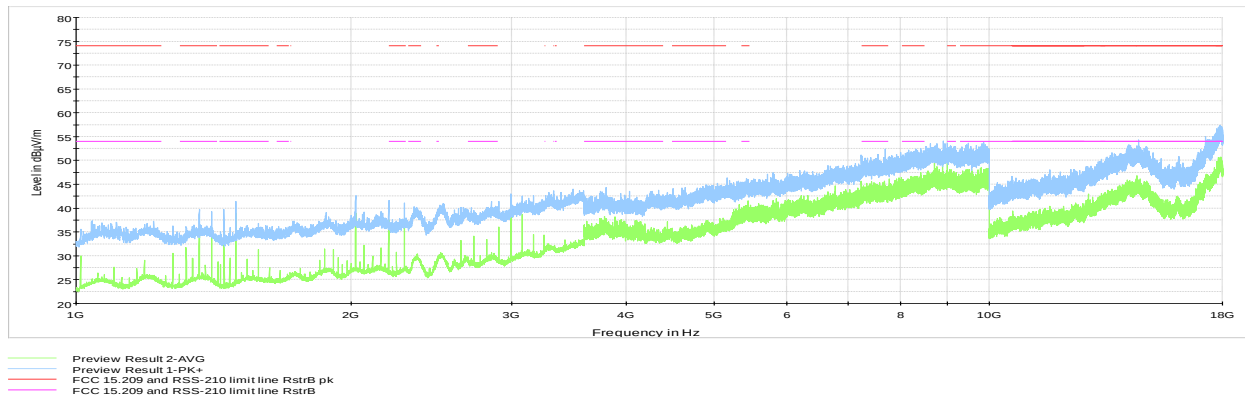


Figure 8.2-53: Cabinet Radiated spurious emissions 1 to 18 GHz, 2.4 GHz WIFI on mid channel

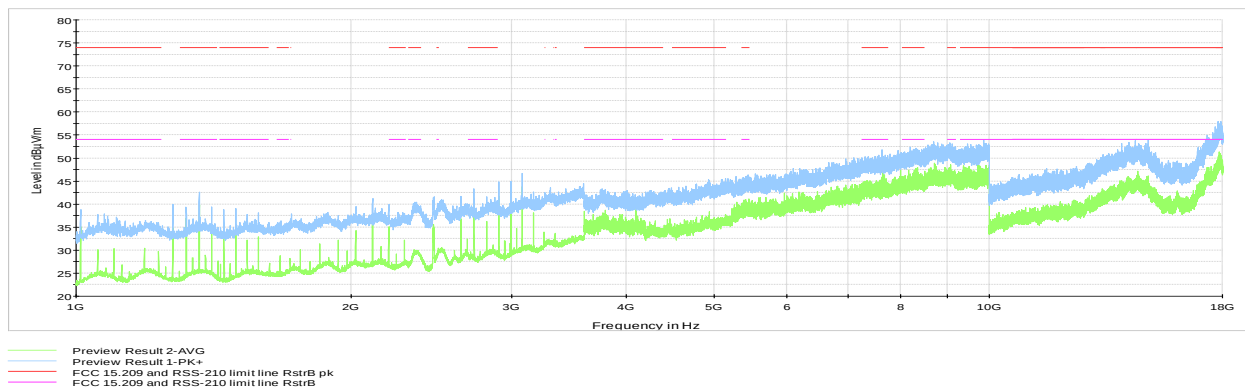


Figure 8.2-54: Cabinet Radiated spurious emissions 1 to 18 GHz, 2.4 GHz WIFI on High channel

Note: Spectrum was investigated from 30 MHz to 25 GHz. Above 18 GHz, no emission related to RF portion were detected within 6 dB below the limit

Test data, continued

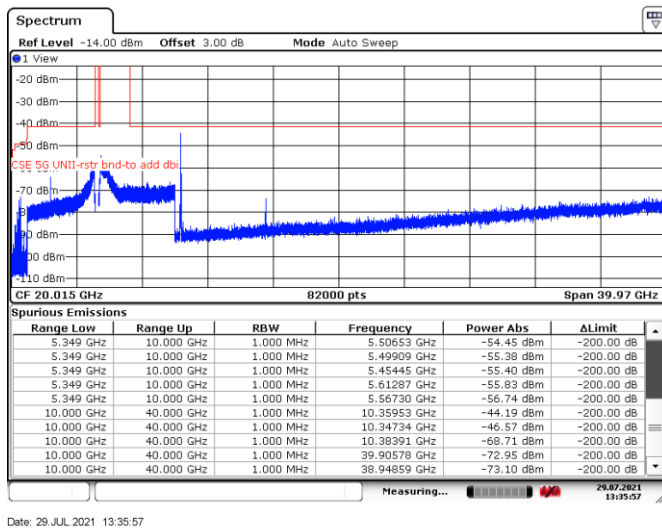


Figure 8.2-55: Spurious emissions within restricted bands, Tx on UNII1 low channel, 802.11a

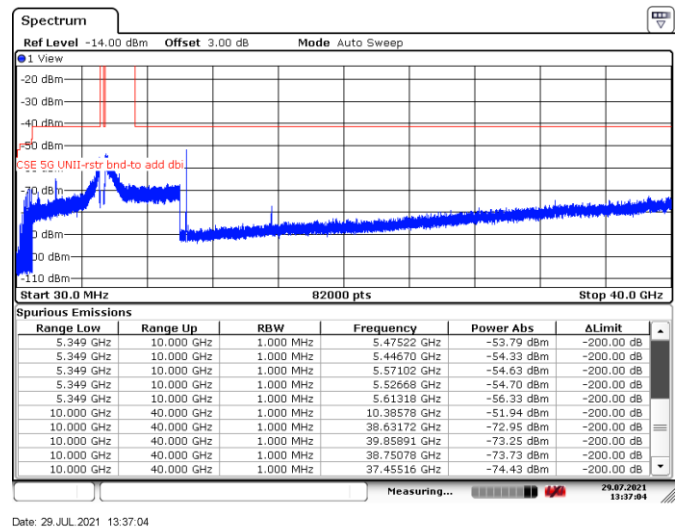


Figure 8.2-56: Spurious emissions within restricted bands, Tx on UNII1 mid channel, 802.11a

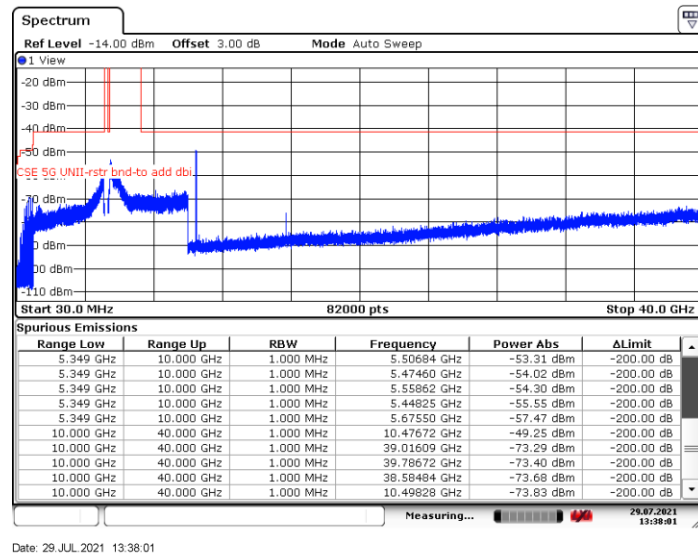


Figure 8.2-57: Spurious emissions within restricted bands, Tx on UNII1 high channel, 802.11a

Note: Peak limit EIRP equivalent: 74 dBμV/m – 95.23 dB = –21.23 dBm
 Average limit EIRP equivalent: 54 dBμV/m – 95.23 dB = –41.23 dBm