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Test report

333641-1TRFWL

Date of issue: October 31, 2017

Applicant:

Cranesmart Systems Inc

Product:

LMI4 Display, UTX-900 Transducer

Model:	Model Variant:
LMI4 / UTX 3.0	LMI4 / UTX-900 Transducer

FCC ID:	IC Registration number:
NFB30UTX	2849A-30UTX

Specifications:

- FCC 47 CFR Part 15 Subpart C, §15.249
  Operation in the 902–928 MHz, 2400–2483.5 MHz, 5725–5875 MHz and 24.0–24.25 GHz
- RSS-210, Issue 9, December 2016, Annex F
  Devices operating in frequency bands 902–928, 2400–2483.5 and 5725–5875 MHz for any application

Test location

Company name:	Nemko Canada Inc.
Address:	303 River Road
City:	Ottawa
Province:	Ontario
Postal code:	K1V 1H2
Country:	Canada
Telephone:	+1 613 737 9680
Facsimile:	+1 613 737 9691
Toll free:	+1 800 563 6336
Website:	www.nemko.com
Site number:	FCC: 176392; IC: 2040A-4 (3 m semi anechoic chamber)

Tested by:	Kevin Rose, Wireless/EMC Specialist
Reviewed by:	David Duchesne, Senior EMC/Wireless Specialist
Date:	October 31, 2017
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 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/Manufacturers

Company name	CRANESMART SYSTEMS INC.
Address	4908, 97th Street, Edmonton, Alberta, Canada, T6E 5S1

1.2 Test specifications

FCC 47 CFR Part 15, Subpart C, Clause 15.249	Operation in the 902–928 MHz, 2400–2483.5 MHz, 5725–5875 MHz and 24.0–24.25 GHz
RSS-210, Issue 9 Annex B.10	Devices operating in frequency bands 902–928, 2400–2483.5 and 5725–5875 MHz for any application

1.3 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.

1.4 Exclusions

None

1.5 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	Not applicable
§15.215(c)	20 dB emission bandwidth	Pass

Note: The EUT uses a 3.6 Vdc cell battery.

2.2 FCC Part 15 Subpart C – Intentional Radiators, test results

Part	Test description	Verdict
§15.249(a)	Field strength of fundamental and harmonics emissions	Pass
§15.249(d)	Spurious emissions (except harmonics)	Pass

2.3 IC RSS-GEN, Issue 4, test results

Clause	Test description	Verdict
6.6	Occupied bandwidth	Pass
7.1.2	Receiver Radiated Limits	Pass
7.1.3	Receiver Conducted Limits	Not applicable
8.8	AC power lines conducted emission limits	Not applicable

Note: 1 None

2.4 RSS-210, Issue 9, test results

Part	Test description	Verdict
§B.10 (a)	Field strength of fundamental and harmonics emissions	Pass
§B.10 (b)	Spurious emissions (except harmonics)	Pass

Section 3 Equipment under test (EUT) details

3.1 Sample information

Receipt date	June 26, 2017
Nemko sample ID number	1 and 2

3.2 EUT information

Product name	LMI4 Display, UTX-900 Transducer
Model	LMI4 / UTX 3.0
Model variant	LMI4 Display, UTX-900 Transducer
Serial number	44448-2, 40899-3, 42871-6, 42871-9, 44379-8 / 44187-3, 44187-4, 42764-10, 44704-6, 44187-5

3.3 Technical information

Operating band	902–928 MHz
Operating frequency	915.72–927.415 MHz
Modulation type	GFSK + Digital Modulation Techniques
Occupied bandwidth (99 %)	217.95
Emission designator	F1D
Power requirements	3.6 V_{DC} Cell battery.
Antenna information	Internal PCB antenna The EUT uses a unique antenna coupling/ non-detachable antenna to the intentional radiator.

3.4 Product description and theory of operation

UTX 3.0 Angle Transducer measures crane boom angle and wirelessly sends this information to the LMI4 display inside the crane cab for the operator.

3.5 EUT exercise details

The EUT was setup for each angle transducer and display to work together.

3.6 EUT setup Figure

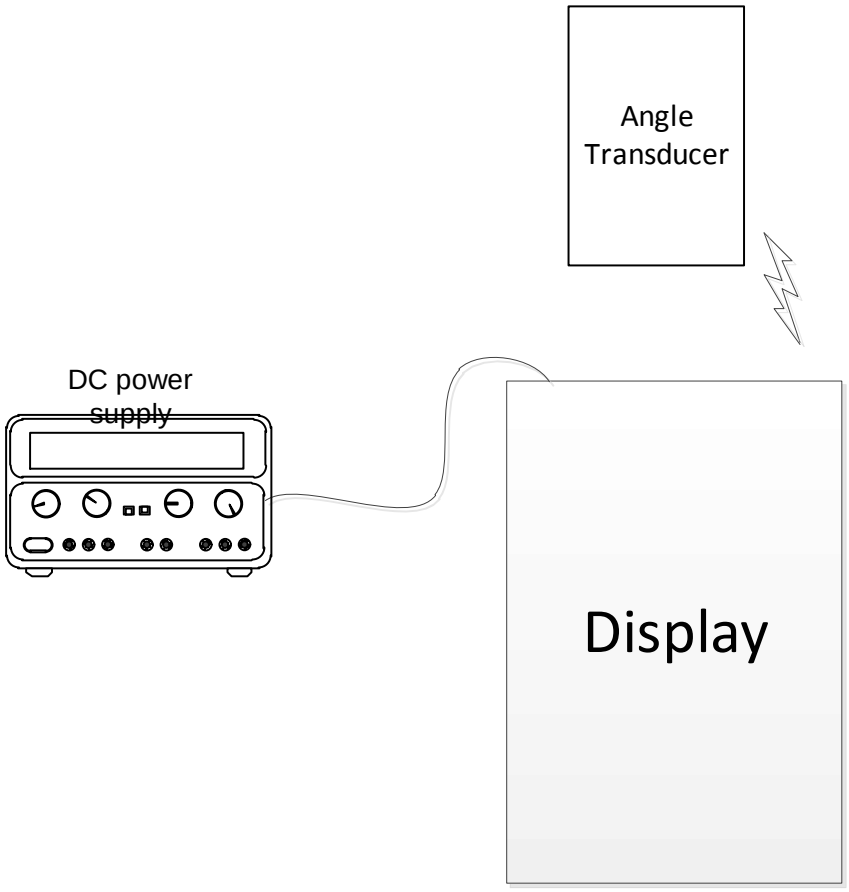


Figure 3.6-1: Setup diagram

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

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

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
3 m EMI test chamber	TDK	SAC-3	FA002047	1 year	Dec. 01/17
Flush mount turntable	Sunol	FM2022	FA002082	—	NCR
Controller	Sunol	SC104V	FA002060	—	NCR
Antenna mast	Sunol	TLT2	FA002061	—	NCR
AC Power source	Chenwa	2700M-10k	FA002716	—	VOU
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 26	FA002043	1 year	Jan. 31/18
Bilog antenna (20–3000 MHz)	Sunol	JB3	FA002108	1 year	June 27/18
Horn antenna (1–18 GHz)	EMCO	3115	FA000825	1 year	June 21/18
Horn with Preamp	ETS-Lindgren	3117-PA	FA002840	1 year	Nov. 11/17
Spectrum analyzer	Rohde & Schwarz	FSP	FA001920	2 year	Aug. 20/17

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

Section 8 Testing data

8.1 FCC Clause 15.215(c) Emission bandwidth and RSS-Gen Clause 6.6 Occupied bandwidth

8.1.1 Definitions and limits

FCC Part 15.215(c)

Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§15.217 through 15.257 and in Subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80 % of the permitted band in order to minimize the possibility of out-of-band operation.

RSS-Gen Clause 6.6 Occupied bandwidth

When an occupied bandwidth value is not specified in the applicable RSS, the transmitted signal bandwidth to be reported is to be its 99 percent emission bandwidth, as calculated or measured.

The transmitter shall be operated at its maximum carrier power measured under normal test conditions.

The span of the analyzer shall be set to capture all products of the modulation process, including the emission skirts. The resolution bandwidth shall be set to as close to 1 percent of the selected span as is possible without being below 1 percent. The video bandwidth shall be set to 3 times the resolution bandwidth. Video averaging is not permitted. Where practical, a sampling detector shall be used since a peak or, peak hold, may produce a wider bandwidth than actual.

The trace data points are recovered and are directly summed in linear terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5 percent of the total is reached and that frequency recorded. The process is repeated for the highest frequency data points. This frequency is recorded.

The span between the two recorded frequencies is the occupied bandwidth.

8.1.2 Test summary

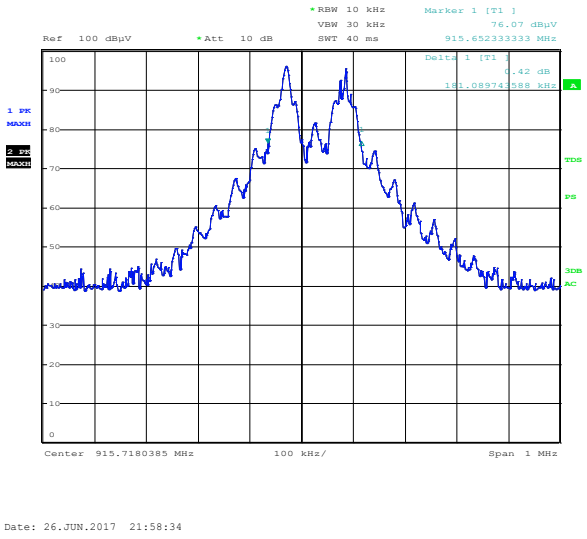
Verdict	Pass		
Test date	June 26, 2017	Temperature	23 °C
Test engineer	Kevin Rose	Air pressure	1001 mbar
Test location	Ottawa	Relative humidity	41.3 %

8.1.3 Observations, settings and special notes

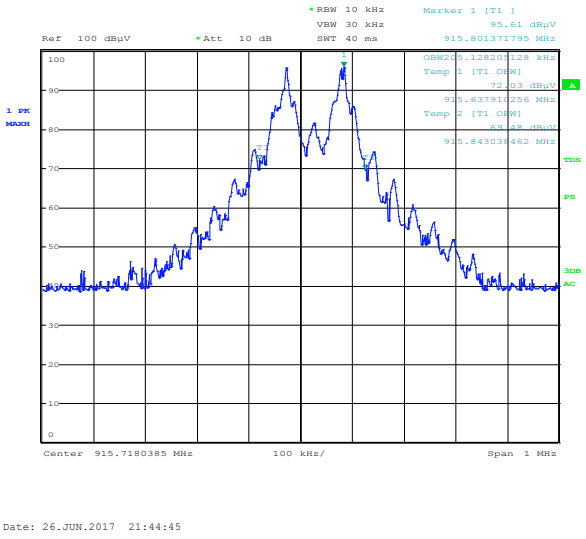
Spectrum analyzer settings:

Resolution bandwidth:	10 kHz
Video bandwidth:	30 kHz
Detector mode:	Peak
Trace mode:	Max Hold
Function:	20 dB BW (for FCC); 99 % bandwidth (for IC)

8.1.4 Test data



Plot 8.1-1: 20 dB bandwidth example



Plot 8.1-2: 99 % occupied bandwidth example

Table 8.1-1: 20 dB bandwidth results

Lower 20 dBc Freq., MHz	Lower 20 dBc Freq. limit, MHz	Lower margin, MHz	Upper 20 dBc Freq., MHz	Upper 20 dBc Freq. limit, MHz	Upper margin, MHz
915.625	902	13.625	927.501	928	0.499

Table 8.1-2: 99% bandwidth results

Frequency (MHz)	99 % bandwidth (kHz)
915.744	205.23
921.750	217.95
927.415	210.74

8.2 FCC Clause 15.249(a) and RSS-210 B.10 (a) Field strength of fundamental and harmonics emissions

8.2.1 Definitions and limits

In addition to the provisions of §15.205 and RSS Gen the field strength of emissions from intentional radiators operated under this section shall not exceed the following:

Table 8.2-1: Field strength limits

Fundamental frequencies (MHz)	Field strength of fundamental		Field strength of harmonics	
	(mV/m)	(dBµV/m)	(µV/m)	(dBµV/m)
902–928	50	94	500	54
2400–2483.5	50	94	500	54
5725–5875	50	94	500	54
24.0–24.25*	250	108	2500	68

Note: * - Only FCC band.

(e) As shown in §15.35(b), for frequencies above 1000 MHz, the field strength limits in paragraphs (a) and (b) of this section are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation. For point-to-point operation under paragraph (b) of this section, the peak field strength shall not exceed 2500 millivolts/meter (128 dBµV/m) at 3 meters along the antenna azimuth.

8.2.2 Test summary

Verdict	Pass		
Test date	October 10, 2017	Temperature	22 °C
Test engineer	Kevin Rose	Air pressure	1003 mbar
Test location	Ottawa	Relative humidity	41%

8.2.3 Observations, settings and special notes

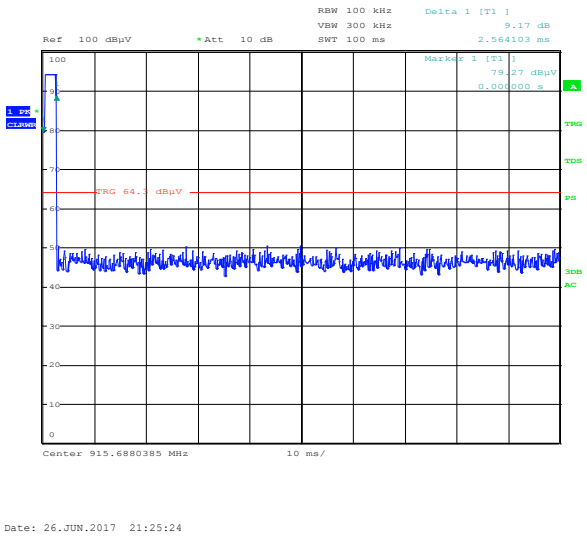
- **The spectrum was searched from 915 MHz to the 10th harmonic at a distance of 3 m.**
- **The test was performed with vertical and horizontal antenna polarizations and the EUT was measured on three orthogonal axis, only the highest emissions were reported.**

Spectrum analyzer/receiver settings:

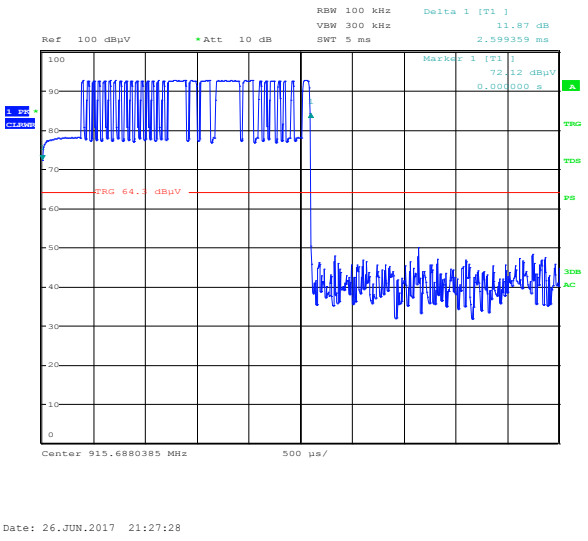
Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	Peak
Trace mode:	Max Hold
Average measurements:	Duty cycle/average factor was used for calculation of the average level.

8.2.4 Test data, continued

Duty cycle correction factor measurement:



Plot 8.2-1: 100 ms transmissions



Plot 8.2-2: Single transmission duration

Duty cycle calculation: $20 \times \log_{10} (Tx_{100\ ms} / 100\ ms) = 20 \times \log_{10} (2.6\ ms / 100\ ms) = -31.83$ dB

Table 8.2-2: Field strength of fundamental measurement results

Channel	Frequency, (MHz)	Average field strength, (dBµV/m)	Average limit, (dBµV/m)	Margin, (dB)
Low	915.74	93.15	94	0.85
Mid	921.75	92.82	94	1.18
High	927.41	93.38	94	0.62

Note: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable. Average field strength was calculated as follows: Peak field strength (dBµV/m) + duty cycle factor (dB).

Table 8.2-3: Field strength of harmonics measurement results

Channel	Frequency, (MHz)	Peak field strength, (dBµV/m)	Peak limit, (dBµV/m)	Margin, (dB)	Duty cycle factor, (dB)	Average field strength, (dBµV/m)	Average limit, (dBµV/m)	Margin, (dB)
Low	1831.4	42.10	74.00	31.90	20.0	22.10	54	31.90
Mid	1843.39	47.22	74.00	26.78	20.0	27.22	54	26.78
High	1854.74	42.57	74.00	31.43	20.0	22.57	54	31.43

Note: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable. Average field strength was calculated as follows: Peak field strength (dBµV/m) + duty cycle factor (dB).

8.3 FCC Clause 15.249(d) and RSS-210 B.10 (b) Spurious emissions (except for harmonics)

8.3.1 Definitions and limits

Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in FCC §15.209 and RSS-Gen, whichever is the lesser attenuation.

Table 8.3-1: Field strength of spurious emissions

Frequency (MHz)	Field strength (µV/m)	(dBµV/m)	Measurement distance (m)
30–88	100	40.0	3
88–216	150	43.5	3
216–960	200	46.0	3
above 960	500	54.0	3

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

8.3.2 Test summary

Verdict	Pass		
Test date	June 26, 2017	Temperature	23 °C
Test engineer	Kevin Rose	Air pressure	1001 mbar
Test location	Ottawa	Relative humidity	41.3 %

8.3.3 Observations, settings and special notes

The spectrum was searched from 30 MHz to the 10th harmonic at a distance of 3 m.
The test was performed with vertical and horizontal antenna polarizations and the EUT was measured on three orthogonal axis, only the highest emissions were reported.
For duty cycle factor calculation please refer to section 8.3.

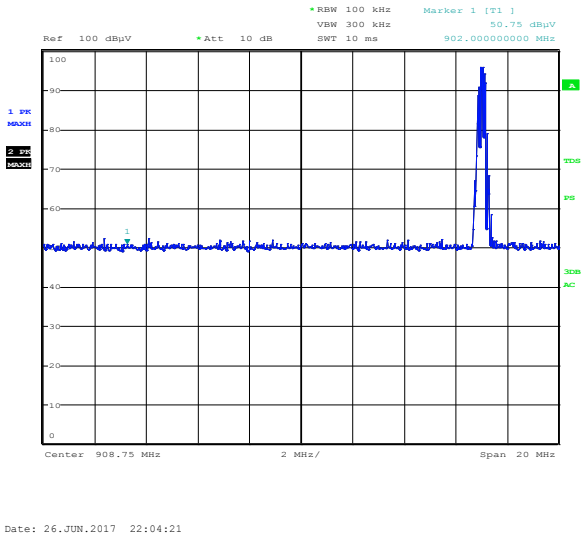
Spectrum analyzer/receiver settings for frequencies below 1 GHz:

Resolution bandwidth:	120 kHz
Video bandwidth:	300 kHz
Detector mode:	Quasi-Peak
Trace mode:	Max Hold

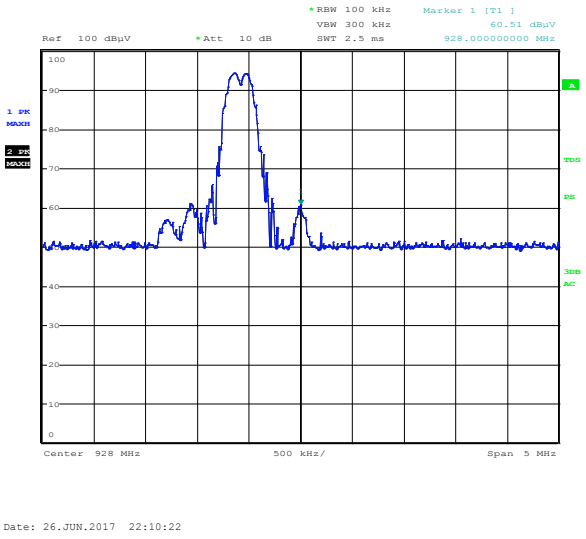
Spectrum analyzer/receiver settings for frequencies above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	Peak
Trace mode:	Max Hold
Average measurements:	Duty cycle/average factor was used for calculation of the average level.

8.3.4 Test data



Plot 8.3-1: Lower band edge



Plot 8.3-2: upper band edge

Plot 8.3-3: Upper band edge measurement

Table 8.3-2: Field strength of spurious emissions measurement results

Channel	Frequency, (MHz)	Peak field strength, (dBµV/m)	Peak limit, (dBµV/m)	Margin, (dB)	Duty cycle factor, (dB)	Average field strength, (dBµV/m)	Average limit, (dBµV/m)	Margin, (dB)
Low	902	50.75	74.00	23.25	-20.00	30.75	54.00	23.25
High	928	60.51	74.00	13.49	-20.00	40.51	54.00	13.49

Note: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable. Average field strength was calculated as follows: Peak field strength (dBµV/m) + duty cycle factor (dB).(The Duty cycle factor was greater than 20 dB. Therefore a max number of 20 dB was used

8.4 FCC 15.249(d) and RSS-210 Annex B10(b) Spurious emissions (except for harmonics)

8.4.1 Definitions and limits

FCC
Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation.
IC
Emissions radiated outside of the specified frequency bands, except for harmonic emissions, shall be attenuated by at least 50 dB below the level of the fundamental emissions or to the general field strength limits listed in RSS-Gen, whichever is less stringent.

Table 8.4-1: 15.209 and RSS-Gen emissions field strength 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 8.4-2: 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 above 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	June 29, 2017	Temperature	31 °C
Test engineer	Kevin Rose	Air pressure	1003 mbar
Verdict	Pass	Relative humidity	43 %

8.4.3 Observations, settings and special notes

The spectrum was searched from 30 kHz to 10th harmonic of the fundamental frequency.
Radiated measurements were performed at a distance of 3 m.

Spectrum analyzer settings for frequencies below 1000 MHz:

Detector mode	Peak or Quasi-Peak
Resolution bandwidth	100 kHz
Video bandwidth	300 kHz
Trace mode	Max Hold

Spectrum analyzer settings for peak measurements at the frequencies above 1000 MHz:

Detector mode	Peak
Resolution bandwidth	1 MHz
Video bandwidth	3 MHz
Trace mode	Max Hold

Spectrum analyzer settings for average measurements at the frequencies above 1000 MHz:

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

8.4.4 Test data

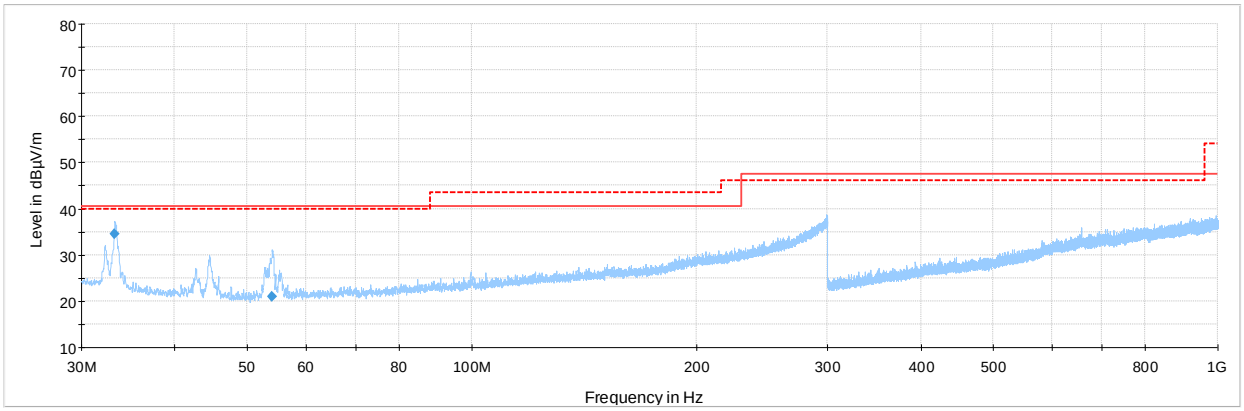


Figure 8.4-1: Field strength of spurious emissions below 1000 MHz

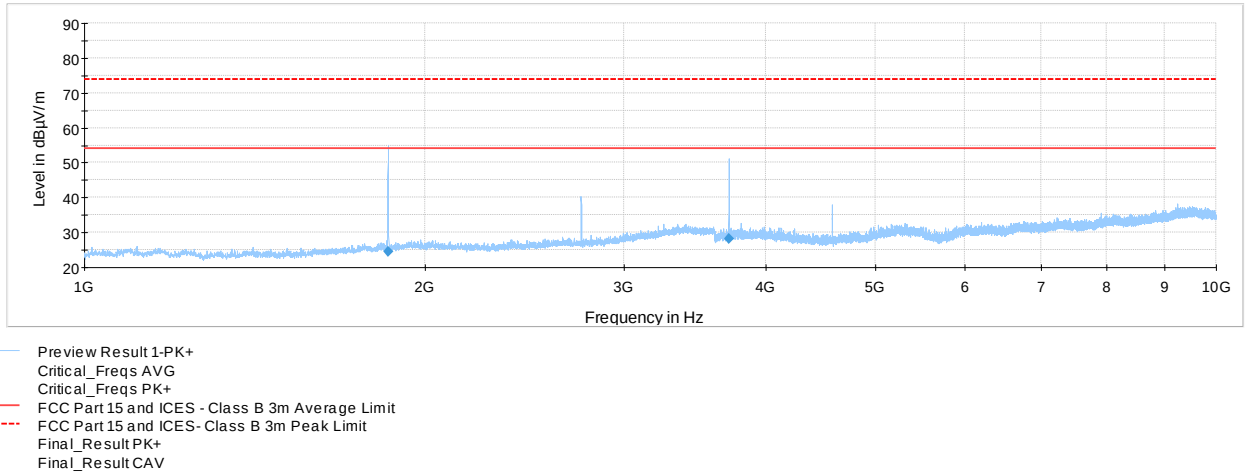
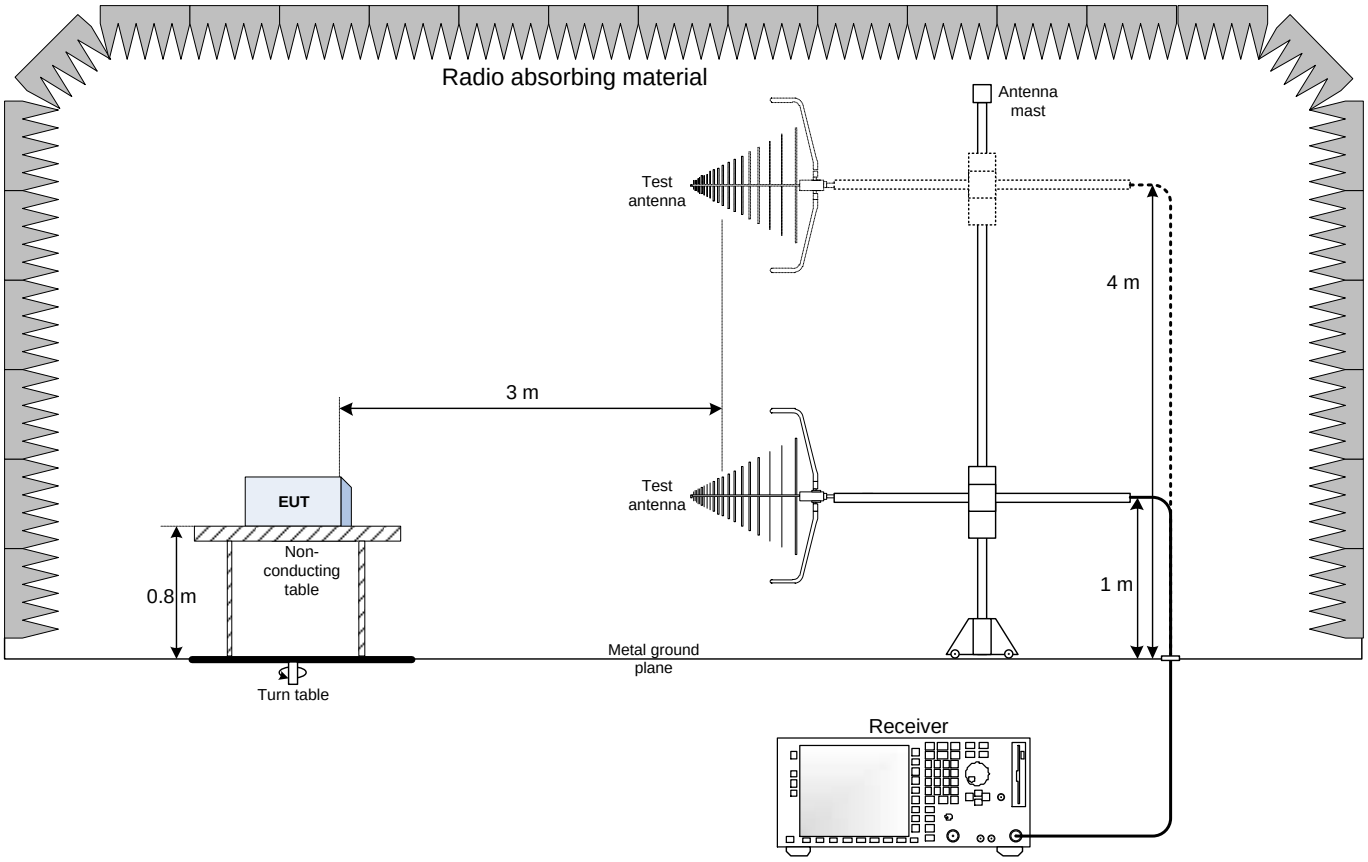


Figure 8.4-2: Field strength of spurious emissions above 1000 MHz

Note: all measurement results indicated in the plot were taken with a peak detector, which is more stringent measurement, and still comply with quasi-peak limit.

Section 9 Block Figures 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