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RADIO TEST REPORT – TRFWL

Project ID
PRJ0033391

Report ID
REP010654

Type of assessment:
Permissive Change verification

Type of radio equipment:
Wi-Fi device

Equipment class:
DTS

Applicant:
SolidRun Ltd.

Description of product:
LMA BT and Wi-Fi module

Model(s)/HVIN(s):
SRG0400-WBT

Product marketing name (PMN):
LBEE5HY1MW

FCC identifier:
FCC ID: 2BA24LBEE5HY1MW

ISED certification number:
IC: 12107A-LBEE5HY1MW

Specifications:

- FCC 47 CFR Part 15 Subpart C, §15.247
- RSS-247, Issue 3, August 2023, Section 5

Date of issue: August 18, 2023

Hossein Zamani, EMC/RF Specialist
Tested by

Signature

Andrey Adelberg, Senior EMC/RF Specialist
Reviewed by

Signature

Lab locations

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Test site identifier	**Organization**	**Ottawa/Almonte**	**Montreal**	**Cambridge**
	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.

Copyright notification

Table of Contents

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 3, August 2023, Section 5	Digital Transmission Systems (DTSs), 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.
RSS-Gen, Issue 5, April 2018	General Requirements for Compliance of Radio Apparatus
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

1.3 Exclusions

C2PC limited assessment due to an antenna change and host integration for LMA.

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.
Determining compliance is based on the results of the compliance measurement, not taking into account measurement uncertainty, in accordance with section 1.3 of ANSI C63.10 v2013.

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
REP010654	August 10, 2023	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 Model variant declaration

N/A

2.4 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 3 Test conditions

3.1 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 ±5 %, for which the equipment was designed.

Section 4 Information provided by the applicant

4.1 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.

4.2 Applicant / Manufacturer

Name	SolidRun Ltd.
Address	Acre, 2412401, Israel

4.3 EUT information

Product	LMA BT and Wi-Fi module
Model number	SRG0400-WBT
Model name	LBEE5HY1MW
HMN	SRG0400
Power supply requirements	DC: 12 V from external 100–240 V(AC) power adapter
Product description and theory of operation	The equipment will securely connect the Indoor Air quality sensors to the network cloud by sending data via ETP. It will use a default wirepas connectivity protocol.

4.4 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	2400–2483.5 MHz
Frequency Min	2412
Frequency Max	2462
Channel bandwidth	20 MHz
Type of modulation	802.11b: DSSS (CCK, DQPSK, DBPSK) 802.11g/n(HT20): OFDM (QPSK, BPSK, 16-QAM, 64-QAM)
Emission classification	F1D, W7D
Transmitter spurious, dBµV/m @ 3 m	57.8 (Peak) and 50.5 (average) at 2400 MHz
Antenna information	Antenna information 2.4/5GHz FPC antenna, gain: 3 dBi (at 2.4 GHz)

4.5 EUT setup details

4.5.1 Radio exercise details

Operating conditions	Once unit powered, the PCB is connected to a laptop through UART/ USB to control Wi-Fi and Fujitsu Chip. Then Linux commands are sent through a Putty platform to set either the unit power on maximum or the baud rates and all other functionality of a radio module. For Quectel it the same procedure but using AT commands through Putty.
Transmitter state	Transmitter set into continuous mode.

4.5.2 EUT setup configuration

Table 4.5-1: *EUT sub assemblies*

Description	Brand name	Model, Part number, Serial number, Revision level
AC adaptor	Power Supply	MN: ICP12-120-1000D, PN: ICP12-120-1000DSD4

Table 4.5-2: *EUT interface ports*

Description	Qty.
SMA	1
USB	1

Table 4.5-3: *Support equipment*

Description	Brand name	Model, Part number, Serial number, Revision level
Laptop	Lenovo	SN: PF39SXL6, MN: 20SU-S012N

Table 4.5-4: *Inter-connection cables*

Cable description	From	To	Length (m)
USB cable	EUT	Laptop	1
USB cable	EUT	Laptop	1

EUT setup configuration, continued

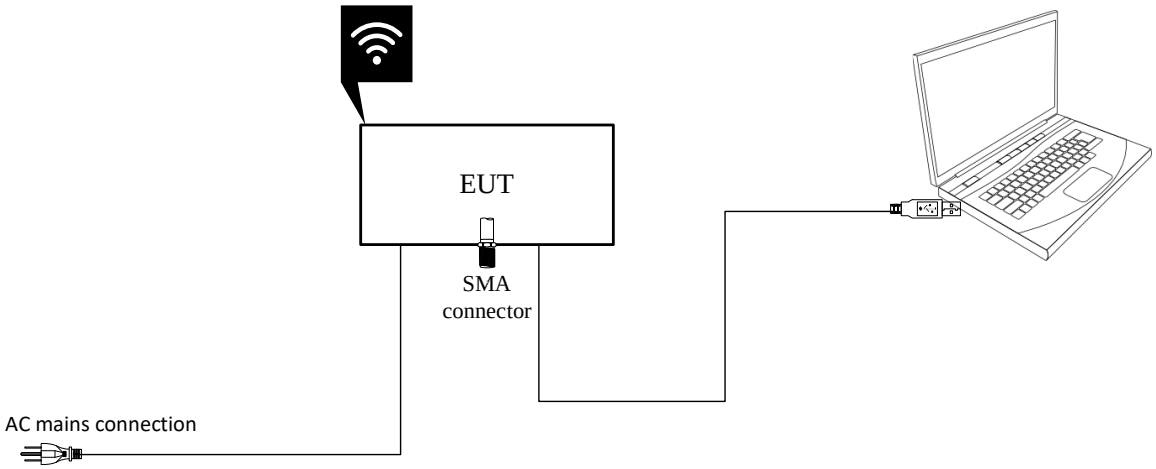


Figure 4.5-1: *Radiated testing block diagram*

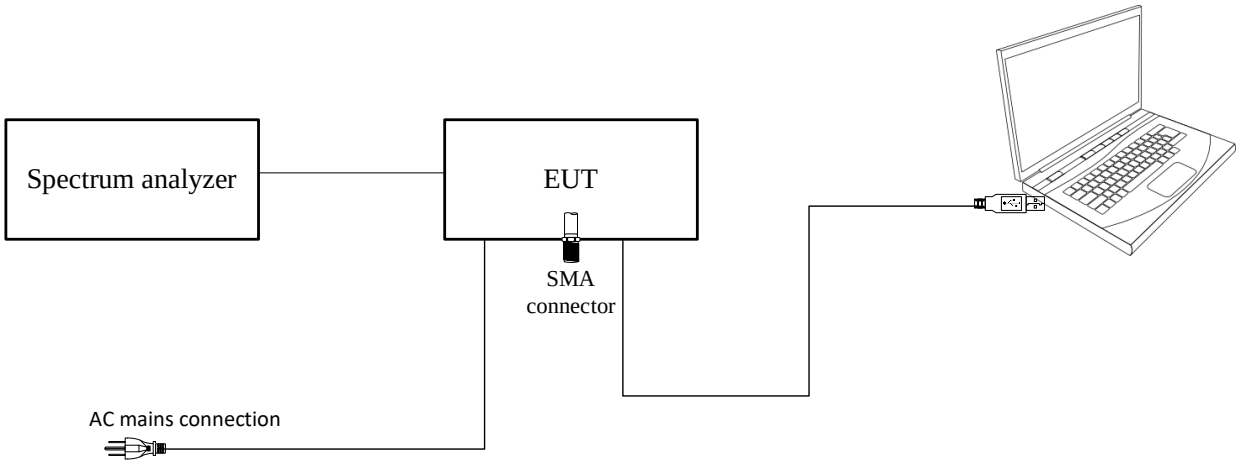


Figure 4.5-2: *Antenna port testing block diagram*

Section 5 Summary of test results

5.1 Testing location

Test location (s)	Montreal

5.2 Testing period

Test start date	April 24, 2023	Test end date	May 9, 2023

5.3 Sample information

Receipt date	April 3, 2023	Nemko sample ID number(s)	PRJ00333910001 and PRJ00333910002

5.4 FCC test results

Table 5.4-1: *FCC requirements results*

Part	Test description	Verdict
Generic requirements		
§15.207(a)	Conducted limits	Pass
§15.31(e)	Variation of power source	Pass
§15.31(m)	Number of tested frequencies	Pass
§15.203	Antenna requirement	Pass
§15.247(c)(1)	Fixed point-to-point operation with directional antenna gains greater than 6 dBi	Not applicable[1]
§15.247(c)(2)	Transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams	Not applicable[2]
§15.247(d)	Spurious emissions	Pass
§15.247(f)	Time of occupancy for hybrid systems	Not applicable[3]
DTS specific requirements		
§15.247(a)(2)	Minimum 6 dB bandwidth	Not tested
§15.247(b)(3)	Maximum peak output power	Pass
§15.247(e)	Power spectral density	Not tested

Notes: [1]EUT does not utilize directional antenna gains greater than 6 dBi
[2]EUT does not emit multiple directional beams.
[3]EUT is not hybrid system.
Some tests were omitted due to C2PC limited assessment

5.5 ISED test results

Table 5.5-1: *ISED requirements results*

Part	Test description	Verdict
Generic requirements		
RSS-Gen, 7.3	Receiver radiated emission limits	Not applicable[1]
RSS-Gen, 7.4	Receiver conducted emission limits	Not applicable[1]
RSS-Gen, 6.9	Operating bands and selection of test frequencies	Pass
RSS-Gen, 8.8	AC powerline conducted emissions limits	Pass
RSS-247, 5.5	Unwanted emissions	Pass
DTS specific requirements		
RSS-247, 5.2 (a)	Minimum 6 dB bandwidth	Not tested
RSS-247, 5.2 (b)	Maximum power spectral density	Not tested
RSS-247, 5.4 (d)	Transmitter output power and e.i.r.p. requirements for systems employing digital modulation techniques	Pass
RSS-247, 5.4 (e)	Transmitter e.i.r.p. requirements for point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band	Not applicable
RSS-247, 5.4 (f)	Transmitter requirements for operation in the 2400–2483.5 MHz band with multiple directional beams	Not applicable[2]

Notes: [1]According 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.
[2]EUT does not emit multiple directional beams.
EUT is an AC powered device.
Some tests were omitted due to C2PC limited assessment

Section 6 Test equipment

6.1 Test equipment list

Table 6.1-1: *Equipment list*

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
50 Ω coax cable	C.C.A.	None	FA002603	—	VOU
50 Ω coax cable	C.C.A.	None	FA002605	—	VOU
50 Ω coax cable	C.C.A.	None	FA002831	—	VOU
50 Ω coax cable	Huber + Suhner	None	FA002607	—	VOU
50 Ω coax cable	Sucoflex	None	FA002563	—	VOU
2.4 GHz band Notch Filter	Microwave Circuits	N0324413	FA002693	—	VOU
High Pass Filter (> 1100 MHz)	Microwave Circuits	H1G212G1	FA002689	—	VOU
3 m EMI test chamber (Emissions)	TDK	SAC-3	FA002532e	1 year	March 8, 2024
Flush mount turntable	Sunol	FM2022	FA002550	—	NCR
Antenna mast	Sunol	TLT2	FA002552	—	NCR
3 Phase AC Power Supply	apc AC Power	AFC-33045T	FA002677	—	VOU
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 26	FA002043	1 year	November 28, 2023
Bilog antenna (20–2000 MHz)	Sunol	JB1	FA002517	1 year	March 24, 2024
Horn antenna (1–18 GHz)	EMCO	3115	FA001451	1 year	March 10, 2024
Horn antenna (18–40 GHz)	EMCO	3116	FA002487	1 year	April 13, 2024

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

Table 6.1-2: *Automation software details*

Test description	Manufacturer of Software	Details
Radiated emissions as of January 29, 2021	Rohde & Schwarz	EMC32, Software for EMC Measurements, Version 10.60.20
Conducted emissions as of January 29, 2021	Rohde & Schwarz	EMC32, Software for EMC Measurements, Version 10.60.20

Section 7 Testing data

7.1 Variation of power source

7.1.1 References, definitions and limits

FCC §15.31 (e):

For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

7.1.2 Test summary

Verdict	Pass		
Test date	May 2, 2023	Temperature	22.39 °C
Tested by	Hossein Zamani	Air pressure	990.20 mbar
Test location	Montreal	Relative humidity	34.47 %

7.1.3 Observations, settings and special notes

The testing was performed as per ANSI C63.10 Section 5.13.

a) Where the device is intended to be powered from an external power adapter, the voltage variations shall be applied to the input of the adapter provided with the device at the time of sale. If the device is not marketed or sold with a specific adapter, then a typical power adapter shall be used.
b) For devices, where operating at a supply voltage deviating ±15% from the nominal rated value may cause damages or loss of intended function, test to minimum and maximum allowable voltage per manufacturer's specification and document in the report.
c) For devices with wide range of rated supply voltage, test at 15% below the lowest and 15% above the highest declared nominal rated supply voltage.
d) For devices obtaining power from an input/output (I/O) port (USB, firewire, etc.), a test jig is necessary to apply voltage variation to the device from a support power supply, while maintaining the functionalities of the device.
e) For battery-operated equipment, the equipment tests shall be performed using a variable power supply.

7.1.4 Test data

EUT Power requirements:	☐ AC	☒ DC	☐ Battery
If EUT is an AC or a DC powered, was the noticeable output power variation observed?	☐ YES	☒ NO	☐ N/A
If EUT is battery operated, was the testing performed using fresh batteries?	☐ YES	☐ NO	☒ N/A
If EUT is rechargeable battery operated, was the testing performed using fully charged batteries?	☐ YES	☐ NO	☒ N/A

7.2 Number of frequencies

7.2.1 References, definitions and limits

FCC §15.31:

(m) Measurements on intentional radiators or receivers shall be performed and, if required, reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table.

RSS-Gen, Clause 6.9:

Except where otherwise specified, measurements shall be performed for each frequency band of operation for which the radio apparatus is to be certified, with the device operating at the frequencies in each band of operation shown in table below. The frequencies selected for measurements shall be reported in the test report.

Table 7.2-1: *Frequency Range of Operation*

Frequency range over which the device operates (in each band)	Number of test frequencies required	Location of measurement frequency inside the operating frequency range
1 MHz or less	1	Center (middle of the band)
1–10 MHz	2	1 near high end, 1 near low end
Greater than 10 MHz	3	1 near high end, 1 near center and 1 near low end

Notes: "near" means as close as possible to or at the centre / low end / high end of the frequency range over which the device operates.

7.2.2 Test summary

Verdict	Pass		
Test date	April 27, 2023	Temperature	22 °C
Tested by	Hossein Zamani	Air pressure	1021 mbar
Test location	Montreal	Relative humidity	30.1 %

7.2.3 Observations, settings and special notes

ANSI C63.10, Clause 5.6.2.1:

The number of channels tested can be reduced by measuring the center channel bandwidth first and then applying the following relaxations as appropriate:

a) For each operating mode, if the measured channel bandwidth on the middle channel is at least 150% of the minimum permitted bandwidth, then it is not necessary to measure the bandwidth on the high and low channels.

b) For multiple-input multiple-output (MIMO) systems, if the measured channel bandwidth on testing the middle channel exceeds the minimum permitted bandwidth by more than 50% on one transmit chain, then it is not necessary to repeat testing on the other chains.

c) If the measured channel bandwidth on the middle channel is less than 50% of the maximum permitted bandwidth, then it is not necessary to measure the bandwidth on the high and low channels.

ANSI C63.10, Clause 5.6.2.2:

For devices with multiple operating modes, measurements on the middle channel can be used to determine the worst-case mode(s). The worst-case modes are as follows:

a) Band edge requirements—Measurements on the mode with the widest bandwidth can be used to cover the same channel (center frequency) on modes with narrower bandwidth that have the same or lower output power for each modulation family (e.g., OFDM and direct sequence spread spectrum).

b) Spurious emissions—Measure the mode with the highest output power and the mode with the highest output power spectral density for each modulation family (e.g., OFDM and direct sequence spread spectrum).

c) In-band PSD—Measurements on the mode with the narrowest bandwidth can be used to cover all modes within the same modulation family of an equal or lower output power provided the result is less than 50% of the limit.

7.2.4 Test data

Table 7.2-2: *Test channels selection*

Start of Frequency range, MHz	End of Frequency range, MHz	Frequency range bandwidth, MHz	Low channel, MHz	Mid channel, MHz	High channel, MHz
2400	2483.5	83.5	2412	2436	2462

7.3 Antenna requirement

7.3.1 References, definitions and limits

FCC §15.203:

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

FCC §15.247:

(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

RSS-Gen, Clause 6.8:

The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report.

7.3.2 Test summary

Verdict	Pass		
Test date	April 27, 2023	Temperature	22 °C
Tested by	Hossein Zamani	Air pressure	1021 mbar
Test location	Montreal	Relative humidity	30.1 %

7.3.3 Observations, settings and special notes

None

7.3.4 Test data

Must the EUT be professionally installed? ☒ YES ☐ NO

Does the EUT have detachable antenna(s)? ☒ YES ☐ NO

If detachable, is the antenna connector(s) non-standard? ☐ YES ☒ NO ☐ N/A

Table 7.3-1: *Antenna information*

Antenna type	Manufacturer	Model number	Maximum gain	Connector type
FPC antenna	Pulse LARSEN Antenna	W3918XXXX	3 dBi @2.4 GHz	U.FL

7.4 AC power line conducted emissions limits

7.4.1 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 µH/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 7.4-1: *Conducted emissions limit*

	Conducted emissions limit, dBµV	
Frequency of emission, MHz	**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.

7.4.2 Test summary

Verdict	Pass		
Test date	May 2, 2023	Temperature	22 °C
Tested by	Hossein Zamani	Air pressure	1021 mbar
Test location	Montreal	Relative humidity	30.1 %

7.4.3 Observations, settings and special notes

Port under test – Coupling device	AC main port – Artificial Mains Network (AMN)
EUT power input during test	12 V_{DC} (via external 100–240 V_{AC}, 50/60 Hz power adapter)
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)

7.4.4 Test data

Table 7.4-2: *Conducted emissions results on phase line*

Frequency, MHz	Quasi-Peak result, dBµV	Quasi-Peak limit, dBµV	Quasi-Peak margin, dB	Correction factor, dB
22.732750	53.3	60.0	6.7	9.9
22.984750	53.5	60.0	6.5	9.8
23.239000	53.7	60.0	6.3	9.8
23.491000	53.1	60.0	6.9	9.9
23.743000	53.3	60.0	6.7	9.9
23.995000	53.4	60.0	6.6	9.9
24.247000	53.6	60.0	6.4	9.9
24.501250	53.6	60.0	6.4	9.9
24.753250	54.0	60.0	6.0	9.9
25.005250	54.5	60.0	5.5	9.9
25.257250	53.5	60.0	6.5	9.9
25.511500	53.4	60.0	6.6	9.9
25.763500	54.3	60.0	5.7	9.9
26.015500	53.9	60.0	6.1	9.9
26.267500	53.0	60.0	7.0	9.9
26.521750	53.6	60.0	6.4	9.9
26.773750	53.5	60.0	6.5	9.9
27.025750	52.4	60.0	7.6	9.9
27.532000	51.6	60.0	8.4	9.9
27.784000	52.6	60.0	7.4	9.9

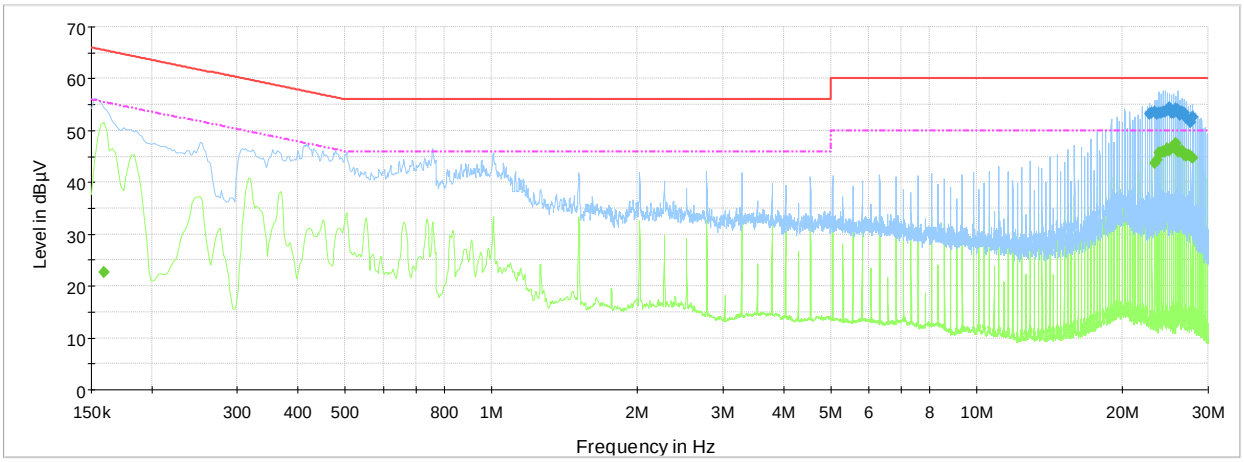
Frequency, MHz	CAverage result, dBµV	CAverage limit, dBµV	CAverage margin, dB	Correction factor, dB
0.159000	22.7	55.5	32.8	9.9
23.236750	43.7	50.0	6.3	9.8
23.491000	44.2	50.0	5.8	9.9
23.743000	45.7	50.0	4.3	9.9
23.995000	45.7	50.0	4.3	9.9
24.247000	46.0	50.0	4.0	9.9
24.501250	46.0	50.0	4.0	9.9
24.753250	46.5	50.0	3.5	9.9
25.005250	46.1	50.0	3.9	9.9
25.257250	46.7	50.0	3.3	9.9
25.511500	46.8	50.0	3.2	9.9
25.763500	47.5	50.0	2.5	9.9
26.015500	46.0	50.0	4.0	9.9
26.269750	45.9	50.0	4.1	9.9
26.521750	46.1	50.0	3.9	9.9
26.773750	45.2	50.0	4.8	9.9
27.025750	45.1	50.0	4.9	9.9
27.280000	45.4	50.0	4.6	9.9
27.532000	45.1	50.0	4.9	9.9
27.784000	44.8	50.0	5.2	9.9

Table 7.4-3: *Conducted emissions results on neutral line*

Frequency, MHz	Quasi-Peak result, dBµV	Quasi-Peak limit, dBµV	Quasi-Peak margin, dB	Correction factor, dB
0.417750	44.6	57.5	13.0	9.9
22.480750	47.9	60.0	12.1	10.0
22.732750	47.2	60.0	12.8	10.0
22.984750	48.8	60.0	11.2	9.9
23.239000	48.3	60.0	11.7	9.9
23.491000	48.6	60.0	11.4	9.9
23.743000	49.3	60.0	10.7	9.9
23.995000	49.2	60.0	10.8	9.9
24.247000	49.2	60.0	10.8	9.9
24.501250	49.3	60.0	10.7	9.9
24.753250	50.5	60.0	9.5	9.9
25.005250	48.9	60.0	11.1	9.9
25.259500	49.1	60.0	10.9	9.9
25.511500	50.1	60.0	9.9	9.9
25.763500	49.4	60.0	10.6	9.9
26.015500	49.9	60.0	10.1	9.9
26.267500	48.9	60.0	11.1	9.9
26.519500	48.4	60.0	11.6	9.9
26.773750	48.4	60.0	11.7	9.9
27.025750	47.8	60.0	12.2	9.9

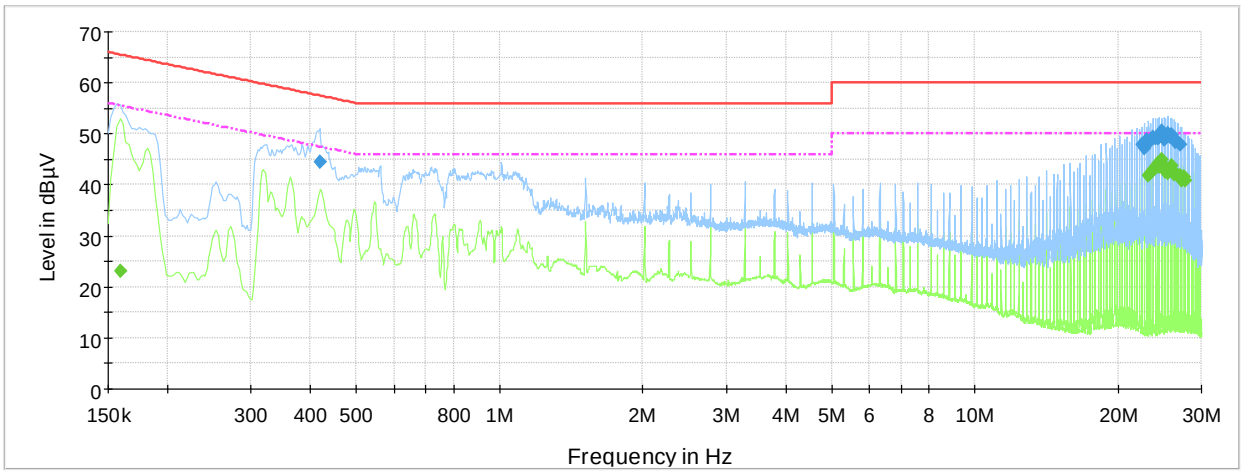
Frequency, MHz	CAverage result, dBµV	CAverage limit, dBµV	CAverage margin, dB	Correction factor, dB
0.159000	23.2	55.5	32.3	10.0
23.239000	41.7	50.0	8.3	9.9
23.491000	42.4	50.0	7.6	9.9
23.743000	43.1	50.0	6.9	9.9
23.995000	43.3	50.0	6.7	9.9
24.249250	44.2	50.0	5.8	9.9
24.501250	43.4	50.0	6.6	9.9
24.753250	44.9	50.0	5.1	9.9
25.005250	43.7	50.0	6.3	9.9
25.259500	42.4	50.0	7.6	9.9
25.511500	42.3	50.0	7.7	9.9
25.763500	42.7	50.0	7.3	9.9
26.015500	43.9	50.0	6.1	9.9
26.267500	42.0	50.0	8.0	9.9
26.521750	42.3	50.0	7.7	9.9
26.773750	41.7	50.0	8.3	9.9
27.025750	41.8	50.0	8.2	9.9
27.280000	40.9	50.0	9.1	9.9
27.532000	41.6	50.0	8.4	9.9
27.784000	40.9	50.0	9.1	9.9

Test data, continued



CE 150 kHz to 30 MHz phase Wi-Fi 2.4 GHz
Preview Result 2-AVG
Preview Result 1-PK+
CISPR 32 Limit - Class B, Mains (QP)
CISPR 32 Limit - Class B, Mains (Avg)
Final_Result QPK
Final_Result CAV

Plot 7.4-1: *Conducted emissions on phase line*



CE 150 kHz to 30 MHz neutral Wi-Fi 2.4 GHz
Preview Result 2-AVG
Preview Result 1-PK+
CISPR 32 Limit - Class B, Mains (QP)
CISPR 32 Limit - Class B, Mains (Avg)
Final_Result QPK
Final_Result CAV

Plot 7.4-2: *Conducted emissions on neutral line*

7.5 Transmitter output power and e.i.r.p. requirements for DTS in 2.4 GHz

7.5.1 References, definitions and limits

FCC §15.247:

(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

(3) For systems using digital modulation in the 2400–2483.5 MHz band: 1 W (30 dBm). As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(c) Operation with directional antenna gains greater than 6 dBi.

(1) Fixed point-to-point operation:

(i) Systems operating in the 2400–2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

(iii) Fixed, point-to-point operation, as used in paragraphs (c)(1)(i) and (c)(1)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum or digitally modulated intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

(2) In addition to the provisions in paragraphs (b)(1), (b)(3), (b)(4) and (c)(1)(i) of this section, transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams, simultaneously or sequentially, for the purpose of directing signals to individual receivers or to groups of receivers provided the emissions comply with the following:

(i) Different information must be transmitted to each receiver.

(ii) If the transmitter employs an antenna system that emits multiple directional beams but does not do emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device, i.e., the sum of the power supplied to all antennas, antenna elements, staves, etc. and summed across all carriers or frequency channels, shall not exceed the limit specified in paragraph (b)(1) or (b)(3) of this section, as applicable. However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as follows:

(A) The directional gain shall be calculated as the sum of 10 log (number of array elements or staves) plus the directional gain of the element or stave having the highest gain.

(B) A lower value for the directional gain than that calculated in paragraph (c)(2)(ii)(A) of this section will be accepted if sufficient evidence is presented, e.g., due to shading of the array or coherence loss in the beamforming.

(iii) If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the power limit specified in paragraph (c)(2)(ii) of this section. If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the limit specified in paragraph (c)(2)(ii) of this section. In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the limit specified in paragraph (c)(2)(ii) of this section by more than 8 dB.

(iv) Transmitters that emit a single directional beam shall operate under the provisions of paragraph (c)(1) of this section.

References, definitions and limits, continued

RSS-247, Clause 5.4:

Devices shall comply with the following requirements, where applicable:

d. For DTSs employing digital modulation techniques operating in the 2400–2483.5 MHz band,, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

As an alternative to a peak power measurement, compliance can be based on a measurement of the maximum conducted output power. The maximum conducted output power is the total transmit power delivered to all antennas and antenna elements, averaged across all symbols in the signalling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or transmitting at a reduced power level. If multiple modes of operation are implemented, the maximum conducted output power is the highest total transmit power occurring in any mode.

e. Fixed point-to-point systems in the 2400–2483.5 MHz band are permitted to have an e.i.r.p. higher than 4 W provided that the higher e.i.r.p. is achieved by employing higher gain directional antennas and not higher transmitter output powers. Point-to-multipoint systems, omnidirectional applications and multiple co-located transmitters transmitting the same information are prohibited from exceeding an e.i.r.p. of 4 W.

f. Transmitters operating in the band 2400–2483.5 MHz, may employ antenna systems that emit multiple directional beams simultaneously or sequentially, for the purpose of directing signals to individual receivers or to groups of receivers, provided that the emissions comply with the following:

i. Different information must be transmitted to each receiver.

ii. If the transmitter employs an antenna system that emits multiple directional beams, but does not emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device (i.e. the sum of the power supplied to all antennas, antenna elements, staves, etc., and summed across all carriers or frequency channels) shall not exceed the applicable output power limit specified in sections 5.4(b) and 5.4(d). However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as the sum of 10 log (number of array elements or staves) plus the directional gain of the element or stave having the highest gain.

iii. If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the applicable power limit specified in sections 5.4(b) and 5.4(d). If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the applicable limit specified in sections 5.4(b) and 5.4(d). In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the applicable limit specified in sections 5.4(b) and 5.4(d) by more than 8 dB.

iv. Transmitters that transmit a single directional beam shall operate under the provisions of sections 5.4(b), 5.4(d) and 5.4(e).

7.5.2 Test summary

Verdict	Pass				
Test date	May 6, 2023	Test engineer	Hossein Zamani		
Temperature	23 °C	Relative humidity	28 %	Air pressure	1011 mbar

7.5.3 Observations, settings and special notes

The test was performed as per KDB 558074, section 8.3 with reference to ANSI C63.10 subclause 11.9.1 (peak power) using method RBW≥DTS bandwidth (Maximum peak conducted output power) subclause 11.9.2 (average power) using method AVGSA-1 (trace averaging with the EUT transmitting at full power throughout each sweep).
Spectrum analyser settings:

Resolution bandwidth	1M
Video bandwidth	≥3 × RBW
Frequency span	5 MHz
Detector mode	Peak
Trace mode	Maxhold

7.5.4 Test data

Table 7.5-1: *Peak output power and EIRP results (antenna port measurement)*

Modulation	Frequency, MHz	Conducted output power, dBm	Output power limit, dBm	Output power margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
802.11b	2412	17.82	30.00	12.18	3.00	20.82	36.00	15.18
802.11b	2437	17.66	30.00	12.34	3.00	20.66	36.00	15.34
802.11b	2462	17.73	30.00	12.27	3.00	20.73	36.00	15.27
802.11g	2412	21.31	30.00	8.69	3.00	24.31	36.00	11.69
802.11g	2437	22.96	30.00	7.04	3.00	25.96	36.00	10.04
802.11g	2462	21.73	30.00	8.27	3.00	24.73	36.00	11.27
802.11n HT20	2412	20.64	30.00	9.36	3.00	23.64	36.00	12.36
802.11n HT20	2437	22.49	30.00	7.51	3.00	25.49	36.00	10.51
802.11n HT20	2462	20.43	30.00	9.57	3.00	23.43	36.00	12.57

Note: EIRP [dBm] = Conducted output power [dBm] + Antenna gain [dBi]

Table 7.5-2: *Average output power and EIRP results (antenna port measurement)*

Modulation	Frequency, MHz	Conducted output power, dBm	Output power limit, dBm	Output power margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
802.11b	2412	14.78	30.00	15.22	3.00	17.78	36.00	18.22
802.11b	2437	14.66	30.00	15.34	3.00	17.66	36.00	18.34
802.11b	2462	14.75	30.00	15.25	3.00	17.75	36.00	18.25
802.11g	2412	10.73	30.00	19.27	3.00	13.73	36.00	22.27
802.11g	2437	13.9	30.00	16.10	3.00	16.90	36.00	19.10
802.11g	2462	10.52	30.00	19.48	3.00	13.52	36.00	22.48
802.11n HT20	2412	10.22	30.00	19.78	3.00	13.22	36.00	22.78
802.11n HT20	2437	13.55	30.00	16.45	3.00	16.55	36.00	19.45
802.11n HT20	2462	10.23	30.00	19.77	3.00	13.23	36.00	22.77

Note: EIRP [dBm] = Conducted output power [dBm] + Antenna gain [dBi]

7.6 Spurious (out-of-band) unwanted emissions

7.6.1 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.

RSS-Gen:

8.9 Except where otherwise indicated in the applicable RSS, radiated emissions shall comply with the field strength limits shown in table below.

8.10 Restricted frequency bands are designated primarily for safety-of-life services (distress calling and certain aeronautical activities), certain satellite downlinks, radio astronomy and some government uses. The following conditions related to the restricted frequency bands apply:

a The transmit frequency, including fundamental components of modulation, of licence-exempt radio apparatus shall not fall within the restricted frequency bands.

b Unwanted emissions that fall into restricted frequency bands listed in table 7 shall comply with the limits specified in table below.

c Unwanted emissions that do not fall within the restricted frequency bands shall comply either with the limits specified in the applicable RSS or with those specified in table below.

Table 7.6-1: *FCC §15.209 and RSS-Gen – Radiated emission limits*

	Field strength of emissions		
Frequency, MHz	**µV/m**	**dBµV/m**	**Measurement distance, 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 7.6-2: *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	Above 38.6
8.41425–8.41475	167.72–173.2	3500–4400	
12.29–12.293	240–285	4500–5150	
12.51975–12.52025	322–335.4	5350–5460	

Note: Certain frequency bands listed in Table 7.6-2 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 7.6-3: *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			

7.6.2 Test summary

Verdict	Pass				
Test date	May 6, 2023	Test engineer	Hossein Zamani		
Temperature	23 °C	Relative humidity	28 %	Air pressure	1011 mbar

7.6.3 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.
- Radiated measurements were performed at a distance of 3 m.
- 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 maximum conducted (average) output power procedure to demonstrate compliance, the spurious emissions limit is −30 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:	10 Hz
Detector mode:	Peak
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

7.6.1 Test data

Figure 7.6-1: *Band edge spurious emissions at low band edge*

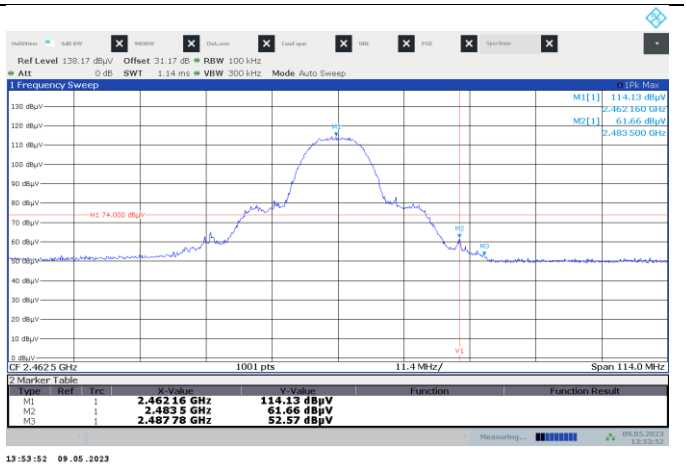


Figure 7.6-2: *Band edge spurious emissions at high band edge*

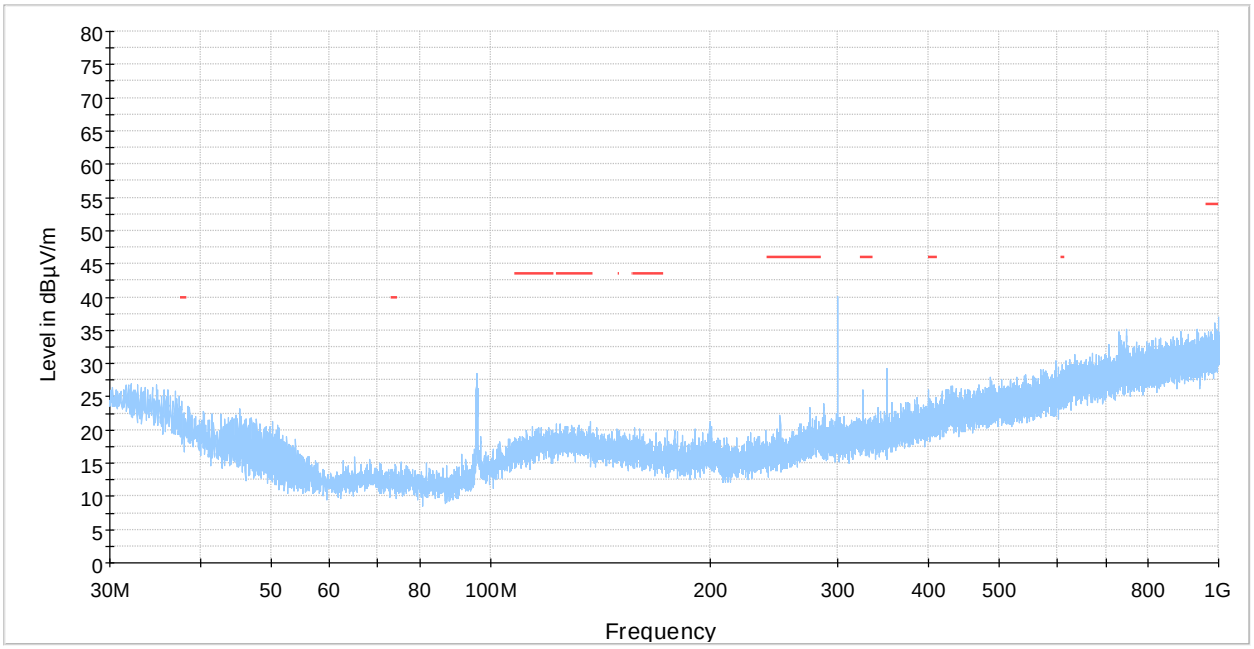
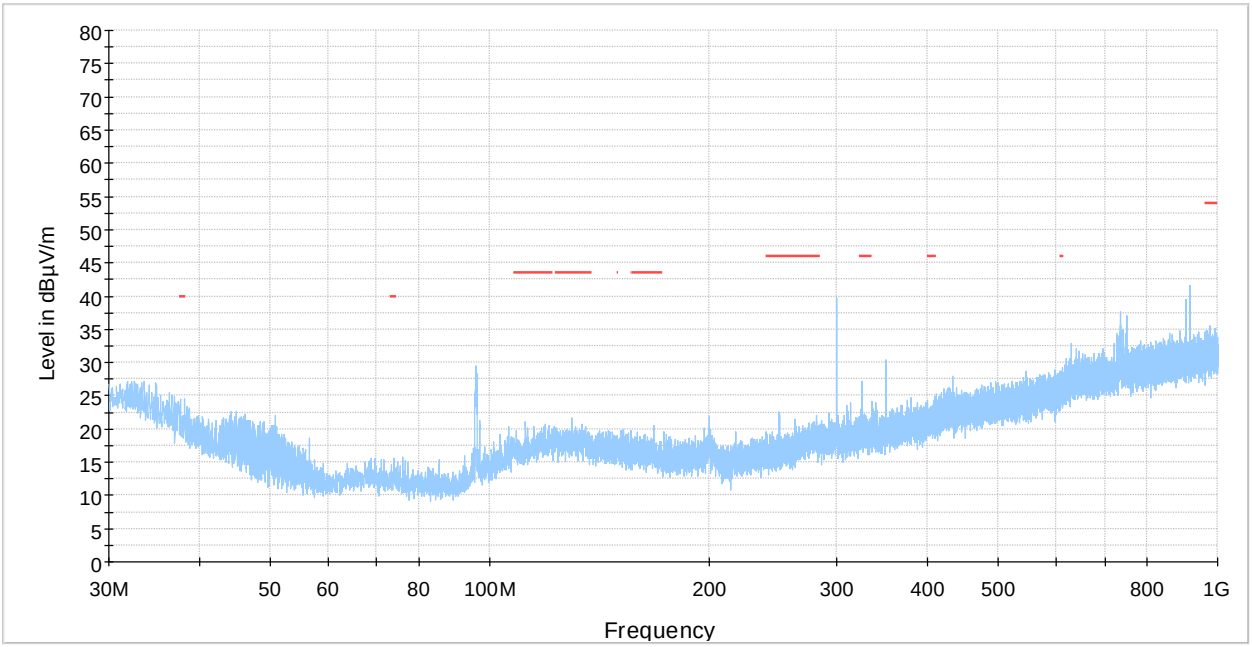


Figure 7.6-3: *radiated spurious emissions from 30 MHz to 1000 MHz at low channel*



SPR 30 MHz to 1000 MHz Wi-Fi 2.4 GHz mid channel

Preview Result 1-PK+
FCC 15.209 and RSS-210 limit line RstrB

Figure 7.6-4: *radiated spurious emissions from 30 MHz to 1000 MHz at mid channel*

Test data, continued

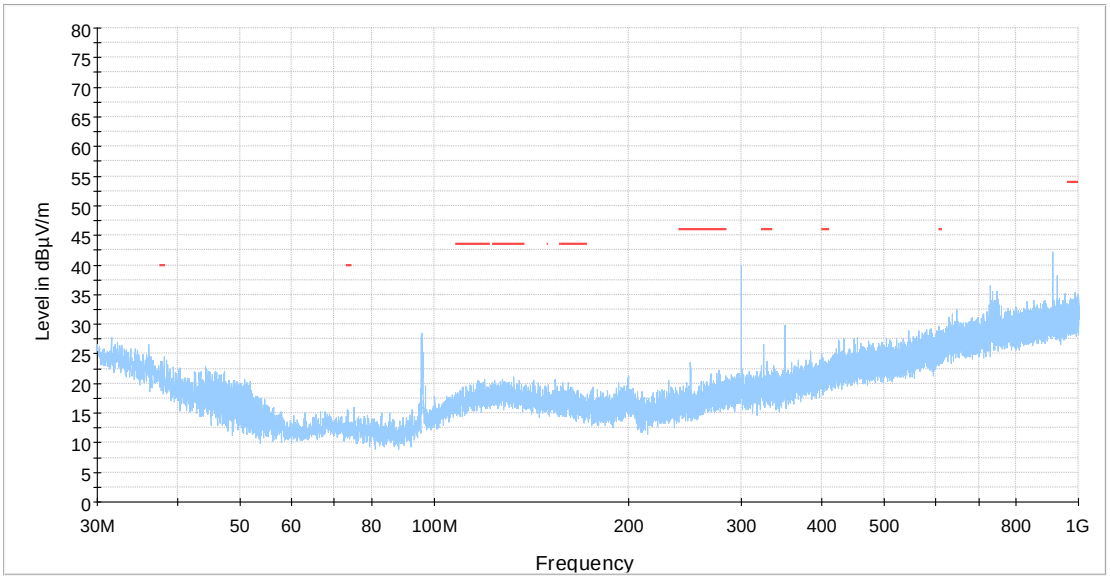


Figure 7.6-5: *radiated spurious emissions from 30 MHz to 1000 MHz at high channel*

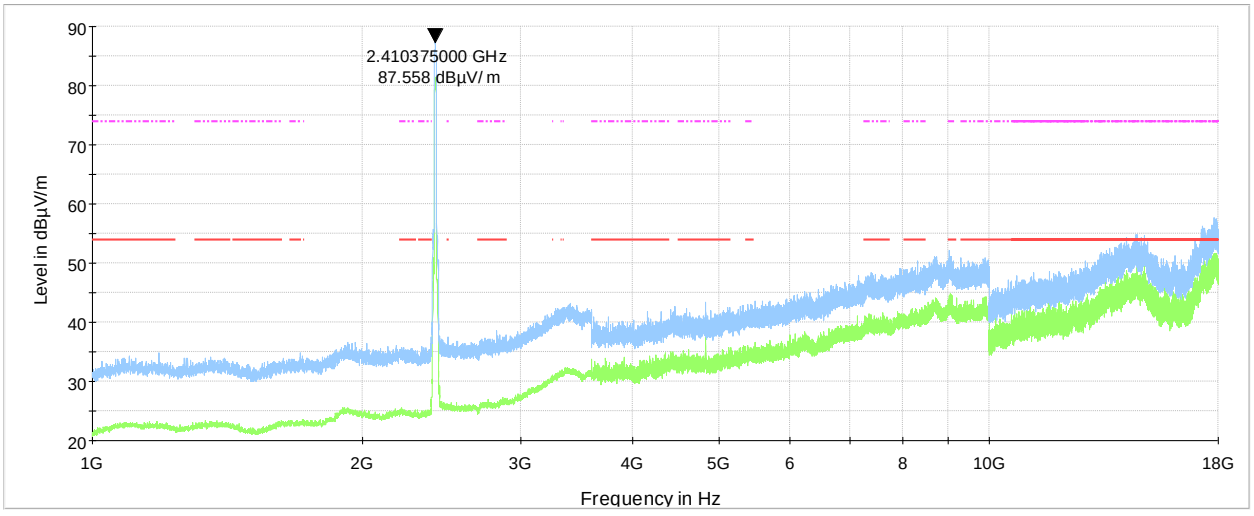
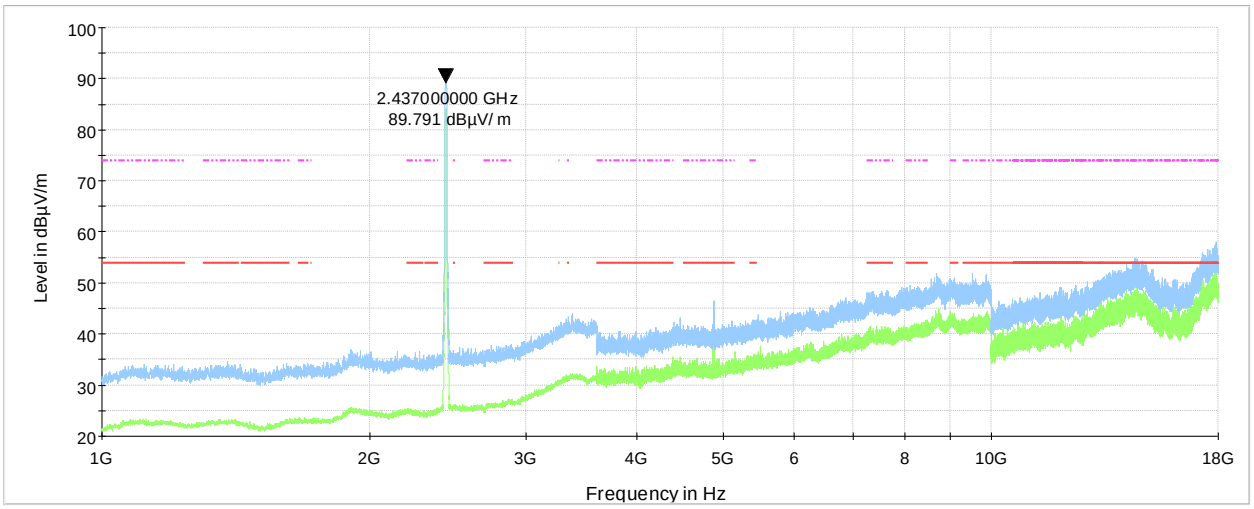
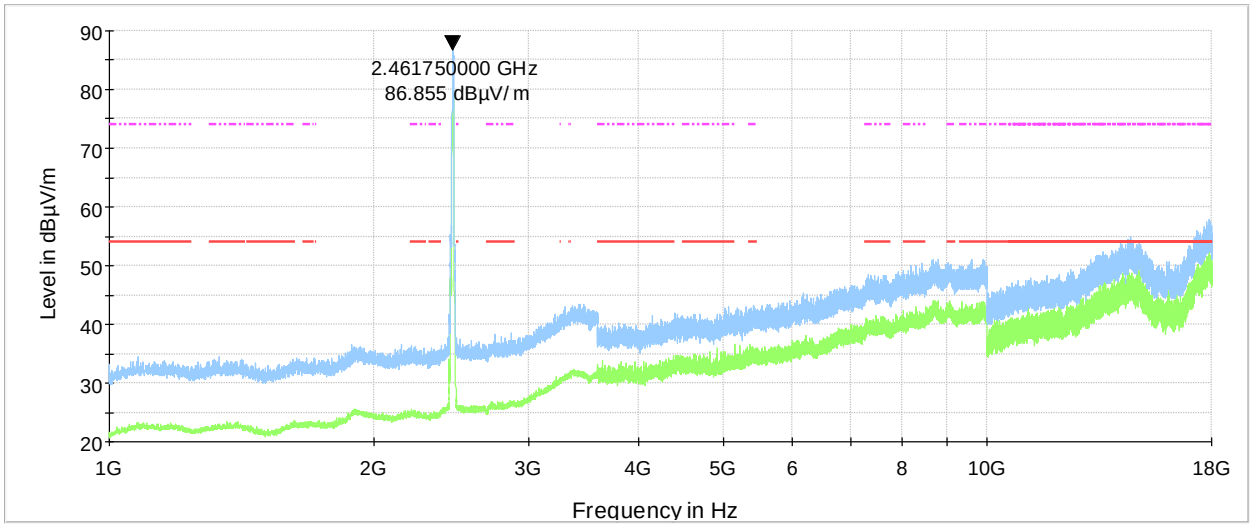


Figure 7.6-6: *radiated spurious emissions from 1 GHz to 18 GHz at low channel*



SPR 1 GHz to 18 GHz Wi-Fi 2.4 GHz mid channel
Preview Result 2-AVG
Preview Result 1-PK+
FCC 15.209 and RSS-210 limit line RstrB
FCC 15.209 and RSS-210 limit line RstrB pk

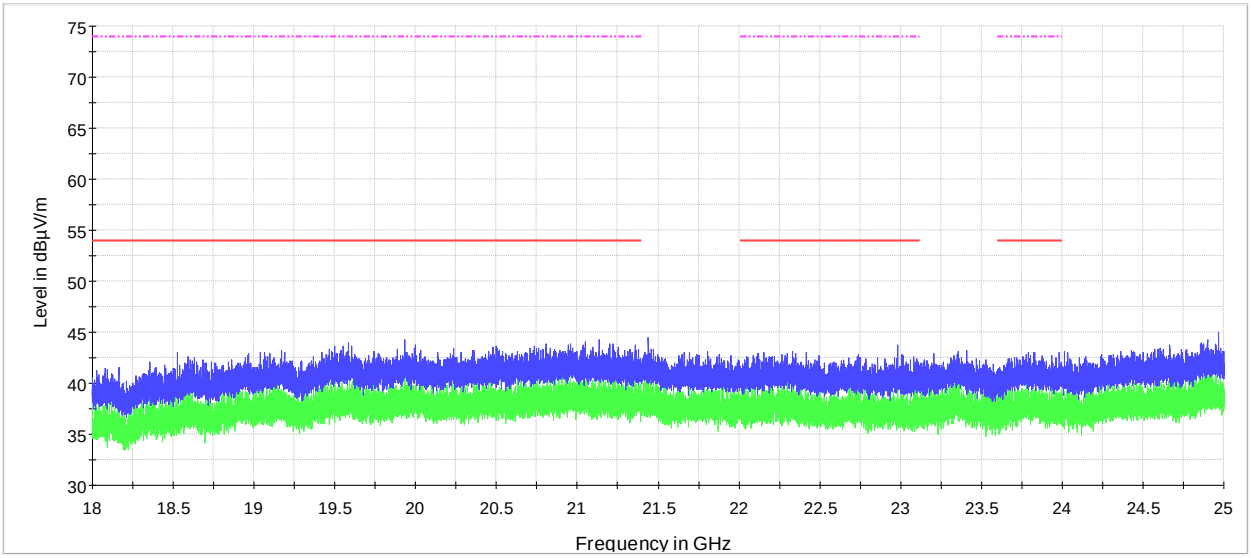
Figure 7.6-7: *radiated spurious emissions from 1 GHz to 18 GHz at mid channel*



SPR 1 GHz to 18 GHz Wi-Fi 2.4 GHz high channel
Preview Result 2-AVG
Preview Result 1-PK+
FCC 15.209 and RSS-210 limit line RstrB
FCC 15.209 and RSS-210 limit line RstrB pk

Figure 7.6-8: *radiated spurious emissions from 1 GHz to 18 GHz at high channel*

Test data, continued



SPR 18 GHz to 25 GHz Wi-Fi 2.4 GHz low channel
AVG_MAXH
PK+_MAXH
FCC 15.209 and RSS-210 limit line RstrB
FCC 15.209 and RSS-210 limit line RstrB pk

Figure 7.6-9: *radiated spurious emissions from 18 GHz to 25 GHz at low channel*

SPR 18 GHz to 25 GHz Wi-Fi 2.4 GHz mid channel
AVG_MAXH
PK+_MAXH
FCC 15.209 and RSS-210 limit line RstrB
FCC 15.209 and RSS-210 limit line RstrB pk

Figure 7.6-10: *radiated spurious emissions from 18 GHz to 25 GHz at mid channel*

Test data, continued

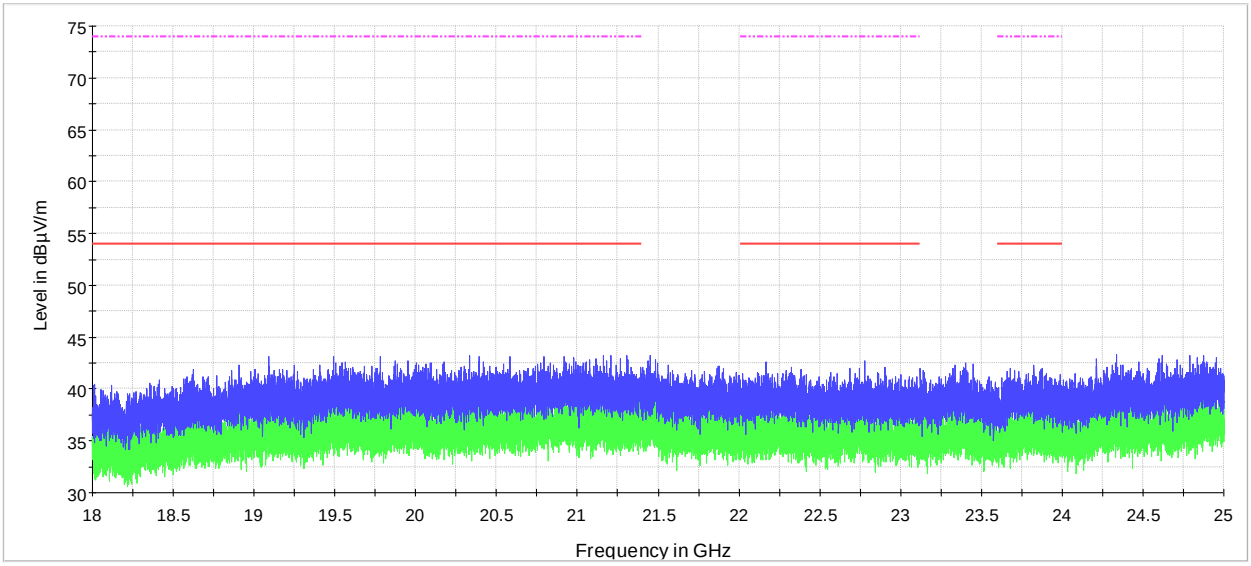
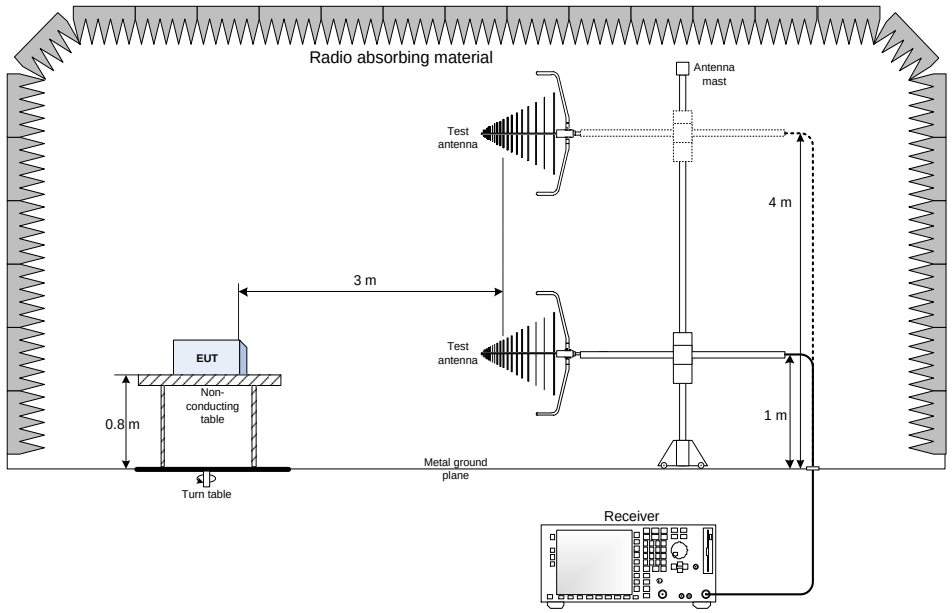


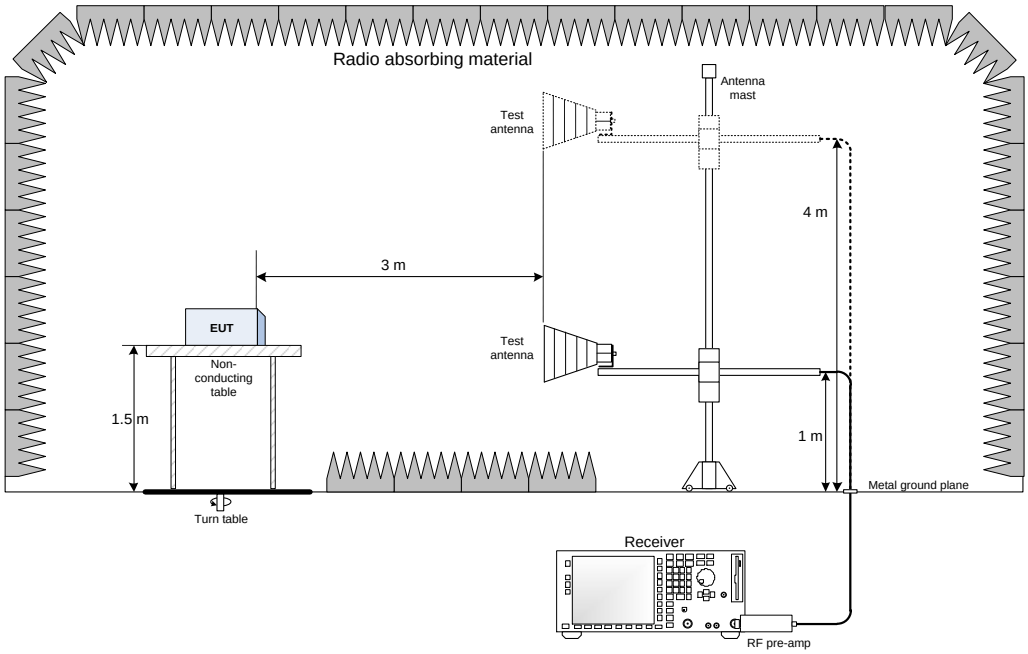
Figure 7.6-11: *radiated spurious emissions from 18 GHz to 25 GHz at high channel*

Section 8 Test setup diagrams

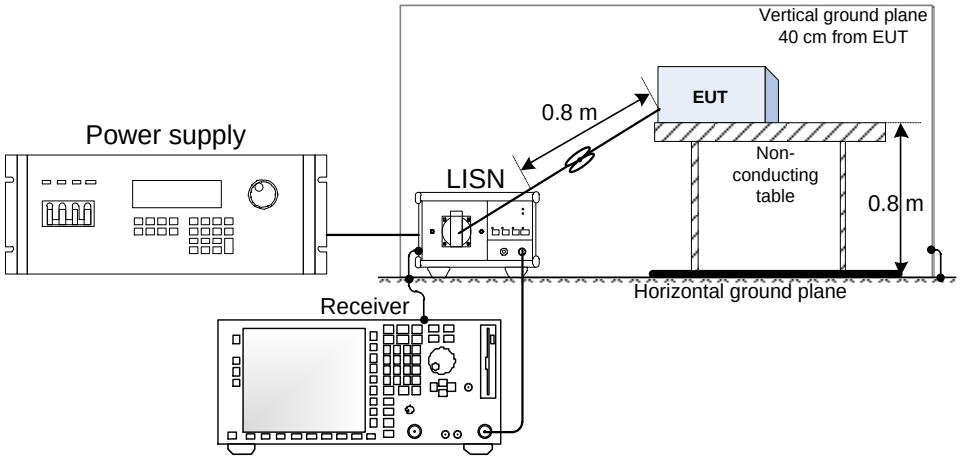
8.1 Radiated emissions set-up for frequencies below 1 GHz



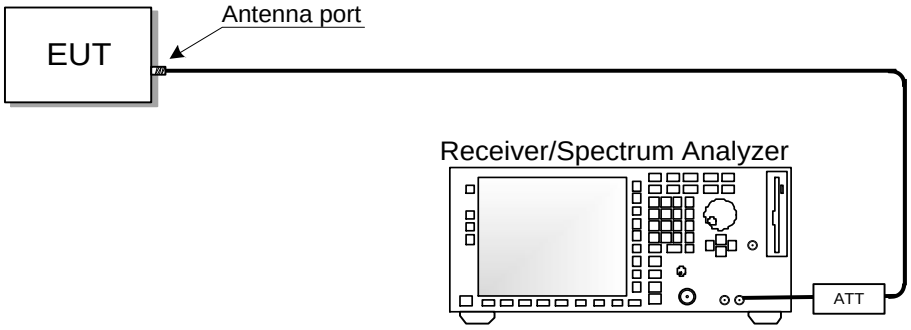
8.2 Radiated emissions set-up for frequencies above 1 GHz



8.3 AC mains conducted emissions set-up



8.4 Antenna port set-up



End of the test report