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Wireless test report – 369976-1TRFWL

Applicant:

Redline Communications

Product name:

RDL-3000-RMF

Model:

RDL-3000 Ellipse

FCC ID:

QC8-RDL3000RMF

Specifications:

- FCC 47 CFR Part 15 Subpart H, §15.709

  White Space devices; General technical requirements.

Date of issue: April 8, 2019

Test engineer(s):	David Duchesne, Senior EMC/Wireless Specialist	Signature:	
Reviewed by:	Kevin Rose, Wireless/EMC Specialist	Signature:	

Test location(s)

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Website	www.nemko.com
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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 contain in this report are within Nemko Canada's ISO/IEC 17025 accreditation.

Copyright notification

Table of contents

Section 1. Report summary

1.1 Applicant and manufacturer

Company name	Avaya Inc.
Address	302 Town Centre Blvd, Markham, ON, Canada, L3R 0E8

1.2 Test specifications

FCC 47 CFR Part 15, Subpart H	White Space devices

1.3 Test methods

ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
416721 D01 White Space Test Procedures v03	Certification test procedures for white space devices authorized under subpart h of the part 15 rules
662911 D01 Multiple Transmitter Output v02r01	Emissions Testing of Transmitters with Multiple Outputs in the Same Band
662911 D02 MIMO with Cross-Polarized Antennas v01	MIMO with Cross-Polarized Antenna

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 1.5 below. 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 Exclusions

None

1.6 Test report revision history

Table 1.6-1: *Test report revision history*

Revision #	Date of issue	Details of changes made to test report
TRF	April 8, 2019	Original report issued

Section 2. Summary of test results

2.1 Testing period

Test start date	March 25, 2019
Test end date	March 29, 2019

2.2 FCC Part 15 Subpart H requirements test results

Table 2.2-1: *FCC 15.709 results*

Part	Test description	Verdict
§15.709(a)(2)	Radiated power limits	Pass
§15.709(b)(1), (c)(1–3)	Conducted power and PSD	Pass
§15.709(b)(1), (d)(1), (d)(3)	Adjacent Channel Emissions – Band-edge Measurement	Pass
§15.709(b)(1), (d)(1), (d)(3)	Adjacent Channel Emissions – Adjacent Channel Measurement	Pass
§15.709(d)(2)	Radiated Emissions beyond Adjacent-Channel (15.209)	Pass
§15.709(c)(4)	AC power line conducted emissions	Pass

Notes: None

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	March 19, 2019
Nemko sample ID number	Item # 1

3.2 EUT information

Product name	RDL-3000-RMF
Model	RDL-3000 Ellipse
Serial number	160PC13030002

3.3 Technical information

Frequency band	470–698 MHz
Frequency Min	476 MHz (12 MHz), 479 MHz (18 MHz), 482 MHz (24 MHz)
Frequency Max (MHz)	692 MHz (12 MHz), 689 MHz (18 MHz), 686 MHz (24 MHz)
RF power Max (W)	0.091 (19.6 dBm)
Channel BW	12, 18, 24 MHz
Type of modulation	BPSK, 256QAM
Power requirements	48 V_{DC} via PoE
Antenna information	AFD-DB-600-2ft-02 (11 dBi) and ALP-SB-60055-D1 (Log P 11 dbi)

3.4 Product description and theory of operation

The RDL-3000-RMF is a 2x2 MIMO broadband radio that provides high capacity, long range communications link. Operating in 470-698MHz band, RDL-3000-RMF is configured via firmware options and electronic product keys.
RDL-3000-RMF is a Fixed WSD that supports PAWS Protocol to Access White Space Database. It operates with Nominet, FCC approved database provider.
It fully complies with WSDB channel availability and EIRP information that includes scheduled changes in channel availability by making a re-check contact with DB every 20 minutes.

3.5 EUT exercise details

EUT was controlled from Laptop with WebGUI at the IP addresses: 192.168.25.2.

3.6 EUT setup diagram

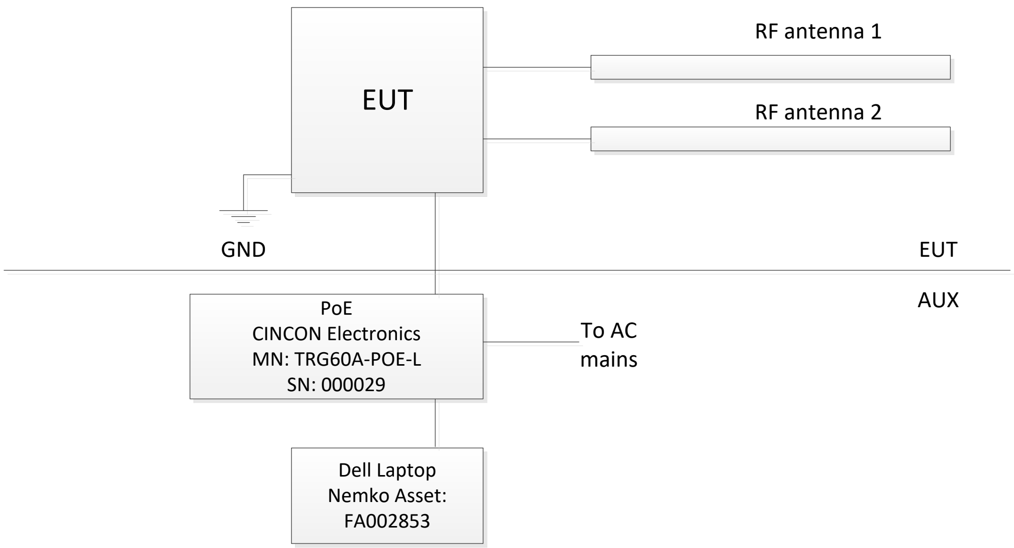


Figure 3.6-1: *Setup diagram with Log-P antennas*

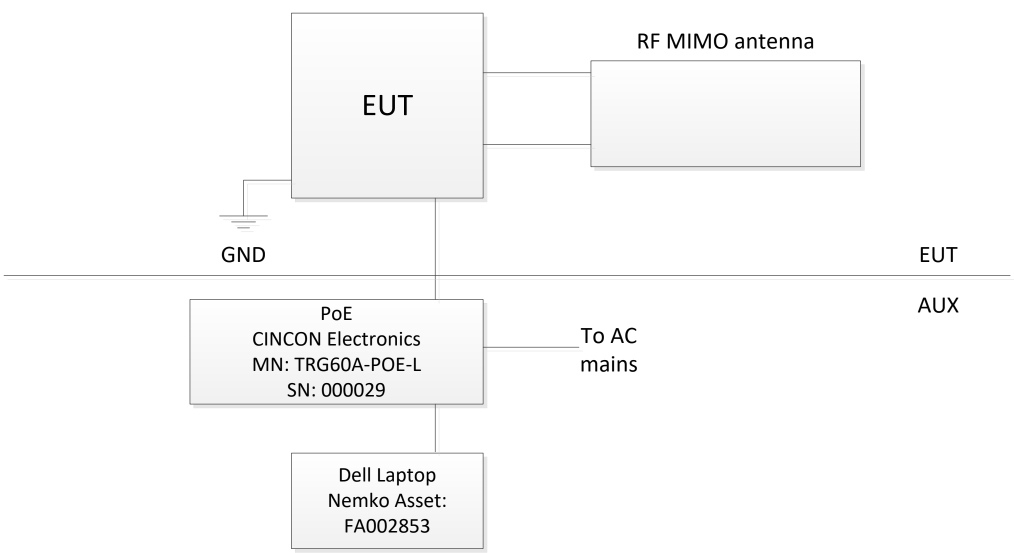


Figure 3.6-2: *Setup diagram with Flat MIMO antenna*

Section 4. Engineering considerations

4.1 Modifications incorporated in the EUT for compliance

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

4.2 Technical judgment

None

4.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 5. Test conditions

5.1 Atmospheric conditions

Temperature	15–30 °C
Relative humidity	20–75 %
Air pressure	86–106 kPa

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.

5.2 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 ±5 %, for which the equipment was designed.

Section 6. Measurement uncertainty

6.1 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 6.1-1: *Measurement uncertainty*

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

Section 7. Test equipment

7.1 Test equipment list

Table 7.1-1: *Equipment list*

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
3 m EMI test chamber	TDK	SAC-3	FA002047	1 year	January 24, 2020
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 26	FA002043	1 year	May 26, 2019
Spectrum analyzer	Rohde & Schwarz	FSU	FA001877	1 year	October 26, 2019
Preamp (1–18 GHz)	ETS Lindgren	124334	FA002873	1 year	November 4, 2019
Bilog antenna (20–2000 MHz)	Sun AR	JB1	FA003009	1 year	September 6, 2019
Horn antenna (1–18 GHz)	EMCO	3115	FA000825	1 year	October 8, 2019
50 Ω coax cable	Huber + Suhner	None	FA002074	1 year	May 12, 2019
50 Ω coax cable	Huber + Suhner	None	FA002830	1 year	May 8, 2019
Notch filter 2400–2483 MHz	Microwave Circuits	2400–2483 MHz	FA001940	—	VOU

Notes: VOU - verify on use

Section 8. Testing data

8.1 FCC 15.31(e) Variation of power source

8.1.1 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.

8.1.2 Test date

Start date	March 22, 2019

8.1.3 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.

For battery-operated equipment, the equipment tests shall be performed using a variable power supply.

8.1.4 Test data

The EUT is powered via POE. The client provided a POE adapter for testing. The AC input of the POE adapter was varied.

8.2 FCC 15.31(m) Number of frequencies

8.2.1 Definitions and limits

FCC §15.31:

(m) Measurements on intentional radiators or receivers, other than TV broadcast 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:

Table 8.2-1: *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.

8.2.2 Test date

Start date	March 22, 2019

8.2.3 Observations, settings and special notes

Per ANSI C63.10 Subclause 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.

Per ANSI C63.10 Subclause 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.

8.2.4 Test data

Table 8.2-2: *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
12 MHz Bandwidth					
470	698	228	476	584	692
18 MHz Bandwidth					
470	698	228	479	587	689
24 MHz Bandwidth					
470	698	228	482	584	686

8.3 FCC 15.203 Antenna requirement

8.3.1 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.

KDB 1416721 D01,v03,II.2.c)i.
The maximum gain of the transmitting antenna used with a Fixed WSD must be declared by the manufacturer in the certification application.

8.3.2 Test date

Start date	March 22, 2019

8.3.3 Observations, settings and special notes

If the transmitting antenna gain exceeds 6 dBi for fixed white space device operating at up to 36 dBm EIRP or exceeds 10 dBi for fixed white space device operating at up to 40 dBm EIRP, the conducted output power, power spectral density, band edge emissions, and adjacent channel emissions limits shall all be reduced by the amount in dB by which the gain exceeds 6 dBi or 10 dBi respectively.

8.3.4 Test data

- Maximum antenna gain: 11 dBi.
- The EUT is professionally installed.

8.4 FCC 15.709(c)(4) AC power line conducted emissions limits

8.4.1 Definitions and limits

White space devices connected to the AC power line are required to comply with the conducted limits set forth in §15.207.
15.207: 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 subclause 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.

Table 8.4-1: *Conducted emissions limit*

Frequency of emission, MHz	Conducted limit, dBμV	
	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.

8.4.2 Test date

Start date	March 29, 2019

8.4.3 Observations, settings and special notes

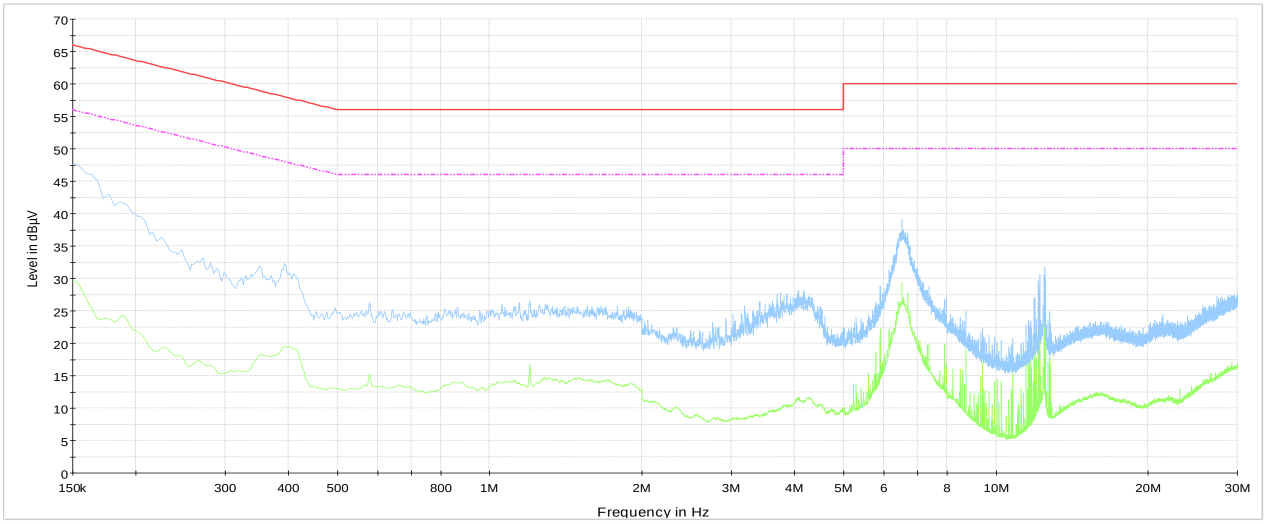
- The spectral plots have been corrected with transducer factors. (i.e. cable loss, LISN factors, and attenuators)
- The EUT was tested with the MIMO antenna to demonstrate compliance.

Port under test – Coupling device	AC Input of POE – 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.

Receiver settings:

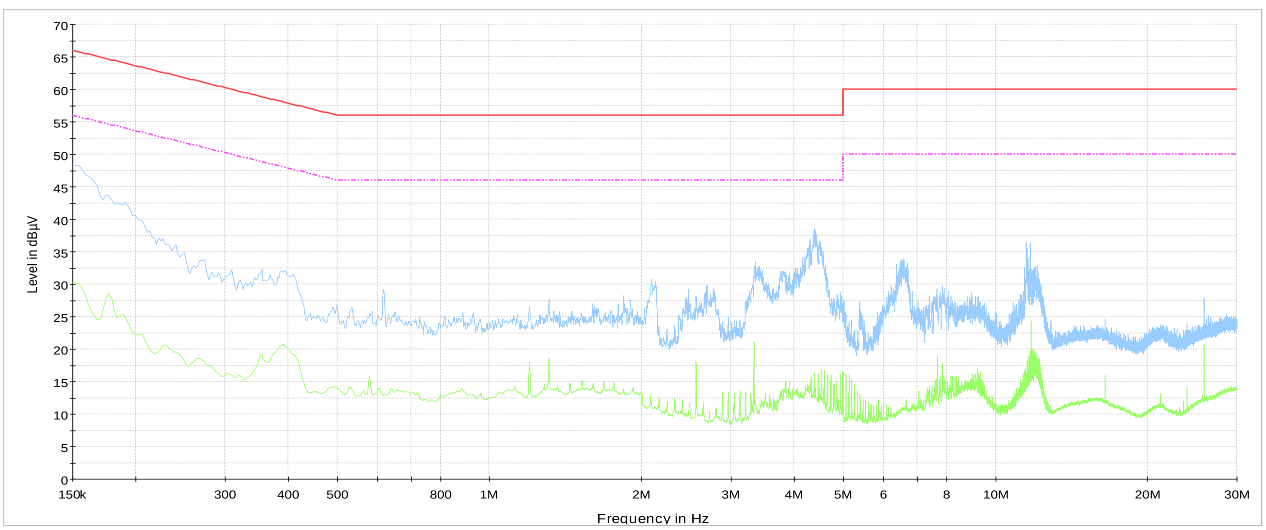
Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Peak and Average (Preview measurement), Quasi-peak and CAverage (Final measurement)
Trace mode	Max Hold
Measurement time	– 100 ms (Peak and Average preview measurement) – 100 ms (Quasi-peak final measurement) – 160 ms (CAverage final measurement)

8.4.4 Test data



120 VAC 60 Hz, Phase
Preview Result 2-AVG
Preview Result 1-PK+
CISPR 32 Mains Q-Peak Class B Limit
CISPR 32 Mains Average Class B Limit

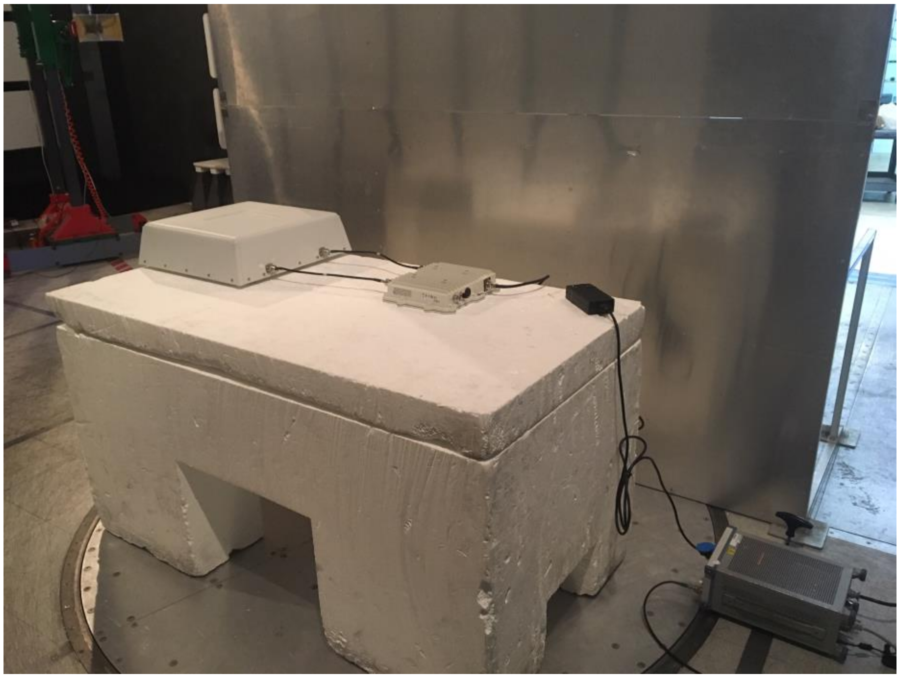
Plot 8.4-1: *Conducted emissions on phase line*



120VAC 60 Hz, Neutral
Preview Result 2-AVG
Preview Result 1-PK+
CISPR 32 Mains Q-Peak Class B Limit
CISPR 32 Mains Average Class B Limit

Plot 8.4-2: *Conducted emissions on neutral line*

8.4.5 Setup photos



Plot 8.4-3: *Conducted emissions on phase line setup photos*

Plot 8.4-4: *Conducted emissions on neutral line setup photos*

8.5 FCC 15.709(b)(1), (c)(1), (c)(2), (c)(3) Conducted Power and PSD

8.5.1 Definitions and limits

(b)(1) For operation at EIRP levels of 36 dBm (4000 mW) or less, fixed white space devices may operate at EIRP levels between the values shown in the table provided that the conducted power and the conducted power spectral density (PSD) limits are linearly interpolated between the values shown and the adjacent channel emission limit of the higher value shown in the table is met. Operation at EIRP levels above 36 dBm (4000 mW) shall follow the requirements for 40 dBm (10,000 mW).

Table 8.5-1: *Output power and PSD limits for Fixed WSD*

EIRP, dBm/6 MHz	Conducted power limit*, dBm/6 MHz	Conducted PSD limit, dBm/100 kHz
16	10	−7.4
20	14	−3.4
24	18	0.6
28	22	4.6
32	26	8.6
36	30	12.6
40	30	12.6

Notes: The conducted power spectral density from a fixed white space device shall not be greater than the values shown in the table when measured in any 100 kHz band during any time interval of continuous transmission, except that a 40 mW fixed white space device operating in a four megahertz channel within a seven megahertz guard band must comply with a conducted power spectral density limit of −5.4 dBm.

(c)(1) The conducted power, PSD and adjacent channel limits for fixed white space devices operating at up to 36 dBm (4000 milliwatts) EIRP shown in the table above are based on a maximum transmitting antenna gain of 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(c)(2) The conducted power, PSD and adjacent channel limits for fixed white space devices operating at greater than 36 dBm (4000 milliwatts) EIRP shown in the table above are based on a maximum transmitting antenna gain of 10 dBi. If transmitting antennas of directional gain greater than 10 dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 10 dBi.

(c)(3) Maximum conducted output power is the total transmit power over the occupied bandwidth delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power 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.

8.5.2 Test date

Start date	March 25, 2019

8.5.3 Observations, settings and special notes

Output power and Spectrum analyser settings:

Resolution bandwidth	100 kHz
Video bandwidth	300 kHz
Frequency span	>10 MHz
Detector mode	RMS
Trace mode	Power averaging over 10 sweeps (minimum)
Power integration	Use the integrated band/channel power analyzer function to determine the average power within the 6-MHz channel bandwidth.

8.5.4 Test data

Output power and PSD limit calculation for 6 MHz channel.

The EUT is equipped with two antenna ports. Therefore; Total power (dBm) = is declared power (dBm) + 3 dB
Max antenna gain is 11 dBi, cable loss is 1 dB, total system gain is 10 dBi,
Therefore EIRP = Total power (dBm) + System gain (10 dBi). Output power and PSD limits are based on the EIRP level.

Example calculation: For 32 dBm EIRP output power limit is 26 dBm/6 MHz and PSD limit is 8.6 dBm/100 kHz.
Since antenna gain is 4 dB higher than 6 dBi maximum limit, the output power limit and PSD limit must be reduced by 4 dB:

Declared output power for 12 MHz channel is 19 dBm. EIRP is 19 dBm + 3 dB + 10 dBi = 32 dBm, therefore Output power limit is 22 dBm/6 MHz and PSD limit is 4.6 dBm/100 kHz
Declared output power for 18 MHz channel is 18 dBm. EIRP is 18 dBm + 3 dB + 10 dBi = 31 dBm, therefore Output power limit is 21 dBm/6 MHz and PSD limit is 3.6 dBm/100 kHz
Declared output power for 24 MHz channel is 17 dBm. EIRP is 17 dBm + 3 dB + 10 dBi = 30 dBm, therefore Output power limit is 20 dBm/6 MHz and PSD limit is 2.6 dBm/100 kHz

Table 8.5-2: *Output power and PSD results for 12 MHz channel*

Frequency, MHz	Modulation	Output power measurement at Ant 1, dBm/6 MHz	Output power measurement at Ant 2, dBm/6 MHz	Total output power[1], dBm/6 MHz	Output power limit, dBm/6 MHz	Margin, dB
476	BPSK	16.4	16.4	19.4	22.0	2.6
476	256QAM	16.4	16.5	19.5	22.0	2.5
584	BPSK	16.2	16.5	19.4	22.0	2.6
584	256QAM	16.6	16.5	19.5	22.0	2.5
692	BPSK	16.4	16.5	19.4	22.0	2.6
692	256QAM	16.7	16.5	19.6	22.0	2.4

Frequency, MHz	Modulation	PSD measurement at Ant 1, dBm/100 kHz	PSD measurement at Ant 2, dBm/100 kHz	Total PSD[2], dBm/100 kHz	PSD limit, dBm/100 kHz	Margin, dB
476	BPSK	-0.1	0.1	3.0	4.6	1.6
476	256QAM	0.1	0.1	3.1	4.6	1.5
584	BPSK	-0.7	-0.6	2.4	4.6	2.2
584	256QAM	-0.1	-0.2	2.9	4.6	1.7
692	BPSK	0.2	0.3	3.3	4.6	1.3
692	256QAM	0.5	0.2	3.4	4.6	1.2

Notes: [1]Total output power =10*LOG((10^(Output power Ant 1/10))+(10^(Output power Ant 2/10)))
[2]Total PSD =10*LOG((10^(PSD Ant 1/10))+(10^(PSD Ant 2/10)))

Table 8.5-3: *Output power and PSD results for 18 MHz channel*

Frequency, MHz	Modulation	Output power measurement at Ant 1, dBm/6 MHz	Output power measurement at Ant 2, dBm/6 MHz	Total output power[1], dBm/6 MHz	Output power limit, dBm/6 MHz	Margin, dB
479	BPSK	15.1	15.1	18.1	21.0	2.9
479	256QAM	15.0	15.1	18.0	21.0	3.0
587	BPSK	14.8	15.1	17.9	21.0	3.1
587	256QAM	14.8	15.2	18.0	21.0	3.0
689	BPSK	15.3	14.8	18.1	21.0	2.9
689	256QAM	15.3	14.8	18.1	21.0	2.9

Frequency, MHz	Modulation	PSD measurement at Ant 1, dBm/100 kHz	PSD measurement at Ant 2, dBm/100 kHz	Total PSD[2], dBm/100 kHz	PSD limit, dBm/100 kHz	Margin, dB
479	BPSK	-2.4	-2.6	0.5	3.6	3.1
479	256QAM	-2.8	-2	0.6	3.6	3.0
587	BPSK	-1.2	0.4	2.7	3.6	0.9
587	256QAM	-0.9	-0.7	2.2	3.6	1.4
689	BPSK	-1.3	-2.4	1.2	3.6	2.4
689	256QAM	-1.5	-2	1.3	3.6	2.3

Notes: [1]Total output power =10*LOG((10^(Output power Ant 1/10))+(10^(Output power Ant 2/10)))
[2]Total PSD =10*LOG((10^(PSD Ant 1/10))+(10^(PSD Ant 2/10)))

8.5.4 Test data, continued

Table 8.5-4: *Output power and PSD results for 24 MHz channel*

Frequency, MHz	Modulation	Output power measurement at Ant 1, dBm/6 MHz	Output power measurement at Ant 2, dBm/6 MHz	Total output power[1], dBm/6 MHz	Output power limit, dBm/6 MHz	Margin, dB
482	BPSK	13.3	13.4	16.4	20.0	3.6
482	256QAM	13.3	13.4	16.4	20.0	3.6
587	BPSK	13.1	13.4	16.3	20.0	3.7
587	256QAM	13.1	13.4	16.3	20.0	3.7
686	BPSK	13.6	13.2	16.4	20.0	3.6
686	256QAM	13.6	13.1	16.4	20.0	3.6

Frequency, MHz	Modulation	PSD measurement at Ant 1, dBm/100 kHz	PSD measurement at Ant 2, dBm/100 kHz	Total PSD[2], dBm/100 kHz	PSD limit, dBm/100 kHz	Margin, dB
482	BPSK	-2.7	-2.6	0.4	2.6	2.2
482	256QAM	-2.9	-2.4	0.4	2.6	2.2
587	BPSK	-2	-1.8	1.1	2.6	1.5
587	256QAM	-1.7	-1.5	1.4	2.6	1.2
686	BPSK	-1.5	-1.7	1.4	2.6	1.2
686	256QAM	-1.3	-2.0	1.4	2.6	1.2

Notes: [1]Total output power =10*LOG((10^(Output power Ant 1/10))+(10^(Output power Ant 2/10)))
[2]Total PSD =10*LOG((10^(PSD Ant 1/10))+(10^(PSD Ant 2/10)))

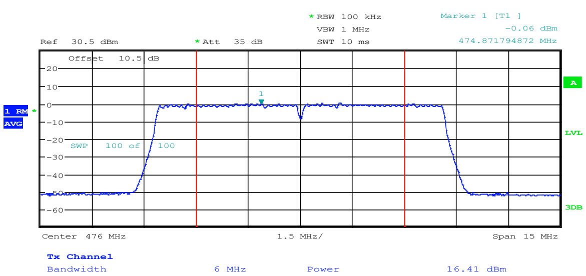


Figure 8.5-1: *Output power and PSD on 12 MHz channel, sample plot*

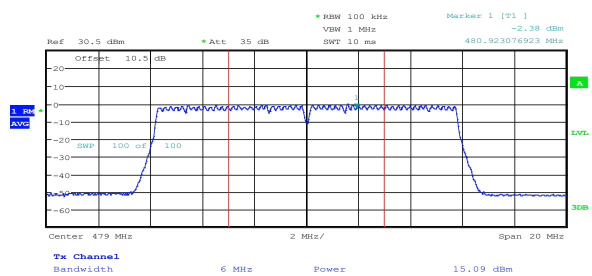


Figure 8.5-2: *Output power and PSD on 18 MHz channel, sample plot*

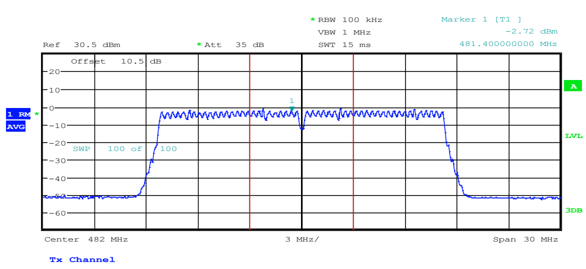


Figure 8.5-3: *Output power and PSD on 24 MHz channel, sample plot*

8.6 FCC 15.709(b)(1), (d)(1), (d)(3) Adjacent Channel Emissions – Band-edge Measurement

8.6.1 Definitions and limits

(d)(1) The adjacent channel emission limits shown in the tables in paragraphs (b)(1) and (2) of this section apply in the six-megahertz channel immediately adjacent to each white space channel or group of contiguous white space channels in which the white space device is operating.

(d)(3) Emission measurements in the adjacent bands shall be performed using a minimum resolution bandwidth of 100 kHz with an average detector. A narrower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 100 kHz.

Table 8.6-1: *Adjacent channel emission limits for Fixed WSD*

EIRP, dBm/6 MHz	Conducted adjacent channel emission limit, dBm/100 kHz
16	−62.8
20	−58.8
24	−54.8
28	−50.8
32	−46.8
36	−42.8
40	−42.8

8.6.2 Test date

Start date	March 25, 2019

8.6.3 Observations, settings and special notes

None.

Spectrum analyser settings:

Resolution bandwidth	10 kHz
Video bandwidth	30 kHz
Frequency span	200 kHz
Detector mode	RMS
Trace mode	Power averaging over 10 sweeps (minimum)
Power integration	Use the integrated band/channel power analyzer function to determine the average power within the 100-kHz channel bandwidth.

8.6.4 Test data

Table 8.6-2: *Band edge measurement results*

TX Freq., MHz	Modulation	Frequency, MHz	Band edge measurement at Ant 1, dBm/100 kHz	Band edge measurement at Ant 2, dBm/100 kHz	Total band edge measurement[1], dBm/100 kHz	Band edge limit, dBm/100 kHz	Margin, dB
12 MHz channel							
482 (Low)	BPSK	476	-58.7	-57.9	-55.3	-50.8	4.5
482 (Low)	256QAM	476	-59.3	-58.3	-55.8	-50.8	5.0
482 (Low)	BPSK	488	-59.8	-60.7	-57.2	-50.8	6.4
482 (Low)	256QAM	488	-59.7	-60.7	-57.2	-50.8	6.4
584 (Mid)	BPSK	578	-58.5	-58.8	-55.6	-50.8	4.8
584 (Mid)	256QAM	578	-58.4	-58.6	-55.5	-50.8	4.7
584 (Mid)	BPSK	590	-57.9	-59.3	-55.5	-50.8	4.7
584 (Mid)	256QAM	590	-58.0	-55.9	-53.8	-50.8	3.0
686 (High)	BPSK	680	-58.5	-56.9	-54.6	-50.8	3.8
686 (High)	256QAM	680	-56.8	-57.0	-53.9	-50.8	3.1
686 (High)	BPSK	692	-58.9	-57.7	-55.2	-50.8	4.4
686 (High)	256QAM	692	-59.3	-57.9	-55.5	-50.8	4.7
18 MHz channel							
485 (Low)	BPSK	476	-60.1	-61.3	-57.6	-50.8	6.8
485 (Low)	256QAM	476	-60.8	-61.2	-58.0	-50.8	7.2
485 (Low)	BPSK	494	-61.6	-62.3	-58.9	-50.8	8.1
485 (Low)	256QAM	494	-61.4	-62.1	-58.7	-50.8	7.9
587 (Mid)	BPSK	578	-59.4	-60.0	-56.7	-50.8	5.9
587 (Mid)	256QAM	578	-59.5	-59.9	-56.7	-50.8	5.9
587 (Mid)	BPSK	596	-58.8	-57.4	-55.0	-50.8	4.2
587 (Mid)	256QAM	596	-58.8	-57.4	-55.0	-50.8	4.2
683 (High)	BPSK	674	-59.2	-58.4	-55.8	-50.8	5.0
683 (High)	256QAM	674	-59.4	-58.3	-55.8	-50.8	5.0
683 (High)	BPSK	692	-60.2	-59.1	-56.6	-50.8	5.8
683 (High)	256QAM	692	-60.3	-59.1	-56.6	-50.8	5.8
24 MHz channel							
488 (Low)	BPSK	476	-59.2	-59.2	-56.2	-50.8	5.4
488 (Low)	256QAM	476	-59.1	-59.4	-56.2	-50.8	5.4
488 (Low)	BPSK	500	-60.6	-60.0	-57.3	-50.8	6.5
488 (Low)	256QAM	500	-60.4	-60.0	-57.2	-50.8	6.4
584(Mid)	BPSK	572	-58.0	-57.8	-54.9	-50.8	4.1
584(Mid)	256QAM	572	-58.0	-57.8	-54.9	-50.8	4.1
584(Mid)	BPSK	596	-57.3	-55.9	-53.5	-50.8	2.7
584(Mid)	256QAM	596	-57.2	-55.9	-53.5	-50.8	2.7
680 (High)	BPSK	668	-58.1	-57.5	-54.8	-50.8	4.0
680 (High)	256QAM	668	-58.3	-57.5	-54.9	-50.8	4.1
680 (High)	BPSK	692	-60.2	-59.0	-56.5	-50.8	5.7
680 (High)	256QAM	692	-60.0	-58.8	-56.3	-50.8	5.5

Notes: [1]Total band edge =10*LOG((10^(Band edge Ant 1/10))+(10^(Band edge Ant 2/10)))

8.6.4 Test data, continued

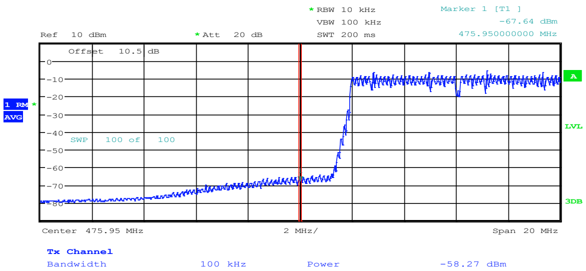


Figure 8.6-1: *Lower band edge for 12 MHz channel, sample plot*

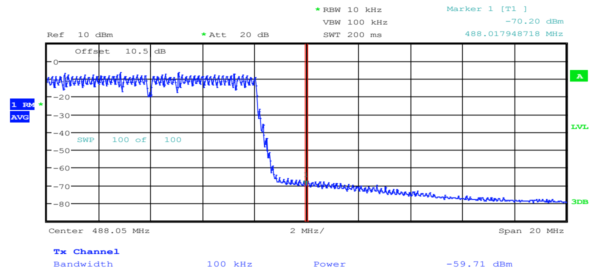


Figure 8.6-2: *Upper band edge for 12 MHz channel, sample plot*

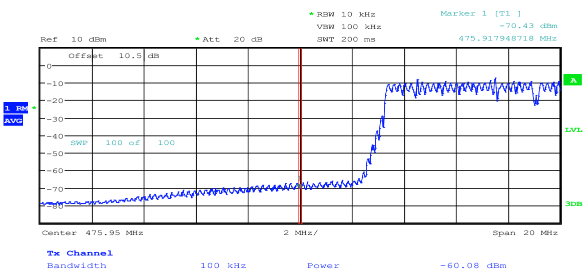


Figure 8.6-3: *Lower band edge for 18 MHz channel, sample plot*

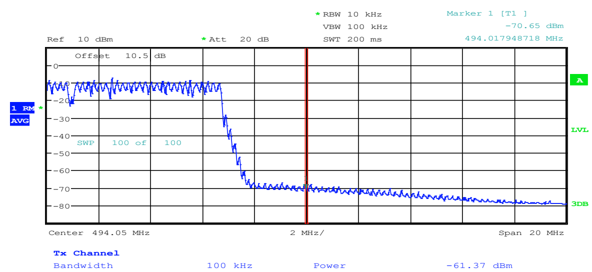


Figure 8.6-4: *Upper band edge for 18 MHz channel, sample plot*

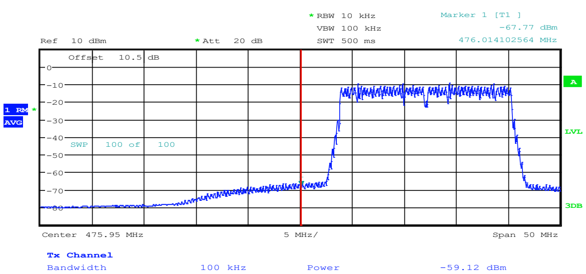


Figure 8.6-5: *Lower band edge for 24 MHz channel, sample plot*

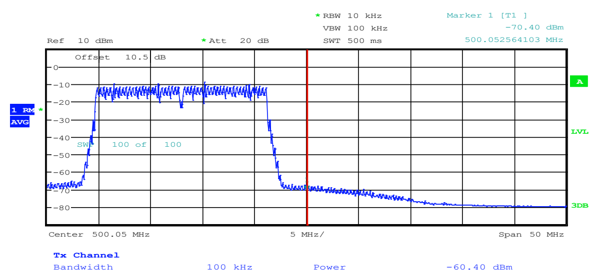


Figure 8.6-6: *Upper band edge for 24 MHz channel, sample plot*

8.7 FCC 15.709(b)(1), (d)(1), (d)(3) Adjacent Channel Emissions – Adjacent Channel Measurement

8.7.1 Definitions and limits

(d)(1) The adjacent channel emission limits shown in the tables in paragraphs (b)(1) and (2) of this section apply in the six-megahertz channel immediately adjacent to each white space channel or group of contiguous white space channels in which the white space device is operating.

(d)(3) Emission measurements in the adjacent bands shall be performed using a minimum resolution bandwidth of 100 kHz with an average detector. A narrower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 100 kHz.

Table 8.7-1: *Adjacent channel emission limits for Fixed WSD*

EIRP, dBm/6 MHz	Conducted adjacent channel emission limit, dBm/100 kHz
16	−62.8
20	−58.8
24	−54.8
28	−50.8
32	−46.8
36	−42.8
40	−42.8

8.7.2 Test date

Start date	March 26, 2019

8.7.3 Observations, settings and special notes

None

Spectrum analyser settings:

Resolution bandwidth	100 kHz
Video bandwidth	300 kHz
Frequency span	6 MHz
Detector mode	RMS
Trace mode	Power averaging over 10 sweeps (minimum)

8.7.4 Test data

***Table 8.7-2:** Adjacent channel measurement results*

TX Freq., MHz	Modulation	Frequency, MHz	Adj. channel measurement at Ant 1, dBm/100 kHz	Adj. channel measurement at Ant 2, dBm/100 kHz	Total Adj. channel measurement, dBm/100 kHz	Adj. channel limit, dBm/100 kHz	Margin, dB
12 MHz channel							
482 (Low)	BPSK	470.0–475.9	-59.4	-59.3	-56.3	-50.8	5.5
482 (Low)	256QAM	470.0–475.9	-59.3	-59.4	-56.3	-50.8	5.5
482 (Low)	BPSK	488.1–494.0	-61.5	-61.2	-58.3	-50.8	7.5
482 (Low)	256QAM	488.1–494.0	-61.2	-61.1	-58.1	-50.8	7.3
584 (Mid)	BPSK	572.0–577.9	-58.5	-58.4	-55.4	-50.8	4.6
584 (Mid)	256QAM	572.0–577.9	-58.5	-58.6	-55.5	-50.8	4.7
584 (Mid)	BPSK	590.1–596.0	-56.7	-55.8	-53.2	-50.8	2.4
584 (Mid)	256QAM	590.1–596.0	-56.6	-55.8	-53.2	-50.8	2.4
686 (High)	BPSK	674.0–679.9	-57.9	-57.9	-54.9	-50.8	4.1
686 (High)	256QAM	674.0–679.9	-57.8	-57.9	-54.8	-50.8	4.0
686 (High)	BPSK	692.1–698.0	-58.0	-57.9	-54.9	-50.8	4.1
686 (High)	256QAM	692.1–698.0	-58.0	-57.9	-54.9	-50.8	4.1
18 MHz channel							
485 (Low)	BPSK	470.0–475.9	-62.7	-60	-58.1	-50.8	7.3
485 (Low)	256QAM	470.0–475.9	-62.7	-59.9	-58.1	-50.8	7.3
485 (Low)	BPSK	494.1–500.0	-62.2	-61.2	-58.7	-50.8	7.9
485 (Low)	256QAM	494.1–500.0	-62.2	-61.3	-58.7	-50.8	7.9
587 (Mid)	BPSK	572.0–577.9	-58.8	-59	-55.9	-50.8	5.1
587 (Mid)	256QAM	572.0–577.9	-58.8	-58.9	-55.8	-50.8	5.0
587 (Mid)	BPSK	596.1–602.0	-56.1	-58.1	-54.0	-50.8	3.2
587 (Mid)	256QAM	596.1–602.0	-56.1	-58.2	-54.0	-50.8	3.2
683 (High)	BPSK	668.0–673.9	-57.6	-58.8	-55.1	-50.8	4.3
683 (High)	256QAM	668.0–673.9	-57.7	-58.9	-55.2	-50.8	4.4
683 (High)	BPSK	692.1–698.0	-58.1	-59.1	-55.6	-50.8	4.8
683 (High)	256QAM	692.1–698.0	-58.2	-59.1	-55.6	-50.8	4.8
24 MHz channel							
488 (Low)	BPSK	470.0–475.9	-58.9	-58.2	-55.5	-50.8	4.7
488 (Low)	256QAM	470.0–475.9	-58.7	-58.2	-55.4	-50.8	4.6
488 (Low)	BPSK	500.1–506.0	-60.6	-59.8	-57.2	-50.8	6.4
488 (Low)	256QAM	500.1–506.0	-60.6	-59.7	-57.1	-50.8	6.3
584 (Mid)	BPSK	566.0–571.9	-56.8	-56.2	-53.5	-50.8	2.7
584 (Mid)	256QAM	566.0–571.9	-56.8	-56.1	-53.4	-50.8	2.6
584 (Mid)	BPSK	596.1–602.0	-56.3	-53.8	-51.9	-50.8	1.1
584 (Mid)	256QAM	596.1–602.0	-56.3	-53.7	-51.8	-50.8	1.0
680 (High)	BPSK	662.0–667.9	-57.5	-56.3	-53.8	-50.8	3.0
680 (High)	256QAM	662.0–667.9	-57.6	-56.1	-53.8	-50.8	3.0
680 (High)	BPSK	692.1–698.0	-59.4	-57.5	-55.3	-50.8	4.5
680 (High)	256QAM	692.1–698.0	-59.4	-57.5	-55.3	-50.8	4.5

Notes: [1] Total Adj. channel =10*LOG((10^(Adj. channel Ant 1/10))+(10^(Adj. channel Ant 2/10)))

8.7.4 Test data, continued

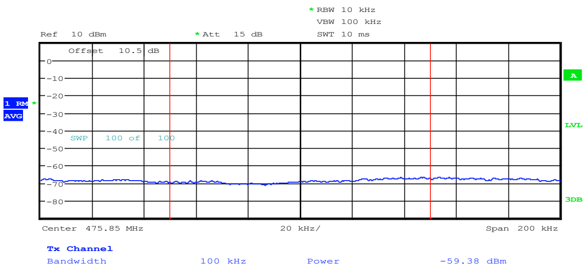


Figure 8.7-1: *Adjacent Low channel for 12 MHz channel, sample plot*

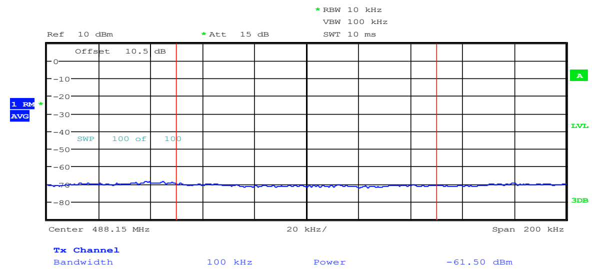


Figure 8.7-2: *Adjacent High channel for 12 MHz channel, sample plot*

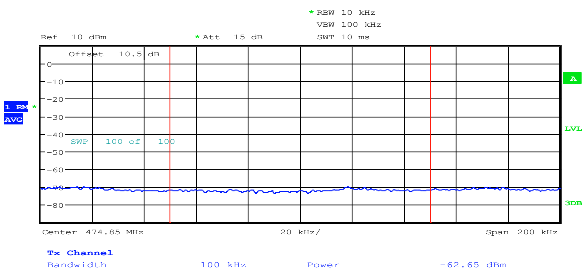


Figure 8.7-3: *Adjacent Low channel for 18 MHz channel, sample plot*

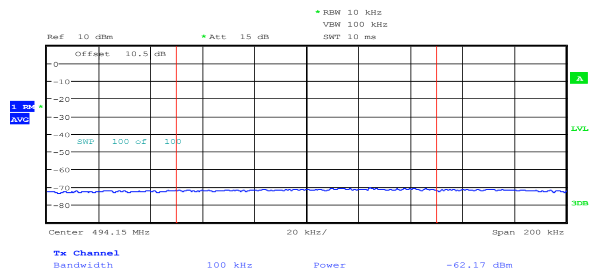


Figure 8.7-4: *Adjacent High channel for 18 MHz channel, sample plot*

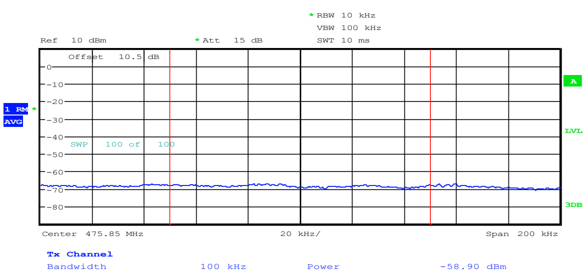


Figure 8.7-5: *Adjacent Low channel for 24 MHz channel, sample plot*

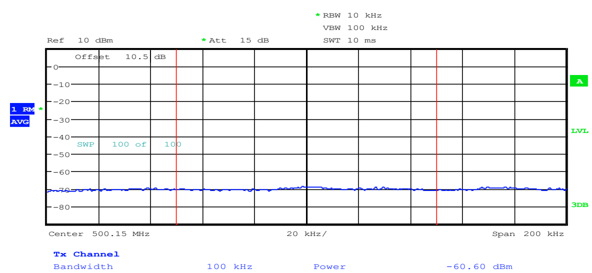


Figure 8.7-6: *Adjacent High channel for 24 MHz channel, sample plot*

8.8 FCC 15.709(d)(2) Radiated emissions beyond adjacent channel

8.8.1 Definitions and limits

(d)(2) At frequencies beyond the six-megahertz channel immediately adjacent to each white space channel or group of contiguous white space channels in which the white space device is operating the white space device shall meet the requirements of §15.209.

Table 8.8-1: *FCC §15.209 – Radiated emission limits*

Frequency, MHz	Field strength of emissions µV/m	Field strength of emissions 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

8.8.2 Test date

Start date	March 22, 2019

8.8.3 Observations, settings and special notes

- The spectrum was searched from 30 MHz to the 10th harmonic. EUT was set to transmit with 100 % duty cycle.
- Radiated measurements were performed at a distance of 3 m, the EUT was transmitting on both MIMO chains simultaneously.

Spectrum analyser settings for radiated measurements:

Resolution bandwidth:	Frequencies below 1 GHz: 100 kHz, Frequencies above 1 GHz: 1 MHz
Video bandwidth:	Frequencies below 1 GHz: 300 kHz, Frequencies above 1 GHz: 3 MHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for average radiated measurements above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	10 Hz
Detector mode:	Peak
Trace mode:	Max Hold

8.8.4 Test data

Table 8.8-2: *Radiated field strength measurement results*

TX Freq., MHz	Frequency, MHz	Peak Field strength[1], dBµV/m		Peak margin, dB	Average Field strength, dBµV/m		Average margin, dB
		Measured	Limit		Measured	Limit	
With Flat Antenna							
12 MHz channel							
584 (Mid)	1168	44.5	74.0	29.5	N/A[2]	54.0	9.5
24 MHz channel							
584 (Mid)	1168	44.2	74.0	29.8	N/A[2]	54.0	9.8
With Log-P antenna							
12 MHz channel							
476 (Low)	1428	47.3	74.0	26.7	N/A[2]	54.0	6.7
584 (Mid)	1752	47.1	74.0	26.9	N/A[2]	54.0	6.9
692 (High)	2076	45.5	74.0	28.5	N/A[2]	54.0	8.5
18 MHz channel							
479 (Low)	1437	44.2	74.0	29.8	N/A[2]	54.0	9.8
587 (Mid)	1761	45.5	74.0	28.5	N/A[2]	54.0	8.5
689 (High)	2067	45.7	74.0	28.3	N/A[2]	54.0	8.3
24 MHz channel							
584 (Mid)	1752	44.1	74.0	29.9	N/A[2]	54.0	9.9
686 (High)	2058	44.9	74.0	29.1	N/A[2]	54.0	9.1

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)

– Correction factor = antenna factor ACF (dB) + cable loss (dB) − amplifier gain (dB)

[2] The peak level met the average limit. No need for average measurement. See Average margin with measured peak value.

All other emissions were greater than 10 dB from the limit.

8.8.4 Test data, continued

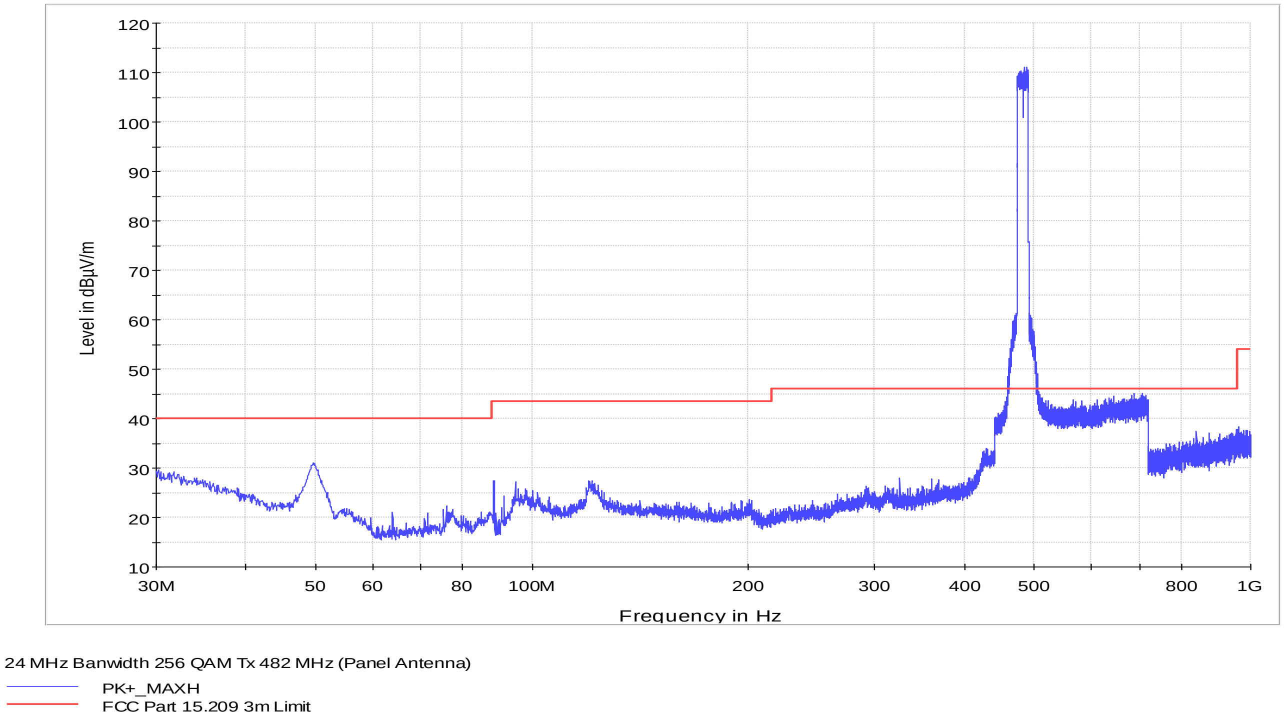


Figure 8.8-1: *Radiated spurious emissions below 1 GHz with Flat antenna, sample plot*

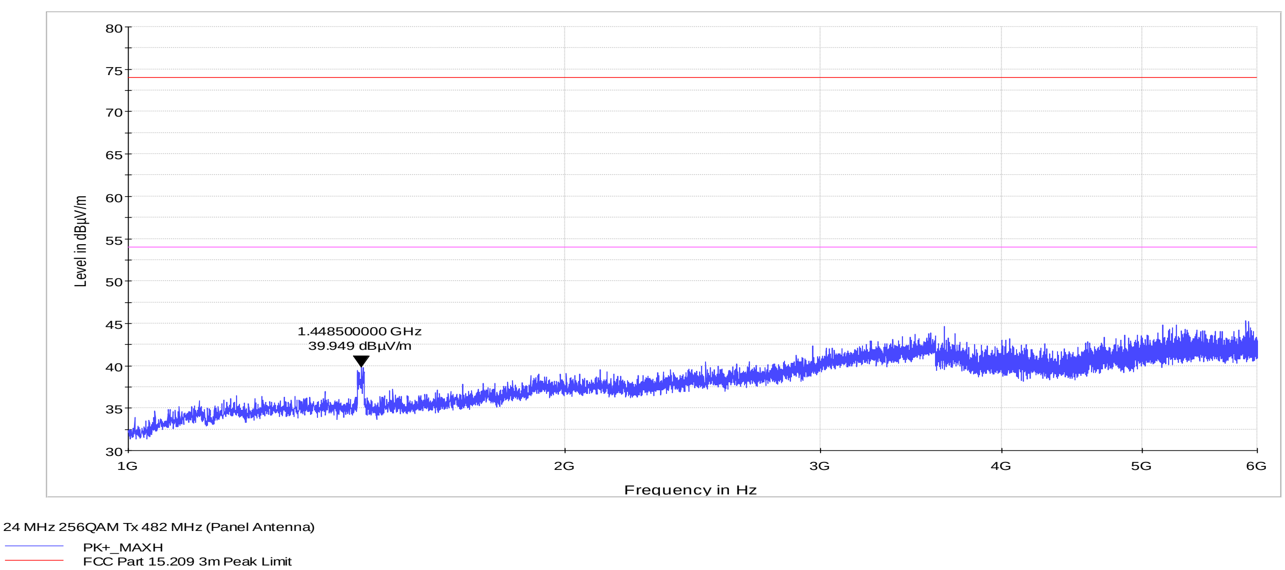
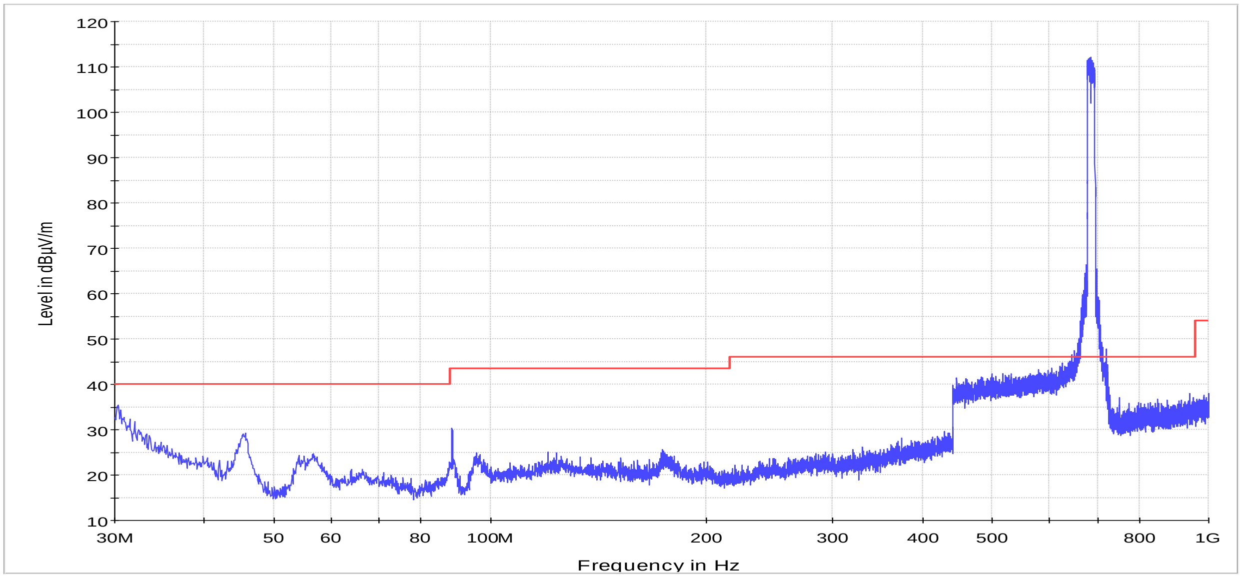


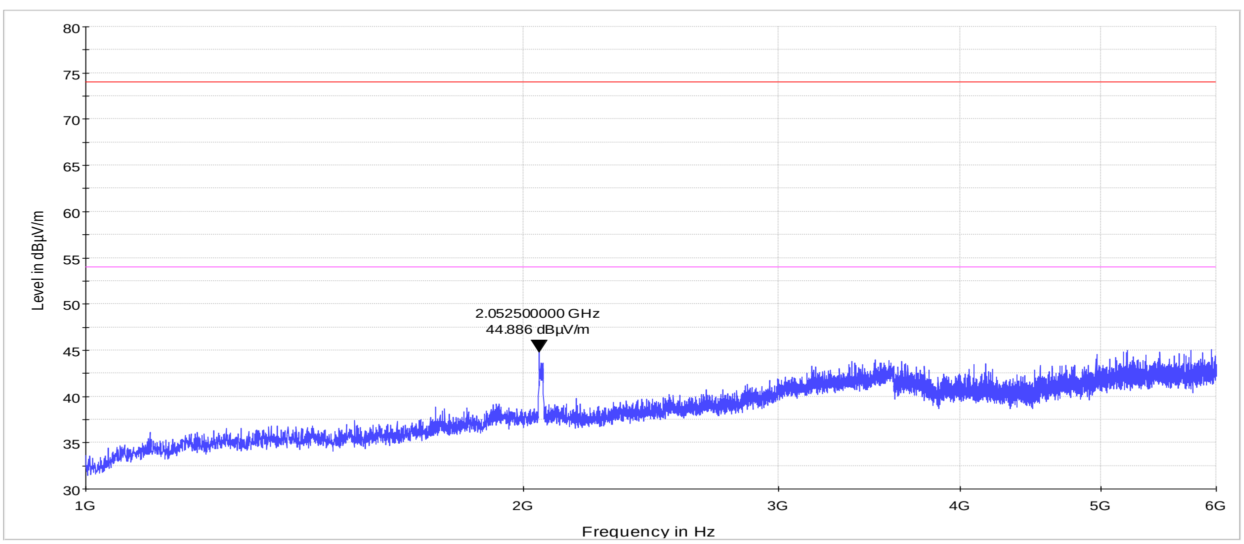
Figure 8.8-2: *Radiated spurious emissions within above 1 GHz with Flat antenna, sample plot*

8.8.4 Test data, continued



24 MHz Banwidth 256 QAM Tx og Antenna)
PK+_MAXH
FCC Part 15.209 3m Limit

Figure 8.8-3: *Radiated spurious emissions below 1 GHz with Log-P antenna, sample plot*



24 MHz 256QAM Tx 686 MI na)
PK+_MAXH
FCC Part 15.209 3m Peak Limit
FCC Part 15.209 3m Average Limit

Figure 8.8-4: *Radiated spurious emissions above 1 GHz with Log-P antenna, sample plot*

8.8.5 Setup photos

Figure 8.8-5: *Radiated spurious emissions below 1 GHz with Flat antenna setup photo*

Figure 8.8-6: *Radiated spurious emissions below 1 GHz with Flat antenna setup photo*

8.8.5 Setup photos, continued

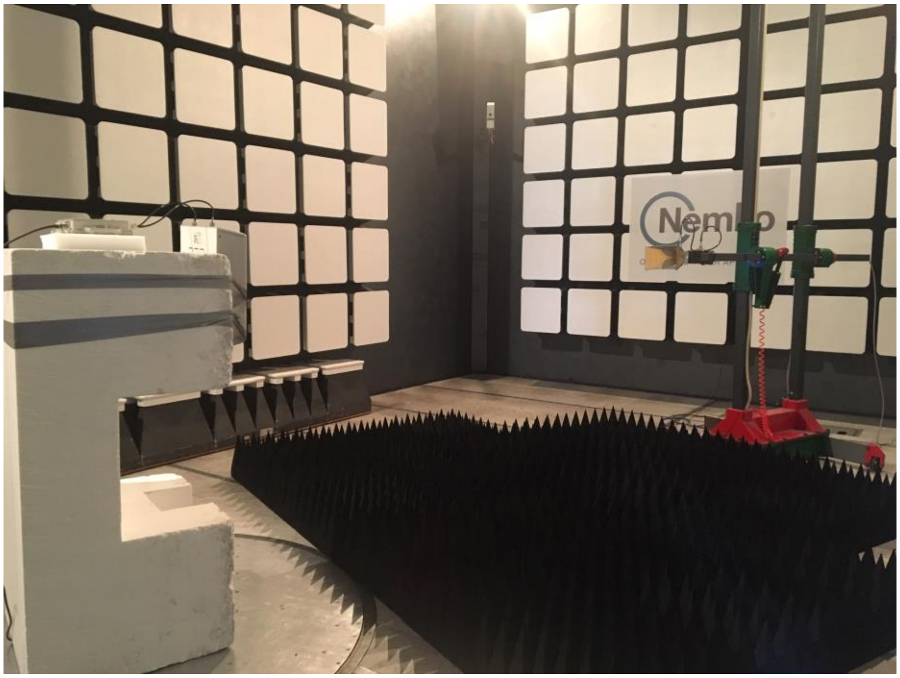


Figure 8.8-7: *Radiated spurious emissions above 1 GHz with Flat antenna setup photo*

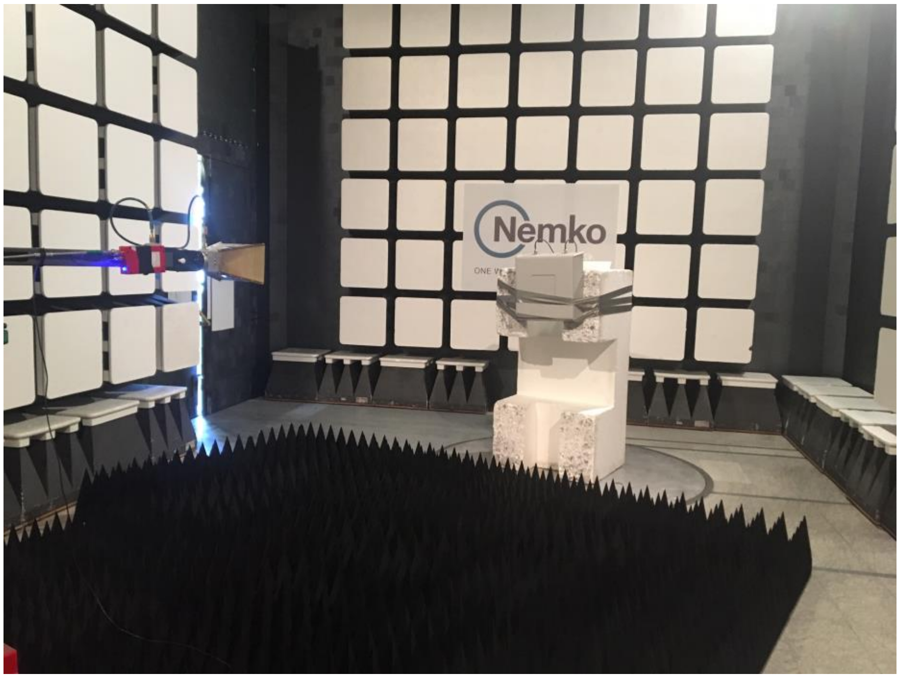


Figure 8.8-8: *Radiated spurious emissions above 1 GHz with Flat antenna setup photo*

8.8.5 Setup photos, continued

Figure 8.8-9: *Radiated spurious emissions below 1 GHz with Log-P antenna setup photo*

Figure 8.8-10: *Radiated spurious emissions below 1 GHz with Log-P antenna setup photo*

8.8.5 Setup photos, continued

Figure 8.8-11: *Radiated spurious emissions above 1 GHz with Log-P antenna setup photo*

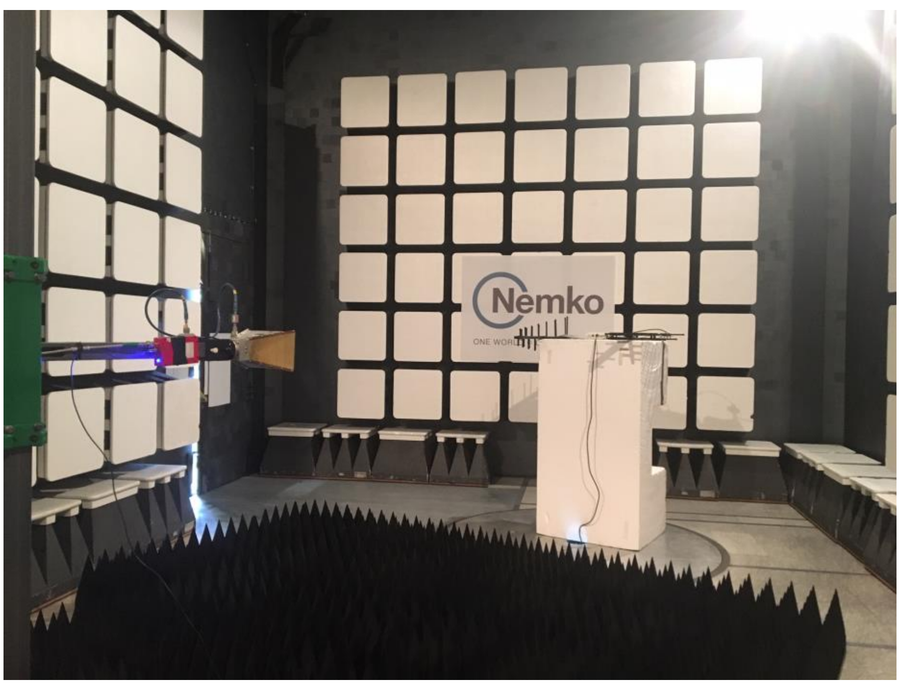
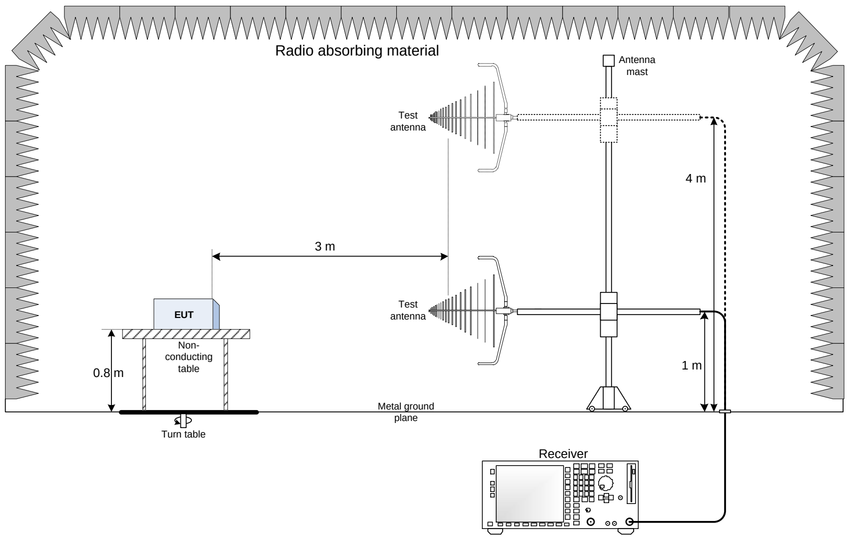


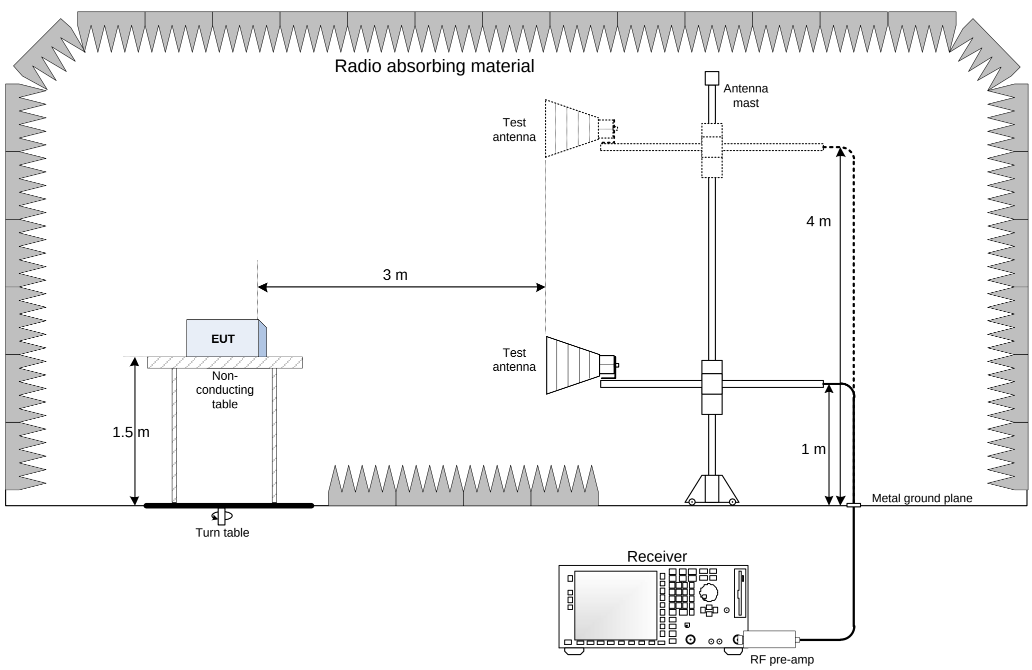
Figure 8.8-12: *Radiated spurious emissions above 1 GHz with Log-P antenna setup photo*

Section 9. Block diagrams of test set-ups

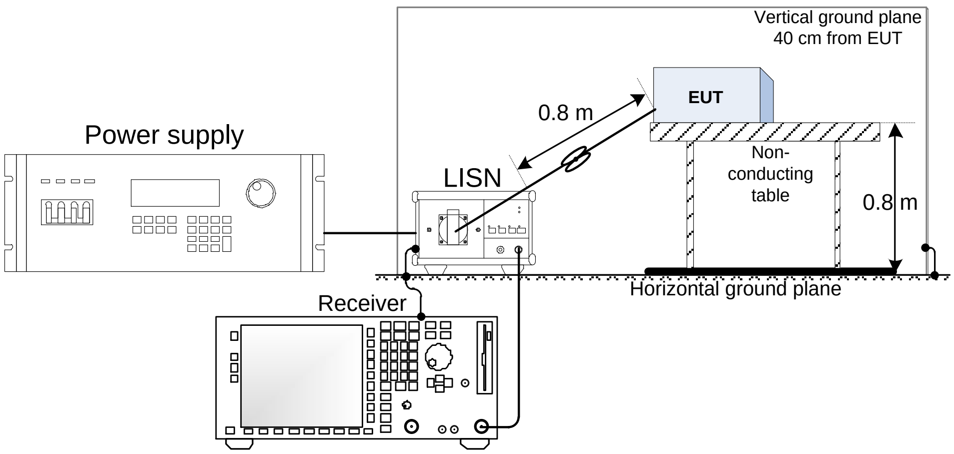
9.1 Radiated emissions set-up for frequencies below 1 GHz



9.2 Radiated emissions set-up for frequencies above 1 GHz



9.3 Conducted emissions set-up



9.4 Antenna port set-up