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Wireless test report – 357091-1TRFWL

Applicant:

Alert Labs Inc.

Product name:

Alert Labs Sentree A/C Sensor

Model:

ALF-000008-001

FCC ID:

2AKXF-ALB030

IC Registration number:

22365-ALB030

Specifications:

- FCC 47 CFR Part 15 Subpart C, §15.247

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

- RSS-247, Issue 2, Feb 2017, Section 5

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

  5) Standard specifications for frequency hopping systems and digital transmission systems operating in the bands 902–928 MHz, 2400–2483.5 MHz and 5725–5850 MHz

Date of issue: July 26, 2018

Test engineer(s):	Yong Huang, Wireless/EMC Specialist	Signature:	
Reviewed by:	Kevin Rose, Wireless/EMC Specialist	Signature:	

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
Toll free	+1 800 563 6336
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.

Copyright notification

Table of contents

Section 1. Report summary

1.1 Applicant and manufacturer

Company name	Alert Labs Inc.
Address	Alert Labs Inc. 132 Queen St S Unit #2 Kitchener, ON N2G 1V9

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 5725–585 MHz
RSS-247, Issue 2, Feb 2017, 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 v04 (April 5, 2017)	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
RSS-Gen, Issue 5, April 2018	General Requirements for Compliance of Radio Apparatus

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

Revision #	Date of issue	Details of changes made to test report
TRF	July 26, 2018	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
§15.31(m)	Number of tested frequencies	Pass
§15.203	Antenna requirement	Pass

Notes: EUT is an AC powered device.

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

2.3 ISED RSS-Gen, Issue 5, test results

Table 2.3-1: *RSS-Gen results*

Part	Test description	Verdict
7.3	Receiver radiated emission limits	Not applicable
7.4	Receiver conducted emission limits	Not applicable
6.9	Operating bands and selection of test frequencies	Pass
8.8	AC power-line conducted emissions limits	Pass

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

2.4 ISED RSS-247, Issue 2, test results for digital transmission systems (DTS)

Table 2.4-1: *RSS-247 results for DTS*

Part	Test description	Verdict
5.2 (a)	Minimum 6 dB bandwidth	Pass
5.2 (b)	Maximum power spectral density	Pass
5.3	Hybrid Systems	
5.3 (a)	Digital modulation turned off	Not applicable
5.3 (b)	Frequency hopping turned off	Not applicable
5.4	Transmitter output power and e.i.r.p. requirements	
5.4 (d)	Systems employing digital modulation techniques	Pass
5.4 (e)	Point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band	Not applicable
5.4 (f)	Transmitters which operate in the 2400–2483.5 MHz band with multiple directional beams	Not applicable
5.5	Unwanted emissions	Pass

Notes: None

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	July 6, 2018
Nemko sample ID number	Item #6, #7and #8

3.2 EUT information

Product name	Alert Labs Sentree A/C Sensor
Model	ALF-000008-001
Serial number	TA0.010.001.092, TA0.010.001.097, TA0.010.001.099

3.3 Technical information

Applicant IC company number	22365
IC UPN number	ALB030
All used IC test site(s) Reg. number	2040G-5
RSS number and Issue number	RSS-247 Issue 2, Feb 2017
Frequency band	902 to928 MHz
Frequency Min (MHz)	903
Frequency Max (MHz)	927.5
RF power Min (W), Conducted/ERP/EIRP	N/A
RF power Max (W), Conducted	0.0714(18.54 dBm)
Field strength, Units @ distance	N/A
Measured BW (kHz) (6 dB)	777.1
Calculated BW (kHz), as per TRC-43	N/A
Type of modulation	LoRa
Emission classification (F1D, G1D, D1D)	F1D
Transmitter spurious, Units @ distance	42.85 dBµV/m @ 3 m, at 2709 MHz
Power requirements	12 V_{DC} via AC/DC power supply(100 to 240 V_{AC})
Antenna information	The EUT uses a non-detachable antenna to the intentional radiator. Helical PCB Antenna, max gain 3.37 dBi

3.4 Product description and theory of operation

Sentree provides a monitoring and diagnostic solution for HVAC systems.

3.5 EUT exercise details

EUT was configured with test firmware provided by client, transmitter was set to continuous transmit mode.
For test purposes, three EUT were provided with test code to transmit at one of 903, 915, or 927.5 MHz, with a spreading factor of 10 and a bandwidth of 500 kHz.

3.6 EUT setup diagram

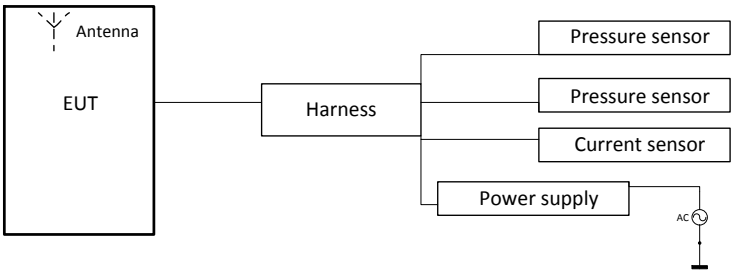


Figure 3.6-1: *Setup diagram*

3.7 EUT sub assemblies

Table 3.7-1: *EUT sub assemblies*

Description	Brand name	Model, Part number, Serial number, Revision level
Alert Labs Sentree A/C Sensor	Alert Labs	SN: TA0.010.001.095, MN: ALF-000008-001
Pressure sensor	WNK	MN: WNK80MAGOD1C1P767, PN: HDW-000040-001
Current sensor	JiangYin Spark	MN: MN: XH-SCT-T16, 70 Aac to 0.333 Vac, PN: ASY-000060-001
harness	None	PN: ASY-000059-001
Power supply	Mean Well	PN: APV-16-12 /ASY-000070-001

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

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	FA002532	2 year	June 5/19
Flush mount turntable	Sunol	FM2022	FA002550	—	NCR
Controller	Sunol	SC104V	FA002551	—	NCR
Antenna mast	Sunol	TLT2	FA002552	—	NCR
50 Ω coax cable	C.C.A.	None	FA002603	—	VOU
50 Ω coax cable	C.C.A.	None	FA002605	—	VOU
50 Ω coax cable	C.C.A.	None	FA002831	—	VOU
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 40	FA002071	1 year	Sept. 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
Pre-amplifier (0.5–18 GHz)	COM-POWER	PAM-118A	FA002561	1 year	Sept. 21/18
High Pass Filter (> 1200 MHz)	Microwave Circuits	H1G212G1	FA002689	—	VOU
50 Ω coax cable	HUBER+SUHNER	SUCOFLEX 100	FA002564	—	VOU
Power sensor	Rohde & Schwarz	NRP18S	FA002730	1 year	July 21/18
High Pass Filter (> 1100 MHz)	Microwave Circuits	H1G212G1	FA002342	—	VOU

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

Section 8. Testing data

8.1 FCC 15.31(e) Variation of power source

8.1.1 Definitions and limits

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	July 18, 2018

8.1.3 Observations, settings and special notes

Power source variation was performed on the 12 V DC input.

8.1.4 Test data

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

8.2 FCC 15.203 and RSS-Gen, section 6.8 Antenna requirement

8.2.1 Definitions and limits

FCC:
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.

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

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

8.2.2 Test date

Start date	July 6, 2018

8.2.3 Observations, settings and special notes

None

8.2.4 Test data

Must the EUT be professionally installed?	☐ YES	☒ NO	
Does the EUT have detachable antenna(s)?	☐ YES	☒ NO	
If detachable, is the antenna connector(s) non-standard?	☐ YES	☐ NO	☒ N/A

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

8.3.1 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.

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 8.3-1: *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.

8.3.2 Test date

Start date	July 4, 2018

8.3.3 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.

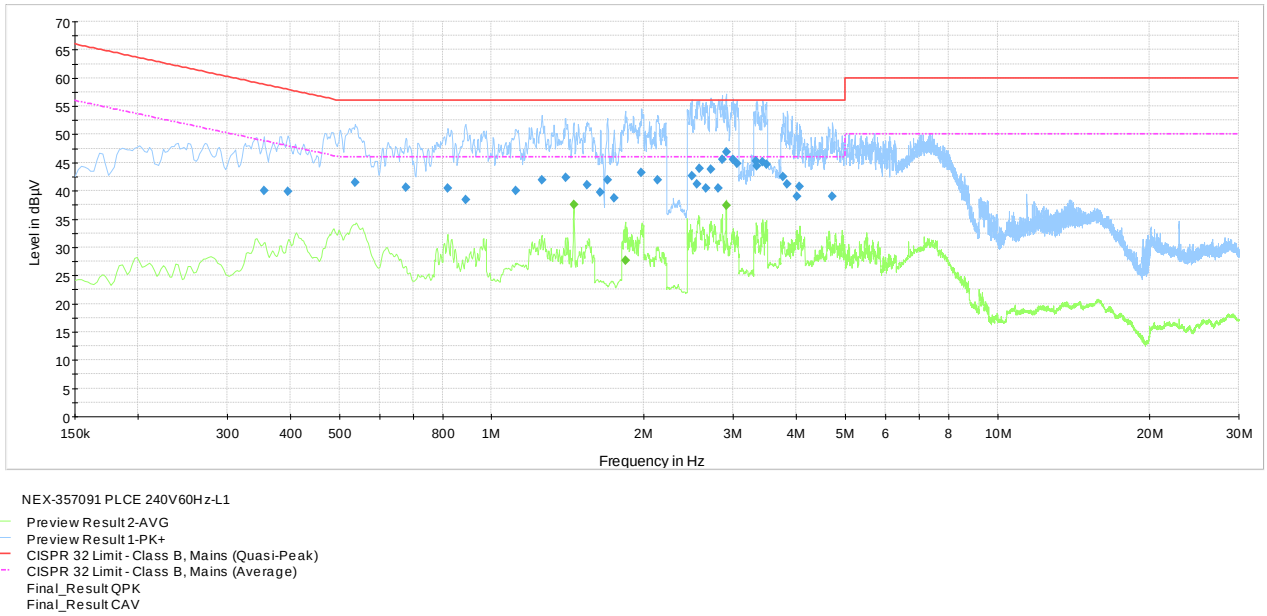
Receiver settings for preview measurements:

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

8.3.4 Test data



Plot 8.3-1: *Conducted emissions on phase line*

Table 8.3-2: Conducted emissions – from AC mains power ports (Quasi-Peak) results

Frequency (MHz)	Quasi-Peak result[1] [and 3] (dBµV)	Quasi-Peak limit (dBµV)	Margin (dB)	Measurement time (ms)	Bandwidth (kHz)	Conductor	Filter	Correction factor[2] (dB)
0.355	40.1	58.9	18.8	100	9	L1	ON	9.4
0.395	39.9	58.0	18.1	100	9	L1	ON	9.5
0.537	41.4	56.0	14.6	100	9	L1	ON	9.5
0.677	40.7	56.0	15.3	100	9	L1	ON	9.5
0.821	40.4	56.0	15.6	100	9	L1	ON	9.5
0.888	38.4	56.0	17.6	100	9	L1	ON	9.5
1.118	40.0	56.0	16.0	100	9	L1	ON	9.6
1.257	41.9	56.0	14.1	100	9	L1	ON	9.6
1.401	42.3	56.0	13.7	100	9	L1	ON	9.6
1.547	41.0	56.0	15.0	100	9	L1	ON	9.6
1.642	39.7	56.0	16.3	100	9	L1	ON	9.6
1.696	42.0	56.0	14.0	100	9	L1	ON	9.6
1.748	38.7	56.0	17.3	100	9	L1	ON	9.6
1.979	43.2	56.0	12.8	100	9	L1	ON	9.6
2.128	41.9	56.0	14.1	100	9	L1	ON	9.6
2.488	42.7	56.0	13.3	100	9	L1	ON	9.7
2.544	41.2	56.0	14.8	100	9	L1	ON	9.7
2.576	44.0	56.0	12.0	100	9	L1	ON	9.7
2.650	40.5	56.0	15.5	100	9	L1	ON	9.7
2.713	43.9	56.0	12.1	100	9	L1	ON	9.7
2.810	40.5	56.0	15.5	100	9	L1	ON	9.7
2.857	45.5	56.0	10.5	100	9	L1	ON	9.7
2.909	46.8	56.0	9.2	100	9	L1	ON	9.7
3.001	45.5	56.0	10.5	100	9	L1	ON	9.7
3.055	44.8	56.0	11.2	100	9	L1	ON	9.7
3.336	45.2	56.0	10.8	100	9	L1	ON	9.7
3.350	44.4	56.0	11.6	100	9	L1	ON	9.7
3.437	45.2	56.0	10.8	100	9	L1	ON	9.8
3.491	44.7	56.0	11.3	100	9	L1	ON	9.8
3.775	42.5	56.0	13.5	100	9	L1	ON	9.8
3.845	41.2	56.0	14.8	100	9	L1	ON	9.8
4.016	39.0	56.0	17.0	100	9	L1	ON	9.8
4.061	40.8	56.0	15.2	100	9	L1	ON	9.8
4.722	39.0	56.0	17.0	100	9	L1	ON	9.8

Notes:
[1] Result (dBµV) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + attenuator (dB)
[3] Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded.

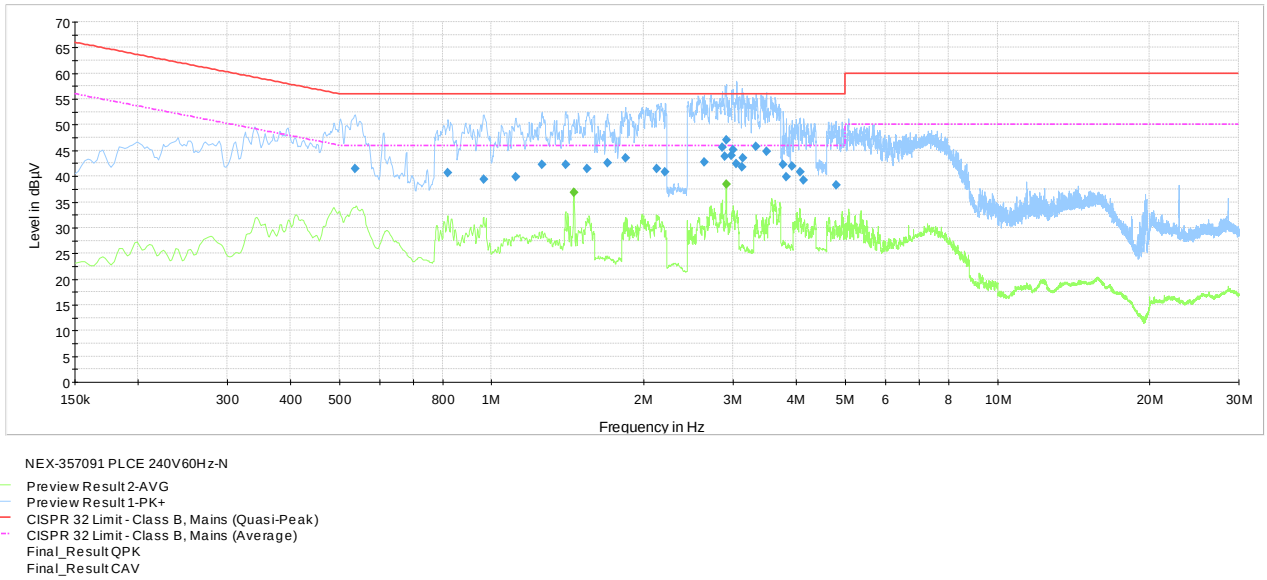
Sample calculation: 40.1 dBµV (result) = 30.7 dBµV (receiver reading) + 9.4 dB (Correction factor)

Table 8.3-3: Conducted emissions – from AC mains power ports (CAverage) results

Frequency (MHz)	CAverage result[1] [and 3] (dBµV)	CAverage limit (dBµV)	Margin (dB)	Measurement time (ms)	Bandwidth (kHz)	Conductor	Filter	Correction factor[2] (dB)
1.453	37.5	46.0	8.5	160	9	L1	ON	9.6
1.838	27.6	46.0	18.4	160	9	L1	ON	9.6
2.909	37.4	46.0	8.6	160	9	L1	ON	9.7

Notes:
[1] Result (dBµV) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + attenuator (dB)
[3] Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded.

Sample calculation: 40.1 dBµV (result) = 30.7 dBµV (receiver reading) + 9.4 dB (Correction factor)



Plot 8.3-2: *Conducted emissions on neutral line*

Table 8.3-4: Conducted emissions – from AC mains power ports (Quasi-Peak) results

Frequency (MHz)	Quasi-Peak result[1] [and 3] (dBµV)	Quasi-Peak limit (dBµV)	Margin (dB)	Measurement time (ms)	Bandwidth (kHz)	Conductor	Filter	Correction factor[2] (dB)
0.537	41.5	56.0	14.5	160	9	N	ON	9.5
0.821	40.6	56.0	15.4	100	9	N	ON	9.5
0.967	39.4	56.0	16.6	100	9	N	ON	9.5
1.115	39.9	56.0	16.1	100	9	N	ON	9.6
1.257	42.3	56.0	13.7	100	9	N	ON	9.6
1.401	42.3	56.0	13.7	100	9	N	ON	9.6
1.547	41.5	56.0	14.5	100	9	N	ON	9.6
1.694	42.6	56.0	13.4	100	9	N	ON	9.6
1.838	43.5	56.0	12.5	100	9	N	ON	9.6
2.121	41.4	56.0	14.6	100	9	N	ON	9.6
2.204	40.8	56.0	15.2	100	9	N	ON	9.7
2.630	42.7	56.0	13.3	100	9	N	ON	9.7
2.857	45.6	56.0	10.4	100	9	N	ON	9.7
2.895	43.8	56.0	12.2	100	9	N	ON	9.7
2.911	47.0	56.0	9.0	100	9	N	ON	9.7
2.983	44.0	56.0	12.0	100	9	N	ON	9.7
2.999	45.2	56.0	10.8	100	9	N	ON	9.7
3.050	42.4	56.0	13.6	100	9	N	ON	9.7
3.125	41.8	56.0	14.2	100	9	N	ON	9.7
3.143	43.6	56.0	12.4	100	9	N	ON	9.7
3.334	45.8	56.0	10.2	100	9	N	ON	9.7
3.491	44.8	56.0	11.2	100	9	N	ON	9.8
3.773	42.3	56.0	13.7	100	9	N	ON	9.8
3.827	39.8	56.0	16.2	100	9	N	ON	9.8
3.928	42.0	56.0	14.0	100	9	N	ON	9.8
4.072	40.8	56.0	15.2	100	9	N	ON	9.8
4.142	39.2	56.0	16.8	100	9	N	ON	9.8
4.794	38.3	56.0	17.7	100	9	N	ON	9.8

Notes:
[1] Result (dBµV) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + attenuator (dB)
[3] Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded.

Sample calculation: 40.1 dBµV (result) = 30.7 dBµV (receiver reading) + 9.4 dB (Correction factor)

Table 8.3-5: Conducted emissions – from AC mains power ports (CAverage) results

Frequency (MHz)	CAverage result[1] [and 3] (dBµV)	CAverage limit (dBµV)	Margin (dB)	Measurement time (ms)	Bandwidth (kHz)	Conductor	Filter	Correction factor[2] (dB)
1.455	36.8	46.0	9.2	160	9	N	ON	9.6
2.909	38.4	46.0	7.6	160	9	N	ON	9.7

Notes:
[1] Result (dBµV) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + attenuator (dB)
[3] Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded.

Sample calculation: 40.1 dBµV (result) = 30.7 dBµV (receiver reading) + 9.4 dB (Correction factor)

8.4 FCC 15.247(a)(2) and RSS-247 5.2(a) Minimum 6 dB bandwidth for DTS systems

8.4.1 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.

ISED:
The minimum 6 dB bandwidth shall be 500 kHz.

8.4.1 Test date

Start date	July 6, 2018

8.4.2 Observations, settings and special notes

Spectrum analyser settings:

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

99% bandwidth is measured for information purpose.

8.4.3 Test data

Table 8.4-1: *6 dB bandwidth results*

Frequency, MHz	6 dB bandwidth, kHz	Limit, kHz	Margin, kHz
903.0	777.1	500	277.1
915.0	672.9	500	172.9
927.5	712.0	500	212.0

Table 8.4-2: *99% occupied bandwidth results*

Frequency, MHz	99% occupied bandwidth, kHz
903.0	664.3
915.0	616.5
927.5	638.2

Note: there is no 99% occupied bandwidth limit in the standard's requirements, the measurement results provided for information purposes only.

8.4.4 Test data, continued

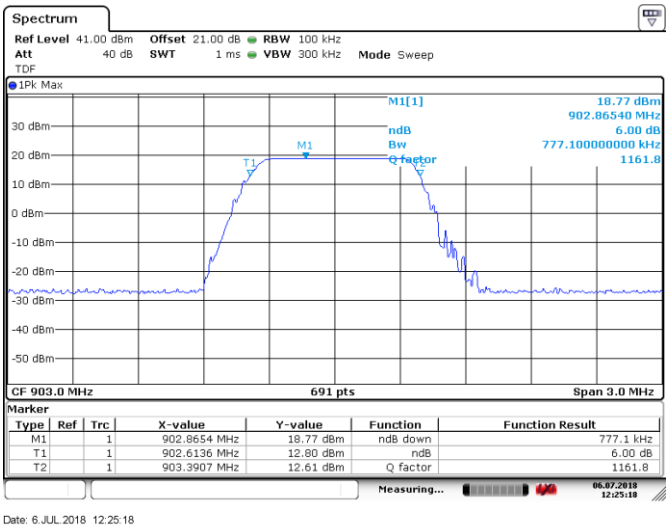


Figure 8.4-1: 6 dB bandwidth on low channel

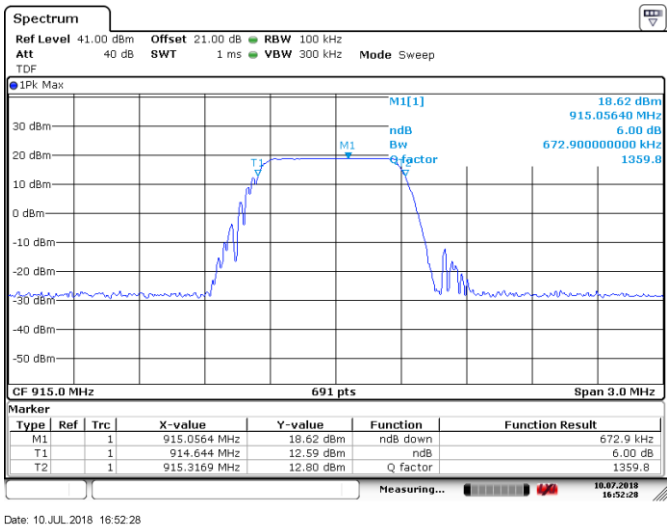


Figure 8.4-2: 6 dB bandwidth on mid channel

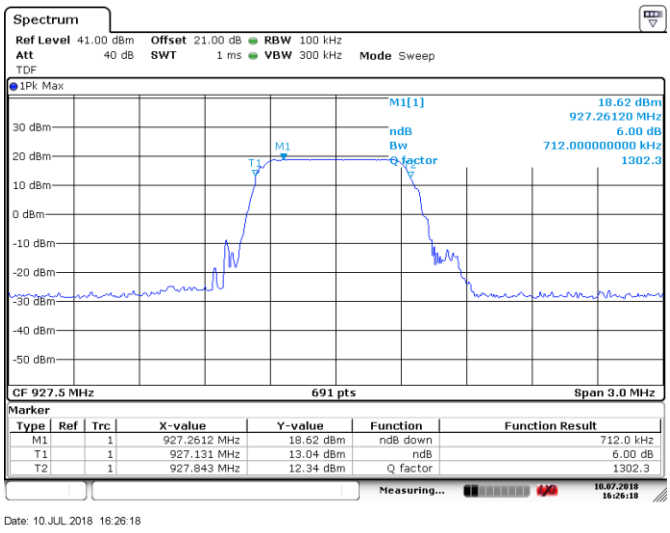


Figure 8.4-3: 6 dB bandwidth on high channel

8.4.1 Test data, continued

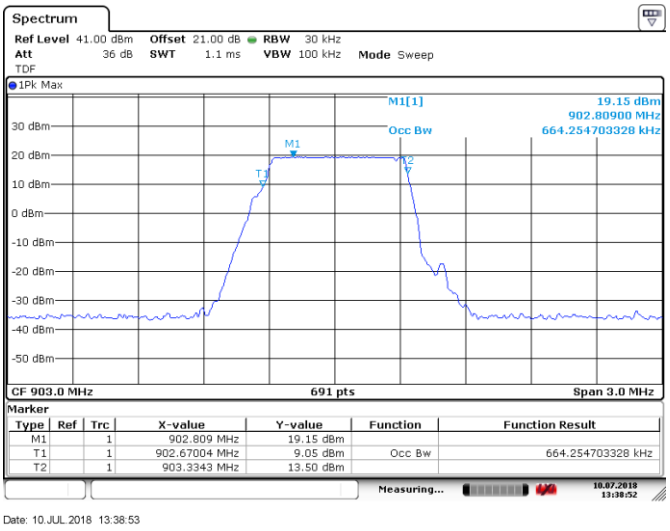


Figure 8.4-4: 99% bandwidth on low channel

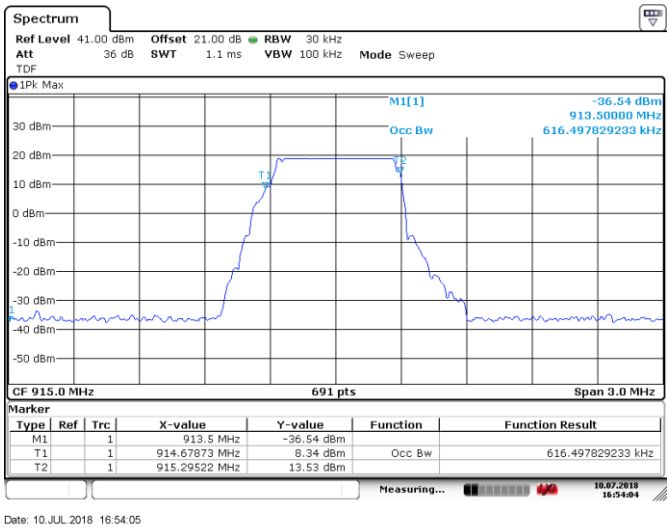


Figure 8.4-5: 99% bandwidth on mid channel

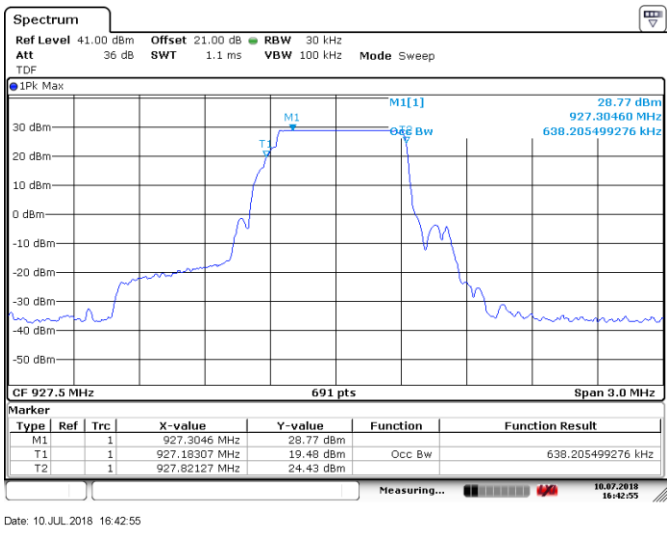


Figure 8.4-6: 99% bandwidth on high channel

8.5 FCC 15.247(b) and RSS-247 5.4 (d) Transmitter output power and e.i.r.p. requirements for DTS in 900 MHz

8.5.1 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 902–928 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:

(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.

ISED:

d. For DTSs employing digital modulation techniques operating in the 902–928 MHz band, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

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

8.5.1 Test date

Start date	July 6, 2018

8.5.2 Observations, settings and special notes

The test was performed using method AVGPM-G (Measurement using a gated RF average-reading power meter).

8.5.3 Test data

Table 8.5-1: *Output power measurements results*

Frequency, MHz	Conducted output power, dBm		Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
	Measured	Limit					
903.0	18.54	30	11.46	3.37	21.91	36	14.09
915.0	18.37	30	11.63	3.37	21.74	36	14.26
927.5	18.40	30	11.60	3.37	21.77	36	14.23

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

8.6.1 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)).

ISED:
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

Table 8.6-1: *FCC §15.209 and RSS-Gen – Radiated emission limits*

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

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

Table 8.6-2: *ISED restricted frequency bands*

MHz	MHz	MHz	GHz
0.090–0.110	12.57675–12.57725	399.9–410	7.25–7.75
0.495–0.505	13.36–13.41	608–614	8.025–8.5
2.1735–2.1905	16.42–16.423	960–1427	9.0–9.2
3.020–3.026	16.69475–16.69525	1435–1626.5	9.3–9.5
4.125–4.128	16.80425–16.80475	1645.5–1646.5	10.6–12.7
4.17725–4.17775	25.5–25.67	1660–1710	13.25–13.4
4.20725–4.20775	37.5–38.25	1718.8–1722.2	14.47–14.5
5.677–5.683	73–74.6	2200–2300	15.35–16.2
6.215–6.218	74.8–75.2	2310–2390	17.7–21.4
6.26775–6.26825	108–138	2483.5–2500	22.01–23.12
6.31175–6.31225	149.9–150.05	2655–2900	23.6–24.0
8.291–8.294	156.52475–156.52525	3260–3267	31.2–31.8
8.362–8.366	156.7–156.9	3332–3339	36.43–36.5
8.37625–8.38675	162.0125–167.17	3345.8–3358	Above 38.6
8.41425–8.41475	167.72–173.2	3500–4400	
12.29–12.293	240–285	4500–5150	
12.51975–12.52025	322–335.4	5350–5460	

Note: Certain frequency bands listed in Table 8.6-2 and above 38.6 GHz are designated for licence-exempt applications. These frequency bands and the requirements that apply to related devices are set out in the 200 and 300 series of RSSs.

Table 8.6-3: *FCC restricted frequency bands*

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

8.6.1 Test date

Start date	July 6, 2018

8.6.2 Observations, settings and special notes

The spectrum was searched from 30 MHz to the 10th harmonic.
EUT was set to transmit with constant duty cycle.
Radiated measurements were performed at a distance of 3 m. . Cabinet radiation emissions tests were performed while the antenna port was terminated with a 50 Ω load in place of the antenna.
Since fundamental power was tested using maximum conducted (average) output power procedure to demonstrate compliance, the spurious emissions limit is −30 dBc/100 kHz.

Spectrum analyser settings for conducted spurious emissions measurements:

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

Spectrum analyser settings for conducted 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 conducted 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 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

8.6.4 Test data

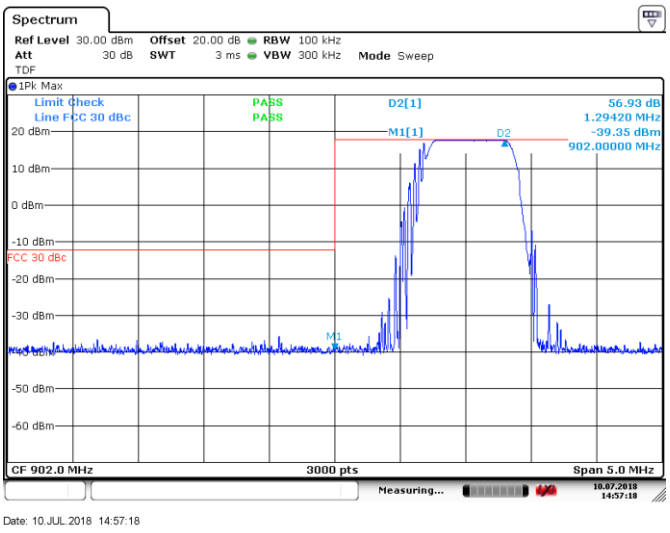


Figure 8.6-1: Conducted spurious emission at band edge outside restricted band, low channel

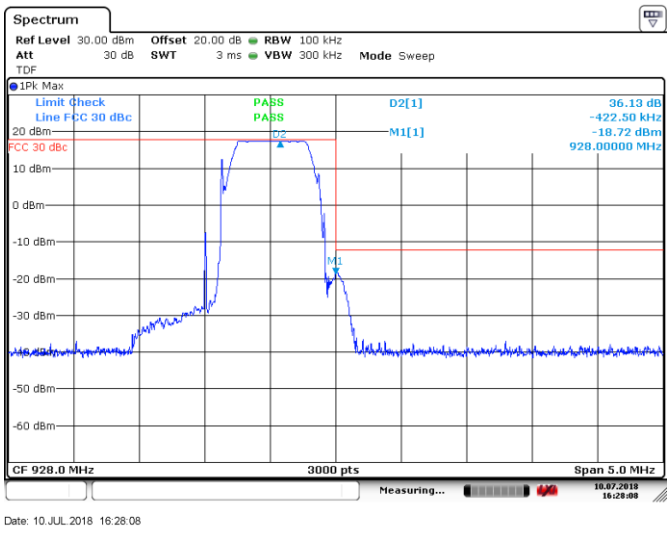


Figure 8.6-2: Conducted spurious emissions at band edge outside restricted band, High channel

8.6.4 Test data, continued

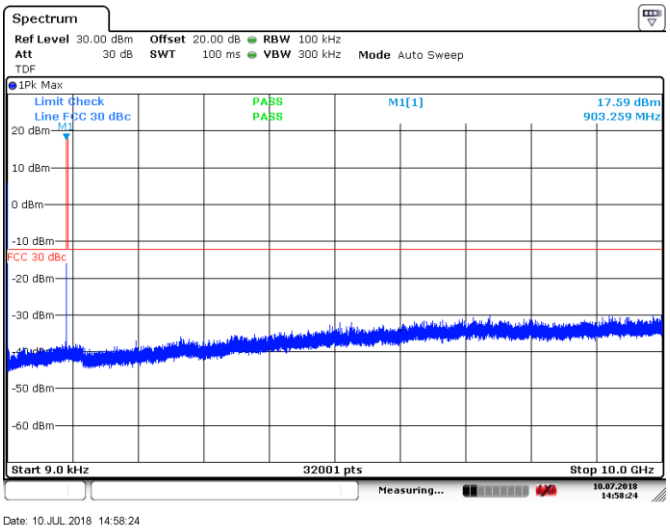


Figure 8.6-3: Conducted spurious emissions outside restricted band, Low channel

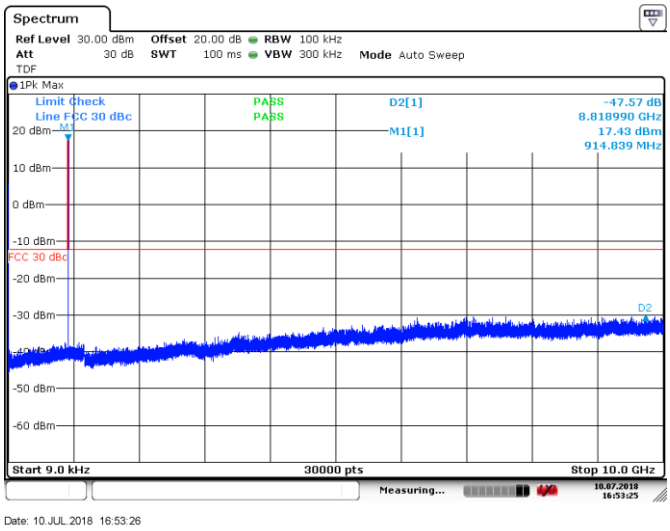


Figure 8.6-4: Conducted spurious emissions outside restricted band, Mid channel

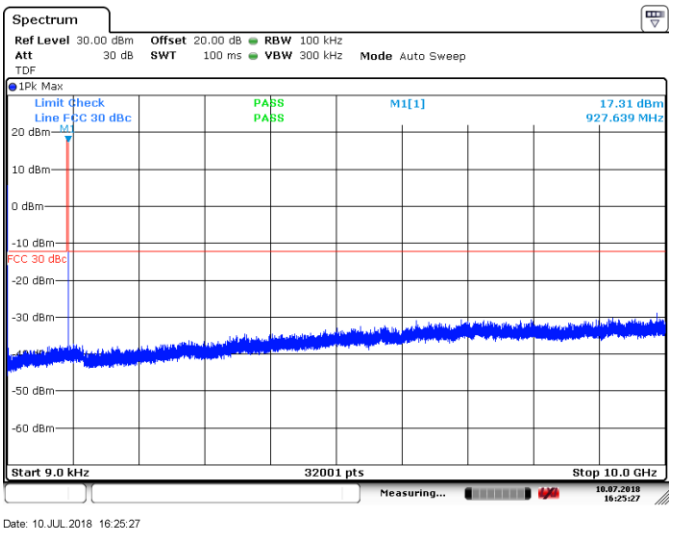


Figure 8.6-5: Conducted spurious emissions outside restricted band, High channel

8.6.4 Test data, continued

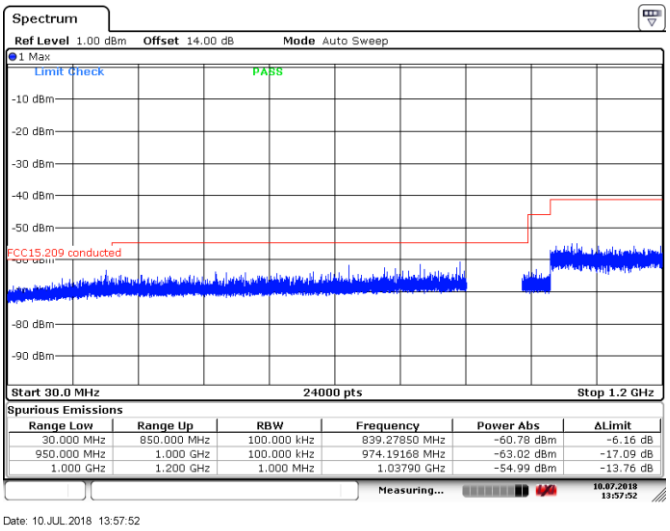


Figure 8.6-6: Conducted spurious emissions below 1.2 GHz, within restricted band, Low channel

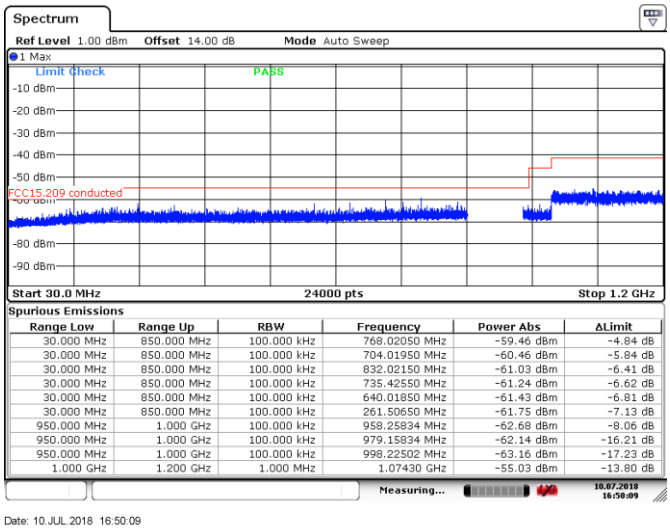


Figure 8.6-7: Conducted spurious emissions below 1.2 GHz, within restricted band, Mid channel

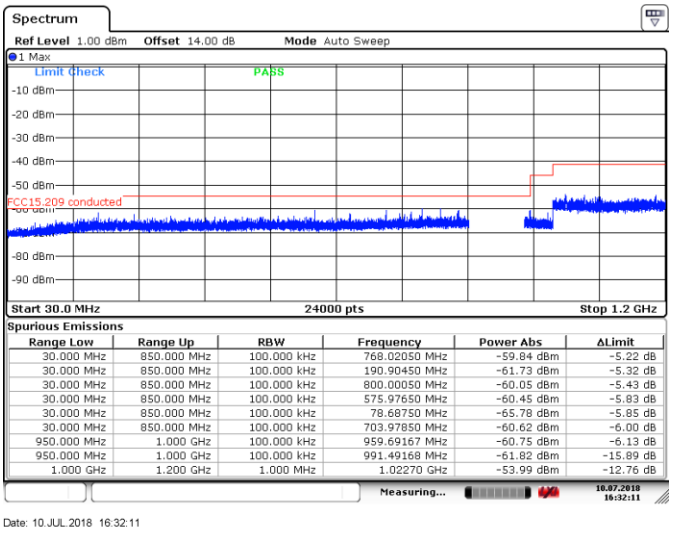


Figure 8.6-8: Conducted spurious emissions below 1.2 GHz, within restricted band, High channel

Note: EUT's antenna gain and ground reflection factor below 1 GHz was included in the factors on above plots
Peak measurements were found below quasi-peak/ average limits, hence no quasi-peak/average measurements were taken and deemed to be compliance.

8.6.4 Test data, continued

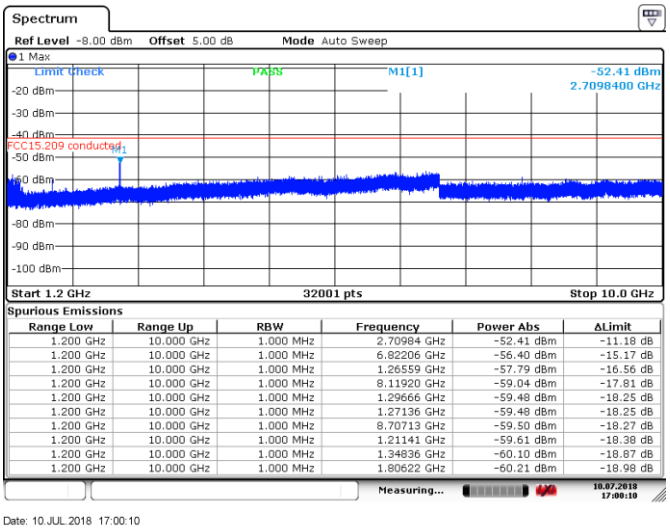


Figure 8.6-9: Conducted spurious emissions above 1.2 GHz, within restricted band, Low channel

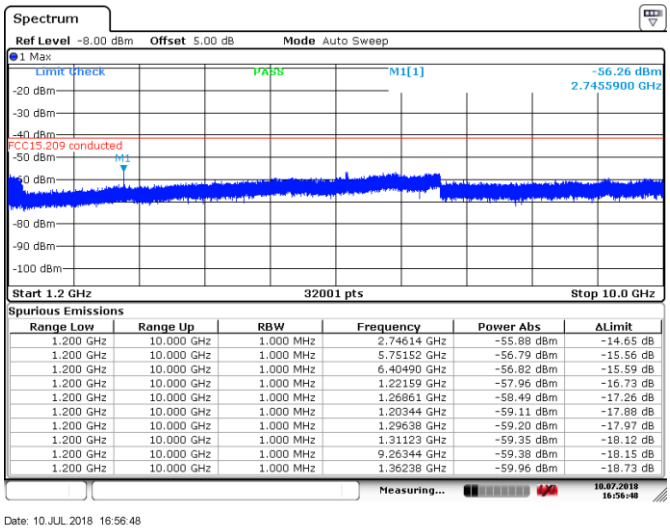


Figure 8.6-10: Conducted spurious emissions above 1.2 GHz, within restricted band, Mid channel

Note: Transmitter spurious emission calculation as below:
E = EIRP – 20log D + 104.8 =-52.41 – 20Log 3 + 104.8 = 42.85 dBµV/m at 3m
margin of compliance = 54 – 42.85 = 11.15 dB
where:
E = electric field strength in dBµV/m,
EIRP = equivalent isotropic radiated power in dBm = -52.41 dBm
D = specified measurement distance in meters = 3 m
Average field strength limit = 54 dBµV/m at 3m

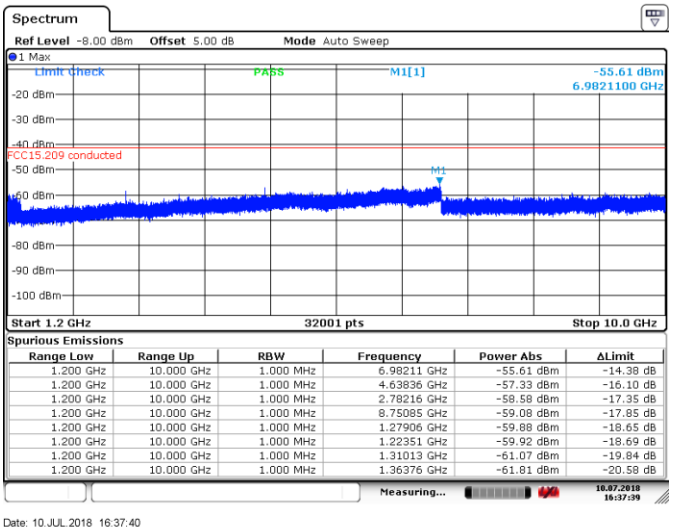


Figure 8.6-11: Conducted spurious emissions above 1.2 GHz, within restricted band, high channel

Note: EUT's antenna gain was included in the factors on above plots
Peak measurements were found below quasi-peak/ average limits, hence no quasi-peak/average measurements were taken and deemed to be compliance.

8.6.4 Test data, continued

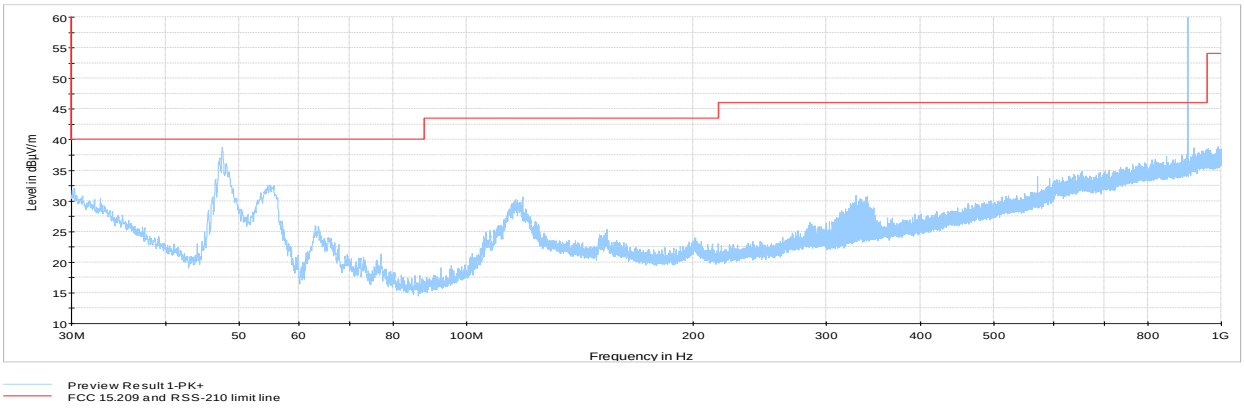


Figure 8.6-12: Cabinet Radiated spurious emissions 30 MHz to1 GHz, Low channel

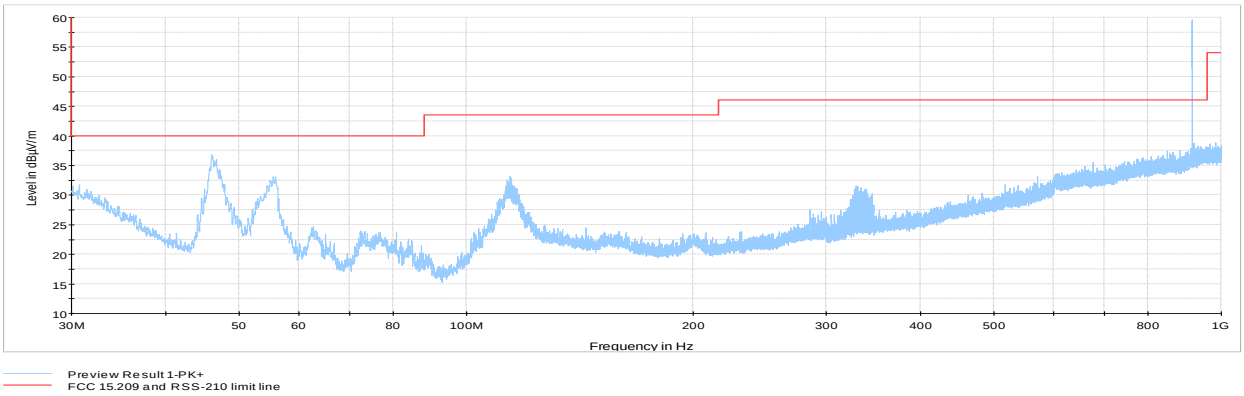


Figure 8.6-13: Cabinet Radiated spurious emissions 30 MHz to1 GHz, Mid channel

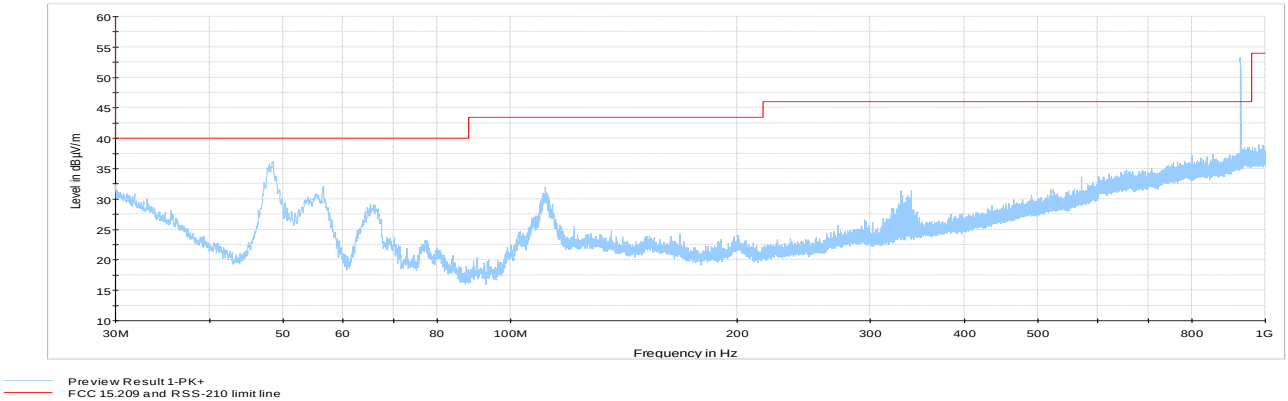


Figure 8.6-14: Cabinet Radiated spurious emissions 30 MHz to1 GHz, High channel

Note: Emissions in band 902 to 928 MHz of plots above are from intentional transmissions. Emissions at 47 MHz are not related to RF portion.

8.6.4 Test data, continued

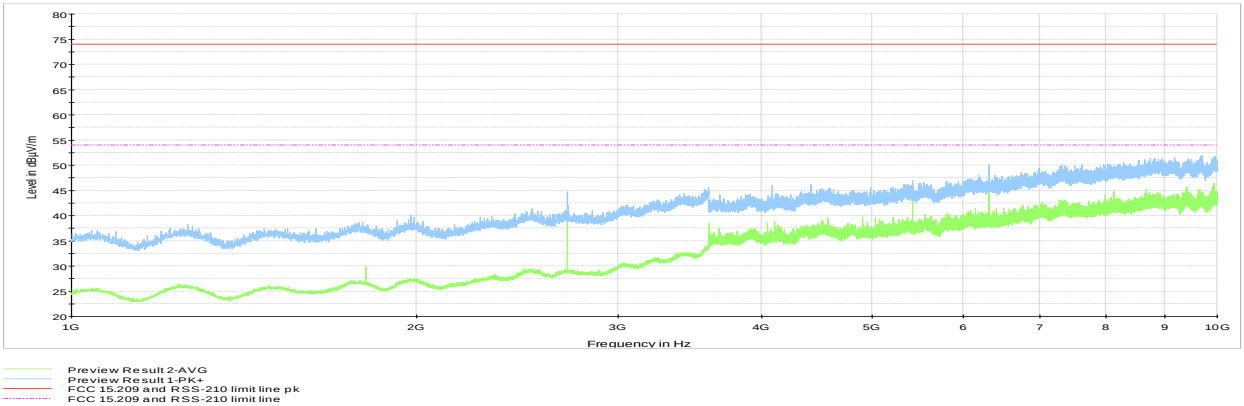


Figure 8.6-15: Cabinet Radiated spurious emissions 1 to10 GHz, Low channel

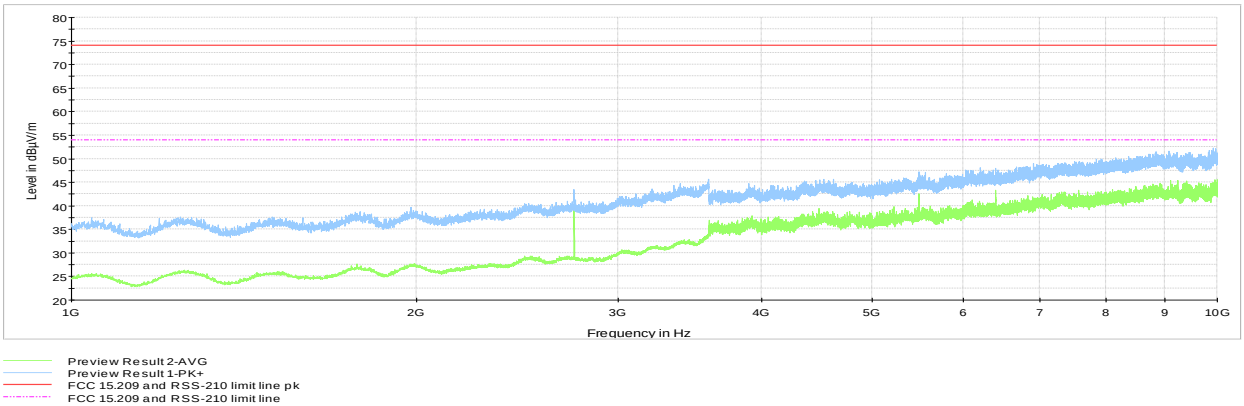


Figure 8.6-16: Cabinet Radiated spurious emissions 1 to10 GHz, Mid channel

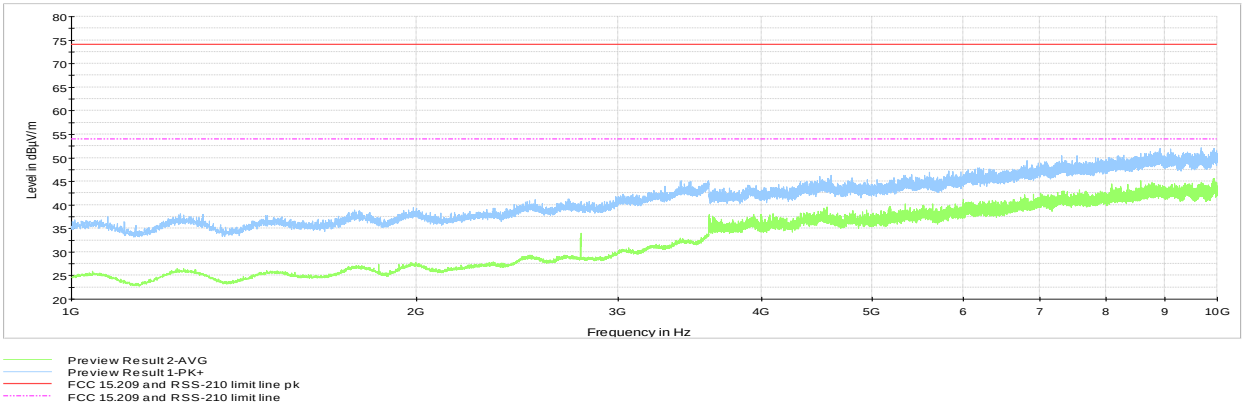


Figure 8.6-17: Cabinet Radiated spurious emissions 1 to10 GHz, High channel

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

8.7.1 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.

ISED:
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(d), (i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

8.7.1 Test date

Start date	July 12, 2018

8.7.2 Observations, settings and special notes

The test was performed using method AVGPSD-1 (trace averaging with EUT transmitting at full power throughout each sweep).
Spectrum analyzer settings:

Resolution bandwidth:	3 kHz
Video bandwidth:	≥3 × RBW
Frequency span:	1.2 MHz
Detector mode:	RMS
Trace mode:	Power average
Averaging sweeps number:	100

8.7.3 Test data

Table 8.7-1: PSD measurements results

Frequency, MHz	PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
903.0	0.16	8	7.84
915.0	-0.39	8	8.39
927.5	-0.46	8	8.46

8.7.1 Test data, continued

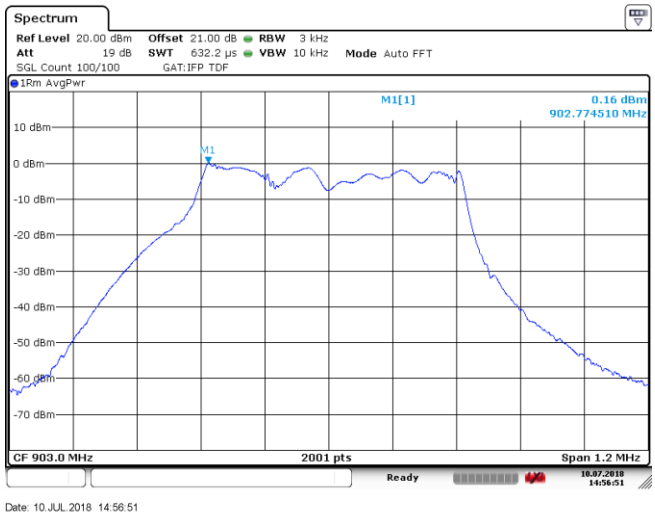


Figure 8.7-1: PSD plot on Low channel

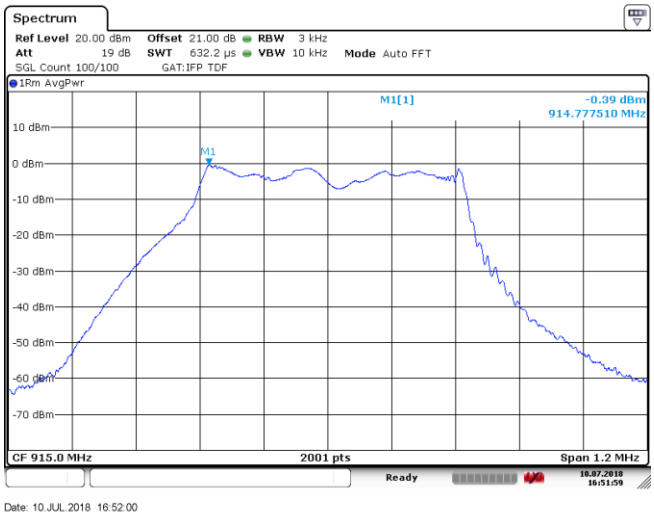


Figure 8.7-2: PSD plot on Mid channel

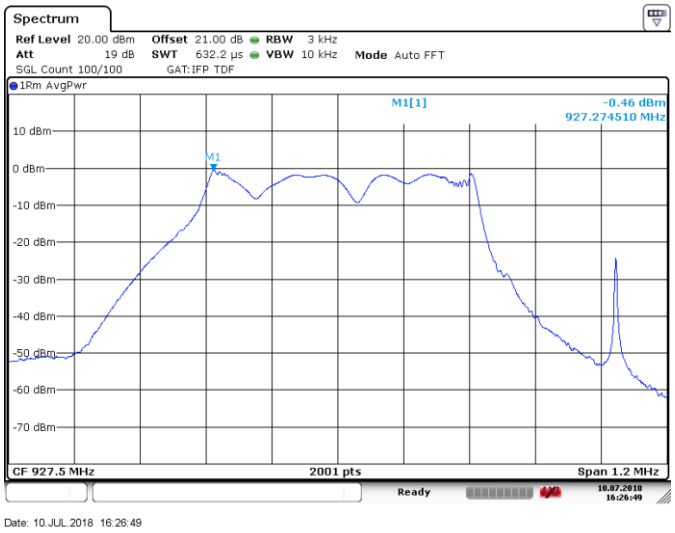
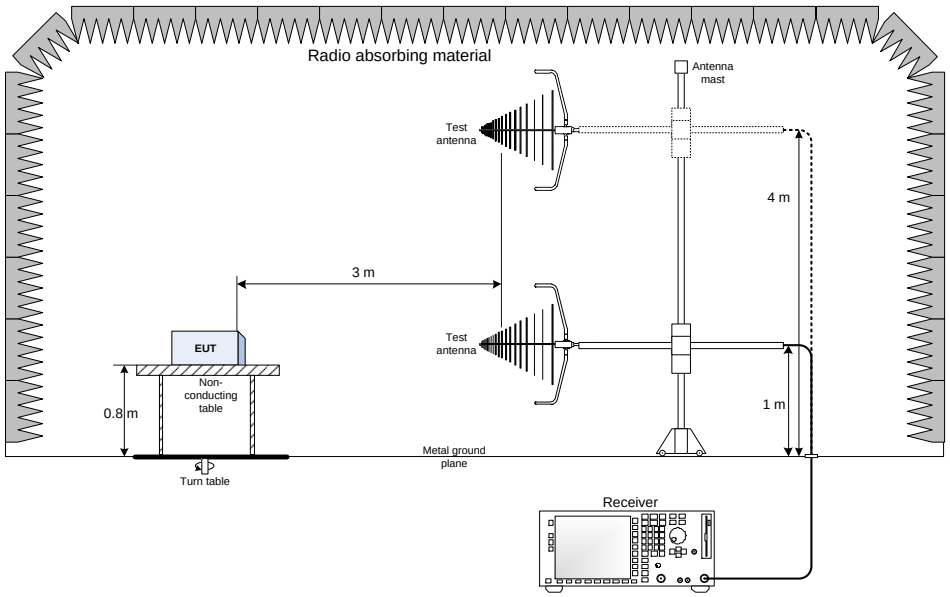


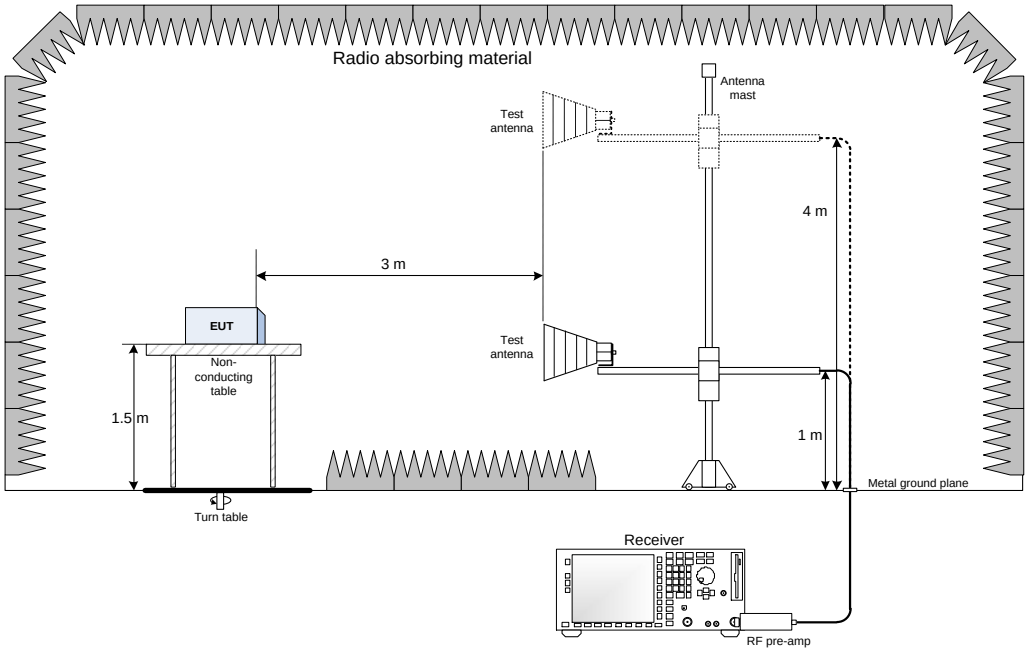
Figure 8.7-3: PSD plot on High channel

Section 9. Block diagrams of test set-ups

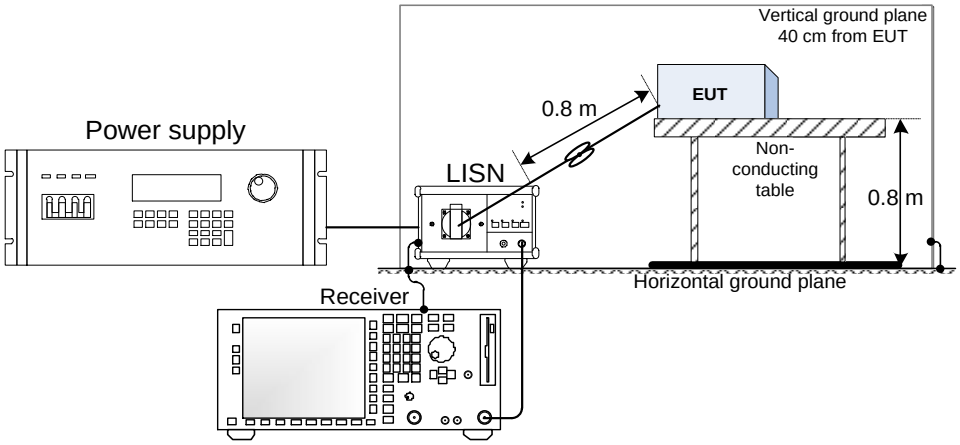
9.1 Radiated emissions set-up for frequencies below 1 GHz



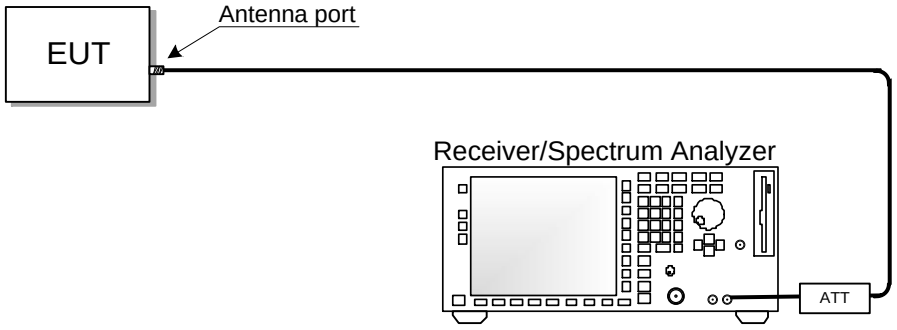
9.2 Radiated emissions set-up for frequencies above 1 GHz



9.3 Conducted emissions set-up



9.4 Antenna port set-up



(End of report)