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Wireless test report – 362809-1TRFWL

Applicant:

Pangaea Services Inc

Product name:

Defender 24/7

Model:

Model 1A

FCC ID:

2AUBV-1

Specifications:

- FCC 47 CFR Part 15 Subpart C, §15.247

  Operation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz

Date of issue: October 3, 2019

Avul Nzenza, Wireless/EMC Specialist	
Test engineer(s)	Signature
Andrey Adelberg, Senior Wireless/EMC Specialist	Andrey Adelberg
Reviewed by	Signature

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

Test location(s)

Company name	Nemko Canada Inc.
Address	292 Labrosse Avenue
City	Pointe-Claire
Province	Quebec
Postal code	H9R 5L8
Country	Canada
Telephone	+1 514 694 2684
Facsimile	+1 514 694 3528
Website	www.nemko.com
Site number	FCC: CA2041; IC: 2040G-5 (3 m SAC)

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.

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Section 1. Report summary

1.1 Applicant and manufacturer

Company name	Pangaea Services Inc
Address	PO Box 2505 Sequim, WA 98382

1.2 Test specifications

FCC 47 CFR Part 15, Subpart C, Clause 15.247	Operation in the 902–928 MHz, 2400–2483.5 MHz, and 5725-5850 MHz.

1.3 Test methods

558074 D01 DTS Meas Guidance v05 (August 24, 2018)	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was completed against all relevant requirements of the test standard. 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 #	Details of changes made to test report
TRF	Original report issued

Section 2. Summary of test results

2.1 FCC Part 15 Subpart C, general requirements test results

Table 2.1-1: FCC general requirements results

Part	Test description	Verdict
§15.207(a)	Conducted limits	Pass
§15.31(e)	Variation of power source	Pass[1]
§15.203	Antenna requirement	Pass[2]

Notes: [1] For battery operated equipment, the equipment tests were performed using a DC power supply in place of the battery.

[2] The Antennas are located within the enclosure of EUT and not user accessible.

2.2 FCC Part 15 Subpart C, intentional radiators test results for digital transmission systems (DTS)

Table 2.2-1: FCC 15.247 results for DTS

Part	Test description	Verdict
§15.247(a)(2)	Minimum 6 dB bandwidth	Pass
§15.247(b)(3)	Maximum peak output power in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands	Pass
§15.247(c)(1)	Fixed point-to-point operation with directional antenna gains greater than 6 dBi	Not applicable
§15.247(c)(2)	Transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams	Not applicable
§15.247(d)	Spurious emissions	Pass
§15.247(e)	Power spectral density	Pass
§15.247(f)	Time of occupancy for hybrid systems	Not applicable

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	Nov. 01, 2018
Nemko sample ID number	#1

3.2 EUT information

Product name	Defender 24/7
Model	Model A1
Serial number	None

3.3 Technical information

Frequency band	2400–2483.5 MHz
Frequency Min (MHz)	2402
Frequency Max (MHz)	2480
RF power (W), Conducted	0.004 (−3.95 dBm)
Field strength, Units @ distance	N/A
Measured BW (MHz) (99%)	1.076
Calculated BW (kHz), as per TRC-43	N/A
Type of modulation	FSK
Emission classification (F1D, G1D, D1D)	1M07F1D
Transmitter spurious, Units @ distance	61.94 dBµV/m Peak and 48.5 dBµV/m Average @ 3 m @ 2483.5 MHz
Power requirements	3.7 V_{DC} (Battery)
Antenna information	Internal PCB antenna The EUT uses a unique antenna coupling/ non-detachable antenna to the intentional radiator. The Antenna Gain is 1.6 dBi

3.4 Product description and theory of operation

Defender 24/7 utilizes users smartphone as a communication hub. Uses a camera for ID, a siren and oscillator to draw attention, GPS and a companion app to provide location and user data, as well as pepper spray for self-defense.

LED flashing every second was used to make sure the device is fully operational

3.5 EUT exercise details

The firmware was set to activate the unit with a continuous transmissions signal.

3.6 EUT setup diagram

Figure 3.6-1: *Setup diagram*

3.7 EUT sub assemblies

Table 3.7-1: *EUT sub assemblies*

Description	Brand name	Model/Part number	Serial number
Defender 24/7	Pangaea Services Inc	MN: A1	Defender 24/7

Section 4. Engineering considerations

4.1 Modifications incorporated in the EUT

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	860–1060 mbar

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

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

6.2 Uncertainty of measurement

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

Test name	Measurement uncertainty, dB
All antenna port measurements	0.55
Conducted spurious emissions	1.13
Radiated spurious emissions	3.78

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	FA002532	2 year	June 5/19
Flush mount turntable	Sunol	FM2022	FA002550	—	NCR
Controller	Sunol	SC104V	FA002551	—	NCR
Antenna mast	Sunol	TLT2	FA002552	—	NCR
LISN	Rohde & Schwarz	ENV216	FA002514	1 year	Jan. 23/20
3 Phase AC Power Source	apc AC Power	45 kVA	FA002677	—	VOU
Power Meter	HIOKI	PW3337	FA002727	1 year	Aug. 8/19
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 40	FA002071	1 year	Nov. 18/18
Bilog antenna (20–2000 MHz)	Sunol	JB1	FA002517	1 year	Dec. 6/18
Horn antenna (1–18 GHz)	EMCO	3115	FA001451	1 year	April 27/19
Horn antenna (18–40 GHz)	EMCO	3116	FA002487	2 year	Sept. 11/19
Pre-amplifier (18–40 GHz)	COM-POWER	PAM-840	FA002508	1 year	Dec 8/18
Pre-amplifier (0.5–18 GHz)	COM-POWER	PAM-118A	FA002561	1 year	Sept. 19/19
2400-2483 MHz Notch Filter	Microwave Circuits	N0324413	FA002693	—	VOU

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

Table 7.1-2: test software

Test description	Manufacturer of Software	Details
Radiated emissions	Rohde & Schwarz	EMC32, Software for EMC Measurements, Version 9.26.01

Notes: None

7.1.1 Testing data

7.2 FCC 15.207(a) AC power line conducted emissions limits

7.2.1 Definitions and limits

FCC:
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.

Table 7.2-1: *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

Note: * - The level decreases linearly with the logarithm of the frequency.
** - A linear average detector is required.

7.2.2 Test date

Start date	November 5, 2018

7.2.3 Observations, settings and special notes

The EUT was set up as tabletop configuration.

The spectral scan has been corrected with transducer factors (i.e. cable loss, LISN factors, and attenuators) for determination of compliance.

A preview measurement was generated with the receiver in continuous scan mode. Emissions detected within 6 dB or above limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement.

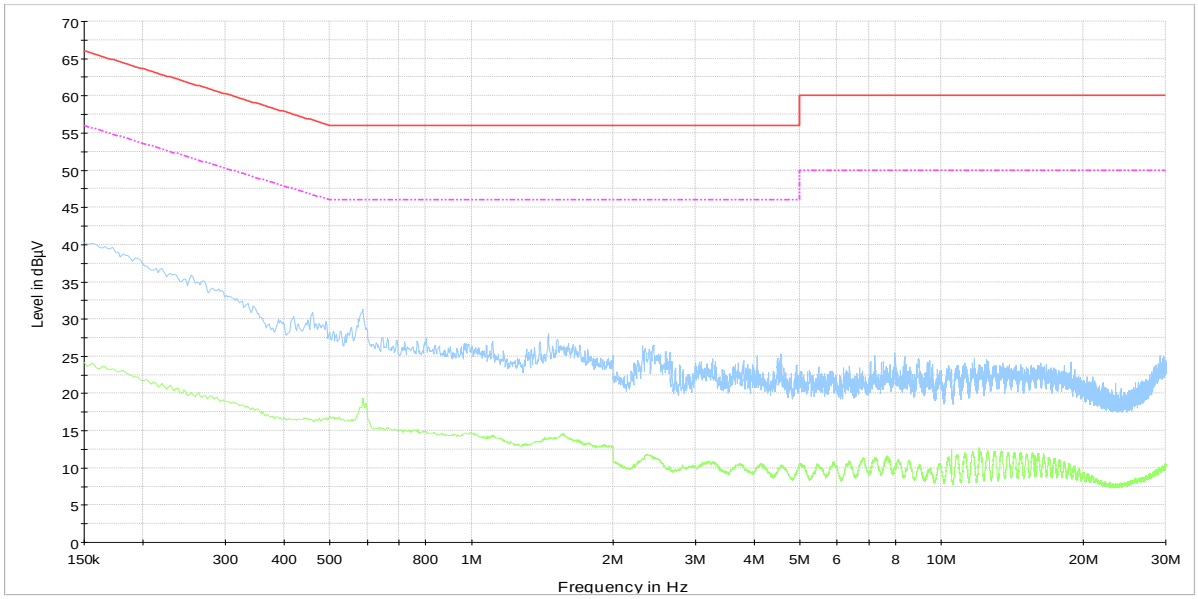
Receiver settings for preview measurements:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Peak and Average
Trace mode	Max Hold
Measurement time	1000 ms

Receiver settings for final measurements:

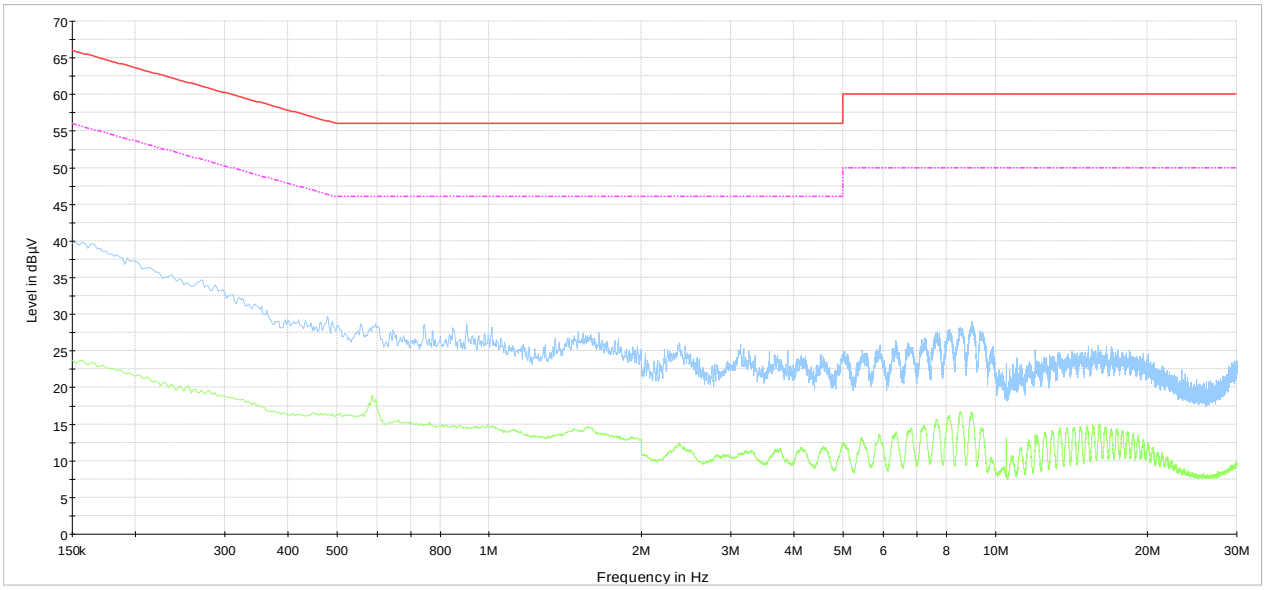
Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Quasi-Peak and Average
Trace mode	Max Hold
Measurement time	1000 ms

7.2.4 Test data



Conducted Emissions_Phase

Plot 7.2-1: *Conducted emissions on phase line*



Conducted Emissions_Neutral

Plot 7.2-2: *Conducted emissions on neutral line*

7.3 FCC 15.247(a)(2) Minimum 6 dB bandwidth for DTS systems

7.3.1 Definitions and limits

FCC:
Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

7.3.2 Test date

Start date	November 5, 2018

7.3.3 Observations, settings and special notes

Spectrum analyser settings:

Resolution bandwidth	100 kHz
Video bandwidth	≥3 × RBW
Frequency span	2 MHz
Detector mode	Peak
Trace mode	Max Hold

7.3.4 Test data

Table 7.3-1: 6 dB bandwidth results

Frequency, MHz	6 dB bandwidth, kHz	Minimum limit, kHz	Margin, kHz
2402	769.23	500.0	269.23
2440	717.94	500.0	217.94
2480	717.94	500.0	217.94

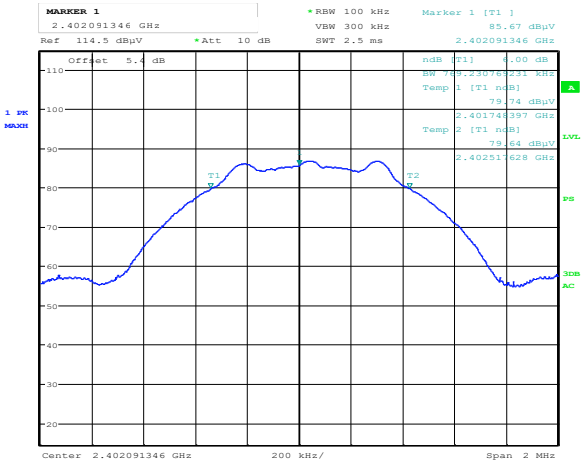


Figure 7.3-1: *6 dB bandwidth on low channel*

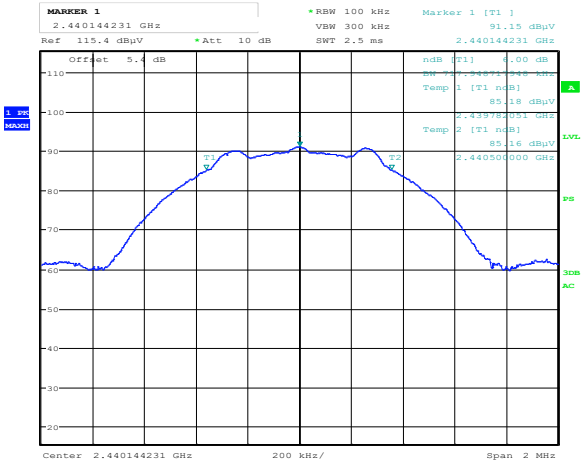


Figure 7.3-2: *6 dB bandwidth on mid channel*

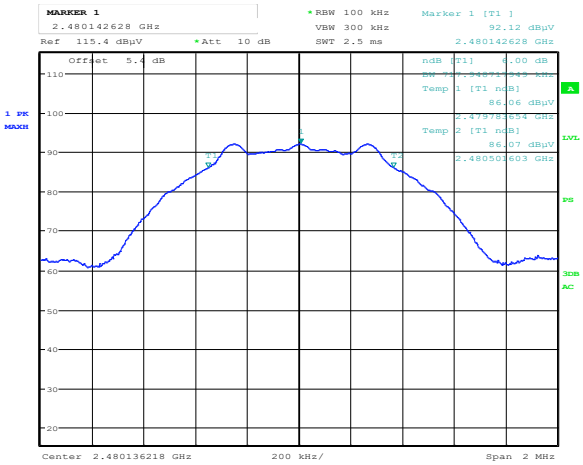


Figure 7.3-3: *6 dB bandwidth on high channel*

7.3.4 Test data, continued

Table 7.3-2: 99% bandwidth results

Frequency, MHz	99% bandwidth, kHz
2402	1057
2440	1076
2480	1070

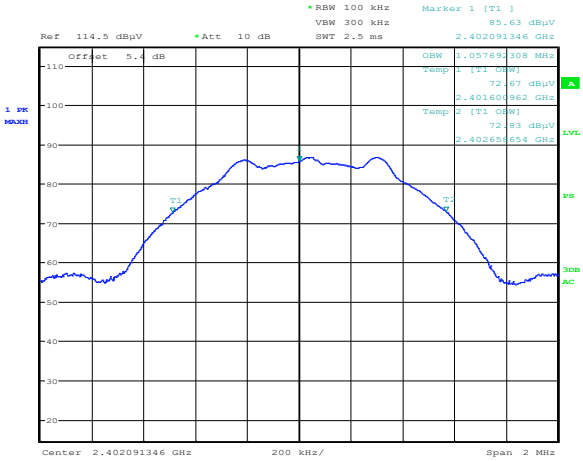


***Figure 7.3-4**: 99% bandwidth on low channel*

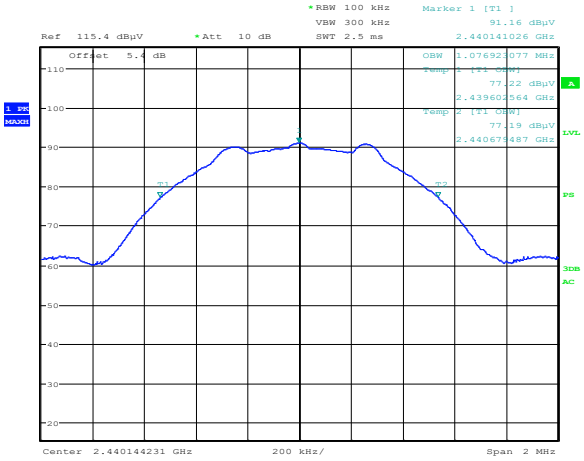


***Figure 7.3-5:** 99% bandwidth on mid channel*

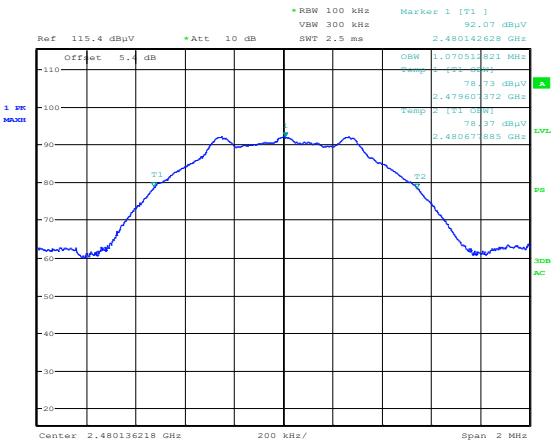


***Figure 7.3-6:** 99% bandwidth on high channel*

7.4 FCC 15.247(b) Transmitter output power and e.i.r.p. requirements for DTS in 2.4 GHz

7.4.1 Definitions and limits

FCC:

(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.

7.4.2 Test date

Start date	November 5, 2018

7.4.3 Observations, settings and special notes

The test was performed according to DTS guidelines section 9.1: Maximum peak conducted output power

7.4.4 Test data

Table 7.4-1: Output power measurements results

Frequency, MHz	Radiated field strength, dBµV/m	dBµV/m to dBm factor, dB	EIRP, dBm	Antenna Gain, dBi	Output Power, dBm	Output Power Limit, dBm	Output Power margin, dBm
2402	87.22	95.23	-8.01	1.6	-9.61	30.00	39.61
2440	91.66	95.23	-3.57	1.6	-5.17	30.00	35.17
2480	92.88	95.23	-2.35	1.6	-3.95	30.00	33.95

Table 7.4-2: EIRP measurements results

Frequency, MHz	Radiated field strength, dBµV/m	dBµV/m to dBm factor, dB	EIRP, dBm	EIRP Limit, dBm	EIRP Power margin, dBm
2402	87.22	95.23	-8.01	36	44.01
2440	91.66	95.23	-3.57	36	39.57
2480	92.88	95.23	-2.35	36	38.35

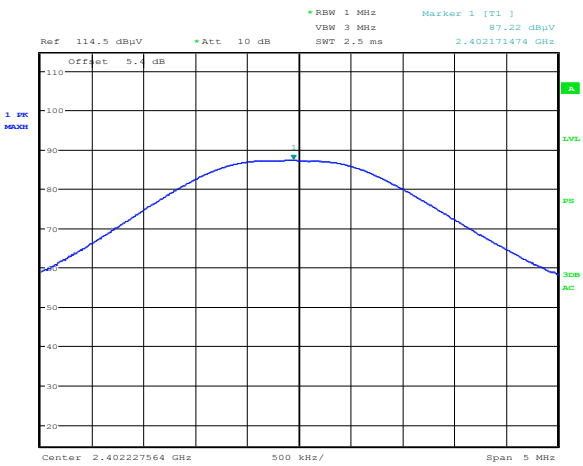


Figure 7.4-1:Field strength of fundamental on low channel

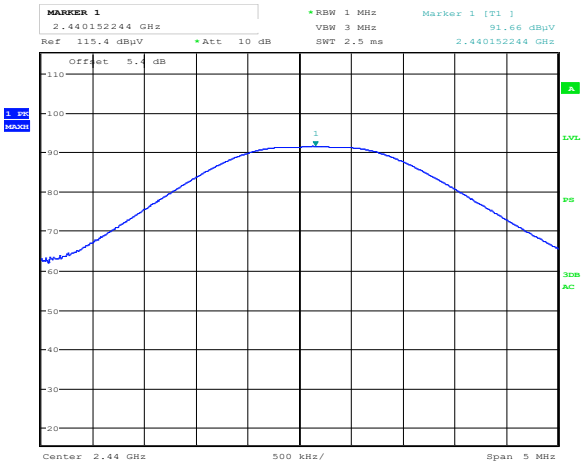


Figure 7.4-2: Field strength of fundamental on mid channel

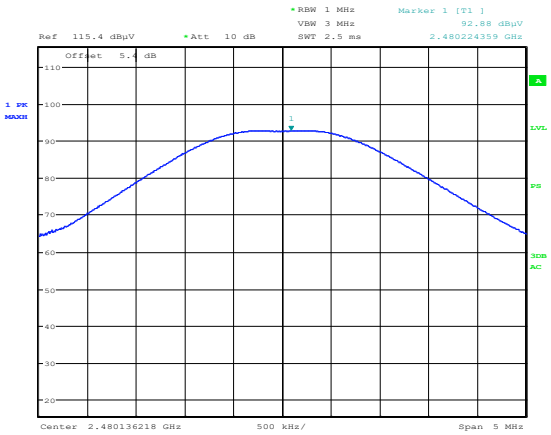


Figure 7.4-3: Field strength of fundamental on high channel

7.5 FCC 15.247(d) Spurious (out-of-band) unwanted emissions

7.5.1 Definitions and limits

FCC:
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)).

Table 7.5-1: FCC §15.209– Radiated emission limits

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

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

Table 7.5-2: *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			

7.5.2 Test date

Start date	November 5, 2018

7.5.3 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

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

7.5.4 Test data

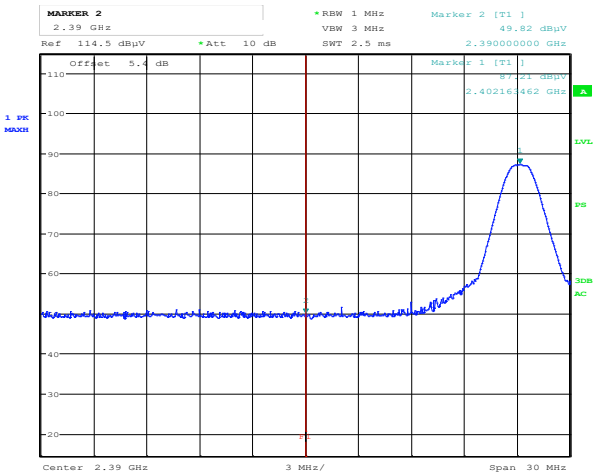


Figure 7.5-1: Lower band edge emissions

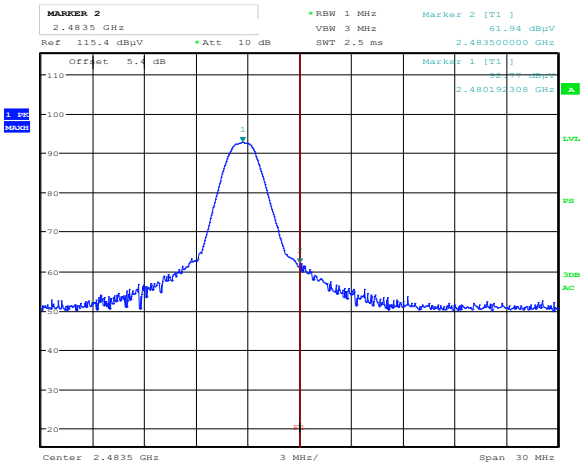


Figure 7.5-2: Upper band edge emissions

Sample of Radiated Spurious (Out-of-band) Emissions Measurements

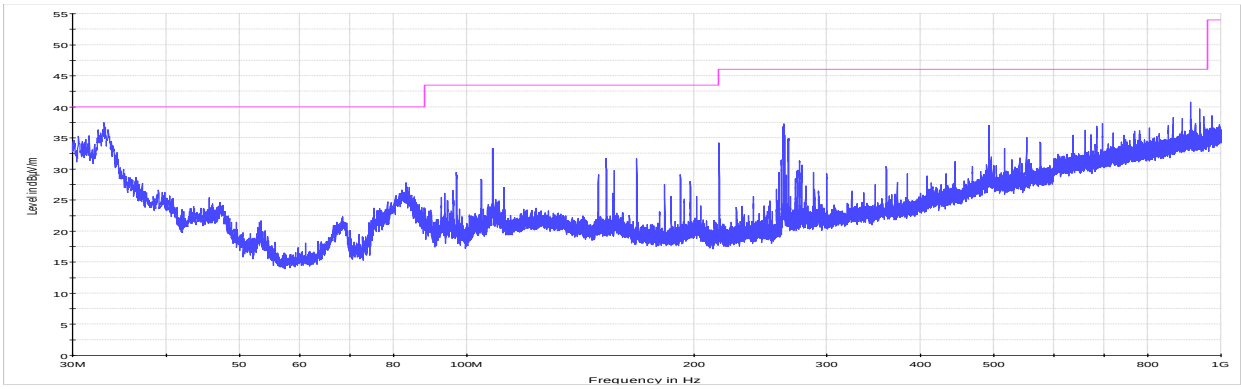


Figure 7.5-3: Radiated spurious (out-of-band) emissions, low channel, 30 to 1000 MHz

Note: Peaks below 50 MHz are digital emissions.

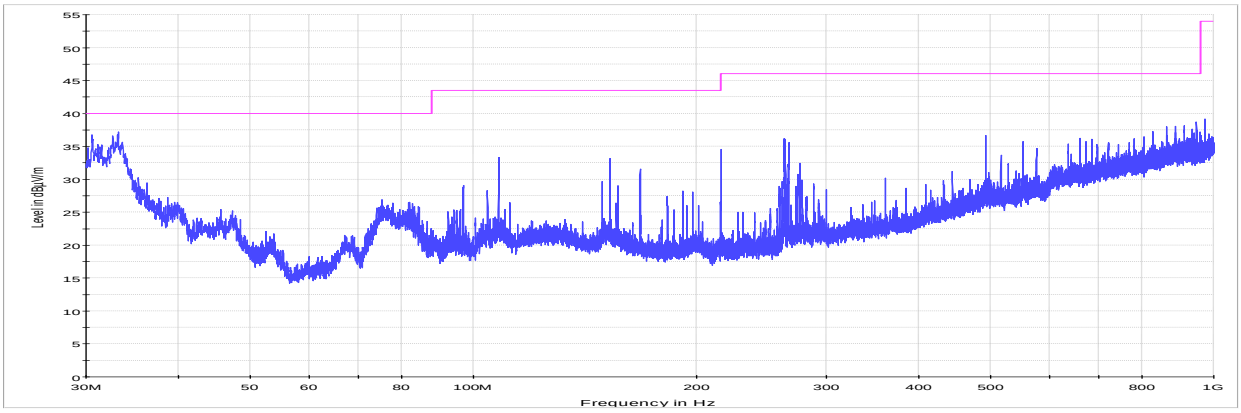


Figure 7.5-4: Radiated spurious (out-of-band) emissions, Mid channel, 30 to 1000 MHz

Note: Peaks below 50 MHz are digital emissions.

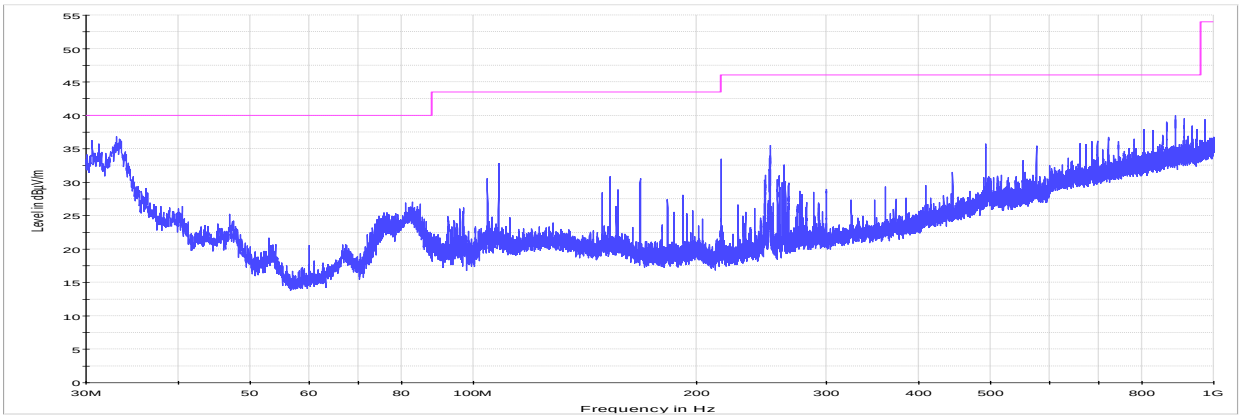


Figure 7.5-5: Radiated spurious (out-of-band) emissions, High channel, 30 to 1000 MHz

Note: Peaks below 50 MHz are digital emissions.

7.5.5 Test data, continued

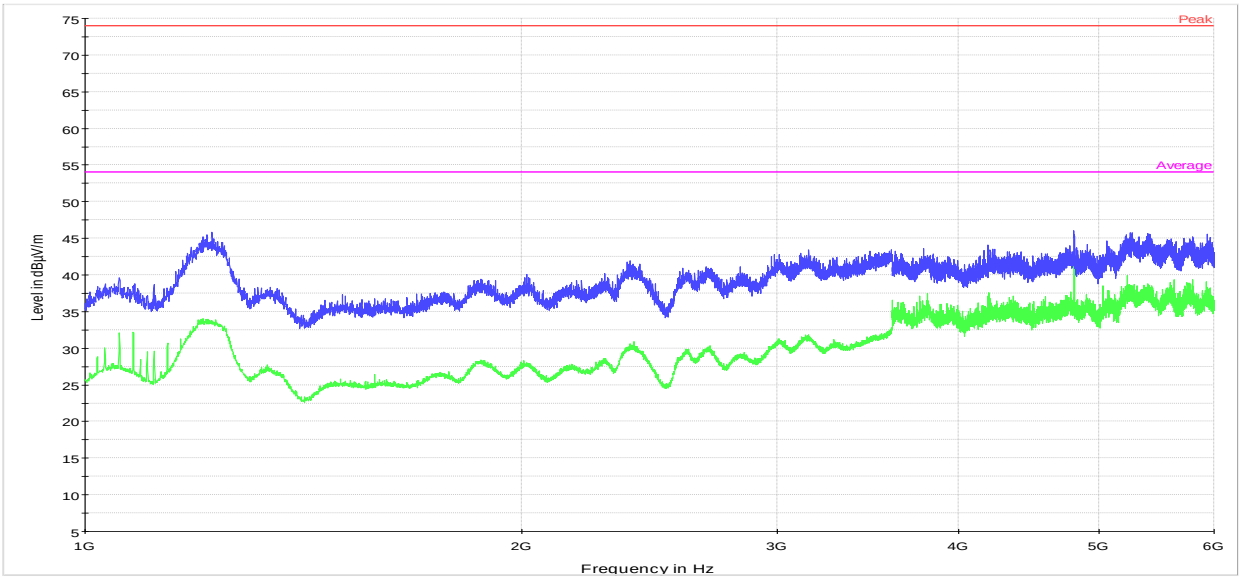


Figure 7.5-6: Radiated spurious emissions, low channel – 1 to 6 GHz

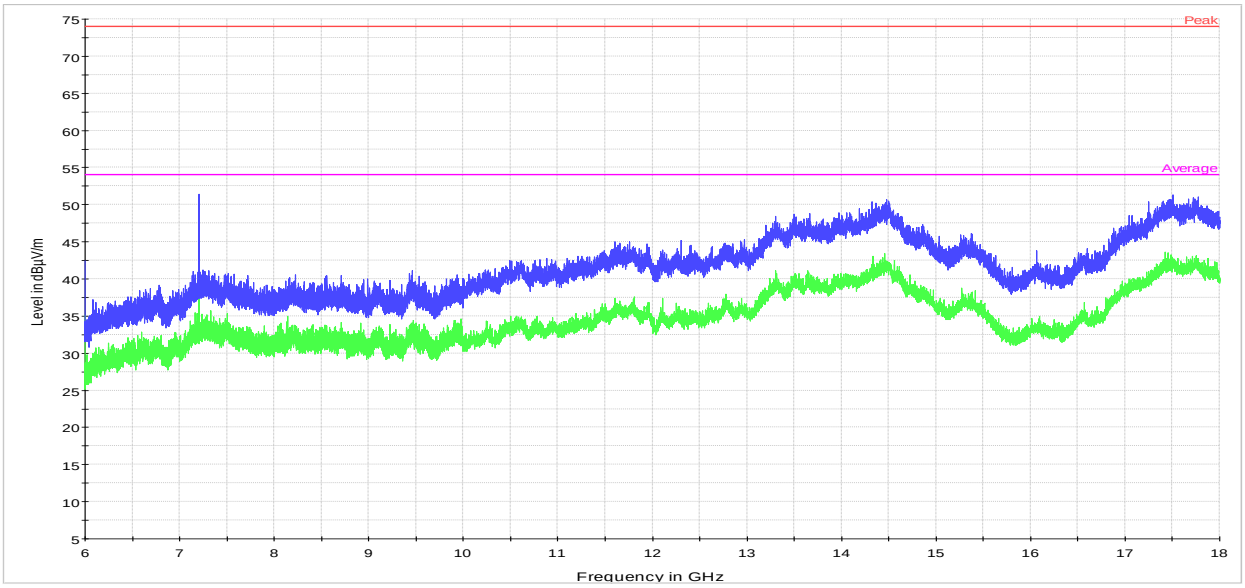


Figure 7.5-7: Radiated spurious emissions, low channel – 6 to 18 GHz

Note: Spectrum was investigated up to 25 GHz, no emission related to RF transmission was detected within 6 dB below the limit above 18 GHz

7.5.6 Test data, continued

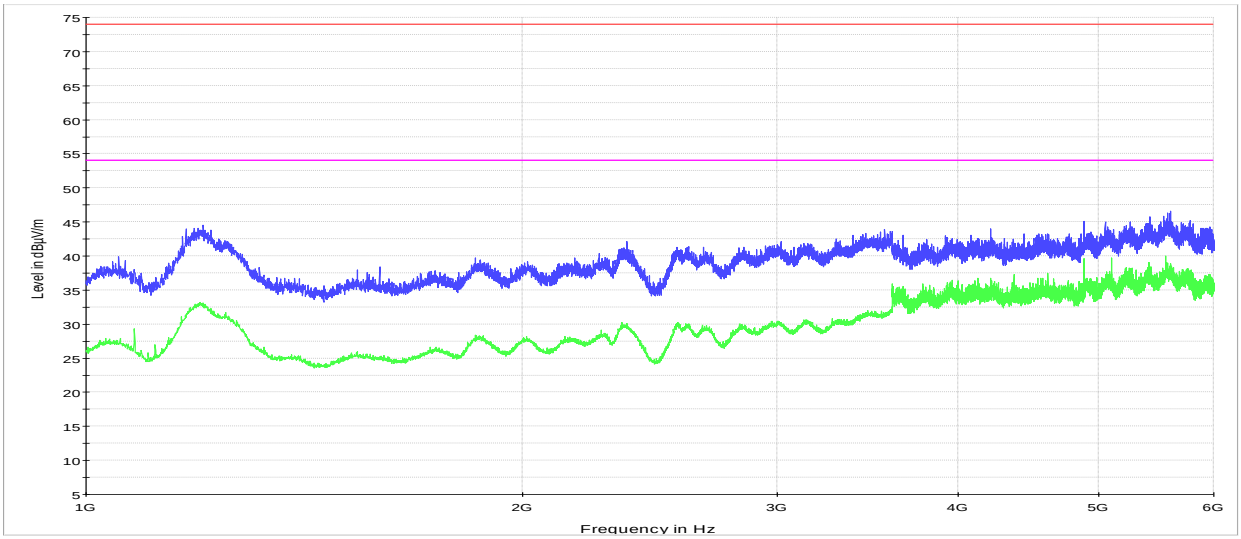


Figure 7.5-8: Radiated spurious emissions, Mid channel – 1 to 6 GHz

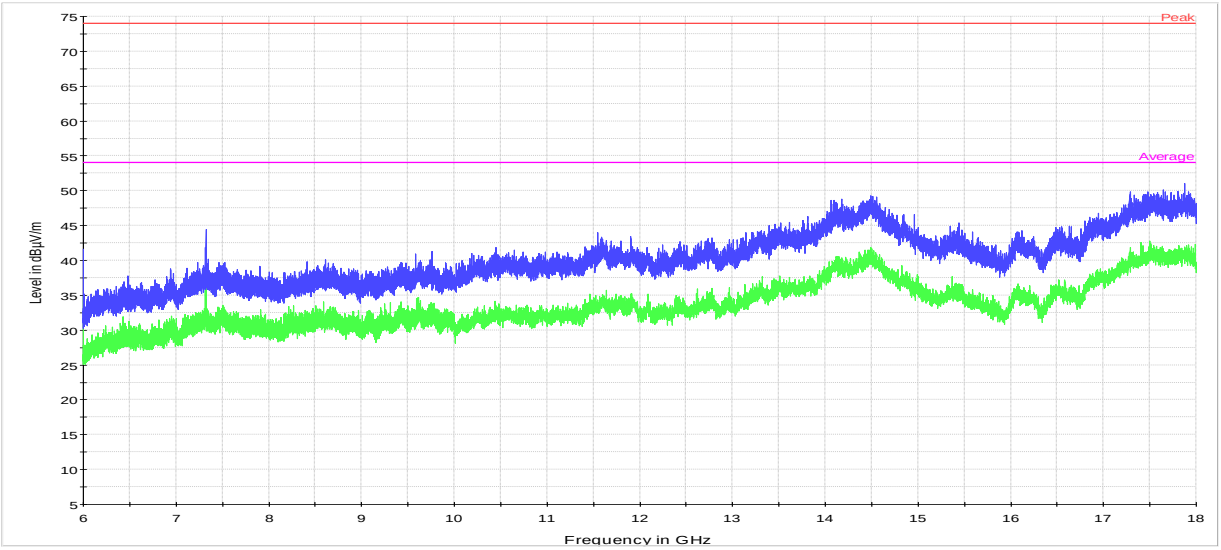


Figure 7.5-9: Radiated spurious emissions, Mid channel – 6 to 18 GHz

Note: Spectrum was investigated up to 25 GHz, no emission related to RF transmission was detected within 6 dB below the limit above 18 GHz

7.5.7 Test data, continued

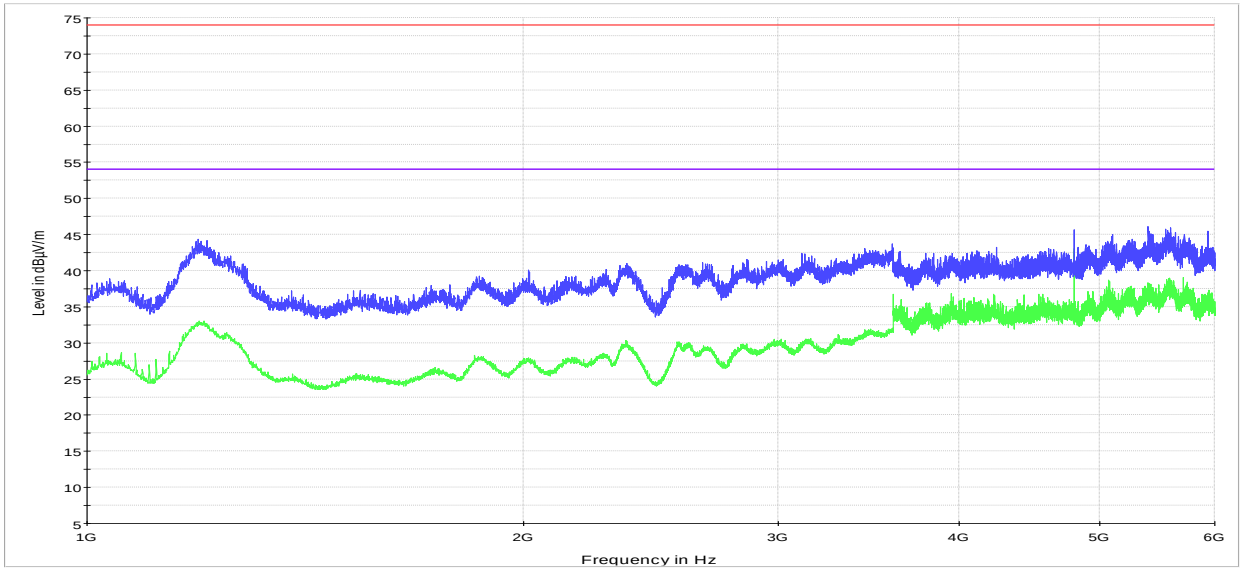


Figure 7.5-10: Radiated spurious emissions, High channel – 1 to 6 GHz

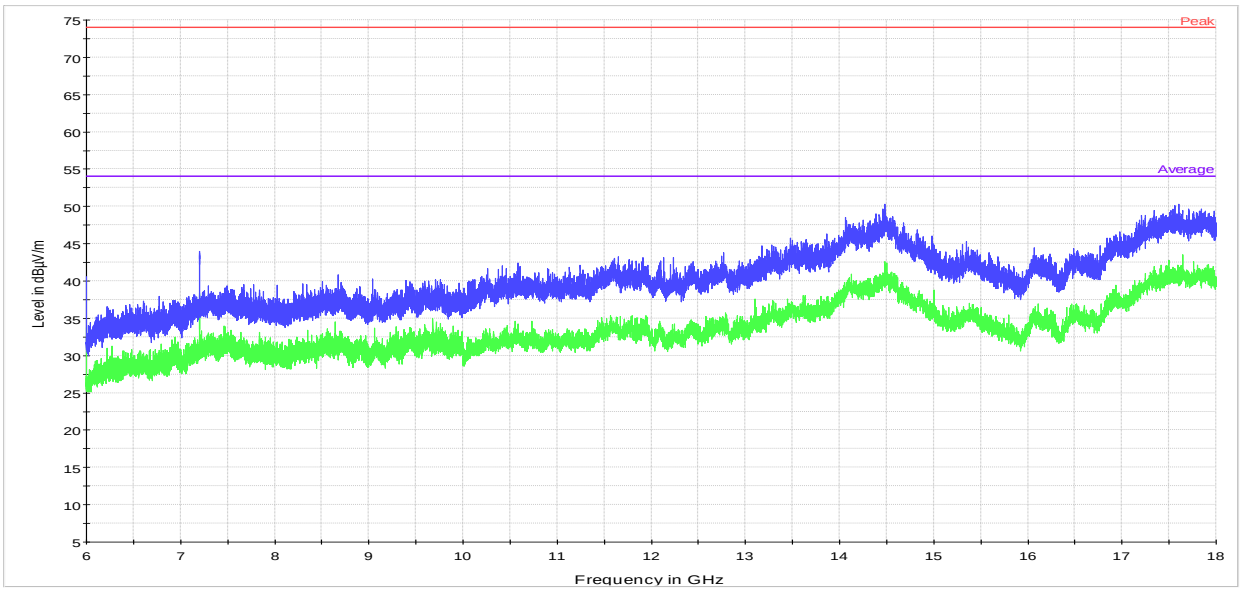


Figure 7.5-11: Radiated spurious emissions, High channel – 6 to 18 GHz

Note: Spectrum was investigated up to 25 GHz, no emission related to RF transmission was detected within 6 dB below the limit above 18 GHz

7.5.5 Test data, continued

Table 7.5-3: Radiated spurious emissions test results.

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2390.00	49.13	74.0	24.87	44.60	54.0	9.40
Low	4804.00	45.27	74.0	28.73	42.07	54.0	11.93
Low	7207.00	51.38	74.0	22.62	42.42	54.0	11.58
Mid	4880.50	45.07	74.0	28.93	39.59	54.0	14.41
Mid	7321.20	44.41	74.0	29.59	37.33	54.0	16.67
High	2483.50	61.94	74.0	12.06	48.50	54.0	5.50
High	4960.00	45.30	74.0	28.70	40.65	54.0	13.35
High	7441.20	45.53	74.0	28.47	39.71	54.0	14.29

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

7.6 FCC 15.247(e) Power spectral density for digitally modulated devices

7.6.1 Definitions and limits

FCC:
For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

7.6.1 Test date

Start date	November 5, 2018

7.6.2 Observations, settings and special notes

The test was performed using method PKPSD (peak PSD).
Spectrum analyser settings:

Resolution bandwidth:	3 kHz
Video bandwidth:	10 kHz
Frequency span:	5 MHz
Detector mode:	Peak
Trace mode:	Max Hold

7.6.3 Test data

Table 7.6-1: PSD measurements results

Frequency, MHz	PSD, dBµV/m /3 kHz	PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
2402	76.02	-20.81	8.00	28.81
2440	77.88	-18.95	8.00	26.95
2480	78.70	-18.13	8.00	26.13

Notes: PSD = Field Strength - 95.23 – Antenna gain

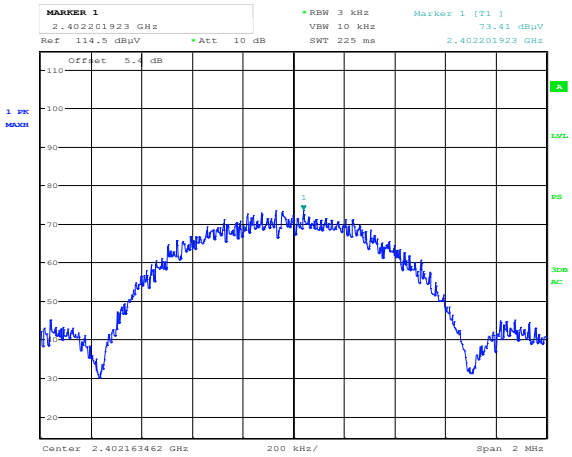


Figure 7.6-1: PSD plot on low channel

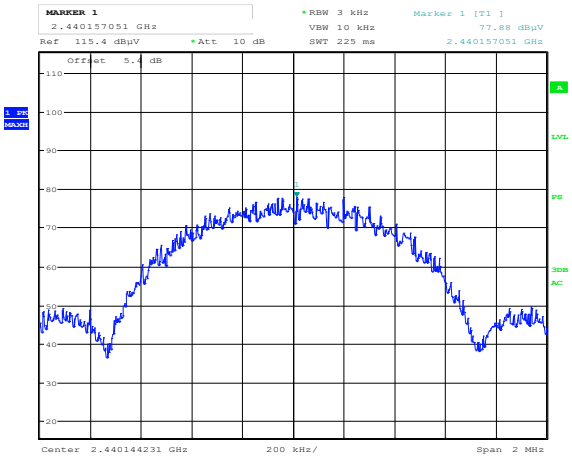


Figure 7.6-2: PSD plot on mid channel

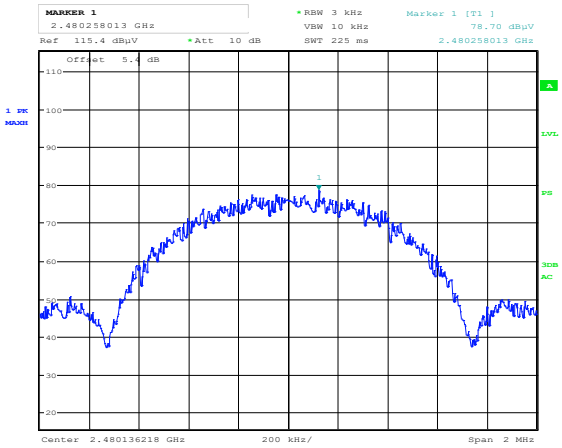
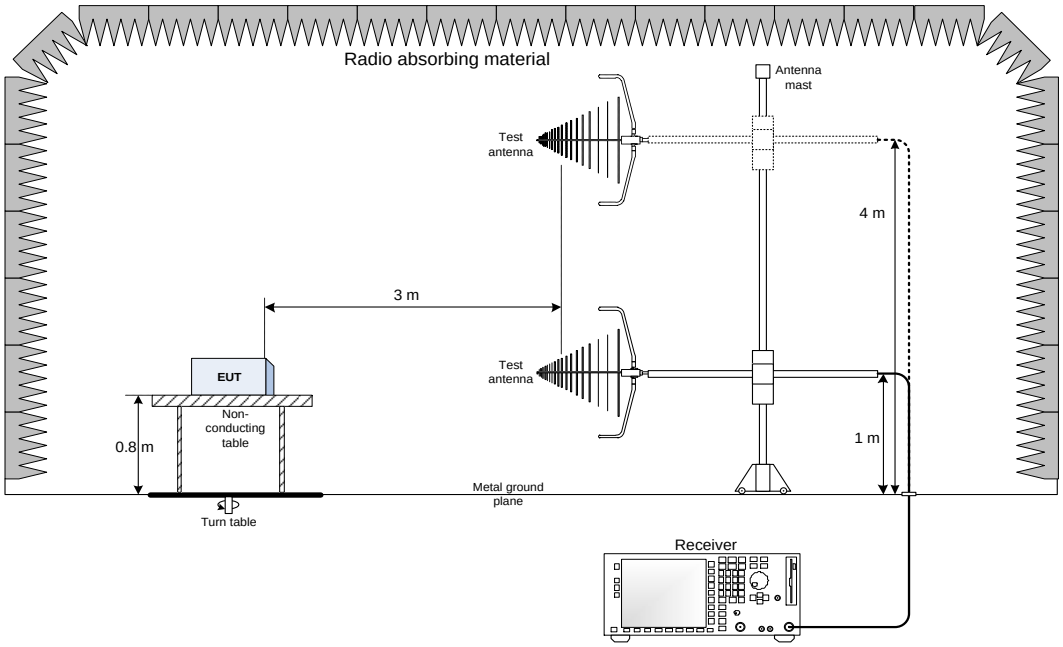


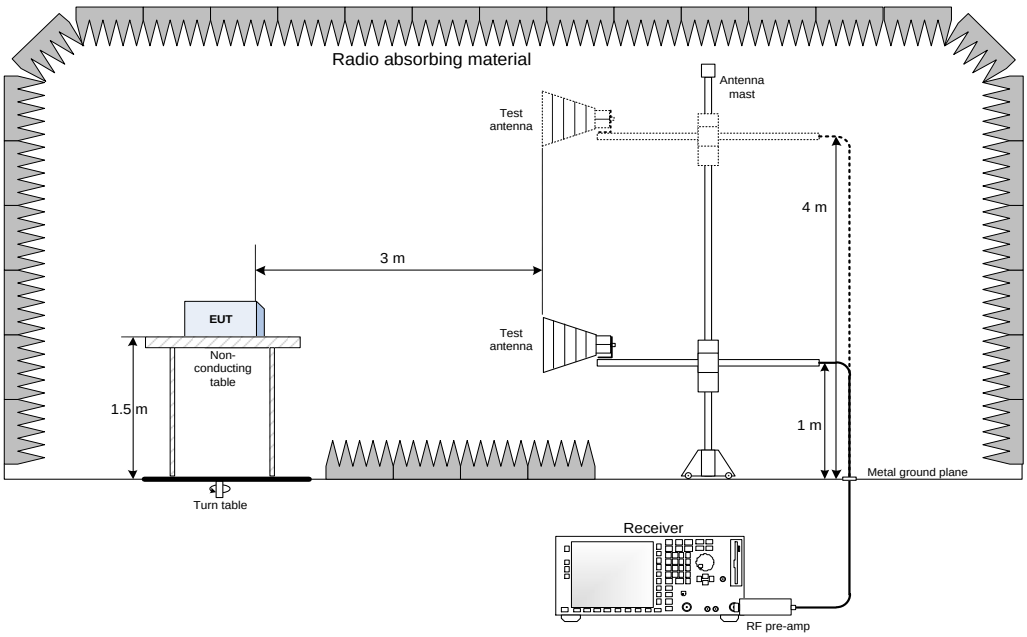
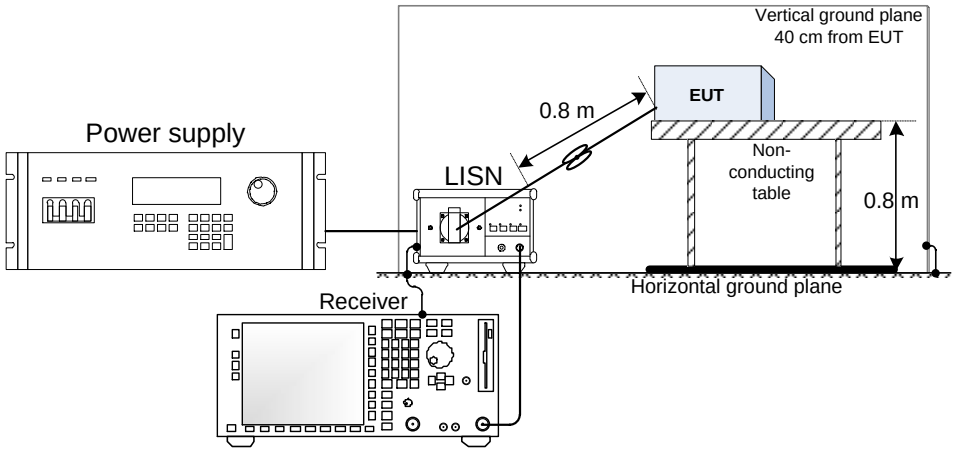
Figure 7.6-3: PSD plot on high channel

Section 8. Block diagrams of test set-ups

8.1 Radiated emissions set-up for frequencies below 1 GHz



8.2 Radiated emissions set-up for frequencies above 1 GHz



8.3 Conducted emissions set-up