

# RADIO TEST REPORT – 454338-1TRFWL

Type of assessment:

**Final product testing**

Type of radio equipment:

**Spread Spectrum/Digital Device (902–928 MHz)**

Equipment class:

**DSS**

Applicant:

**Cysca Technologies Inc**

Product marketing name:

**Wireless Probe WS4 Double Vacuum**

Model (HVIN):

**WS4-2V5**

FCC ID:

**2A2IF-WS42V5**

ISED Certification number:

**27492-WS42V5**

Specifications:

- ◆ FCC 47 CFR Part 15 Subpart C, §15.247
- ◆ RSS-247, Issue 3, August 2023, Section 5

Date of issue: May 8, 2024

Abdoulaye Ndiaye, EMC/ RF specialist

Tested by



David Duchesne, EMC/RF Lab Manager

Reviewed by

Signature

Nemko Canada Inc., a testing laboratory, is accredited by ANSI National Accreditation Board (ANAB).

The tests included in this report are within the scope of this accreditation.

The ANAB symbol is an official symbol of the ANSI National Accreditation Board, used under licence.

ANAB File Number: AT-3195 (Ottawa); AT-3193 (Pointe-Claire); AT-3194 (Cambridge)



---

**Lab locations**

<b>Company name</b>	Nemko Canada Inc.		
<b>Facilities</b>	<i>Ottawa site:</i> 303 River Road Ottawa, Ontario Canada K1V 1H2	<i>Montréal site:</i> 292 Labrosse Avenue Pointe-Claire, Québec Canada H9R 5L8	<i>Cambridge site:</i> 1-130 Saltsman Drive Cambridge, Ontario Canada N3E 0B2
	Tel: +1 613 737 9680 Fax: +1 613 737 9691	Tel: +1 514 694 2684 Fax: +1 514 694 3528	Tel: +1 519 650 4811
<b>Test site identifier</b>	<b>Organization</b>	<b>Ottawa</b>	<b>Montreal</b>
	FCC: ISED:	CA2040 2040A-4	CA2041 2040G-5
<b>Website</b>	<a href="http://www.nemko.com">www.nemko.com</a>		

---

**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.

---

**Copyright notification**

Nemko Canada Inc. authorizes the applicant to reproduce this report provided it is reproduced in its entirety and for use by the company's employees only. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties.

Nemko Canada Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

© Nemko Canada Inc.

## Table of Contents

<b>Table of Contents .....</b>	<b>3</b>
<b>Section 1      Report summary .....</b>	<b>4</b>
1.1    Test specifications .....	4
1.2    Test methods .....	4
1.3    Exclusions .....	4
1.4    Statement of compliance .....	4
1.5    Test report revision history .....	4
<b>Section 2      Engineering considerations .....</b>	<b>5</b>
2.1    Modifications incorporated in the EUT for compliance .....	5
2.2    Technical judgment .....	5
2.3    Model variant declaration .....	5
2.4    Deviations from laboratory tests procedures .....	5
<b>Section 3      Test conditions .....</b>	<b>6</b>
3.1    Atmospheric conditions .....	6
3.2    Power supply range .....	6
<b>Section 4      Measurement uncertainty .....</b>	<b>7</b>
4.1    Uncertainty of measurement .....	7
<b>Section 5      Information provided by the applicant .....</b>	<b>8</b>
5.1    Disclaimer .....	8
5.2    Applicant/Manufacture .....	8
5.3    EUT information .....	8
5.4    Radio technical information .....	9
5.5    EUT setup details .....	9
<b>Section 6      Summary of test results .....</b>	<b>11</b>
6.1    Testing location .....	11
6.2    Testing period .....	11
6.3    Sample information .....	11
6.4    FCC test results .....	11
6.5    ISED test results .....	12
<b>Section 7      Test equipment .....</b>	<b>13</b>
7.1    Test equipment list .....	13
<b>Section 8      Testing data .....</b>	<b>14</b>
8.1    Variation of power source .....	14
8.2    Number of frequencies .....	15
8.3    Antenna requirement .....	17
8.4    Frequency Hopping Systems requirements, 900 MHz operation .....	18
8.5    Transmitter output power and e.i.r.p. requirements for FHSS 900 MHz .....	25
8.6    Spurious (out-of-band) unwanted emissions .....	27

## Section 1 Report summary

---

### 1.1 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 3, Aug 2023, Section 5	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

### 1.2 Test methods

---

558074 D01 15.247 Meas Guidance v05r02 (April 2, 2019)	Guidance for compliance measurements on digital transmission system, frequency hopping spread spectrum system, and hybrid system devices operating under section 15.247 of the FCC rules.
662911 D01 Multiple Transmitter Output v02r01 (October 31, 2013)	Emissions Testing of Transmitters with Multiple Outputs in the Same Band
DA 00-705, Released March 30, 2000	Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
RSS-102, Issue 5, March 19, 2015	Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)

### 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.

Determining compliance is based on the results of the compliance measurement, not taking into account measurement uncertainty, in accordance with section 1.3 of ANSI C63.10 v2013.

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	May 8, 2024	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

---

None

### 2.3 Model variant declaration

---

None

### 2.4 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  $\pm 5\%$ , 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, $\pm$ 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	Cysca Technologies Inc.
Applicant address	816 des, Bd des Seigneurs suite 300, Terrebonne, QC, Canada, J6W 1T9
Manufacture name	Same as applicant
Manufacture address	Same as applicant

### 5.3 EUT information

---

Product	Wireless Probe WS4 Double Vacuum
Model	WS4-2V5
Serial number	0103
Part number	WS4-2V5
Power supply requirements	Battery: 3 V(DC)
Product description and theory of operation	<p>4th Generation Wireless Probes (WS4)</p> <p>The new generation probes have been redesigned for performances' upgrade in terms of data transmission, energy consumption and improved ergonomics. In addition, the external antenna of older models has been replaced by an internal antenna. In addition, the push button, which allows interaction with the probe, has been replaced by a push button.</p> <p>The double probe has the same characteristics as the single vacuum probe. On the other hand, it has two vacuum sensors and two barbs for 5/16" tubing which make it possible to measure a vacuum up to 29.5 inHg, with an absolute accuracy of <math>\pm 0.25</math> inHg. The notch on the metal tip indicates the vacuum port 1, named VAC1, the other being the second port, named VAC2. The probe also includes a temperature sensor with an absolute accuracy of <math>\pm 2^\circ\text{C}</math>.</p>

## 5.4 Radio technical information

---

Category of Wideband Data Transmission equipment	Frequency Hopping Spread Spectrum (FHSS) equipment
Frequency band	902–928 MHz
Frequency Min (MHz)	902.22
Frequency Max (MHz)	927.82
Channel numbers	0–127
RF power Max (W), Conducted	0.049 W and (16.93 dBm)
Field strength, dB $\mu$ V/m @ 3 m	117.80 on High Channel
Measured BW (kHz), 99% OBW	94.64 @ 914.77 MHz
Type of modulation	2-GFSK
Emission classification	F7D
Transmitter spurious, dB $\mu$ V/m @ 3 m	54.76 Peak & 52.05 Average @ 8350.75 MHz on High Channel
Antenna information	P/N=206764-0100 – Manufacturer=Molex – gain=1.2dBi – Omnidirectional antenna – flexible dipole antenna

## 5.5 EUT setup details

---

### 5.5.1 Radio exercise details

---

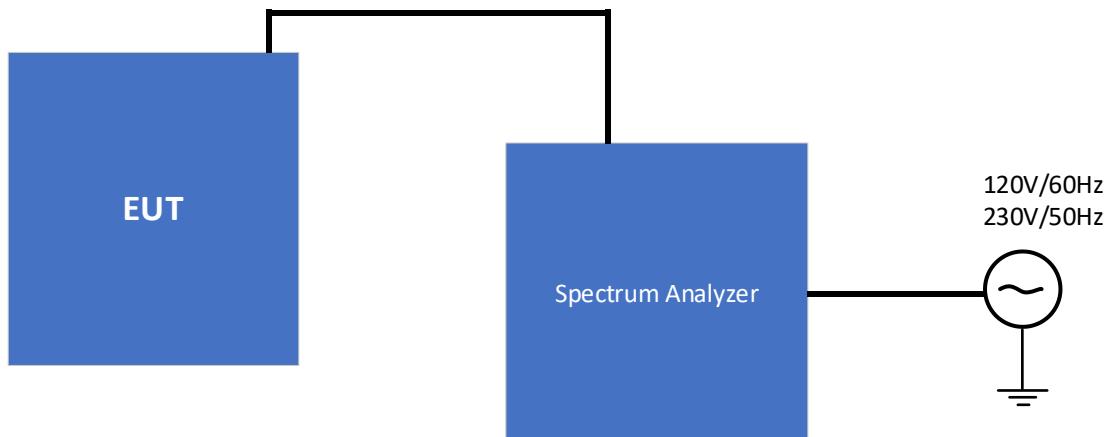
Operating conditions	The EUT is autonomous. It senses ambient temperature and pressure on its vacuum and transmits data according to a predefined time slot, synchronized thanks to its internal RTC. It does not need to be exercised. The transmitter will operate nominally if the EUT is correctly powered (thanks to 2x 1.5V batteries = 3Vdc). The software configures the radio with the following parameters: P=+20dBm, bit rate = 50kbps, 2 GFSK modulation, 200 kHz of channel length
Transmitter state	The transmitter was set into continuous mode either locked on specific channel or in hopping mode accordingly.

## 5.5.2 EUT setup configuration

**Table 5.5-1: EUT interface ports**

Description	Qty.
Vacuum sensors plug	2

Inside Anechoic Chamber

**Figure 5.5-1: Radiated testing block diagram****Figure 5.5-2: Antenna port testing block diagram**

## Section 6 Summary of test results

---

### 6.1 Testing location

---

Test location (s)	Montreal
-------------------	----------

### 6.2 Testing period

---

Test start date	December 6, 2021	Test end date	December 7, 2021
-----------------	------------------	---------------	------------------

### 6.3 Sample information

---

Receipt date	December 6, 2021	Nemko sample ID number(s)	#1
--------------	------------------	---------------------------	----

### 6.4 FCC test results

---

**Table 6.4-1: FCC requirements results**

Part	Test description	Verdict
<b>Generic requirements</b>		
§15.207(a)	Conducted limits	Not applicable
§15.31(e)	Variation of power source	Pass
§15.31(m)	Number of tested frequencies	Pass
§15.203	Antenna requirement	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(f)	Time of occupancy for hybrid systems	Not applicable
<b>FHSS specific requirements</b>		
§15.247(a)(1)(i)	Requirements for operation in the 902–928 MHz band	Pass
§15.247(a)(1)(ii)	Requirements for operation in the 5725–5850 MHz band	Not applicable
§15.247(a)(1)(iii)	Requirements for operation in the 2400–2483.5 MHz band	Not applicable
§15.247(b)(1)	Maximum peak output power in the 2400–2483.5 MHz band and 5725–5850 MHz band	Not applicable
§15.247(b)(2)	Maximum peak output power in the 902–928 MHz band	Pass
<b>DTS specific requirements</b>		
§15.247(a)(2)	Minimum 6 dB bandwidth	Not applicable
§15.247(b)(3)	Maximum peak output power	Not applicable
§15.247(e)	Power spectral density	Not applicable

Notes: EUT is a battery operated device, the testing was performed using fresh batteries.

## 6.5 ISED test results

**Table 6.5-1: ISED requirements results**

Part	Test description	Verdict
<b>Generic requirements</b>		
RSS-Gen, 7.3	Receiver radiated emission limits	Not applicable
RSS-Gen, 7.4	Receiver conducted emission limits	Not applicable
RSS-Gen, 6.9	Operating bands and selection of test frequencies	Pass
RSS-Gen, 8.8	AC powerline conducted emissions limits	Not applicable
RSS-247, 5.5	Unwanted emissions	Pass
RSS-247, 5.3	Hybrid Systems	
RSS-247, 5.3 (a)	Digital modulation turned off	Not applicable
RSS-247, 5.3 (b)	Frequency hopping turned off	Not applicable
<b>FHSS specific requirements</b>		
RSS-247, 5.1 (a)	Bandwidth of a frequency hopping channel	Pass
RSS-247, 5.1 (b)	Minimum channel spacing	Pass
RSS-247, 5.1 (c)	Systems operating in the 902–928 MHz band	Pass
RSS-247, 5.1 (d)	Systems operating in the 2400–2483.5 MHz band	Not applicable
RSS-247, 5.1 (e)	Systems operating in the 5725–5850 MHz band	Not applicable
RSS-247, 5.4	Transmitter output power and e.i.r.p. requirements	
RSS-247, 5.4 (a)	Systems operating in the 902–928 MHz band	Pass
RSS-247, 5.4 (b)	Systems operating in the 2400–2483.5 MHz band	Not applicable
RSS-247, 5.4 (c)	Systems operating in the 5725–5850 MHz	Not applicable
RSS-247, 5.4 (e)	Point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band	Not applicable
RSS-247, 5.4 (f)	Transmitters which operate in the 2400–2483.5 MHz band with multiple directional beams	Not applicable
<b>DTS specific requirements</b>		
RSS-247, 5.2 (a)	Minimum 6 dB bandwidth	Not applicable
RSS-247, 5.2 (b)	Maximum power spectral density	Not applicable
RSS-247, 5.4	Transmitter output power and e.i.r.p. requirements	
RSS-247, 5.4 (d)	Systems employing digital modulation techniques	Not applicable
RSS-247, 5.4 (e)	Point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band	Not applicable
RSS-247, 5.4 (f)	Transmitters which operate in the 2400–2483.5 MHz band with multiple directional beams	Not applicable

Notes: <sup>1</sup>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 a battery operated device, the testing was performed using fresh batteries.

## Section 7 Test equipment

---

### 7.1 Test equipment list

---

**Table 7.1-1: Equipment list**

Equipment	Manufacturer	Model no.	Asset no./ S.N	Cal cycle	Next cal.
3 m EMI test chamber (Emissions)	TDK	SAC-3	FA002532e	2 year	February 25, 2022
Flush mount turntable	Sunol	FM2022	FA002550	—	NCR
Antenna mast	Sunol	TLT2	FA002552	—	NCR
3 Phase AC Power Supply	apc AC Power	AFC-33045T	FA002677	—	VOU
Power Meter	HIOKI	PW3337	FA002727	1 year	March 15, 2022
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 40	FA002071	1 year	March 16, 2022
Bilog antenna (20–2000 MHz)	Sunol	JB1	FA002517	1 year	March 3, 2022
Horn antenna (1–18 GHz)	EMCO	3115	FA001451	1 year	February 16, 2022
Pre-amplifier (0.5–18 GHz)	Com-Power	PAM-118A	FA002561	1 year	August 31, 2022
Notch filter (1-12 GHz)	Microwave Circuit	H1G212G1	492291	—	VOU
Spectrum analyzer	Rohde & Schwarz	FSV 40	FA002731	1 year	March 23, 2022

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

## 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	Abdoulaye Ndiaye

Test date

December 6, 2021

#### 8.1.3 Observations, settings and special notes

---

The testing was performed as per ANSI C63.10 Section 5.13.

- a) Where the device is intended to be powered from an external power adapter, the voltage variations shall be applied to the input of the adapter provided with the device at the time of sale. If the device is not marketed or sold with a specific adapter, then a typical power adapter shall be used.
- b) For devices, where operating at a supply voltage deviating  $\pm 15\%$  from the nominal rated value may cause damages or loss of intended function, test to minimum and maximum allowable voltage per manufacturer's specification and document in the report.
- c) For devices with wide range of rated supply voltage, test at 15% below the lowest and 15% above the highest declared nominal rated supply voltage.
- d) For devices obtaining power from an input/output (I/O) port (USB, firewire, etc.), a test jig is necessary to apply voltage variation to the device from a support power supply, while maintaining the functionalities of the device.

For battery-operated equipment, the equipment tests shall be performed using a variable power supply.

#### 8.1.4 Test data

---

The EUT is battery powered, testing performed with fresh batteries.

## 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	Abdoulaye Ndiaye	Test date	December 6, 2021

### 8.2.3 Observations, settings and special notes

**ANSI C63.10, Clause 5.6.2.1:**

The number of channels tested can be reduced by measuring the center channel bandwidth first and then applying the following relaxations as appropriate:

- For each operating mode, if the measured channel bandwidth on the middle channel is at least 150% of the minimum permitted bandwidth, then it is not necessary to measure the bandwidth on the high and low channels.
- For multiple-input multiple-output (MIMO) systems, if the measured channel bandwidth on testing the middle channel exceeds the minimum permitted bandwidth by more than 50% on one transmit chain, then it is not necessary to repeat testing on the other chains.
- If the measured channel bandwidth on the middle channel is less than 50% of the maximum permitted bandwidth, then it is not necessary to measure the bandwidth on the high and low channels.

**ANSI C63.10, Clause 5.6.2.2:**

For devices with multiple operating modes, measurements on the middle channel can be used to determine the worst-case mode(s). The worst-case modes are as follows:

- Band edge requirements—Measurements on the mode with the widest bandwidth can be used to cover the same channel (center frequency) on modes with narrower bandwidth that have the same or lower output power for each modulation family (e.g., OFDM and direct sequence spread spectrum).
- Spurious emissions—Measure the mode with the highest output power and the mode with the highest output power spectral density for each modulation family (e.g., OFDM and direct sequence spread spectrum).
- In-band PSD—Measurements on the mode with the narrowest bandwidth can be used to cover all modes within the same modulation family of an equal or lower output power provided the result is less than 50% of the limit.

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	902.20	914.75	927.82

## 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.

#### FCC §15.247:

- (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:
- (4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

#### RSS-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	Abdoulaye Ndiaye

Test date

December 6, 2021

### 8.3.3 Observations, settings and special notes

None

### 8.3.4 Test data

**Table 8.3-1: Antenna information**

Antenna type	Manufacturer	Model number	Maximum gain	Connector type
Omnidirectional antenna – flexible dipole antenna	Molex	206764-0100	1.2 dBi	UFL

Note:      –      EUT is not professionally installed.  
              –      EUT does not contain a detachable antenna.

## 8.4 Frequency Hopping Systems requirements, 900 MHz operation

### 8.4.1 References, definitions and limits

#### FCC §15.247:

- (a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:
  - (1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.
  - (i) For frequency hopping systems operating in the 902–928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.
  - (f) For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4. The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

**Table 8.4-1: Summary of the basic requirements**

$P_{\max\text{-pk}} \leq 1 \text{ W}$	$P_{\max\text{-pk}} \leq 0.125 \text{ W}$
$N_{\text{ch}} \geq 75$	$N_{\text{ch}} \geq 15$
$\Delta f \geq \text{MAX} \{ 25 \text{ kHz}, \text{BW}_{20 \text{ dB}} \}$	$\Delta f \geq \text{MAX} [ \text{MAX} \{ 25 \text{ kHz}, 0.67 \times \text{BW}_{20 \text{ dB}} \} \text{ OR } \text{MAX}\{25 \text{ kHz}, \text{BW}_{20 \text{ dB}}\} ]$
max. $\text{BW}_{20 \text{ dB}}$ not specified	max. $\text{BW}_{20 \text{ dB}}$ not specified
$t_{\text{ch}} \leq 0.4 \text{ s}$ for $T = 0.4 \times N_{\text{ch}}$	$t_{\text{ch}} \leq 0.4 \text{ s}$ for $T = 0.4 \times N_{\text{ch}}$

Note:  $t_{\text{ch}}$  = average time of occupancy;  $T$  = period;  $N_{\text{ch}}$  = # hopping frequencies;  $\text{BW}$  = bandwidth;  $\Delta f$  = hopping channel carrier frequency separation

#### RSS-247, Clause 5.1:

- a. The bandwidth of a frequency hopping channel is the 20 dB emission bandwidth, measured with the hopping stopped. The system's radio frequency (RF) bandwidth is equal to the channel bandwidth multiplied by the number of channels in the hopset. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.
- c. For FHSs in the band 902–928 MHz: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping channels and the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 20-second period. If the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping channels and the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 10-second period. The maximum 20 dB bandwidth of the hopping channel shall be 500 kHz.

#### RSS-247, Clause 5.3:

- Hybrid systems employ a combination of both frequency hopping and digital transmission techniques and shall comply with the following:
- a. With the digital transmission operation of the hybrid system turned off, the frequency hopping operation shall have an average time of occupancy on any frequency not exceeding 0.4 seconds within a duration in seconds equal to the number of hopping frequencies multiplied by 0.4.

#### 8.4.2 Test summary

Verdict	Pass
Tested by	Abdoulaye Ndiaye

#### 8.4.3 Observations, settings and special notes

Carrier frequency separation was tested per ANSI C63.10 subclause 7.8.2. Spectrum analyser settings:

Resolution bandwidth	30 kHz
Video bandwidth	$\geq$ RBW
Frequency span	Wide enough to capture the peaks of two adjacent channels
Detector mode	Peak
Trace mode	Max Hold

Number of hopping frequencies was tested per ANSI C63.10 subclause 7.8.3. Spectrum analyser settings:

Resolution bandwidth	To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
Video bandwidth	$\geq$ RBW
Frequency span	The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
Detector mode	Peak
Trace mode	Max Hold

Time of occupancy (dwell time) was tested per ANSI C63.10 subclause 7.8.4. Spectrum analyser settings:

Resolution bandwidth	shall be $\leq$ channel spacing and where possible RBW should be set $\gg 1 / T$ , where T is the expected dwell time per channel.
Video bandwidth	$\geq$ RBW
Frequency span	Zero span, centered on a hopping channel.
Detector mode	Peak
Trace mode	Max Hold

20 dB bandwidth was tested per ANSI C63.10 subclause 6.9.2. Spectrum analyser settings:

Resolution bandwidth	$\geq 1-5\%$ of the 20 dB bandwidth
Video bandwidth	$\geq$ RBW
Frequency span	approximately 2 to 5 times the 20 dB bandwidth, centered on a hopping channel
Detector mode	Peak
Trace mode	Max Hold

#### 8.4.4 Test data

**Table 8.4-2: 20 dB bandwidth results**

Frequency, MHz	20 dB bandwidth, kHz
902.22	111.58
914.77	112.88
927.82	113.60

**Table 8.4-3: 99% occupied bandwidth results**

Frequency, MHz	99% occupied bandwidth, kHz
902.22	94.21
914.77	94.64
927.82	94.06

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

**Table 8.4-4: Carrier frequency separation results**

Carrier frequency separation, kHz	Minimum limit, kHz	Margin, kHz
203.30	113.60	89.70

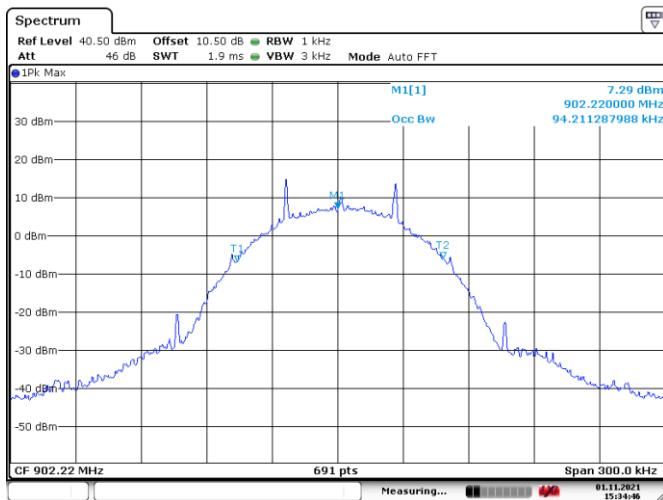
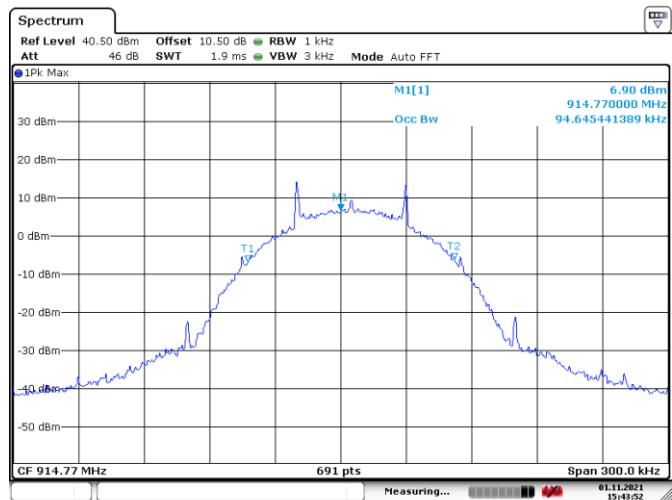
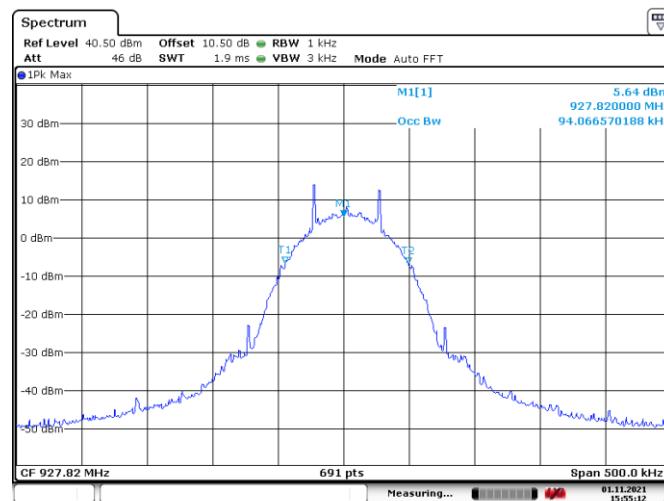
**Table 8.4-5: Number of hopping frequencies results**

Number of hopping frequencies	Minimum limit	Margin
128	50	78

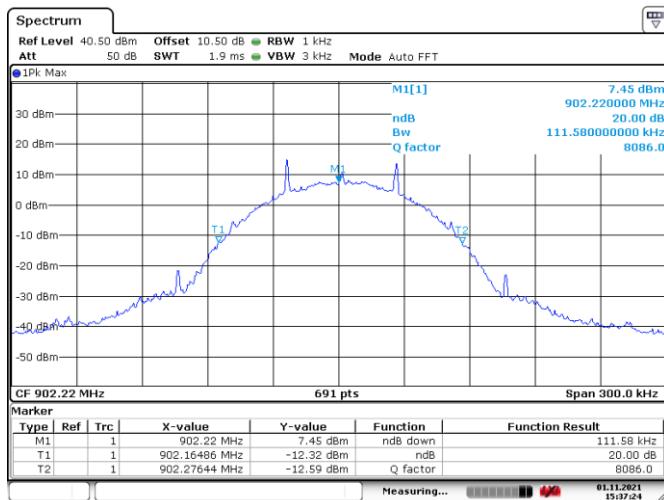
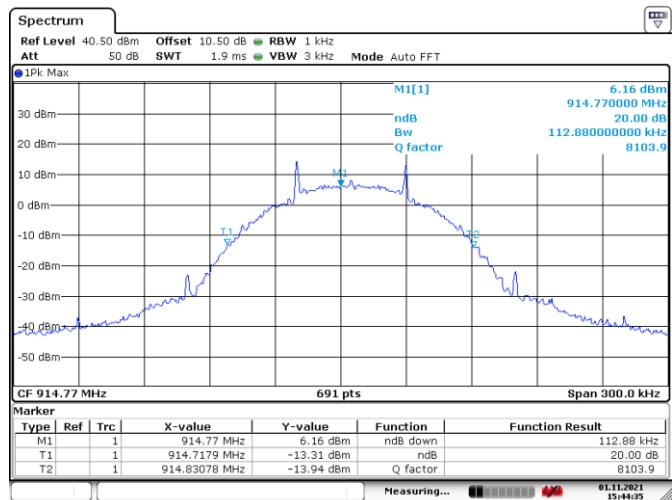
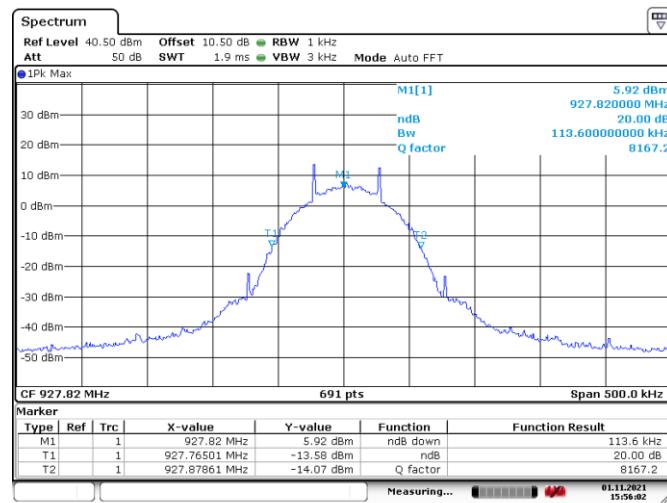
**Table 8.4-6: Average time of occupancy results**

Dwell time of each pulse, ms	Number of pulses within period	Total dwell time within period, ms	Limit, ms	Margin, ms
17.83	5	89.15	400	168.21

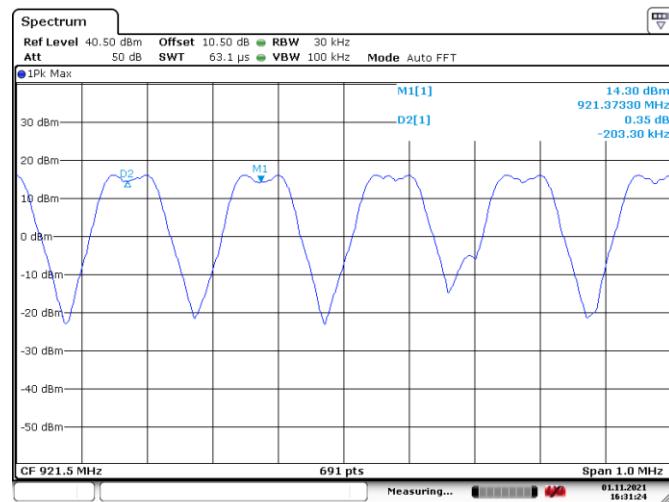
Notes: Measurement Period is 20 s

**Test data, continued**

**Figure 8.4-1:** 99% bandwidth on low channel

**Figure 8.4-2:** 99% bandwidth on mid channel

**Figure 8.4-3:** 99% bandwidth on high channel

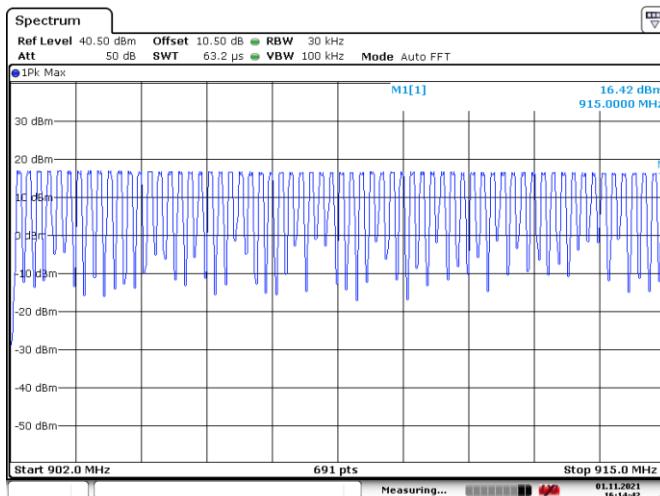
Test data, continued


**Figure 8.4-4:** 20 dB bandwidth on low channel

**Figure 8.4-5:** 20 dB bandwidth on mid channel

**Figure 8.4-6:** 20 dB bandwidth on high channel

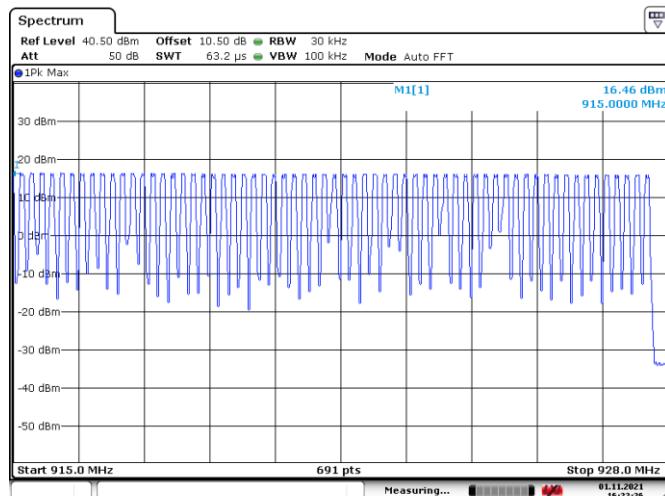
Test data, continued



**Figure 8.4-7: Carrier frequency separation**

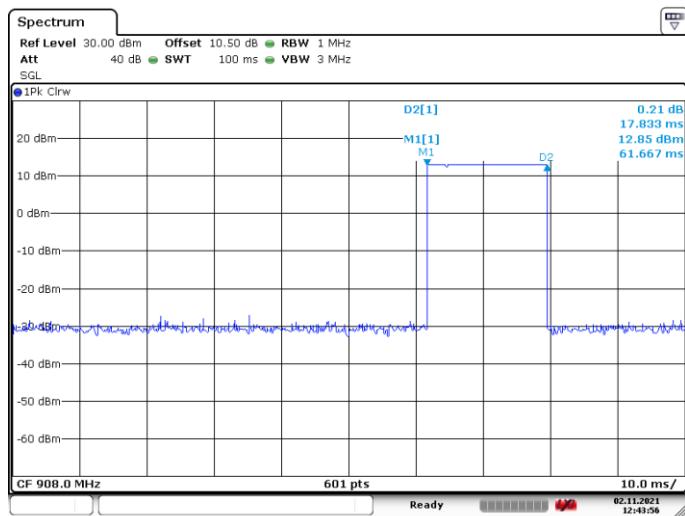


**Figure 8.4-8: Number of hopping channels from 902-915 MHz**

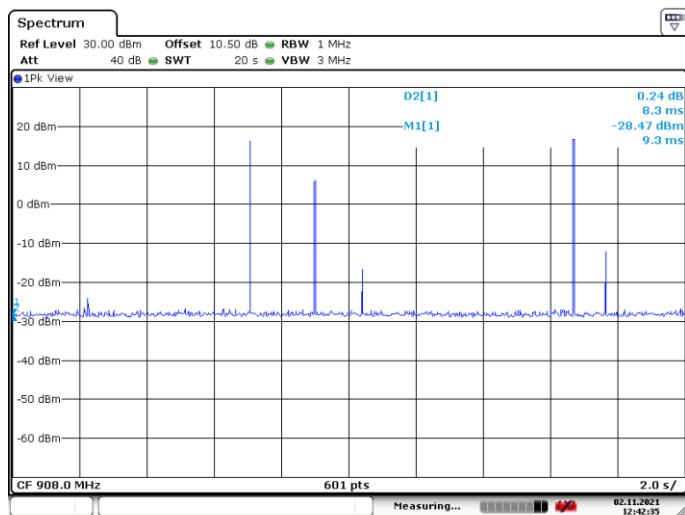


**Figure 8.4-9: Number of hopping channels from 915-928 MHz**

Test data, continued



**Figure 8.4-10: Dwell time**



**Figure 8.4-11: Number of pulses in 20s period**

## 8.5 Transmitter output power and e.i.r.p. requirements for FHSS 900 MHz

### 8.5.1 References, definitions and limits

#### FCC §15.247:

- (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:
- (2) For frequency hopping systems operating in the 902–928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.
- (4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

#### RSS-247, Clause 5.4:

Devices shall comply with the following requirements, where applicable:

- a. For FHSSs operating in the band 902–928 MHz, the maximum peak conducted output power shall not exceed 1.0 W, and the e.i.r.p. shall not exceed 4 W if the hopset uses 50 or more hopping channels; the maximum peak conducted output power shall not exceed 0.25 W and the e.i.r.p. shall not exceed 1 W if the hopset uses less than 50 hopping channels.

### 8.5.2 Test summary

Verdict	Pass
Tested by	Abdoulaye Ndiaye

Test date

December 7, 2021

### 8.5.3 Observations, settings and special notes

Conducted output power was tested per ANSI C63.10 subclause 7.8.5. The hopping shall be disabled for this test.

Spectrum analyser settings:

Resolution bandwidth	> 20 dB bandwidth of the emission being measured
Video bandwidth	≥ RBW
Frequency span	approximately 5 times the 20 dB bandwidth, centered on a hopping channel
Detector mode	Peak
Trace mode	Max Hold

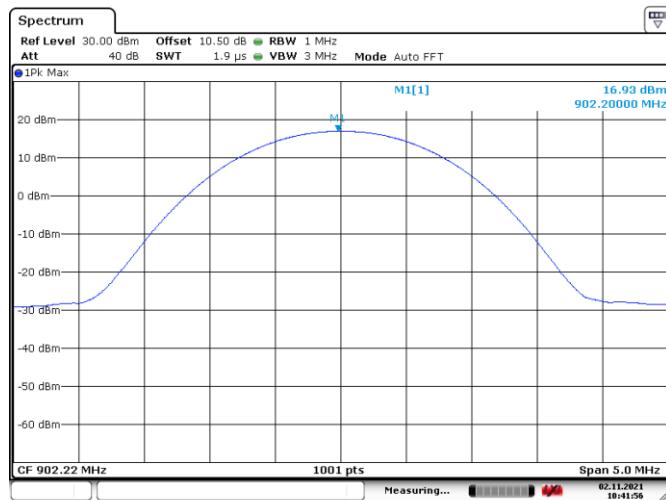
### 8.5.4 Test data

**Table 8.5-1: Output power and EIRP results**

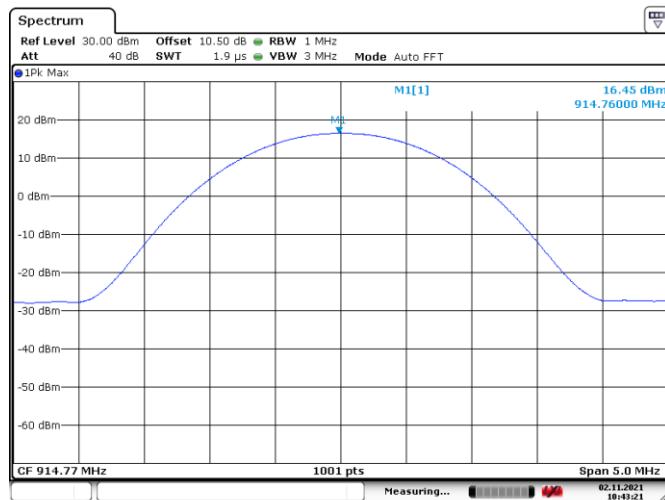
Frequency, MHz	Output power, dBm	Output power limit, dBm	Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
902.22	16.93	30.00	13.07	1.2	18.13	36.00	17.87
914.77	16.45	30.00	13.55	1.2	17.65	36.00	18.35
927.82	15.95	30.00	14.05	1.2	17.15	36.00	18.85

Notes: EIRP = Output power + Antenna gain

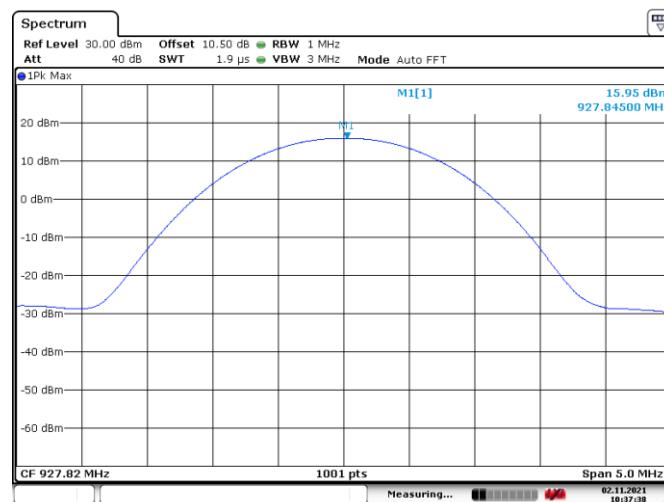
Test data, continued



**Figure 8.5-1: Output power on low channel**



**Figure 8.5-2: Output power on mid channel**



**Figure 8.5-3: Output power on high channel**

## 8.6 Spurious (out-of-band) unwanted emissions

### 8.6.1 References, definitions and limits

#### FCC §15.247:

(d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

#### RSS-247, Clause 5.5:

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(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 × log <sub>10</sub> (F)	300
0.490–1.705	24000/F	87.6 – 20 × log <sub>10</sub> (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 8.6-2: 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	
8.41425–8.41475	167.72–173.2	3500–4400	Above 38.6
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			

**8.6.2 Test summary**

Verdict	Pass	Test date	December 7, 2021
Tested by	Abdoulaye Ndiaye		

#### 8.6.3 Observations, settings and special notes

---

- As part of the current assessment, the test range of 9 kHz to 10<sup>th</sup> harmonic has been fully considered and compared to the actual frequencies utilized within the EUT. Since the EUT contains a transmitter in the GHz range, the EUT has been deemed compliant without formal testing in the 9 kHz to 30 MHz test range, therefore formal test results (tabular data and/or plots) are not provided within this test report.
- EUT was set to transmit with 100 % duty cycle.
- Radiated measurements were performed at a distance of 3 m
- Since fundamental power was tested using the maximum peak conducted output power procedure to demonstrate compliance, the spurious emissions limit is -20 dBc/100 kHz.
- Radiated emissions were performed up to 10 GHz. Therefore, no relevant emissions were noticed.

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

Spectrum analyser settings for conducted spurious emissions measurements:

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

#### 8.6.4 Test data

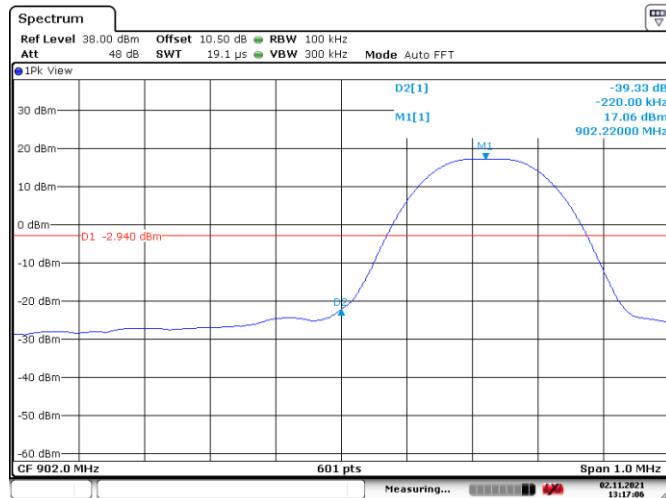


Figure 8.6-1: -20 dBc Conducted spurious emissions at 902 MHz

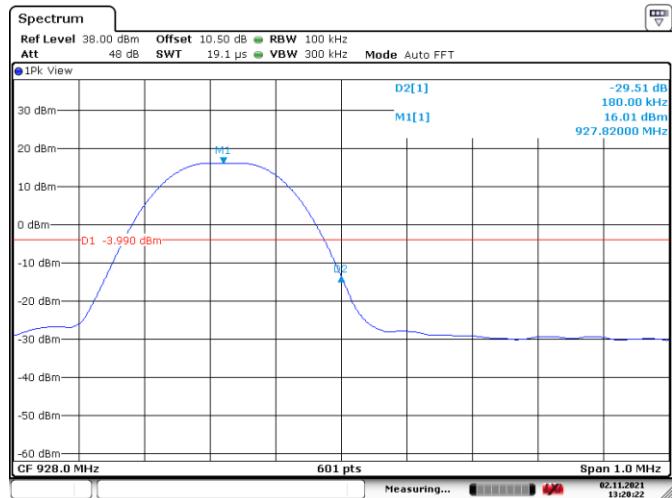


Figure 8.6-2: -20 dBc Conducted spurious emissions at 928 MHz

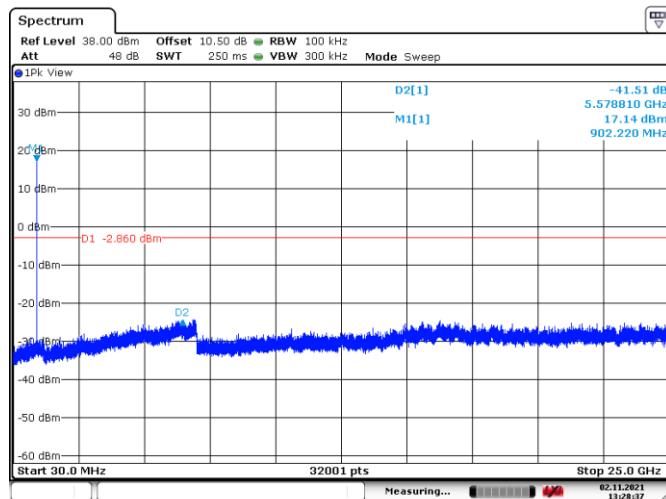


Figure 8.6-3: -20 dBc Conducted spurious emissions on Low Ch

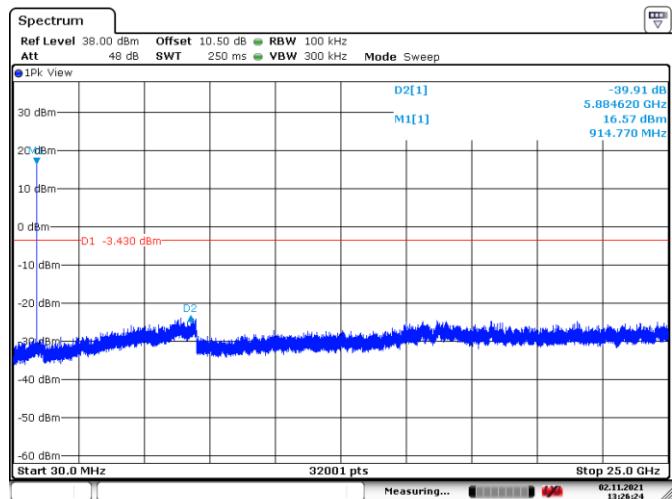
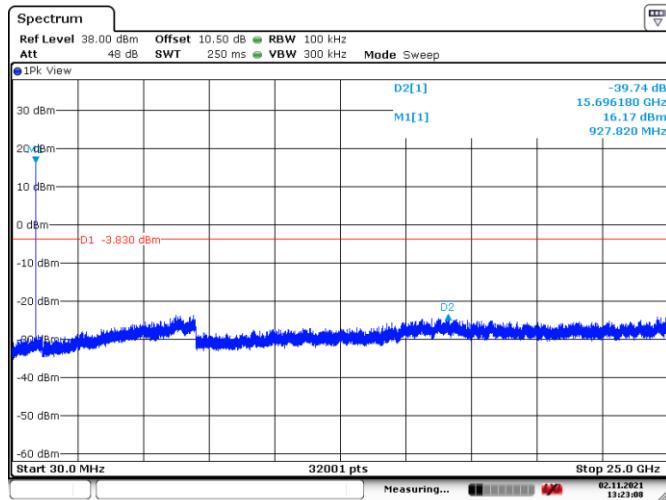


Figure 8.6-4: -20 dBc Conducted spurious emissions on Mid Ch

Test data, continued



**Figure 8.6-5:** -20 dBc Conducted spurious emissions on High Ch

**Table 8.6-4:** Radiated field strength measurement results below 1 GHz

Channel	Frequency, MHz	Quasi Peak Field strength, dB $\mu$ V/m		Margin, dB
		Measured	Limit	
High	975.84	45.2	54.00	8.8

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

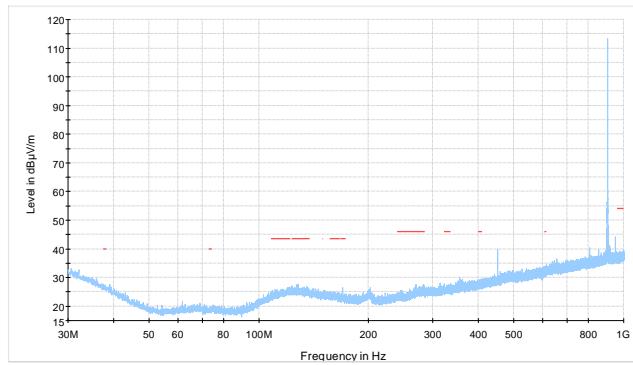
Values higher than 10 dB margin against the limits will not be shown.

**Table 8.6-5:** Radiated field strength measurement results above 1 GHz

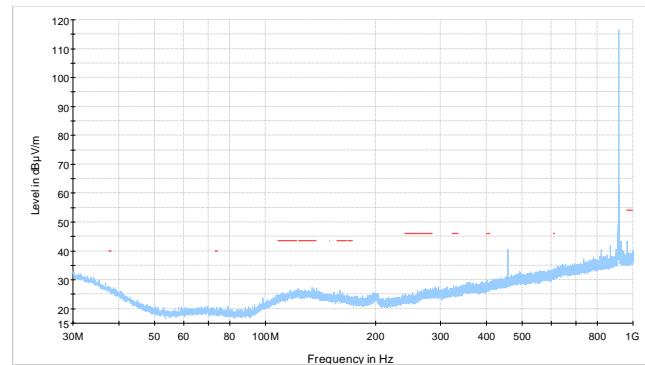
Channel	Frequency, MHz	Peak Field strength, dB $\mu$ V/m		Margin, dB	Average Field strength, dB $\mu$ V/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	8119.98	54.8	74.0	19.2	52.5	54.0	1.5
Mid	8233.00	52.5	74.0	21.5	49.1	54.0	4.9
Mid	3659.12	54.1	74.0	19.9	53.0	54.0	1.0
High	8350.75	54.7	74.0	19.3	52.1	54.0	1.9

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

Test data, continued



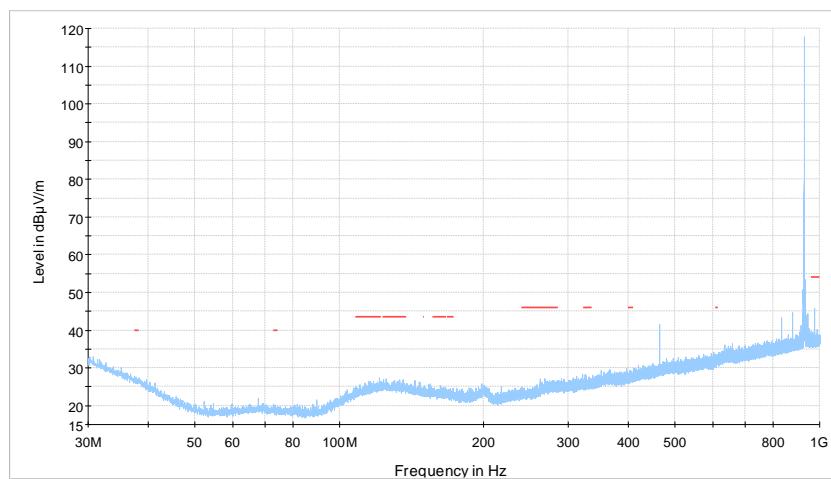
NEX-454338, December 6, 2021  
 Preview Result 1-PK+  
 FCC 15.209 and RSS-210 limit line RstrB



NEX-454338, December 6, 2021  
 Preview Result 1-PK+  
 FCC 15.209 and RSS-210 limit line RstrB

**Figure 8.6-6: Radiated spurious emissions 30MHz-1GHz on Low Ch**

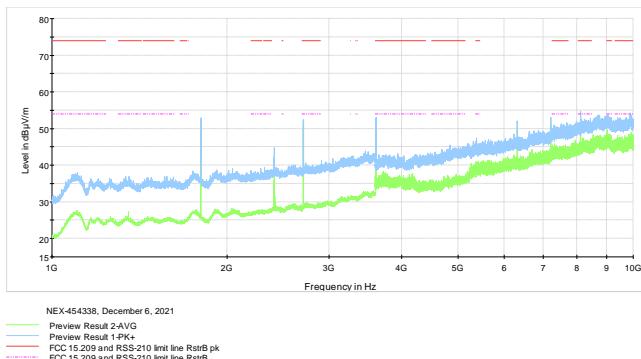
**Figure 8.6-7: Radiated spurious emissions 30MHz-1GHz on Mid Ch**



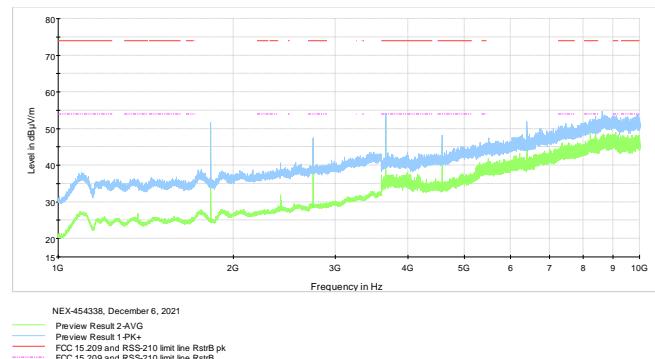
NEX-454338, December 6, 2021  
 Preview Result 1-PK+  
 FCC 15.209 and RSS-210 limit line RstrB

**Figure 8.6-8: Radiated spurious emissions 30MHz-1GHz on High Ch**

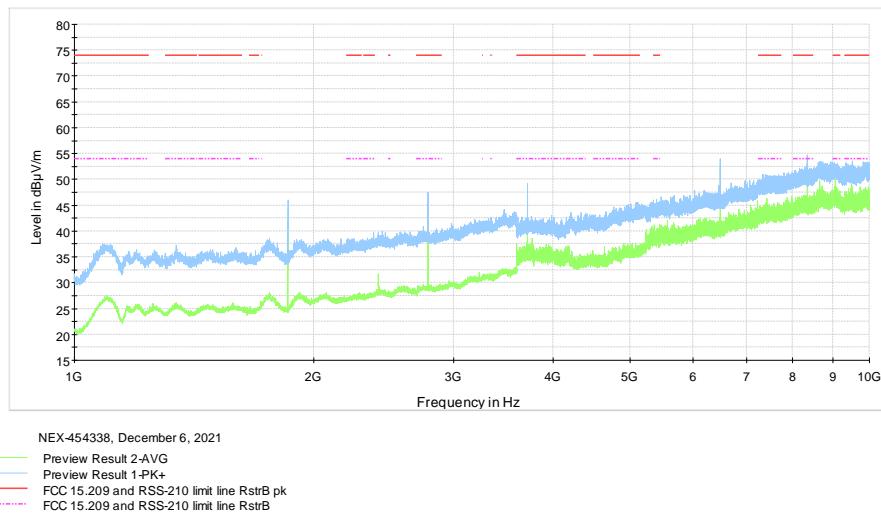
Test data, continued



**Figure 8.6-9: Radiated spurious emissions 1GHz-10GHz on Low Ch**



**Figure 8.6-10: Radiated spurious emissions 1GHz-10GHz on Mid Ch**



**Figure 8.6-11: Radiated spurious emissions 1GHz-10GHz on High Ch**