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Test report

309502-1TRFWL

Date of issue: June 28, 2016

Applicant:

On Ramp Wireless

Product:

nanoNode, RPMA Wireless Module

Model:

NODE103

FCC ID:

XTE-NODE103

IC Registration number:

8655A-NODE103

Specifications:

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

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

◆ **RSS-247, Issue 1, May 2015, Section 5**

Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs)
and Licence-Exempt Local Area Network (LE-LAN) Devices

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FCC 15.247 and RSS-247.docx; Date: May 2015



Test location

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Tested by	Andrey Adelberg, Senior Wireless/EMC Specialist
Reviewed by	David Duchesne, Senior EMC/Wireless Specialist
Review date	June 28, 2016
Reviewer signature	

Limits of responsibility

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

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

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Section 1. Report summary

1.1 Applicant and manufacturer

Company name	On-Ramp Wireless
Address	10301 Meanley Drive
City	San Diego
Province/State	CA
Postal/Zip code	92131
Country	USA

1.2 Test specifications

FCC 47 CFR Part 15, Subpart C, Clause 15.247	Operation in the 902–928 MHz, 2400–2483.5 MHz
RSS-247, Issue 1, May 2015, Section 5	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

1.3 Test methods

558074 D01 DTS Meas Guidance v03r05	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

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

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 Measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, was performed with the supply voltage varied between 85 % and 115 % of the nominal rated supply voltage. No noticeable output power variation was observed

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

Part	Test description	Verdict
§15.247(a)(1)(i)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247(a)(1)(ii)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
§15.247(a)(1)(iii)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
§15.247(a)(2)	Minimum 6 dB bandwidth for systems using digital modulation techniques	Pass
§15.247(b)(1)	Maximum peak output power of frequency hopping systems operating in the 2400–2483.5 MHz band and 5725–5850 MHz band	Not applicable
§15.247(b)(2)	Maximum peak output power of Frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247(b)(3)	Maximum peak output power of systems using digital modulation 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 for digitally modulated devices	Pass
§15.247(f)	Time of occupancy for hybrid systems	Not applicable

2.3 IC RSS-GEN, Issue 4, test results

Part	Test description	Verdict
7.1.2	Receiver radiated emission limits	Not applicable
7.1.3	Receiver conducted emission limits	Not applicable
8.8	Power Line Conducted Emissions Limits for Licence-Exempt Radio Apparatus	Pass

Notes: ¹ According to sections 5.2 and 5.3 of RSS-Gen, Issue 4 the EUT does not have a stand-alone receiver neither scanner receiver, therefore exempt from receiver requirements.

2.4 IC RSS-247, Issue 1, test results

Part	Test description	Verdict
5.1	Frequency Hopping Systems (FHSs)	
5.1 (1)	Bandwidth of a frequency hopping channel	Not applicable
5.1 (2)	Minimum channel spacing for frequency hopping systems	Not applicable
5.1 (3)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
5.1 (4)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
5.1 (5)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
5.2	Digital Transmission Systems (DTSs)	
5.2 (1)	Minimum 6 dB bandwidth	Pass
5.2 (2)	Maximum power spectral density	Pass
5.3	Hybrid Systems	
5.3 (1)	Digital modulation turned off	Not applicable
5.3 (2)	Frequency hopping turned off	Not applicable
5.4	Transmitter output power and e.i.r.p. requirements	
5.4 (1)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
5.4 (2)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
5.4 (3)	Frequency hopping systems operating in the 5725–5850 MHz	Not applicable
5.4 (4)	Systems employing digital modulation techniques	Pass
5.4 (5)	Point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band	Not applicable
5.4 (6)	Transmitters which operate in the 2400–2483.5 MHz band with multiple directional beams	Not applicable
5.5	Out-of-band emissions	Pass

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	May 16, 2016
Nemko sample ID number	133-002400

3.2 EUT information

Product name	nanoNode, RPMA Wireless Module
Model	NODE103
Model variant	N/A
Serial number	740F00B5

3.3 Technical information

Applicant IC company number	8655A
IC UPN number	NODE103
All used IC test site(s) Reg. number	2040A-4
RSS number and Issue number	RSS-247 Issue 1, May 2015
Frequency band	2400–2483.5 MHz
Frequency Min (MHz)	2402
Frequency Max (MHz)	2475.63
RF power Min (W), Conducted	N/A
RF power Max (W), Conducted	0.1968 (22.94 dBm)
Field strength, Units @ distance	N/A
Measured BW (kHz) (6 dB)	1017 (1.362 MHz 99% OBW)
Calculated BW (kHz), as per TRC-43	N/A
Type of modulation	DSSS-BPSK
Emission classification (F1D, G1D, D1D)	1M36G1D
Transmitter spurious, Units @ distance	51.62 dB μ V/m (average) at 2483.5 MHz @ 3 m
Power requirements	3.6 V _{DC} via 120 V _{AC} 60 Hz adapter
Antenna information	Maximum antenna gain of 9 dBi. The EUT uses a unique antenna coupling/ non-detachable antenna to the intentional radiator.

3.4 Product description and theory of operation

Ingenu has developed RPMA, a wireless technology providing the world's best coverage, capacity, long life, and interoperability for IOT devices. The RPMA Network is comprised of Nodes (end points with RF Modems) and Access Points (APs). The nanoNode is one variant of the Nodes offered by Ingenu. The nanoNode is a small form factor wireless network module that easily integrates with a microcontroller or applications processor using a Serial Peripheral Interface (SPI).

3.5 EUT exercise details

EUT was connected to a laptop via USB connector. Special tool was running on the computer that controlled the transmitter parameters.

3.6 EUT setup diagram

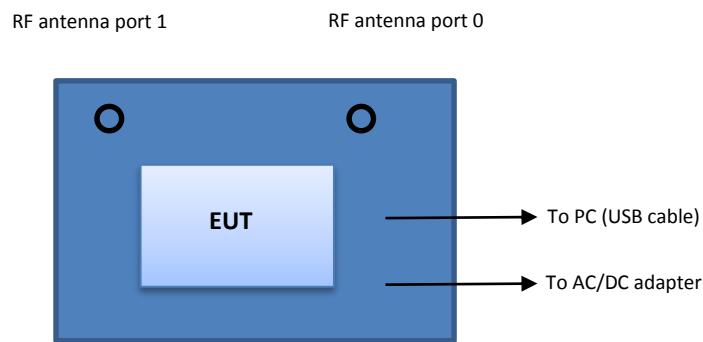


Figure 3.6-1: Setup diagram

3.7 EUT sub assemblies

Table 3.7-1: EUT auxiliary equipment

Description	Brand name	Model/Part number	Serial number
Laptop	Acer	Aspire 3610	LXA7405212 538022F6KS00
Power adapter	CUI	3A-211DN05	—

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 $\pm 5\%$, for which the equipment was designed.

Section 6. Measurement uncertainty

6.1 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
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	Dec. 01/16
Flush mount turntable	Sunol	FM2022	FA002082	—	NCR
Controller	Sunol	SC104V	FA002060	—	NCR
Antenna mast	Sunol	TLT2	FA002061	—	NCR
AC Power source	California Instruments	3001i	FA001021	1 year	Aug. 27/16
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 26	FA002043	1 year	Jan. 07/17
Bilog antenna (20–3000 MHz)	Sunol	JB3	FA002108	1 year	Apr. 28/17
Horn antenna (1–18 GHz)	EMCO	3115	FA000825	1 year	Apr. 26/17
Pre-amplifier (1–18 GHz)	JCA	JCA118-503	FA002091	1 year	April 26/17
LISN	Rohde & Schwarz	ENV216	FA002023	1 year	Mar. 08/17

Note: NCR - no calibration required

Section 8. Testing data

8.1 FCC 15.207(a) and RSS-Gen 8.8 AC power line conducted emissions limits

8.1.1 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 μ H/50 Ω line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

IC:

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

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

Table 8.1-1: Conducted emissions limit

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

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

** - A linear average detector is required.

8.1.2 Test summary

Test date	May 20, 2016	Temperature	22 °C
Test engineer	Andrey Adelberg	Air pressure	1009 mbar
Verdict	Pass	Relative humidity	30 %

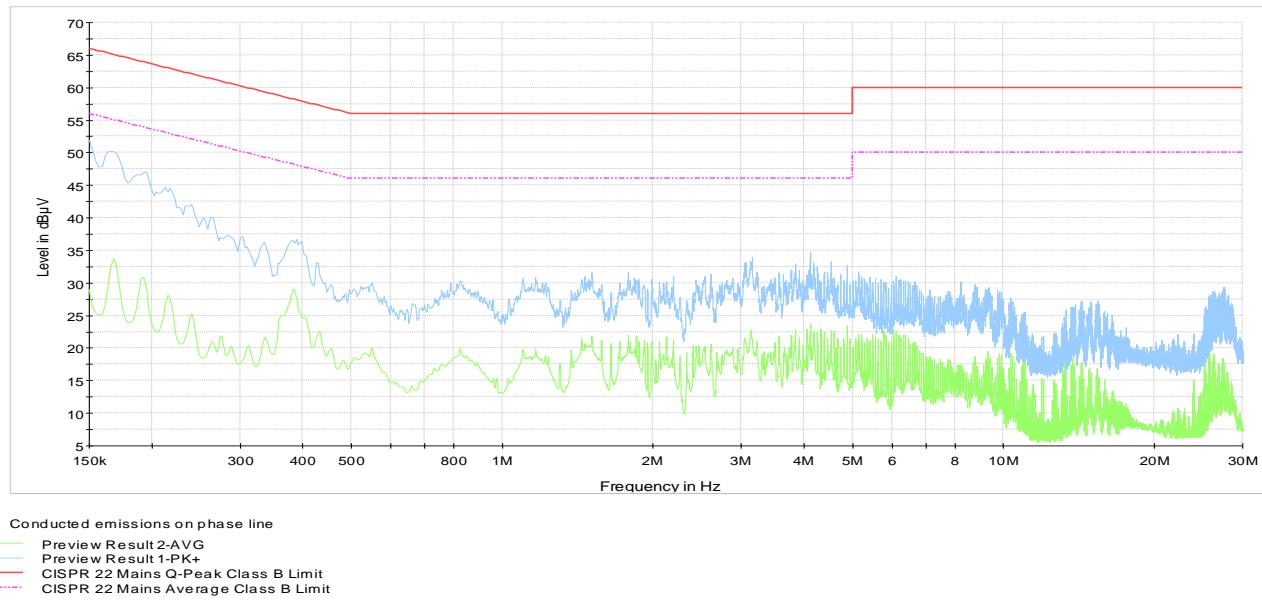
8.1.3 Observations, settings and special notes

Port under test	AC input external adapter
EUT setup configuration	Table top
Measurement details	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:

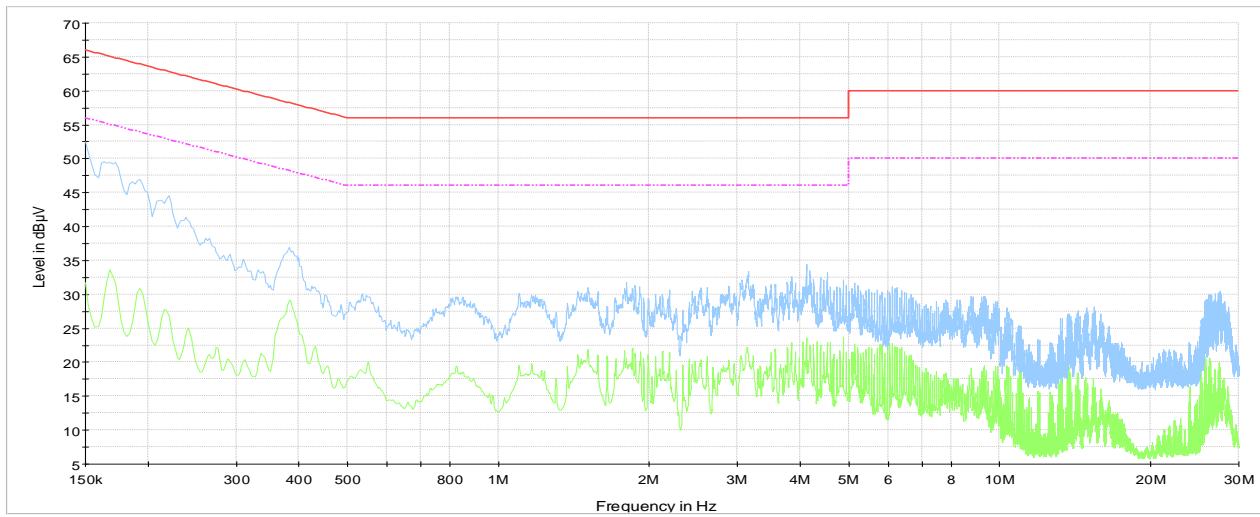
Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	<ul style="list-style-type: none">– Peak and Average (Preview measurement)– Quasi-peak and CAverage (Final measurement)
Trace mode	Max Hold
Measurement time	<ul style="list-style-type: none">– 100 ms (Peak and Average preview measurement)– 1000 ms (Quasi-peak final measurement)– 160 ms (CAverage final measurement)

8.1.4 Test data



The spectral plot has been corrected with transducer factors. (i.e. cable loss, LISN factors, and attenuators)

Plot 8.1-1: Conducted emissions on phase line



The spectral plot has been corrected with transducer factors. (i.e. cable loss, LISN factors, and attenuators)

Plot 8.1-2: Conducted emissions on neutral line

8.2 FCC 15.247(a)(2) and RSS-247 5.2(1) Minimum 6 dB bandwidth for systems using digital modulation techniques

8.2.1 Definitions and limits

FCC §15.247 (a)(2):

(a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(2) 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.

RSS-247, Clause 5.2 (1):

The minimum 6 dB bandwidth shall be 500 kHz.

8.2.2 Test summary

Test date	May 16, 2016	Temperature	22 °C
Test engineer	Andrey Adelberg	Air pressure	1006 mbar
Verdict	Pass	Relative humidity	31 %

8.2.3 Observations, settings and special notes

Measurements were performed as per 558074 D01 DTS Meas Guidance v03r05 (The test was performed using method described in Section 8.1)

Spectrum analyser settings:

Resolution bandwidth	100 kHz
Video bandwidth	≥3 × RBW
Frequency span	5 MHz
Detector mode	Peak
Trace mode	Max Hold

8.2.4 Test data

Table 8.2-1: 6 dB bandwidth results for Anto

Frequency, MHz	6 dB bandwidth, MHz	Limit, MHz	Margin, MHz
2402.00	1.001	0.500	0.501
2439.81	1.001	0.500	0.501
2475.63	1.001	0.500	0.501

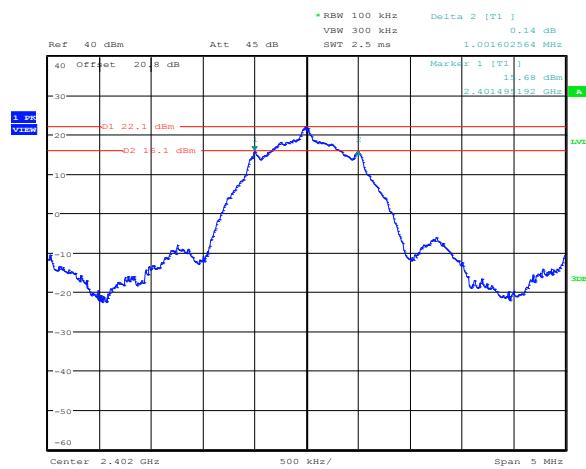
Table 8.2-2: 6 dB bandwidth results for Ant1

Frequency, MHz	6 dB bandwidth, MHz	Limit, MHz	Margin, MHz
2402.00	1.017	0.500	0.517
2439.81	1.010	0.500	0.510
2475.63	1.008	0.500	0.508

Section 8**Test name****Specification****Testing data**

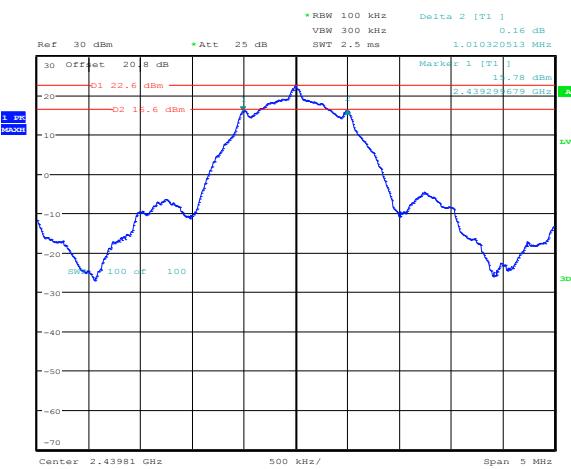
FCC 15.247(a)(2) and RSS-247 5.2(1) Minimum 6 dB bandwidth for systems using digital modulation techniques

FCC Part 15 Subpart C and RSS-247, Issue 1



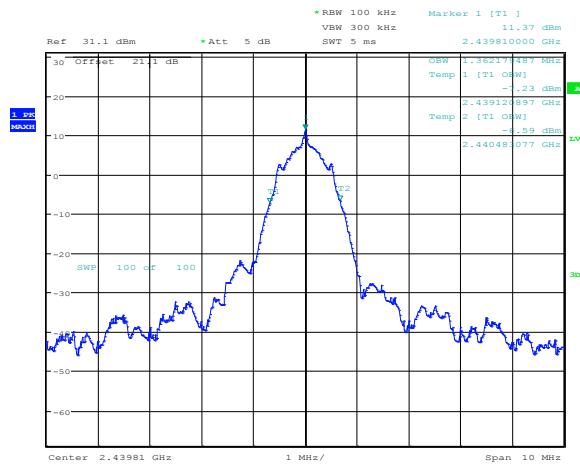
Date: 16.MAY.2016 09:52:03

Figure 8.2-1: 6 dB bandwidth on Anto, sample plot



Date: 16.MAY.2016 12:55:32

Figure 8.2-2: 6 dB bandwidth on Ant1, sample plot



Date: 17.MAY.2016 10:06:22

Figure 8.2-3: 99% occupied bandwidth, sample plot

8.3 FCC 15.247(b) and RSS-247 5.4 (4) Transmitter output power and e.i.r.p. requirements

8.3.1 Definitions and limits

FCC §15.247 (b)(3,4):

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

- (3) For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 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.

RSS-247, Clause 5.4 (4):

For DTSs employing digital modulation techniques operating in the bands 902–928 MHz and 2400–2483.5 MHz, the maximum peak conducted output power shall not exceed 1W. Except as provided in Section 5.4(5), the e.i.r.p. shall not exceed 4 W. Fixed point-to-point systems in the bands 2400–2483.5 MHz and 5725–5850 MHz 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.

8.3.2 Test summary

Test date	May 16, 2016	Temperature	22 °C
Test engineer	Andrey Adelberg	Air pressure	1005 mbar
Verdict	Pass	Relative humidity	31 %

8.3.3 Observations, settings and special notes

The test was performed according to DTS guidelines section 9.2.3.1: Method AVGPM (Measurement using an RF average power meter).

8.3.4 Test data

Table 8.3-1: Output power measurements results for Ant0

Frequency, MHz	Conducted output power, dBm on Ant0	Margin, dB Limit	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
2402.00	22.94	30.00	7.06	9.00	31.94	36.00
2439.81	22.78	30.00	7.22	9.00	31.78	36.00
2475.63	22.61	30.00	7.39	9.00	31.61	36.00

Table 8.3-2: Output power measurements results for Ant1

Frequency, MHz	Conducted output power, dBm on Ant1	Margin, dB Limit	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
2402.00	22.89	30.00	7.11	9.00	31.89	36.00
2439.81	22.84	30.00	7.16	9.00	31.84	36.00
2475.63	22.67	30.00	7.33	9.00	31.67	36.00

8.4 FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) emissions

8.4.1 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(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

Table 8.4-1: FCC §15.209 and RSS-Gen – Radiated emission limits

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

Notes: In the emission table above, the tighter limit applies at the band edges.

For frequencies above 1 GHz the limit on peak RF emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test

Table 8.4-2: IC restricted frequency bands

MHz	MHz	MHz	GHz
0.090–0.110	12.51975–12.52025	399.9–410	5.35–5.46
2.1735–2.1905	12.57675–12.57725	608–614	7.25–7.75
3.020–3.026	13.36–13.41	960–1427	8.025–8.5
4.125–4.128	16.42–16.423	1435–1626.5	9.0–9.2
4.17725–4.17775	16.69475–16.69525	1645.5–1646.5	9.3–9.5
4.20725–4.20775	16.80425–16.80475	1660–1710	10.6–12.7
5.677–5.683	25.5–25.67	1718.8–1722.2	13.25–13.4
6.215–6.218	37.5–38.25	2200–2300	14.47–14.5
6.26775–6.26825	73–74.6	2310–2390	15.35–16.2
6.31175–6.31225	74.8–75.2	2655–2900	17.7–21.4
8.291–8.294	108–138	3260–3267	22.01–23.12
8.362–8.366	156.52475–156.52525	3332–3339	23.6–24.0
8.37625–8.38675	156.7–156.9	3345.8–3358	31.2–31.8
8.41425–8.41475	240–285	3500–4400	36.43–36.5
12.29–12.293	322–335.4	4500–5150	Above 38.6

Note: Certain frequency bands listed in Table 8.4-2 and above 38.6 GHz are designated for low-power licence-exempt applications. These frequency bands and the requirements that apply to the devices are set out in this Standard

Table 8.4-3: FCC restricted frequency bands

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

8.4.2 Test summary

Test date	May 16, 2016	Temperature	23 °C
Test engineer	Andrey Adelberg	Air pressure	1004 mbar
Verdict	Pass	Relative humidity	33 %

8.4.3 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.
Since fundamental power was tested using average method, the spurious emissions limit is –30 dBc/100 kHz.
All plots were adjusted to reflect appropriate correction factors.

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 conducted spurious emissions measurements:

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

8.4.4 Test data



Figure 8.4-1: Duty cycle measurement

Duty cycle correction factor was calculated as follows:

$$20 \times \log_{10} (0.5) = -6 \text{ dB}$$

2483.5 MHz restricted band edge delta marker measurement results:

Antenna 0: Field strength measurement result of the fundamental with 1 MHz RBW is 120.55 dB μ V/m. Delta marker at 2483.5 MHz with 100 kHz RBW is 63.93 dB, therefore peak field strength at 2483.5 MHz is $120.55 - 63.93 = 56.62$ dB μ V/m.

Antenna 1: Field strength measurement result of the fundamental with 1 MHz RBW is 121.21 dB μ V/m. Delta marker at 2483.5 MHz with 100 kHz RBW is 63.59 dB, therefore peak field strength at 2483.5 MHz is $121.21 - 63.59 = 57.62$ dB μ V/m.

Table 8.4-4: Radiated field strength measurement results for Anto

Channel	Frequency, MHz	Peak Field strength, dB μ V/m		Margin, dB	Average Field strength, dB μ V/m		Margin, dB
		Measured	Limit		Calculated	Limit	
Low	2390.0	56.62	74.00	17.07	50.93	54.00	3.07
Low	4804.0	53.42	74.00	20.58	47.42	54.00	6.58
Low*	19211.5	50.88	74.00	23.12	44.88	54.00	9.12
Mid	4879.5	51.71	74.00	22.29	45.71	54.00	8.29
Mid	7319.6	50.47	74.00	23.53	44.47	54.00	9.53
Mid*	19514.4	54.34	74.00	19.66	48.34	54.00	5.66
High	2483.5	56.62	74.00	17.38	50.62	54.00	3.38
High	4951.5	50.42	74.00	23.58	44.42	54.00	9.58
High*	19211.5	50.47	74.00	23.53	44.47	54.00	9.53

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

Average calculation example. 2390 MHz Peak measurement was 56.62 dB μ V/m. Average = $56.62 - 6 = 50.62$ dB μ V/m

* - measurements were performed at 1 m distance to increase the receiver signal-to-noise ratio. Correction factor of 9.54 dB was deducted from the measurement result in order to compare the result with 3 m limit.

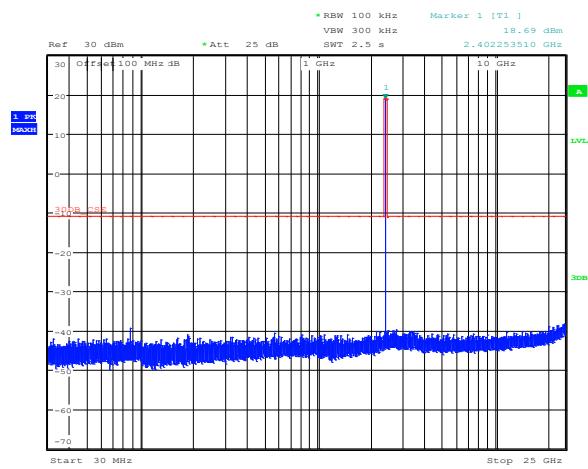
Table 8.4-5: Radiated field strength measurement results for Ant1

Channel	Frequency, MHz	Peak Field strength, dB μ V/m		Margin, dB	Average Field strength, dB μ V/m		Margin, dB
		Measured	Limit		Calculated	Limit	
Low	2390.0	56.07	74.00	17.93	50.07	54.00	3.93
Low	7206.0	47.51	74.00	26.49	41.51	54.00	12.49
Low*	19211.5	50.47	74.00	23.53	44.47	54.00	9.53
Mid*	19514.4	52.47	74.00	21.53	46.47	54.00	7.53
High	4951.3	47.93	74.00	26.07	41.93	54.00	12.07
High	2483.5	57.62	74.00	16.38	51.62	54.00	2.38

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

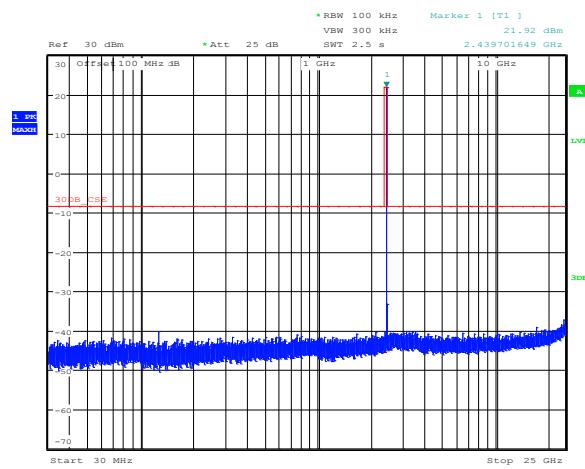
Average calculation example. 2390 MHz Peak measurement was 56.07 dB μ V/m. Average = $56.62 - 6 = 50.07$ dB μ V/m

* - measurements were performed at 1 m distance to increase the receiver signal-to-noise ratio. Correction factor of 9.54 dB was deducted from the measurement result in order to compare the result with 3 m limit.



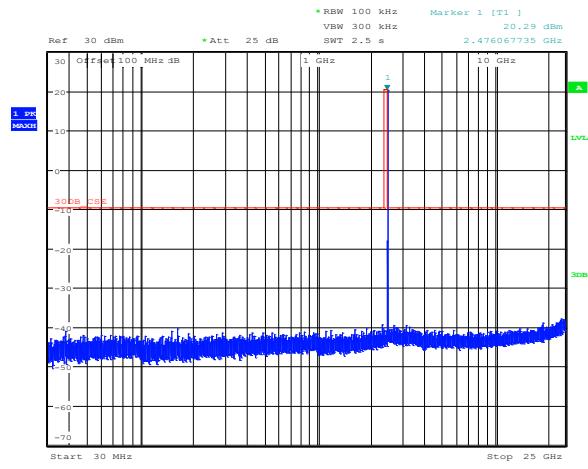
Date: 16.MAY.2016 10:37:54

Figure 8.4-2: Conducted spurious emissions for Anto, low channel



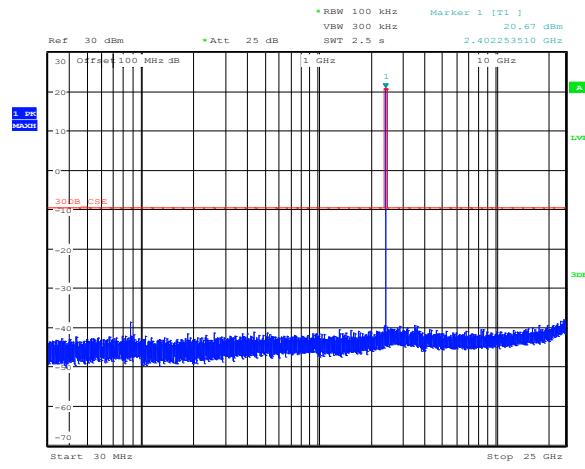
Date: 16.MAY.2016 10:39:00

Figure 8.4-3: Conducted spurious emissions for Anto, mid channel



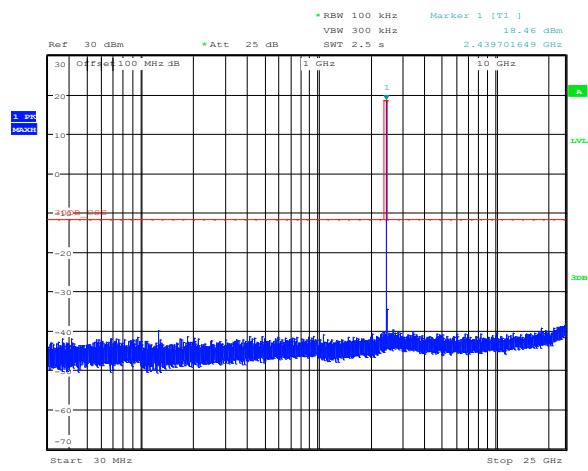
Date: 16.MAY.2016 10:36:30

Figure 8.4-4: Conducted spurious emissions for Anto, high channel



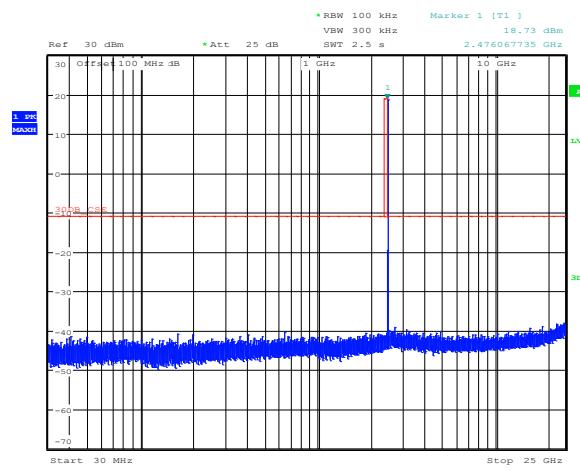
Date: 16.MAY.2016 12:40:30

Figure 8.4-5: Conducted spurious emissions for Ant1, low channel



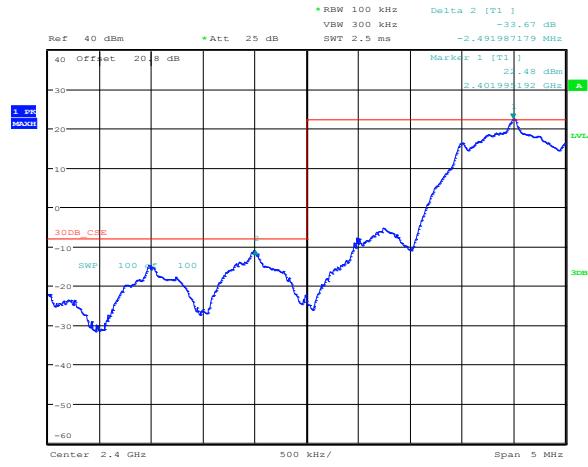
Date: 16.MAY.2016 12:41:38

Figure 8.4-6: Conducted spurious emissions for Ant1, mid channel



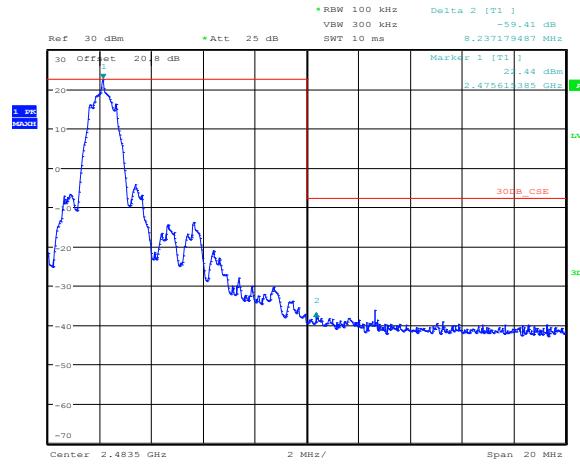
Date: 16.MAY.2016 12:42:58

Figure 8.4-7: Conducted spurious emissions for Ant1, high channel



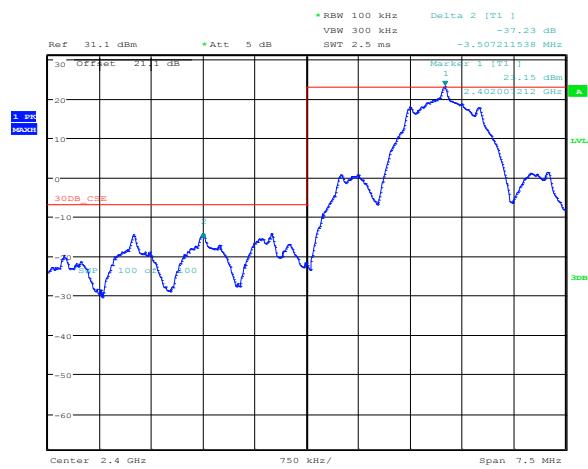
Date: 16.MAY.2016 10:47:05

Figure 8.4-8: Conducted spurious emissions at the lower band edge for Anto, low channel



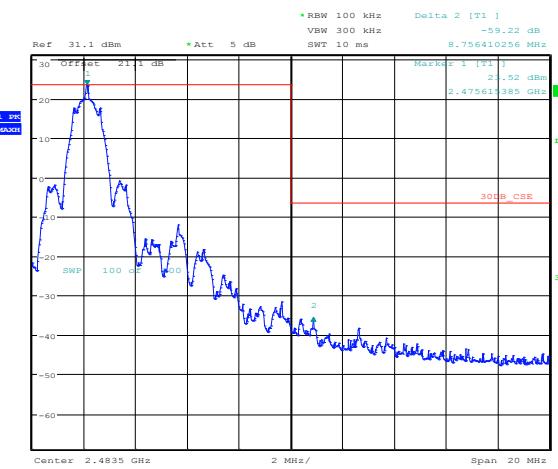
Date: 16.MAY.2016 10:53:16

Figure 8.4-9: Conducted spurious emissions at the upper band edge for Anto, high channel



Date: 16.MAY.2016 14:15:11

Figure 8.4-10: Conducted spurious emissions at the lower band edge for Ant1, low channel



Date: 16.MAY.2016 14:16:17

Figure 8.4-11: Conducted spurious emissions at the upper band edge for Ant1, high channel

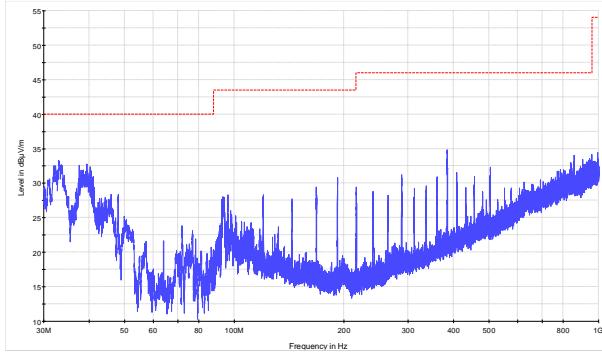


Figure 8.4-12: Radiated spurious emissions below 1 GHz for Anto, low channel

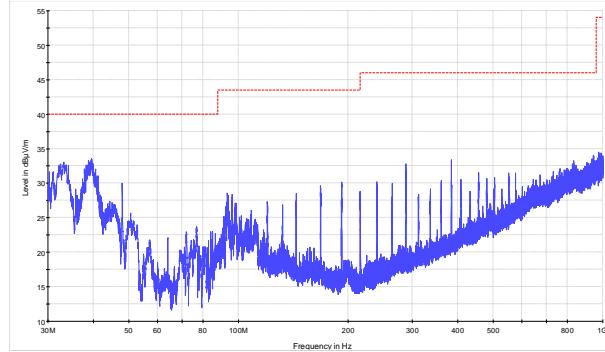


Figure 8.4-13: Radiated spurious emissions below 1 GHz for Anto, mid channel

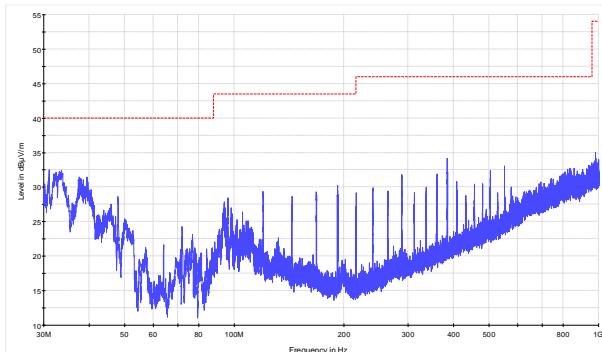


Figure 8.4-14: Radiated spurious emissions below 1 GHz for Anto, high channel

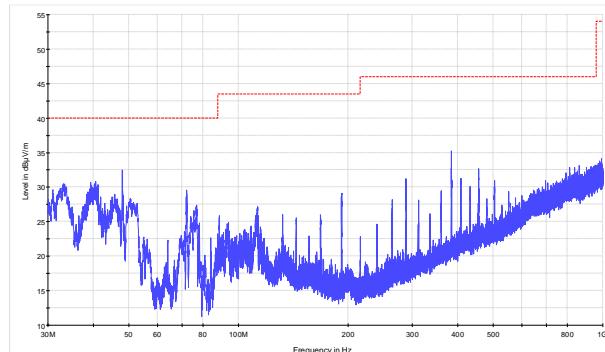


Figure 8.4-15: Radiated spurious emissions below 1 GHz for Ant1, low channel

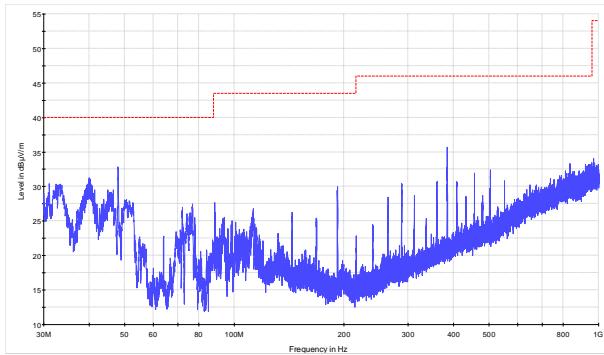


Figure 8.4-16: Radiated spurious emissions below 1 GHz for Ant1, mid channel

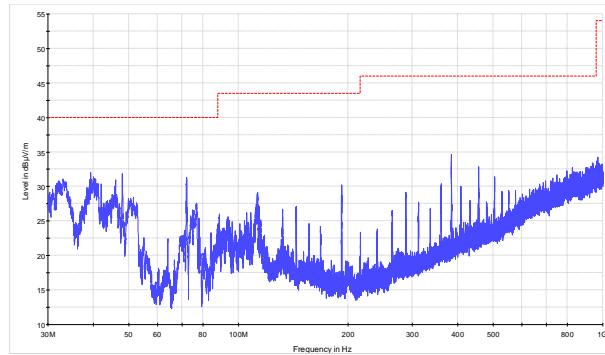


Figure 8.4-17: Radiated spurious emissions below 1 GHz for Ant1, high channel

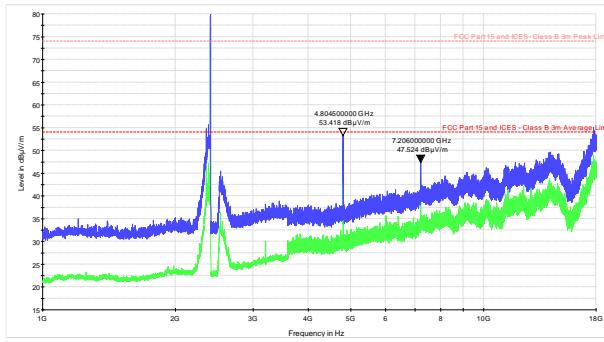


Figure 8.4-18: Radiated spurious emissions below 18 GHz for Ant0, low channel

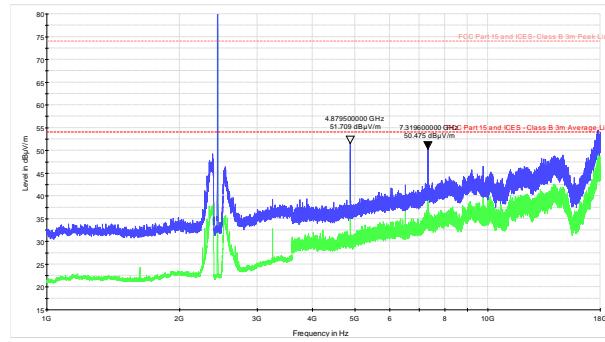


Figure 8.4-19: Radiated spurious emissions below 18 GHz for Ant0, mid channel

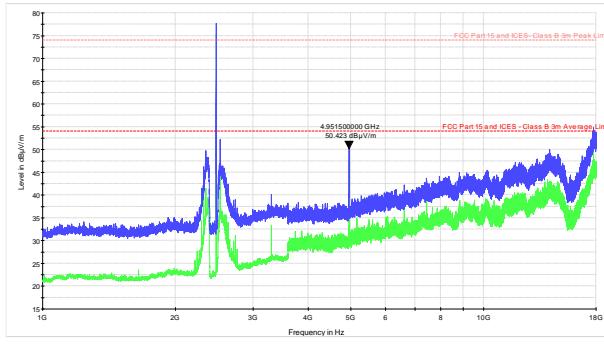


Figure 8.4-20: Radiated spurious emissions below 18 GHz for Ant0, high channel

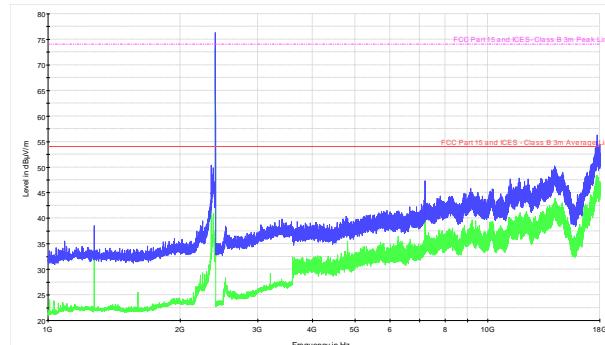


Figure 8.4-21: Radiated spurious emissions below 18 GHz for Ant1, low channel

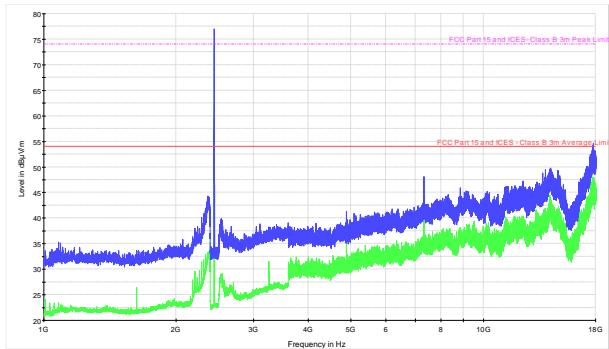


Figure 8.4-22: Radiated spurious emissions below 18 GHz for Ant1, mid channel

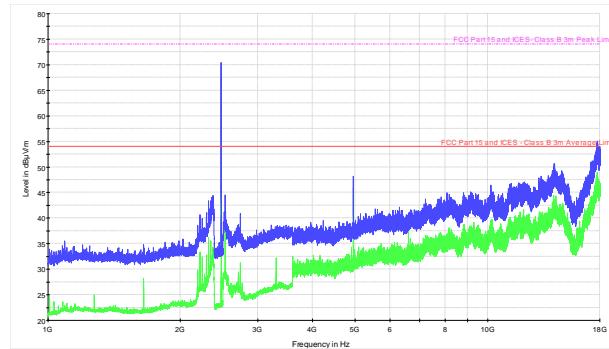
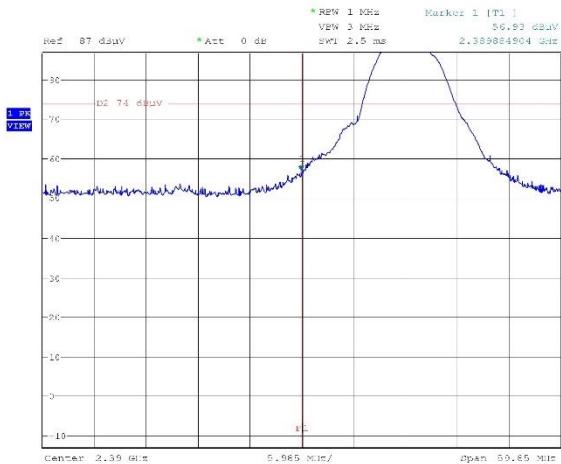
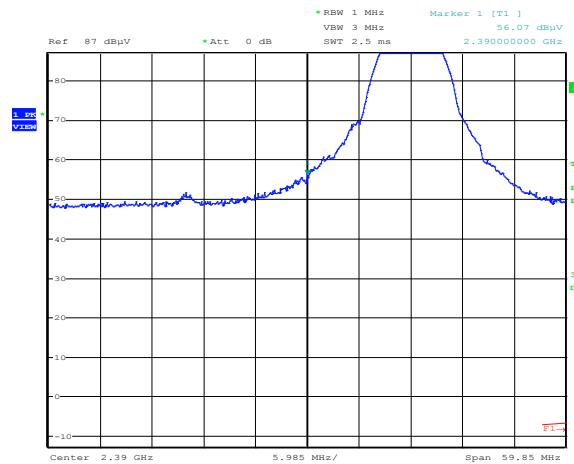


Figure 8.4-23: Radiated spurious emissions below 18 GHz for Ant1, high channel



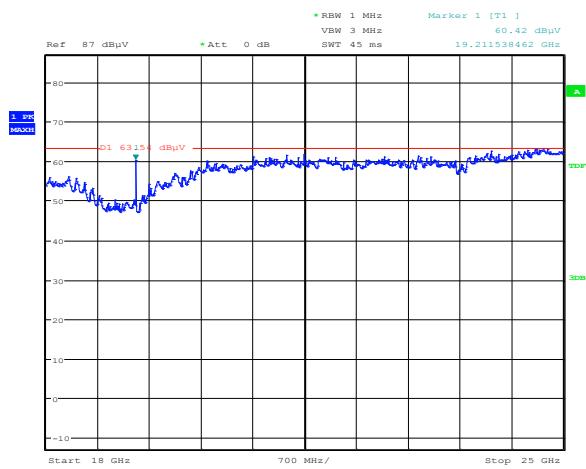
Date: 20.MAY.2016 12:46:58

Figure 8.4-24: Radiated spurious emissions at the lower band edge for Ant0, low channel



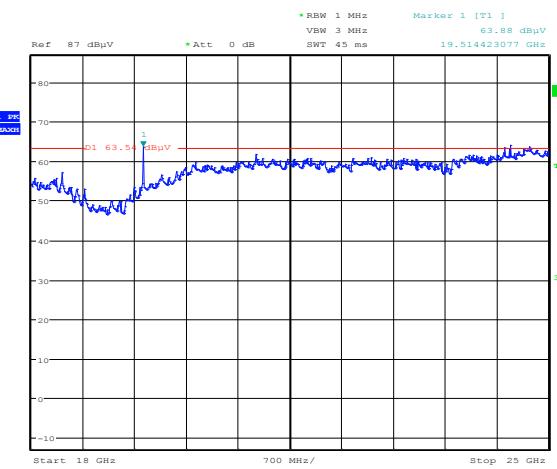
Date: 20.MAY.2016 13:19:43

Figure 8.4-25: Radiated spurious emissions at the lower band edge for Ant1, low channel



Date: 20.MAY.2016 15:15:59

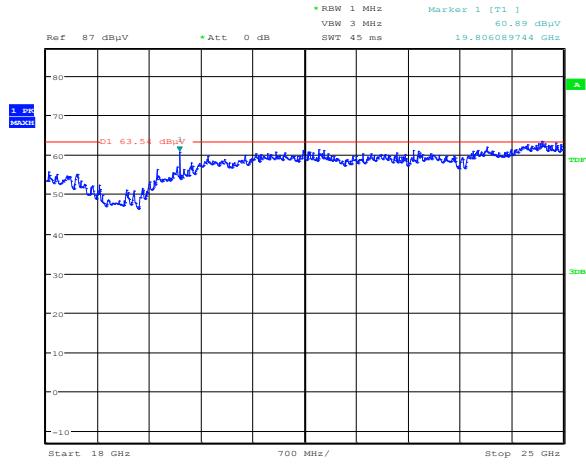
Figure 8.4-26: Radiated spurious emissions above 18 GHz for Anto, low channel



Date: 20.MAY.2016 15:17:01

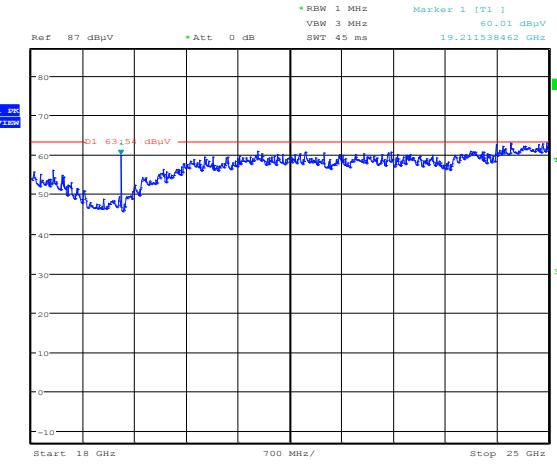
Figure 8.4-27: Radiated spurious emissions above 18 GHz for Anto, mid channel

Note: measurements above 18 GHz were performed at the distance of 1 m. $20 \times \log_{10} (3 \text{ m}/1 \text{ m}) = 9.54 \text{ dB}$ distance correction factor was applied to the average limit on the plots above. On the plots above, where peak trace (in blue) exceeded the average limit line (in red), both Peak and average were assessed and summarized in the Tables 8.4-4 and 8.4-5.



Date: 20.MAY.2016 15:17:31

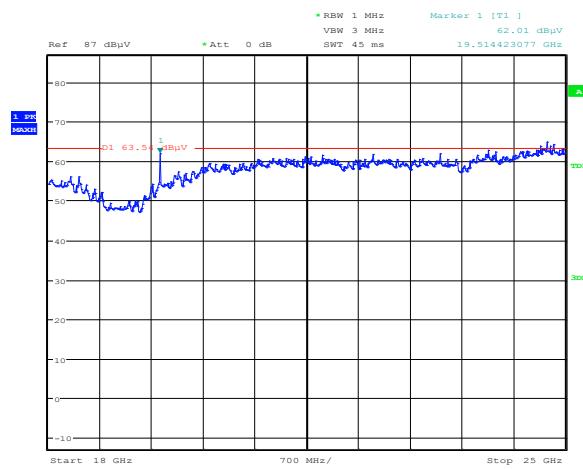
Figure 8.4-28: Radiated spurious emissions above 18 GHz for Anto, high channel



Date: 20.MAY.2016 15:13:27

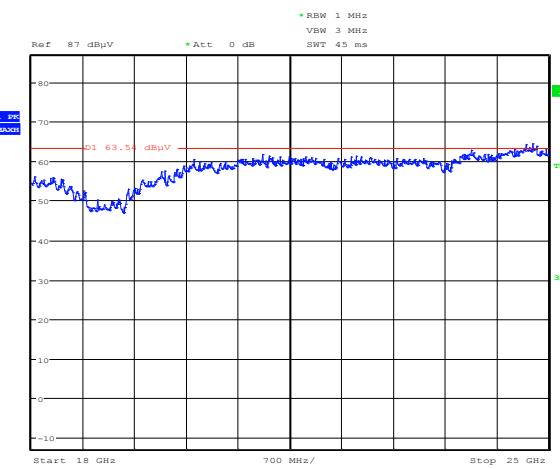
Figure 8.4-29: Radiated spurious emissions above 18 GHz for Ant1, low channel

Note: measurements above 18 GHz were performed at the distance of 1 m. $20 \times \log_{10} (3 \text{ m}/1 \text{ m}) = 9.54 \text{ dB}$ distance correction factor was applied to the average limit on the plots above. On the plots above, where peak trace (in blue) exceeded the average limit line (in red), both Peak and average were assessed and summarized in the Tables 8.4-4 and 8.4-5.



Date: 20.MAY.2016 15:14:12

Figure 8.4-30: Radiated spurious emissions above 18 GHz for Ant1, mid channel



Date: 20.MAY.2016 15:14:55

Figure 8.4-31: Radiated spurious emissions above 18 GHz for Ant1, high channel

Note: measurements above 18 GHz were performed at the distance of 1 m. $20 \times \log_{10} (3 \text{ m}/1 \text{ m}) = 9.54 \text{ dB}$ distance correction factor was applied to the average limit on the plots above. On the plots above, where peak trace (in blue) exceeded the average limit line (in red), both Peak and average were assessed and summarized in the Tables 8.4-4 and 8.4-5.

8.5 FCC 15.247(e) and RSS-247 5.2(2) Power spectral density for digitally modulated devices

8.5.1 Definitions and limits

FCC §15.247 (e):

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.

RSS-247, Clause 5.2 (2):

The transmitter power spectral density conducted from the transmitter 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 Section 5.4(4), (i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

8.5.2 Test summary

Test date	May 16, 2016	Temperature	23 °C
Test engineer	Andrey Adelberg	Air pressure	1005 mbar
Verdict	Pass	Relative humidity	32 %

8.5.3 Observations, settings and special notes

The test was performed using method described in section 10.3 Method AVGPSD-1 (trace averaging with EUT transmitting at full power throughout each sweep). Spectrum analyser settings:

Resolution bandwidth:	3 kHz
Video bandwidth:	10 kHz
Frequency span:	5 MHz
Detector mode:	Sample
Trace mode:	Power averaging
Averaging sweeps number:	100

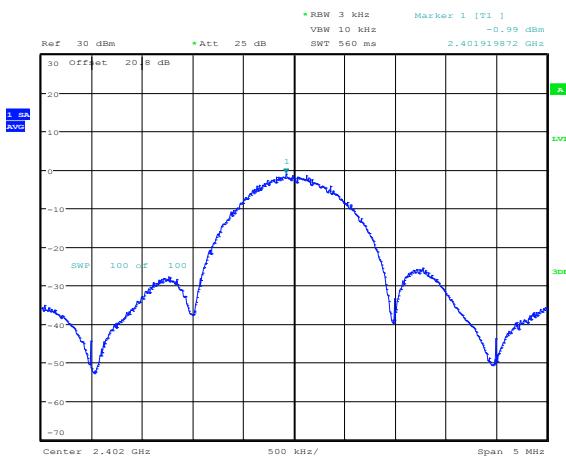
8.5.4 Test data

Table 8.5-1: PSD measurements results for Anto

Frequency, MHz	PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
2402.00	-0.99	8.00	8.99
2439.81	-0.77	8.00	8.77
2475.63	-1.26	8.00	9.26

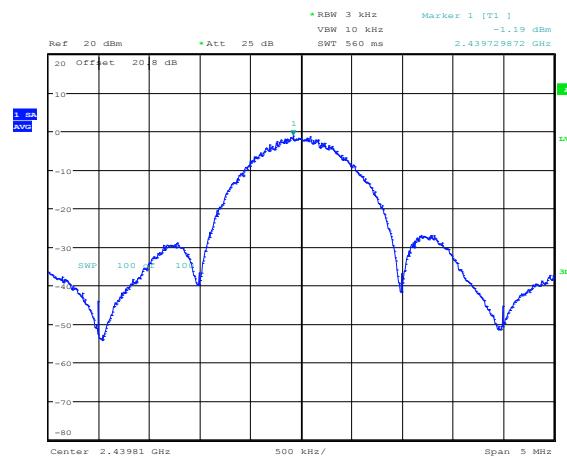
Table 8.5-2: PSD measurements results for Ant1

Frequency, MHz	PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
2402.00	-1.48	8.00	9.48
2439.81	-1.19	8.00	9.19
2475.63	-1.27	8.00	9.27



Date: 16.MAY.2016 10:43:15

Figure 8.5-1: PSD sample plot on Anto

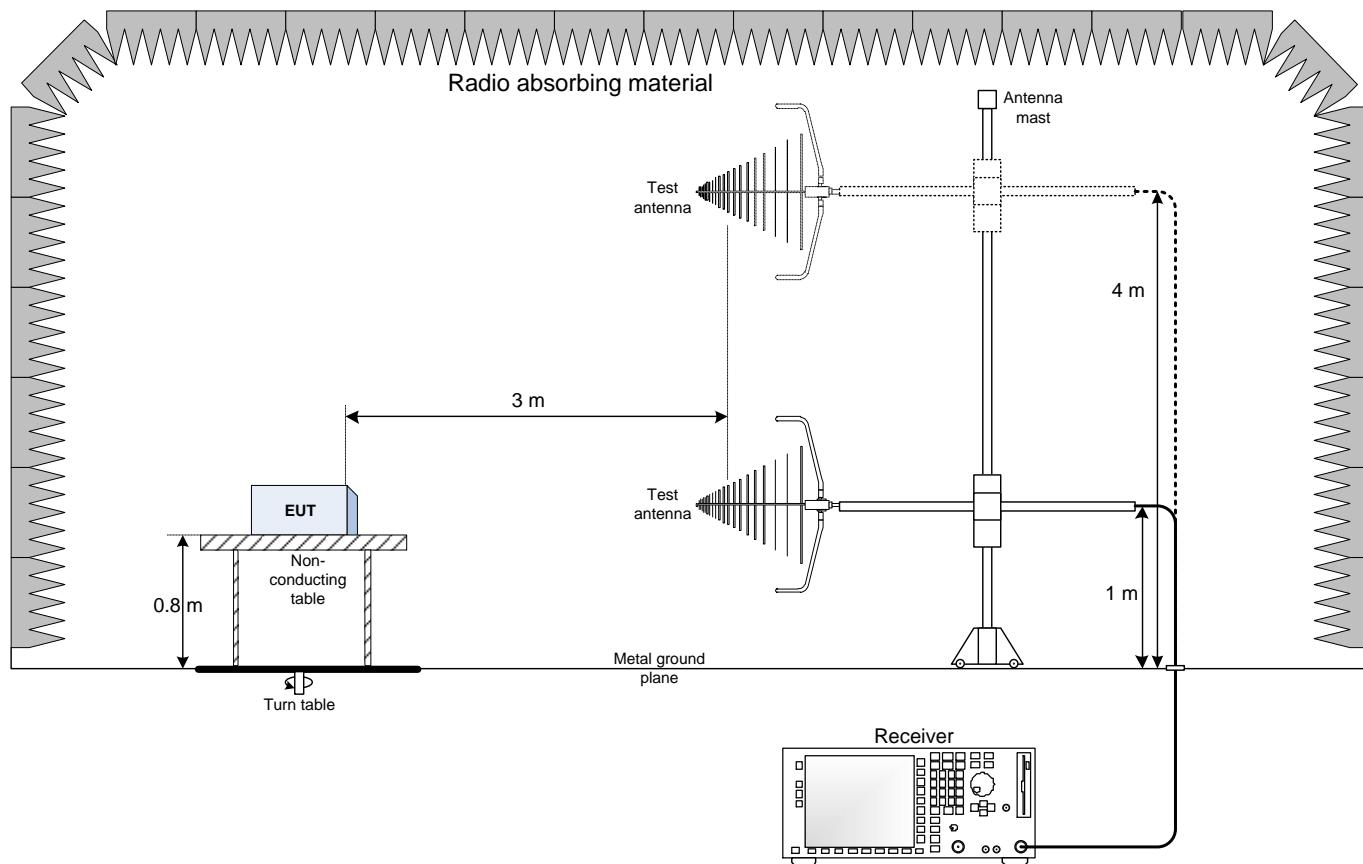


Date: 16.MAY.2016 12:50:01

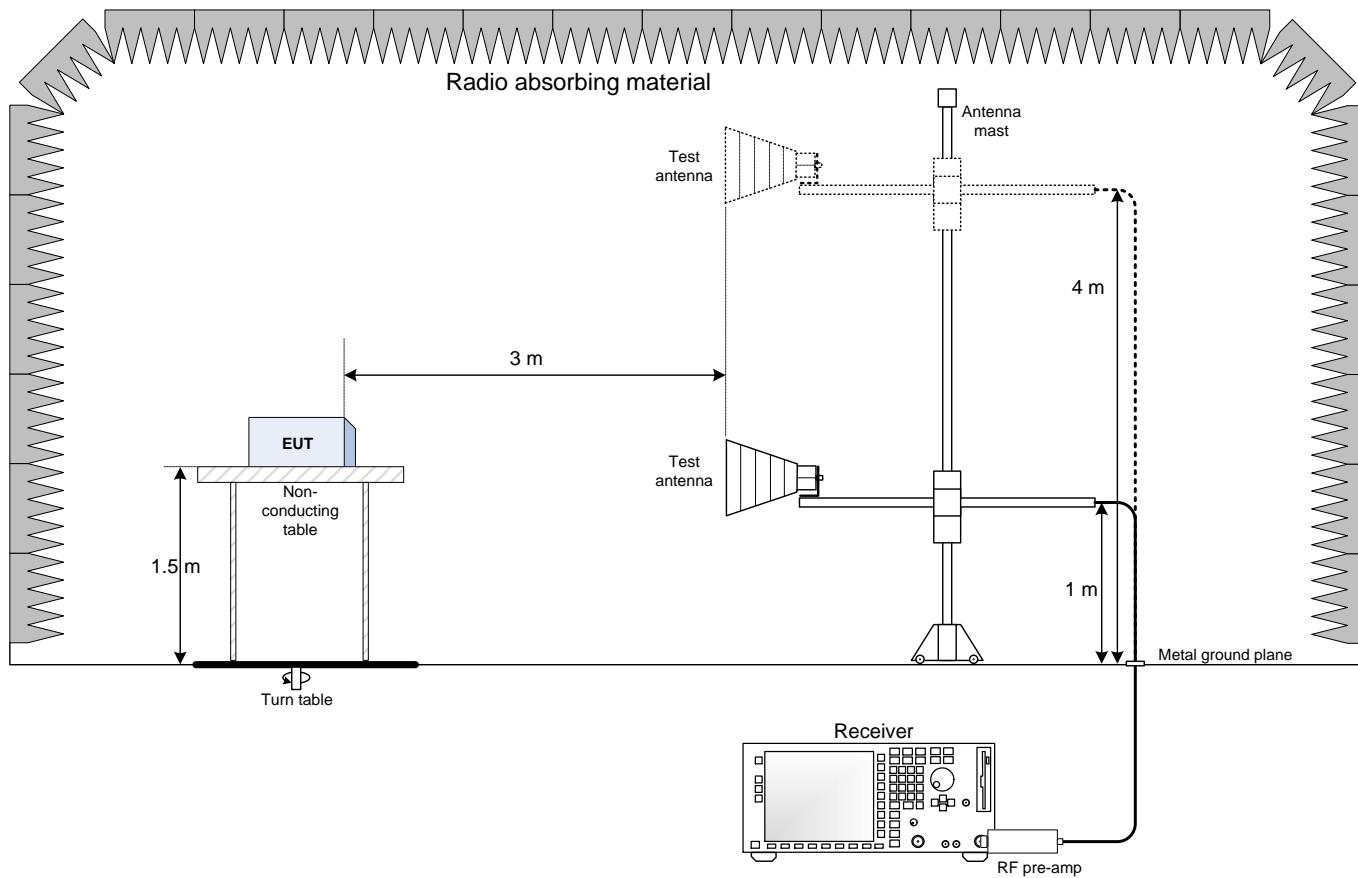
Figure 8.5-2: PSD sample plot on Ant1

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

