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RADIO TEST REPORT – 403703-2TRFWL

Type of assessment:

Final product testing

Applicant:

Ring LLC

Product:

Range Extender

Model:

5AT2S8

FCC ID:

2AEUP5AT2S8

IC Registration number:

20271-5AT2S8

Specifications:

- FCC 47 CFR Part 15, Subpart C, §15.249
- RSS-210 Annex B.10, Issue 10, December 2019

Date of issue: January 28, 2021

Mark Libbrecht, EMC/RF Specialist
Tested by

Signature

Andrey Adelberg, Senior EMC/RF Specialist
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Test site registration	**Organization**	**Recognition numbers and location**
	FCC/ISED	FCC: CA2040; IC: 2040A-4 (Ottawa/Almonte); FCC: CA2041; IC: 2040G-5 (Montreal); **CA0101 (Cambridge)**
Website	www.nemko.com	

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 Test specifications

FCC 47 CFR Part 15, Subpart C, Clause 15.249	Operation within the bands 902–928 MHz, 2400–2483.5 MHz, 5725–5875 MHZ, and 24.0–24.25 GHz.
RSS-210 Annex B.10, Issue 10, December 2019	Licence-Exempt Radio Apparatus: Category I Equipment. Devices operating in 902–928 MHz, 2400–2483.5 MHz, 5725–5875 MHz and 24–24.25 GHz frequency bands for any application.

1.2 Test methods

ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
RSS-Gen, Issue 5, March 2019	General Requirements for Compliance of Radio Apparatus

1.3 Exclusions

None

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 1.3 above. 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 Test report revision history

Table 1.5-1: *Test report revision history*

Revision #	Date of issue	Details of changes made to test report
TRF	January 28, 2021	Original report issued

Section 2. Engineering considerations

2.1 Modifications incorporated in the EUT for compliance

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

2.2 Technical judgment

Power setting = 5.0 dBm used for all measurements

2.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 3. Test conditions

3.1 Atmospheric conditions

Temperature	15 °C – 35 °C
Relative humidity	20 % – 75 %
Air pressure	86 kPa (860 mbar) – 106 kPa (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.

3.2 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 4. Measurement uncertainty

4.1 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 4.1-1: *Measurement uncertainty calculations*

Test name	Measurement uncertainty, ±dB
All antenna port measurements	0.55
Occupied bandwidth	4.45
Conducted spurious emissions	1.13
Radiated spurious emissions	3.78
AC power line conducted emissions	3.55

Section 5. Information provided by the applicant

5.1 Disclaimer

This section contains information provided by the applicant and has been utilized to support the test plan. Inaccurate information provided by the applicant can affect the validity of the results contained within this test report. Nemko accepts no responsibility for the information contained within this section and the impact it may have on the test plan and resulting measurements.

5.2 Applicant/Manufacture

Applicant name	Ring LLC
Applicant address	1523 26th St, Santa Monica, CA 90404, USA
Manufacture name	Leedarson Lighting Co.,Ltd.
Manufacture address	Xingtai industrial zone,Changtai, Zhangzhou Fujian.

5.3 EUT information

Product	Range Extender
Model	5AT2S8
Serial number	None
Part number	None
Power supply requirements	AC: 120 VAC, 60 Hz power cord
Product description and theory of operation	The range extender is only re-transmit signals that are uniquely identified as originating from a transmitter, or set of transmitters, with which the repeater is authorized to operate.

5.4 Radio technical information

Frequency band	902–928 MHz
Frequency Min (MHz)	908.4
Frequency Max (MHz)	916.0
Channel numbers	3
RF power Max (W), Conducted	N/A
Field strength, dBµV/m @ 3 m	92.4 (908.4 MHz), 93.0 (908.42 MHz), 93.7 (916 MHz)
Measured BW (kHz), 99% OBW	96.2 (908.4 MHz), 99.4 (908.42 MHz), 116.5 (916 MHz)
Type of modulation	Z Wave – FSK, GFSK
Emission classification	F1D
Transmitter spurious, dBµV/m @ 3 m	51.7 (Peak) @ 1832 MHz
Antenna information	Monopole antenna Peak gain = 0.8 dBi

5.5 EUT setup details

5.5.1 Radio exercise details

Operating conditions	firmware revision v1.11
Transmitter state	Transmitter state set to transmit at 100% duty cycle
Receiver state	Receiver state in normal operation

5.5.2 EUT setup configuration

Table 5.5-1: *EUT interface ports*

Description	Qty.
10 pin I/O header	1

Table 5.5-2: *Inter-connection cables*

Cable description	From	To	Length (m)
AC Mains	EUT	AC Mains	< 1

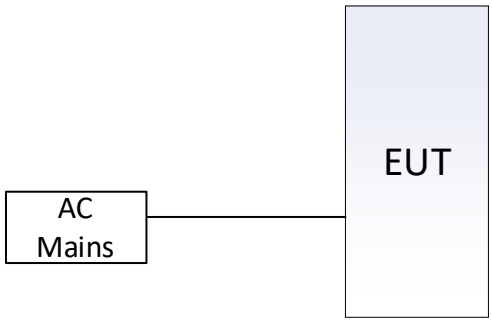


Figure 5.5-1: *Testing block diagram*

Section 6. Summary of test results

6.1 Testing location

Test location (s)	Cambridge

6.2 Testing period

Test start date	December 1, 2020	Test end date	January 19, 2021

6.3 Sample information

Receipt date	December 1, 2020	Nemko sample ID number(s)	1

6.4 FCC Part 15 Subpart A and C, general requirements test results

Table 6.4-1: *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
§15.215(c)	Emission bandwidth	Pass
§15.215(c)	Frequency stability	Pass

Notes: EUT is an AC powered device.

6.5 FCC Part 15 Subpart C, intentional radiators test results

Table 6.5-1: *FCC requirements results*

Part	Test description	Verdict
§15.249(a)	Field strength of fundamental and harmonic emissions	Pass
§15.249(b)(1)	Fixed Point-to-Point operation in the 24.0–24.25 GHz band	Not applicable
§15.249(d)	Radiated emissions except for harmonics	Pass

Notes: None

6.6 ISED RSS-Gen, Issue 5, test results

Table 6.6-1: *RSS-Gen requirements 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
6.7	Occupied bandwidth	Pass
8.11	Frequency stability	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.

6.7 ISED RSS-210, Issue 10, test results

Table 6.7-1: *ISED requirements results*

Section	Test description	Verdict
B.10.a	The field strength of fundamental and harmonic emissions	Pass
B.10.b	Emissions radiated outside of the specified frequency bands, except for harmonic emissions	Pass

Notes: None

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.
Receiver/spectrum analyzer	Rohde & Schwarz	ESR26	FA002969	1 year	November 12, 2021
3 m EMI test chamber	TDK	SAC-3	FA003012	1 year	April 10, 2021
Flush mount turntable	SUNAR	FM2022	FA003006	—	NCR
Controller	SUNAR	SC110V	FA002976	—	NCR
Antenna mast	SUNAR	TLT2	FA003007	—	NCR
Bilog antenna (30–2000 MHz)	SUNAR	JB1	FA003010	1 year	March 17, 2021
Horn antenna (1–18 GHz)	ETS Lindgren	3117	FA002911	1 year	March 11, 2021
Preamp (1–18 GHz)	ETS Lindgren	124334	FA002956	1 year	March 26, 2021

Note: NCR - no calibration required

Section 8. Testing data

8.1 Variation of power source

8.1.1 References, definitions and limits

FCC §15.31:

(e) For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

8.1.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	December 17, 2020

8.1.3 Observations, settings and special notes

None

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 Number of frequencies

8.2.1 References, definitions and limits

FCC §15.31:

(m) Measurements on intentional radiators or receivers shall be performed and, if required, reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table.

RSS-Gen, Clause 6.9:

Except where otherwise specified, measurements shall be performed for each frequency band of operation for which the radio apparatus is to be certified, with the device operating at the frequencies in each band of operation shown in table below. The frequencies selected for measurements shall be reported in the test report.

Table 8.2-1: *Frequency Range of Operation*

Frequency range over which the device operates (in each band)	Number of test frequencies required	Location of measurement frequency inside the operating frequency range
1 MHz or less	1	Center (middle of the band)
1–10 MHz	2	1 near high end, 1 near low end
Greater than 10 MHz	3	1 near high end, 1 near center and 1 near low end

Notes: "near" means as close as possible to or at the centre / low end / high end of the frequency range over which the device operates.

8.2.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	December 1, 2020

8.2.3 Observations, settings and special notes

EUT is limited to 3 channels of operation

8.2.4 Test data

Table 8.2-2: *Test channels selection*

Start of Frequency range, MHz	End of Frequency range, MHz	Frequency range bandwidth, MHz	Low channel, MHz	Mid channel, MHz	High channel, MHz
902	928	26	908.4	908.42	916

8.3 Antenna requirement

8.3.1 References, definitions and limits

FCC §15.203:

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

RSS-Gen, Clause 6.8:

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.

8.3.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	December 1, 2020

8.3.3 Observations, settings and special notes

None

8.3.4 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

Table 8.3-1: *Antenna information*

Antenna type	Manufacturer	Model number	Maximum gain	Connector type
Monopole	Jucheng	N/A	0.8 dBi	N/A

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

• References, 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.

ANSI: C63.10 subclause 6.2
If the EUT normally receives power from another device that in turn connects to the public utility ac power lines, measurements shall be made on that device with the EUT in operation to demonstrate that the device continues to comply with the appropriate limits while providing the EUT with power. If the EUT is
operated only from internal or dedicated batteries, with no provisions for connection to the public utility ac power lines (600 VAC or less) to operate the EUT (such as an adapter), then ac power-line conducted measurements are not required.
For direct current (dc) powered devices where the ac power adapter is not supplied with the device, an “off-the-shelf” unmodified ac power adapter shall be used. If the device is supposed to be installed in a host (e.g., the device is a module or PC card), then it is tested in a typical compliant host.

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 8.3-2: *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.

• Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	December 1, 2020

- Observations, settings and special notes

The EUT was set up as tabletop configuration per ANSI C63.10-2013 measurement procedure.

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.

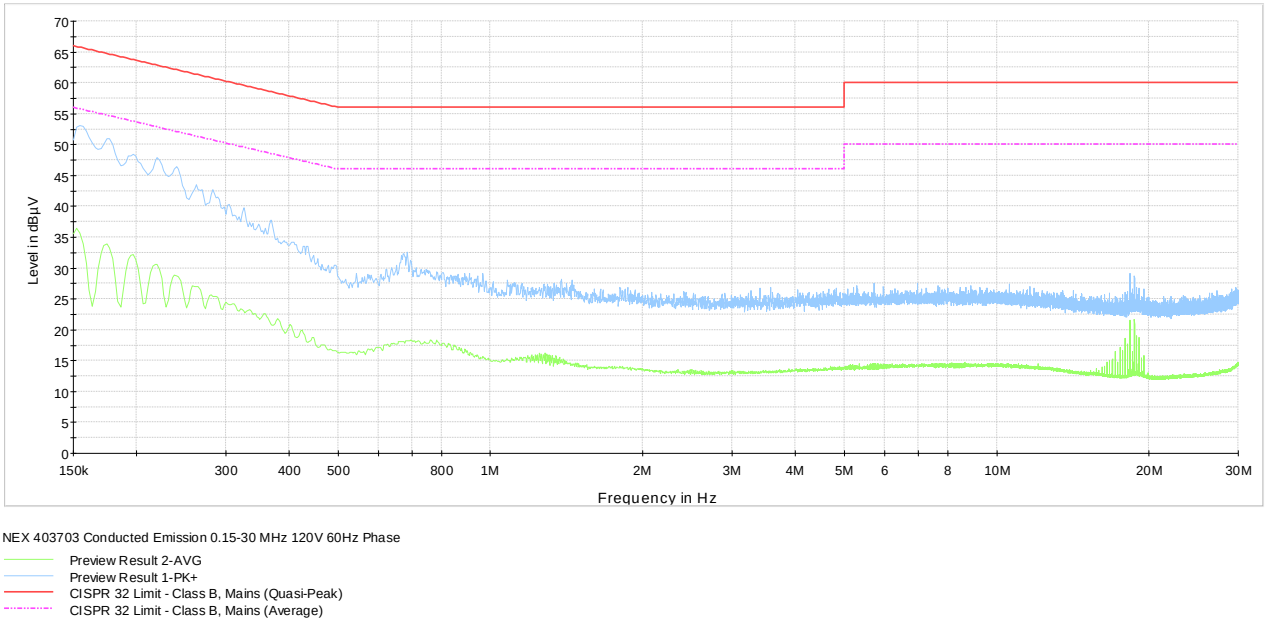
EMI Receiver settings for preview measurements:

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

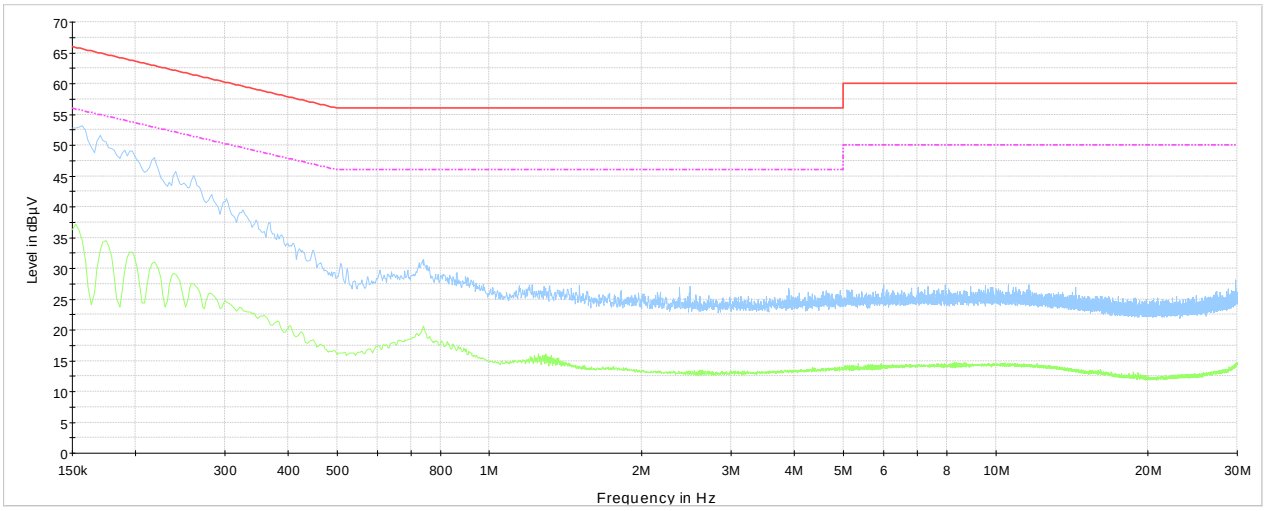
Receiver settings for final measurements:

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

- Test data



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



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

8.4 Field strength of fundamental and harmonics emissions

8.4.1 References, definitions and limits

FCC §15.249:

(a) Except as provided in paragraph (b) of this section, the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following table.

(c) Field strength limits are specified at a distance of 3 meters.

(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 at 3 meters along the antenna azimuth.

ANSI C63.10, Clause 6.3.3:

Radiated total peak emission level

Some wireless devices are subject to a peak limit based on the total peak emission level (i.e., rather than being based on a peak level over a specified bandwidth). Unless otherwise specified, radiated measurements of the fundamental-signal peak field strength shall be made using instrumentation with a bandwidth equal to or greater than the 6 dB bandwidth of the emission.46 For unlicensed wireless devices with fundamental signals subject to quasi-peak (QP) limits, when the QP detector bandwidth is less than the 6 dB bandwidth of the emission, a peak detector with a bandwidth equal to or greater than the 6 dB bandwidth of the emission shall be used.

ANSI C63.10, Clause 4.1.4.2:

Specific detector functions and bandwidths for unlicensed wireless device measurements

4.1.4.2.1 Frequencies less than or equal to 1000 MHz

At any frequency or frequencies less than or equal to 1000 MHz, measurements shall be made with the CISPR quasi-peak detector and related measurement bandwidths, unless otherwise specified. The specifications for the measuring instrument using the CISPR quasi-peak detector are given in CISPR 16-1-1:2010. Where average limits are specified, an average detector shall be used. Where peak limits are also specified, the peak emission shall also be measured with instrumentation properly adjusted for factors, such as pulse desensitization. As an alternative to CISPR quasi-peak measurements or average measurements, a test laboratory may demonstrate compliance with the emission limits using measuring equipment employing a peak detector function as long as the equivalent or greater bandwidths as indicated for CISPR quasi-peak measurements or average measurements, as applicable, are employed.

Pulse-modulated devices with a pulse repetition frequency of 20 Hz or less have additional requirements.

4.1.4.2.2 Frequencies above 1000 MHz

Unless otherwise stated, on any frequency or frequencies above 1000 MHz, measurements shall be made with measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz. Peak measurements can apply to the total peak emission level radiated by the device (i.e., the total peak power level) depending on the applicable regulatory requirement. Note that the use of a pulse desensitization correction factor might be needed to determine the total peak emission level.

ANSI C63.10, Clause 6.3

Radiated emissions testing—common requirements

6.3.3 Radiated total peak emission level

Some wireless devices are subject to a peak limit based on the total peak emission level (i.e., rather than being based on a peak level over a specified bandwidth). Unless otherwise specified, radiated measurements of the fundamental-signal peak field strength shall be made using instrumentation with a bandwidth equal to or greater than the 6 dB bandwidth of the emission.

RSS-210 B.10:

Devices shall comply with the following requirements:

a. The field strength of fundamental and harmonic emissions measured at 3 m shall not exceed the limits in the following table.
The field strength shall be measured using an average detector, except for the fundamental emission in the frequency band 902–928 MHz, which is based on measurements using an International Special Committee on Radio Interference (CISPR) quasi-peak detector.

Table 8.4-1: *Field strength limits*

Fundamental frequency,	Field strength of fundamental,		Field strength of spurious emissions,	
MHz	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
24000–24250	250	108	2500	68

8.4.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	January 18, 2021

8.4.3 Observations, settings and special notes

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

Spectrum analyser settings for radiated measurements below 1 GHz:

Resolution bandwidth	> OBW
Video bandwidth	≥ RBW
Detector mode	Peak
Trace mode	Max Hold

Spectrum analyser settings for radiated measurements above 1 GHz:

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

8.4.1 Test data

Table 8.4-2: *Radiated field strength measurement results*

Frequency, MHz	Peak field strength[1], dBµV/m	Quasi-Peak[2] limit, dBµV/m	Margin, dB
908.40	92.4	94.0	1.6
908.42	93.0	94.0	1.0
916.00	93.7	94.0	0.3
Frequency, MHz	**Peak field strength[1], dBµV/m**	**Average[3] limit, dBµV/m**	**Margin, dB**
1816.80	48.5	54.0	5.5
1816.84	49.6	54.0	4.4
1832.00	51.7	54.0	2.3

Notes: [1]Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.
[2]At frequencies below 1000 MHz, measurements performed using the quasi-peak measurement procedures must satisfy the quasi-peak limits. However, if the peak-measurement results satisfy the quasi-peak limit, then additional quasi-peak measurements are not required to demonstrate compliance.
[3]At frequencies above 1000 MHz, measurements performed using the peak and average measurement procedures must satisfy the respective peak and average limits. However, if the peak-measurement results satisfy the average limit, then additional average measurements are not required to demonstrate compliance.

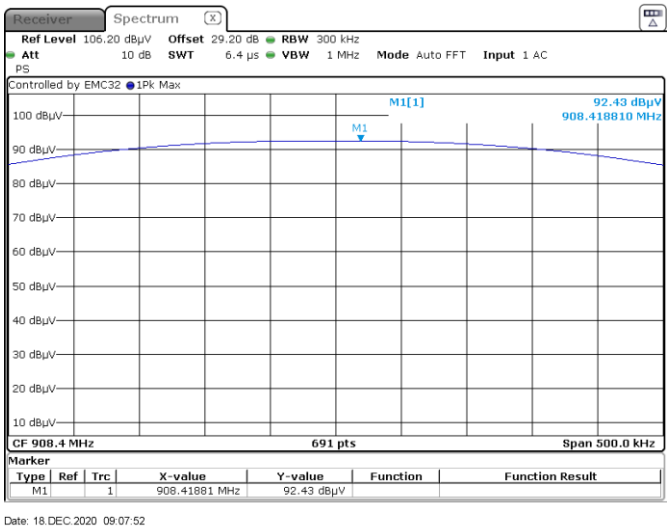


Figure 8.4-1: *Field strength of fundamental emission, 908.4 MHz*

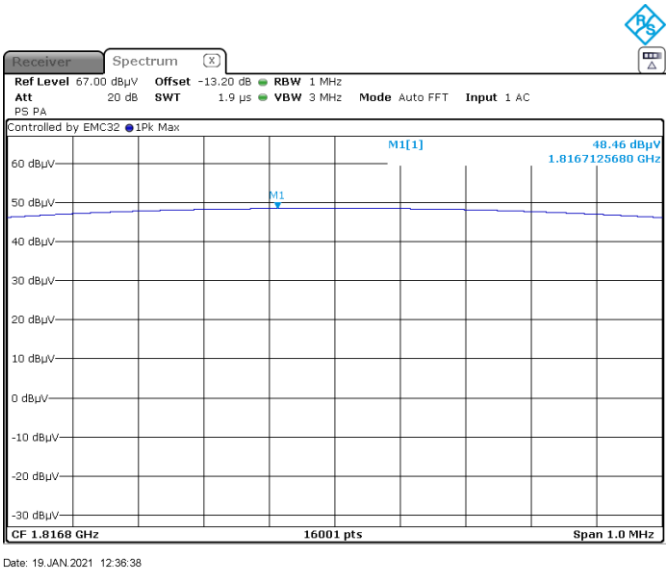


Figure 8.4-2: *Field strength of 2nd harmonic emission*

Test data, continued

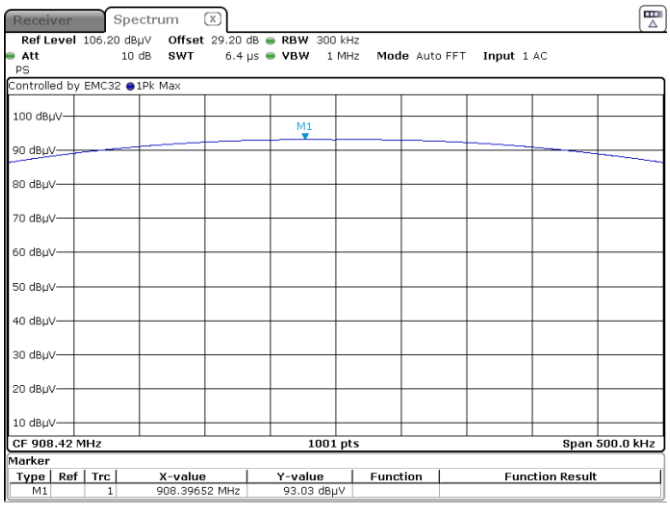


Figure 8.4-3: *Field strength of fundamental emission, 908.42 MHz*

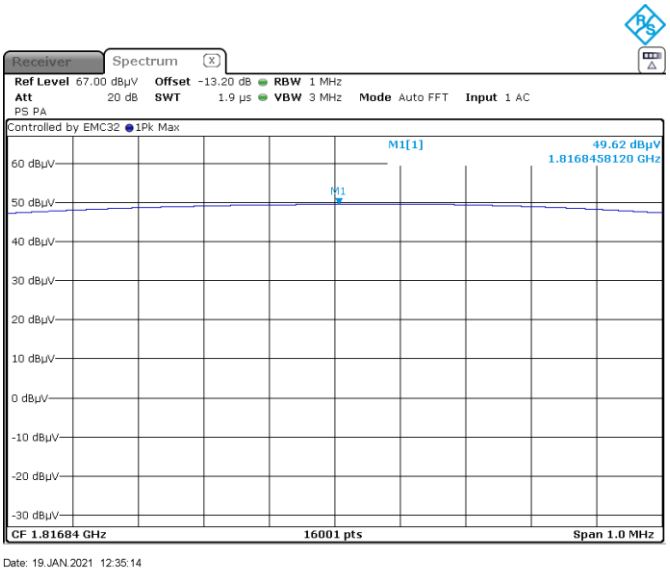


Figure 8.4-4: *Field strength of 2nd harmonic emission*

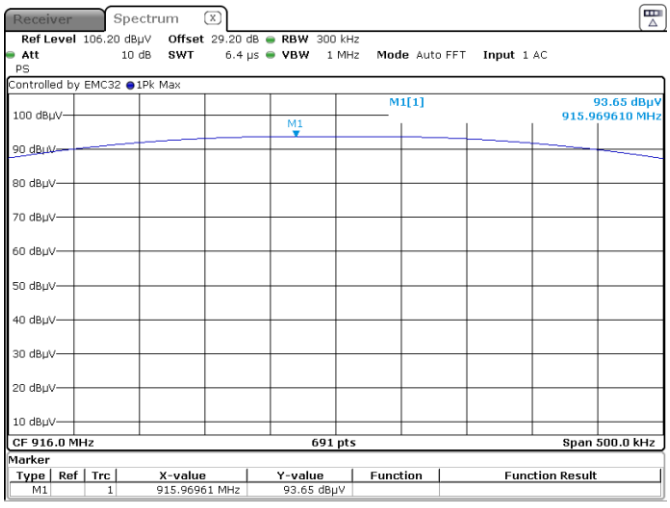


Figure 8.4-5: *Field strength of fundamental emission, 916.0 MHz*

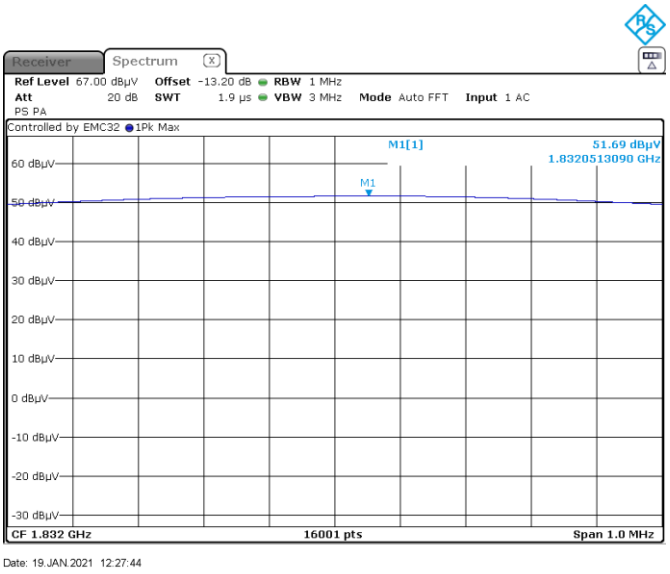


Figure 8.4-6: *Field strength of 2nd harmonic emission*

8.5 Field strength of spurious emissions (except for harmonics)

8.5.1 References, definitions and limits

FCC §15.249:

(d) 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.

ANSI C63.10, Clause 4.1.4.2:

Specific detector functions and bandwidths for unlicensed wireless device measurements

4.1.4.2.1 Frequencies less than or equal to 1000 MHz

At any frequency or frequencies less than or equal to 1000 MHz, measurements shall be made with the CISPR quasi-peak detector and related measurement bandwidths, unless otherwise specified. The specifications for the measuring instrument using the CISPR quasi-peak detector are given in CISPR 16-1-1:2010. Where average limits are specified, an average detector shall be used. Where peak limits are also specified, the peak emission shall also be measured with instrumentation properly adjusted for factors, such as pulse desensitization. As an alternative to CISPR quasi-peak measurements or average measurements, a test laboratory may demonstrate compliance with the emission limits using measuring equipment employing a peak detector function as long as the equivalent or greater bandwidths as indicated for CISPR quasi-peak measurements or average measurements, as applicable, are employed.

Pulse-modulated devices with a pulse repetition frequency of 20 Hz or less have additional requirements.

4.1.4.2.2 Frequencies above 1000 MHz

Unless otherwise stated, on any frequency or frequencies above 1000 MHz, measurements shall be made with measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz. Peak measurements can apply to the total peak emission level radiated by the device (i.e., the total peak power level) depending on the applicable regulatory requirement. Note that the use of a pulse desensitization correction factor might be needed to determine the total peak emission level.

RSS-210 B.10:

Devices shall comply with the following requirements:

b. 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 8.5-1: *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

References, definitions and limits, continued

Table 8.5-2: *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 this table 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 8.5-3: *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			

8.5.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	January 12, 2021

8.5.3 Observations, settings and special notes

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

Spectrum analyser settings for radiated measurements within restricted bands below 1 GHz:

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

Spectrum analyser settings for radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth	1 MHz
Video bandwidth	3 MHz (for Peak); 10 Hz (for Average)
Detector mode	Peak
Trace mode	Max Hold

8.5.1 Test data

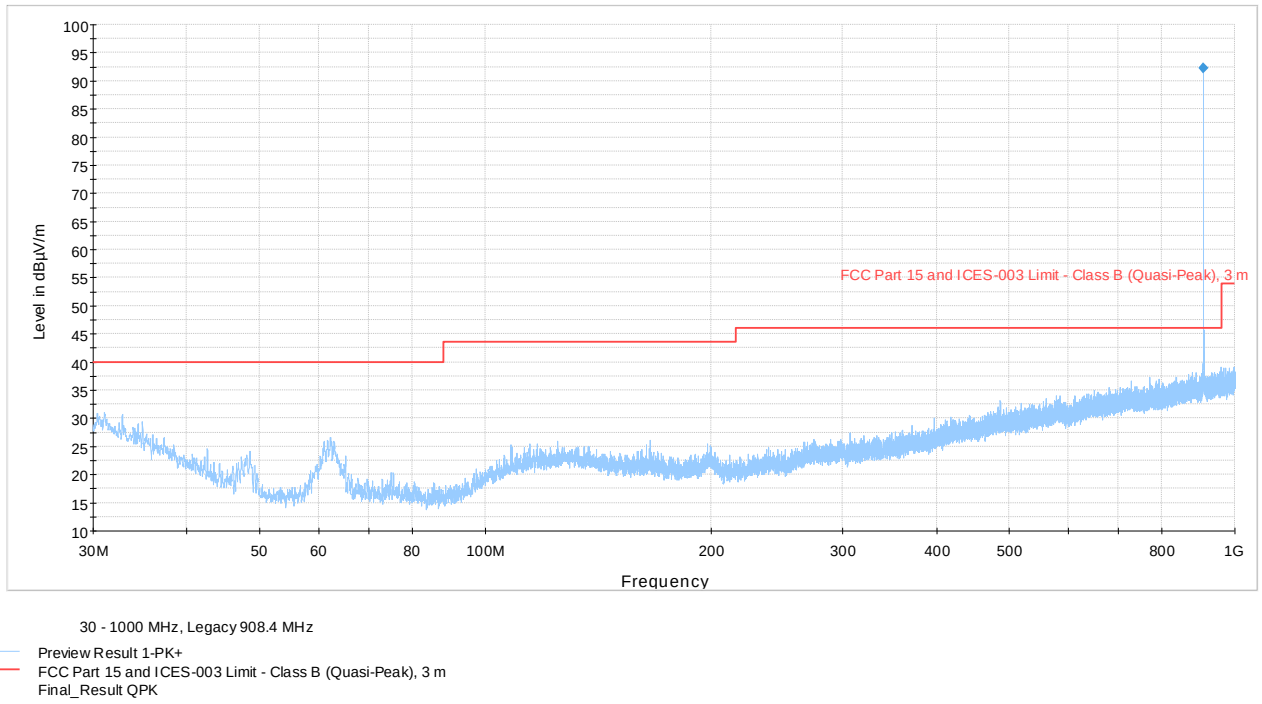


Figure 8.5-1: *Spurious emissions below 1 GHz, 908.4 MHz*

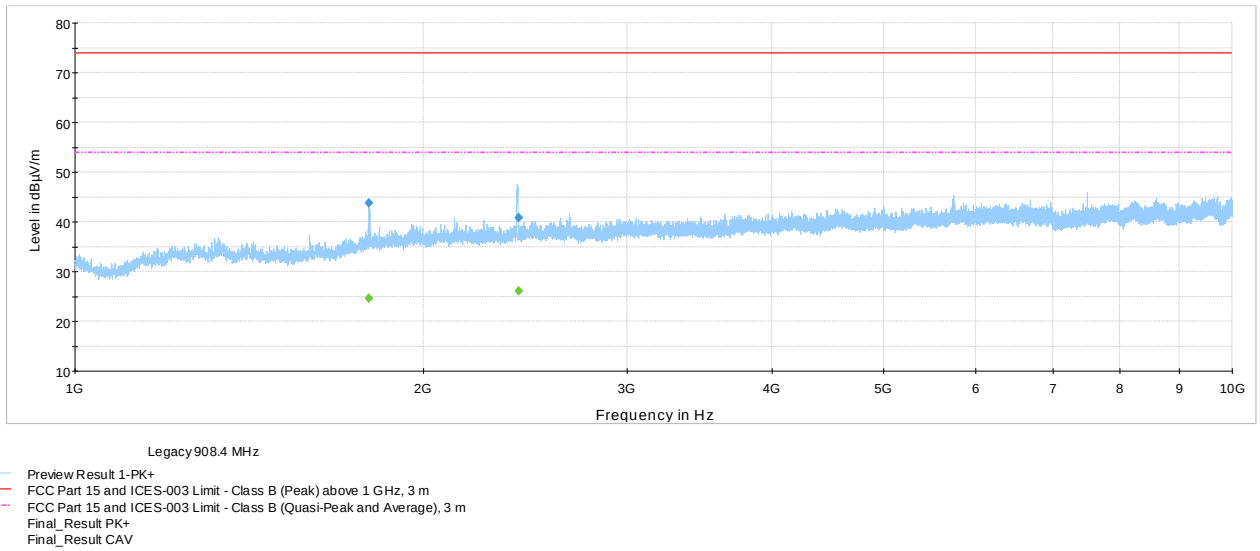


Figure 8.5-2: *Spurious emissions above 1 GHz, 908.4 MHz*

Test data, continued

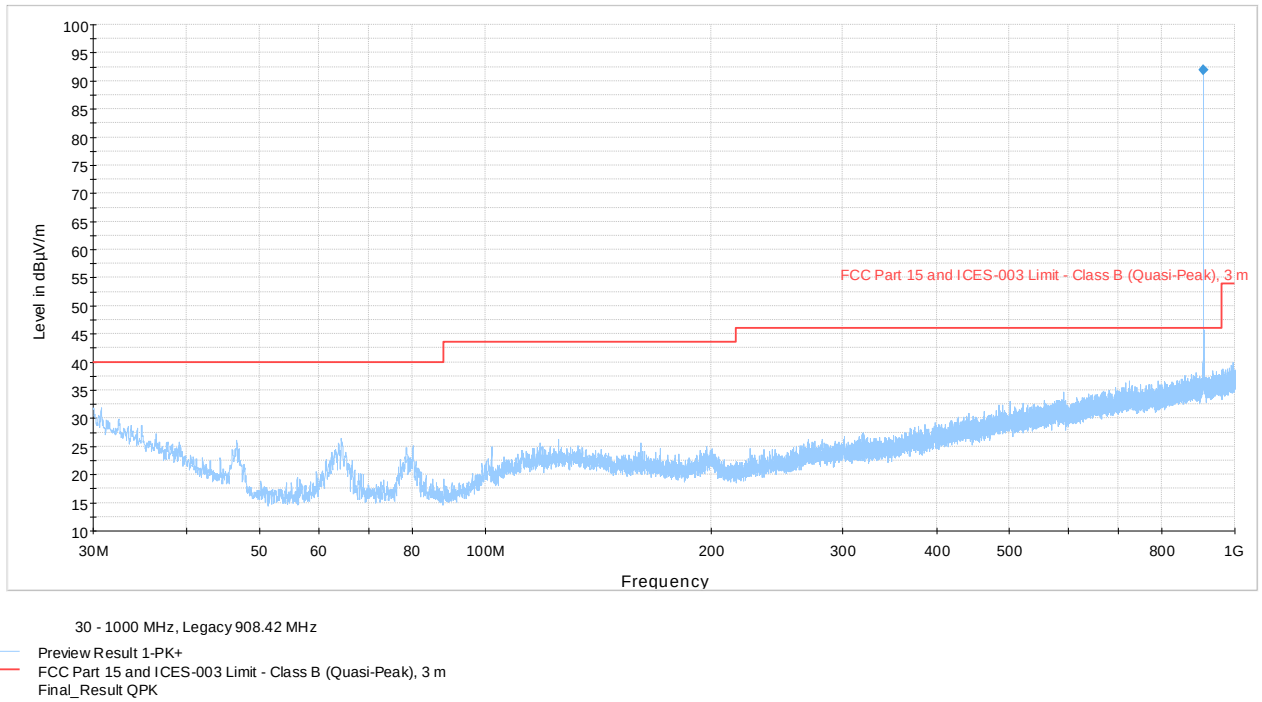


Figure 8.5-3: *Spurious emissions below 1 GHz, 908.42 MHz*

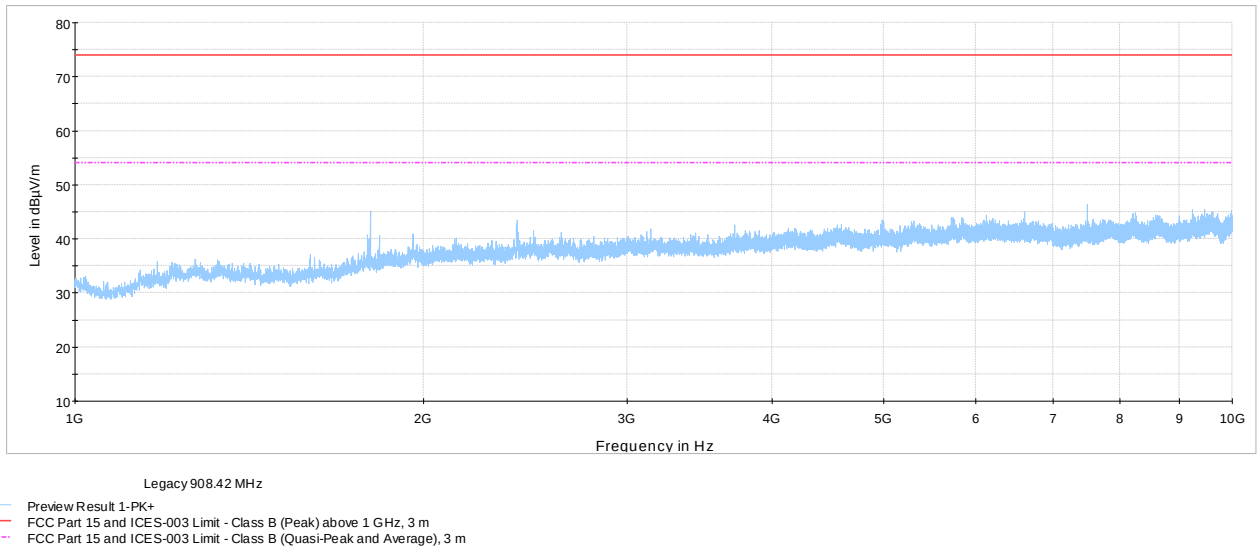


Figure 8.5-4: *Spurious emissions above 1 GHz, 908.42 MHz*

Test data, continued

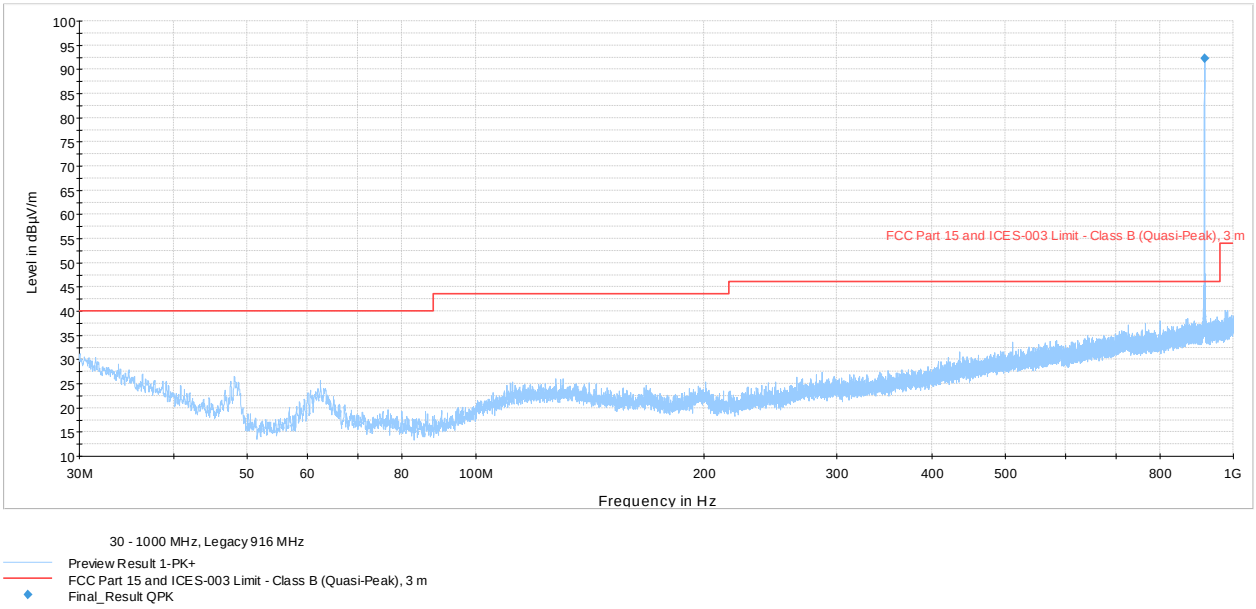


Figure 8.5-5: *Spurious emissions below 1 GHz, 916 MHz*

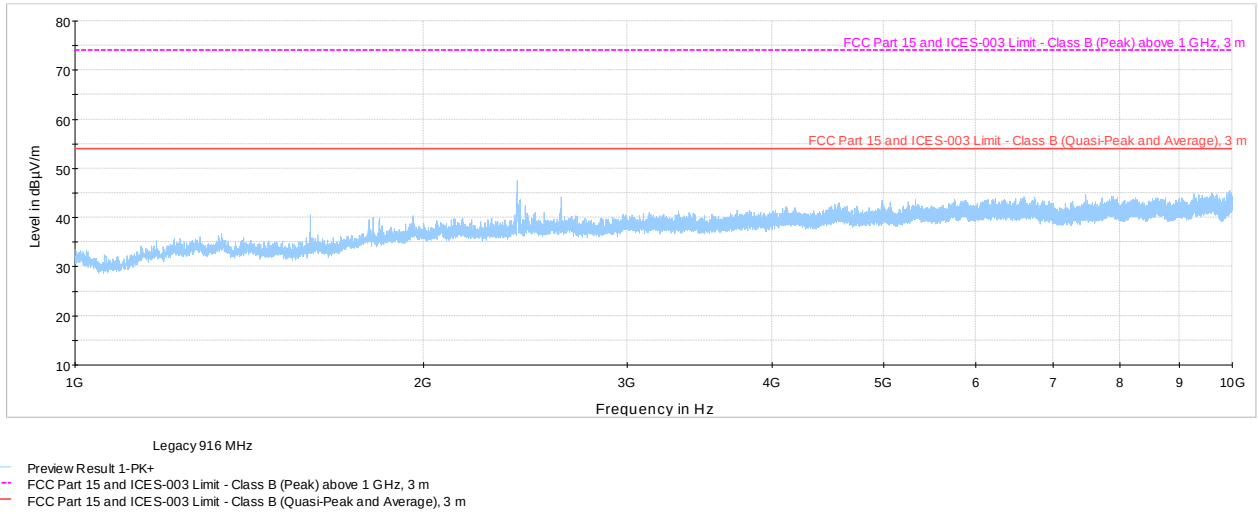


Figure 8.5-6: *Spurious emissions above 1 GHz, 916 MHz*

8.6 Emission bandwidth and frequency stability

8.6.1 References, definitions and limits

FCC §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.

If a 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 6.7:

Occupied bandwidth (or 99% emission bandwidth) and x dB bandwidth

The occupied bandwidth or the "99% emission bandwidth" is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

For the 99% emission bandwidth, the trace data points are recovered and directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached, and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded. The difference between the two recorded frequencies is the occupied bandwidth (or the 99% emission bandwidth).

RSS-Gen, Clause 8.11:

Frequency stability

If the frequency stability of the licence-exempt radio apparatus is not specified in the applicable RSS, the fundamental emissions of the radio apparatus should be kept within at least the central 80% of its permitted operating frequency band in order to minimize the possibility of out-of-band operation.

Table 8.6-1: *Frequency stability limit*

Fundamental frequency band, MHz	Central 80% of permitted operating frequency band, MHz
902–928	904.6–925.4
2400–2483.5	2408.35–2475.15
5725–5875	5740–5860
24000–24250	24025–24225

8.6.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	December 16, 2020

8.6.3 Observations, settings and special notes

Spectrum analyser settings:

Resolution bandwidth	≥ 1 % of emission bandwidth
Video bandwidth	≥ 3 × RBW
Frequency span	Wider than emission bandwidth
Detector mode	Peak

8.6.4 Test data

Table 8.6-2: *Occupied bandwidth measurement result*

Frequency, MHz	20 dB BW, kHz	99% BW, kHz
908.40	108.5	96.2
908.42	97.3	99.4
916.00	125.2	116.5

Table 8.6-3: *FCC occupied bandwidth limitations*

Fundamental frequency, MHz	Lower –20 dBc frequency cross, MHz	Lower limit, MHz	Margin, MHz	Upper –20 dBc frequency cross, MHz	Upper limit, MHz	Margin, MHz
908.4	908.3	904.6	3.7	908.5	925.4	16.9
908.42	908.4	904.6	3.7	908.5	925.4	16.9
916.0	915.9	904.6	11.3	916.1	925.4	

Table 8.6-4: *ISED occupied bandwidth limitations*

Fundamental frequency, MHz	Lower 99% BW frequency cross, MHz	Lower limit, MHz	Margin, MHz	Upper 99% BW frequency cross, MHz	Upper limit, MHz	Margin, MHz
908.4	908.4	904.6	3.7	908.4	925.4	
908.42	908.4	904.6	3.7	908.5	925.4	
916.0	915.9	904.6	11.3	916.1	925.4	

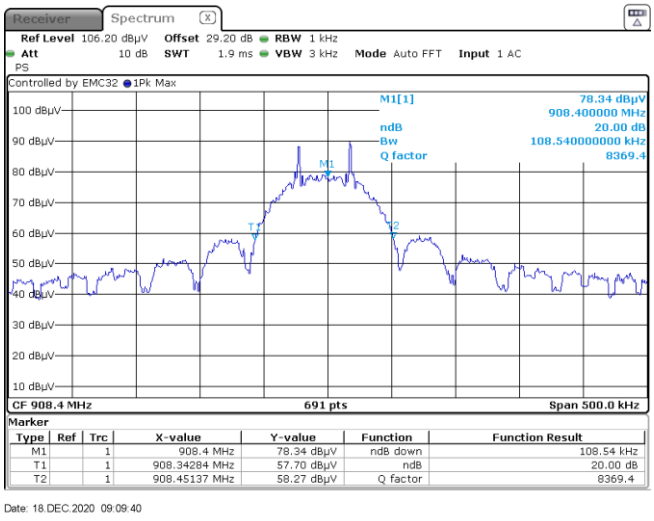


Figure 8.6-1: *20 dB occupied bandwidth, 908.4 MHz*

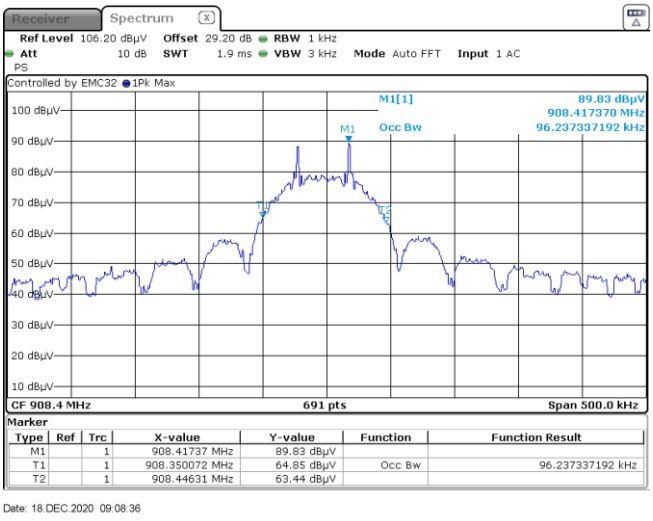


Figure 8.6-2: *99 % occupied bandwidth, 908.4 MHz*

Test data, continued

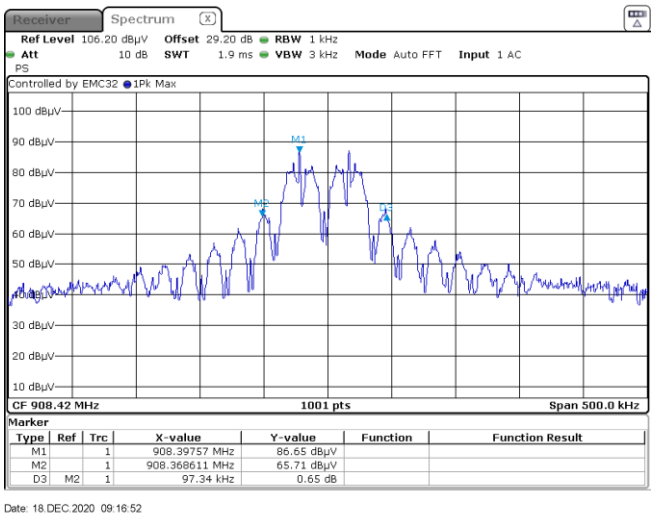


Figure 8.6-3: *20 dB occupied bandwidth, 908.42 MHz*

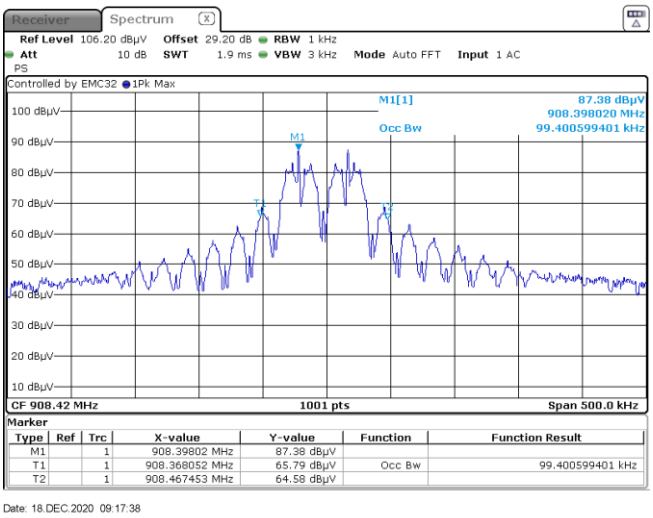


Figure 8.6-4: *99 % occupied bandwidth, 908.42 MHz*

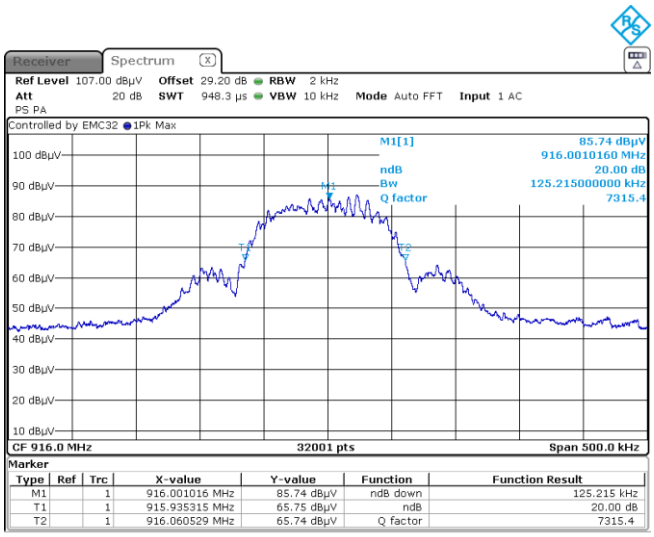


Figure 8.6-5: *20 dB occupied bandwidth, 916 MHz*

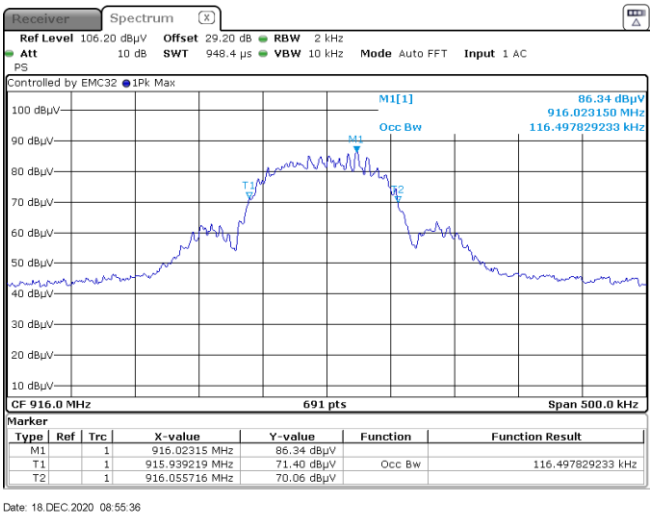
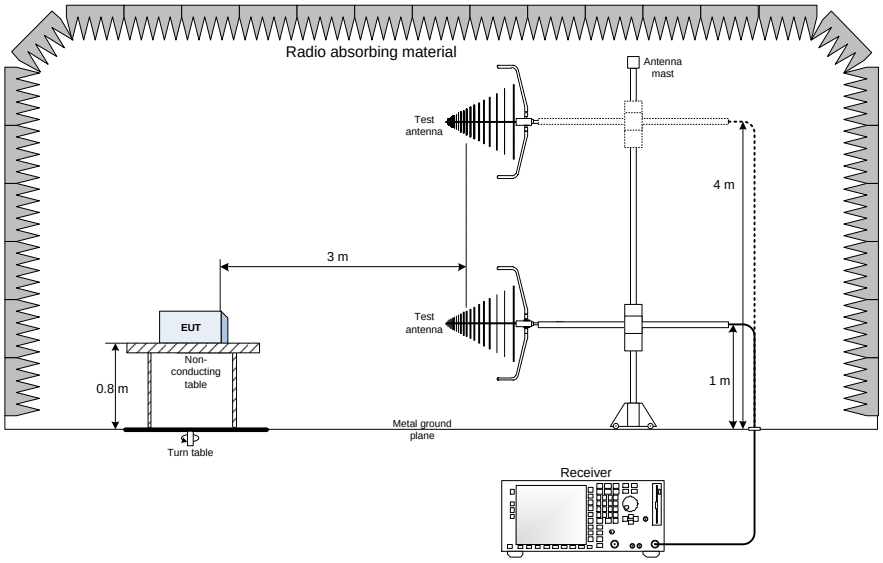


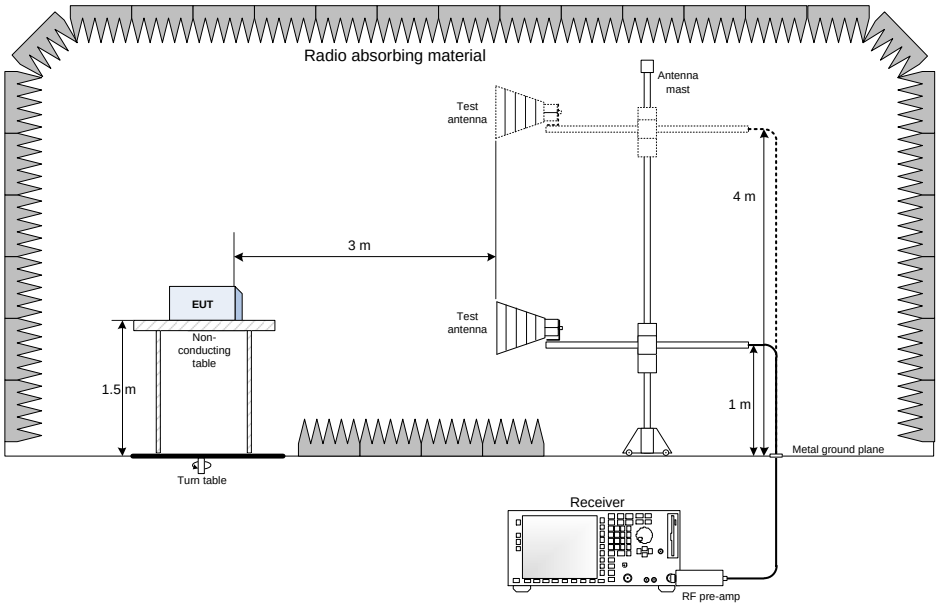
Figure 8.6-6: *99 % occupied bandwidth, 916 MHz*

Section 9. Block diagrams of test set-ups

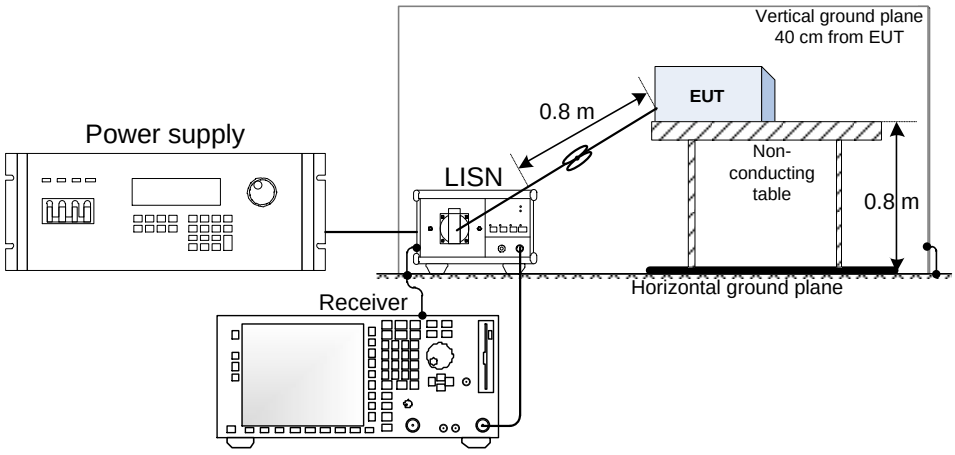
9.1 Radiated emissions set-up for frequencies below 1 GHz



9.2 Radiated emissions set-up for frequencies above 1 GHz



9.3 Conducted emissions set-up



End of Test Report