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RADIO TEST REPORT

Report ID
REP006576

Project ID
PRJ0018887

Type of assessment:
Limited Modular Approval

Applicant:
TopVu Ltd.

Model (HVIN):
RDRG3

Product description:
RFID module

HMN:
RDRG3

FCC identifier:
FCC ID: 2APX4RDRG3

ISED certification number:
IC: 22620-RDRG3

Specifications:

- FCC 47 CFR Part 15 Subpart C, §15.247
- RSS-247, Issue 2, Feb 2017, Section 5

Date of issue: February 17, 2023

Alvin Liu, EMC/RF Specialist
Tested by


Signature

Andrey Adelberg, Senior EMC/RF Specialist
Reviewed by


Signature

Lab locations

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Test site identifier	**Organization**	**Ottawa/Almonte**	**Montreal**	**Cambridge**
	FCC:	CA2040	CA2041	CA0101
	ISED:	2040A-4	2040G-5	24676
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.

Copyright notification

Table of Contents

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 5725–5850 MHz
RSS-247, Issue 2, Feb 2017, Section 5	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

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
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

1.3 Exclusions

Partial testing were performed on the product with the module mounted inside a typical host and connected to the new gain antenna (changed from 2 dBi to 7 dBi) to check the spurious emissions for compliance with all the applicable rules.

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
REP006576	February 17, 2023	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

The applicant determines to change the antenna of the RFID 915 MHz module (from 2 dBi to 7 dBi), and apply Limited Modular Approval, so partial testing was performed on the product with the module mounted inside a typical host (RDRG3) and connected to the new gain antenna to check the spurious emissions for compliance with all the applicable rules. The module contains 4 antenna ports that cannot transmit simultaneously, so output power was tested on all 4 antenna ports, the port with the highest level was select for testing and connected the new antenna to it, other ports were terminated.

2.3 Model variant declaration

There were no model variants declared by the applicant.

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 ±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/Manufacturer

Applicant name	TopVu Ltd.
Applicant address	Unit T, 11 Mary Street, Sudbury, ON, Canada P3C 1B4
Manufacturer name	Same as applicant
Manufacturer address	Same as applicant

5.3 EUT information

Product marketing name	RFID module
Model (HVIN)	RDRG3
HMN	RDRG3
Serial number	3-001-281122
Power supply requirements	Powered via host (powered by 12 – 24 V_{DC} POE)
Description/theory of operation	UHF RFID reader 902–928 MHz

5.4 Radio technical information

Category of Wideband Data Transmission equipment	☒ Frequency Hopping Spread Spectrum (FHSS) equipment ☐ Other types of Wideband Data Transmission equipment (e.g. DSSS, OFDM, etc.).
Frequency band	902–928 MHz
Frequency Min	902.5 MHz
Frequency Max	927.5 MHz
RF power Max, Conducted	0.785 W (28.95 dBm)
Emission designator	375KF1D
Transmitter spurious	Q-Peak 53.6 dBµV/m @ 3 m, 960.017 MHz
Antenna information	Type: Panel antenna, manufacturer: Mobile Mark, model: HD7-915RCP-BLK, gain: 7 dBi

5.5 EUT setup details

5.5.1 Radio exercise details

Operating conditions	EUT was powered via host and connected with 7 dBi antenna, transmitting at low (902.5 MHz), mid (915 MHz) and high (927.5 MHz) with power setting 26 dBm.
Transmitter state	Transmitter set into continuous mode.

5.5.2 EUT test configuration

Table 5.5-1: *EUT sub assemblies*

Description	Brand name	Serial number, Part number, Model, Revision level
RDRG3 (Host)	TopVu	MN: RDRG3, PN: RDRG3-ORE-0E0, SN: 3-001-281122
Panel antenna	Mobile Mark	MN: HD7-915RCP-BLK, PN: ANT-P88+BRACKET1

Table 5.5-2: *EUT interface ports*

Description	Qty.
Panel antenna port	4
Ethernet (POE) of Host	1

Table 5.5-3: *Support equipment*

Description	Brand name	Serial number, Part number, Model, Revision level
POE Switch	D-Link	MN: DGS-1008P, SN: SY3L1IA001127
AC/DC Adapter	LEI	MN: NU90-J540167-I1

Table 5.5-4: *Inter-connection cables*

Cable description	From	To	Length (m)
RF cable	RDRG3	Panel antenna	< 3.0
Ethernet	RDRG3	POE	1.0
AC mains power input	AC mains	AC/DC Adaptor	1.5
DC output	AC/DC Adaptor	POE	1.2

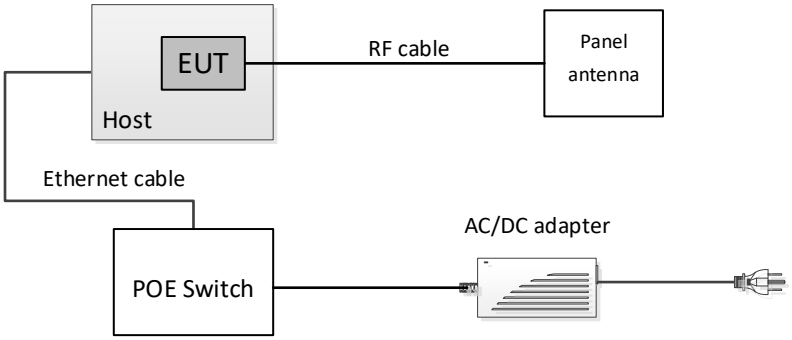


Figure 5.5-1: *Block diagram of EUT test setup*

Section 6 Summary of test results

6.1 Testing location

Test location (s)	Cambridge

6.2 Testing period

Test start date	December 20, 2022	Test end date	February 1, 2023

6.3 Sample information

Receipt date	December 7, 2022	Nemko sample ID number(s)	1, 2

6.4 FCC Part 15, Test results

Table 6.4-1: *FCC requirements results*

Part	Test description	Verdict
§15.207(a)	Conducted limits	Pass
§15.247(b)(2)	Maximum peak output power in the 902–928 MHz band	Pass
§15.247(d)	Spurious emissions	Pass

Notes: None

6.5 ISED RSS-Gen/ ISED RSS-247, Test results

Table 6.5-1: *RSS-Gen/ ISED RSS-247 requirements results*

Part	Test description	Verdict
ISED RSS-Gen, 8.8	AC powerline conducted emissions limits	Pass
RSS-247, 5.4 (a)	Transmitter output power and e.i.r.p. requirements, Systems operating in the 902–928 MHz band	Pass
ISED RSS-247, 5.5	Unwanted emissions	Pass
RSS-247, 5.1 (b)	Minimum channel spacing	Pass
RSS-247, 5.1 (c)	Number of hopping channels, dwell time and occupied channel bandwidth in the 902–928 MHz band	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	December 31, 2023
3 m EMI test chamber	TDK	SAC-3	FA003012	1 year	February 7, 2023
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	FA003009	1 year	January 31, 2023
Horn antenna (1–18 GHz)	ETS Lindgren	3117	FA002911	1 year	April 21, 2023
Preamp (1–18 GHz)	ETS Lindgren	124334	FA002956	1 year	March 30, 2023
Two-line v-network	Rohde & Schwarz	ENV216	FA002965	1 year	December 31, 2023
50 Ω coax cable	Rohde & Schwarz	None	FA003074	1 year	July 13, 2023
50 Ω coax cable	Huber + Suhner	None	FA003047	1 year	July 13, 2023
50 Ω coax cable	Huber + Suhner	None	FA003043	1 year	July 13, 2023

Notes: NCR - no calibration required

Section 8 Testing data

8.1 AC power line conducted emissions limits

8.1.1 References, definitions and limits

FCC §15.207:

(a) 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, Clause 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.

RSS-Gen, Clause 8.8:

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

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

Table 8.1-1: *Conducted emissions limit*

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

Notes: * - The level decreases linearly with the logarithm of the frequency.
** - A linear average detector is required.

8.1.2 Test summary

Verdict	Pass		
Tested by	Alvin Liu	Test date	December 29, 2022

8.1.3 Observations, settings and special notes

Port under test – Coupling device	AC mains power input of POE adapter – Artificial Mains Network (AMN)
EUT power input during test	120 V_{AC}, 60 Hz
EUT setup configuration	Table top
Measurement details	A preview measurement was generated with the receiver in continuous scan mode. Emissions detected within 10 dB or above the limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement.
Additional 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. Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + attenuator (dB) – Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded. – EUT was powered via host on ethernet port, the test was performed on AC input of POE adapter.

Receiver settings:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Peak and Average (Preview), Quasi-peak and CAverage (Final)
Trace mode	Max Hold
Measurement time	100 ms (Preview), 160 ms (Final)

8.1.1 Test data

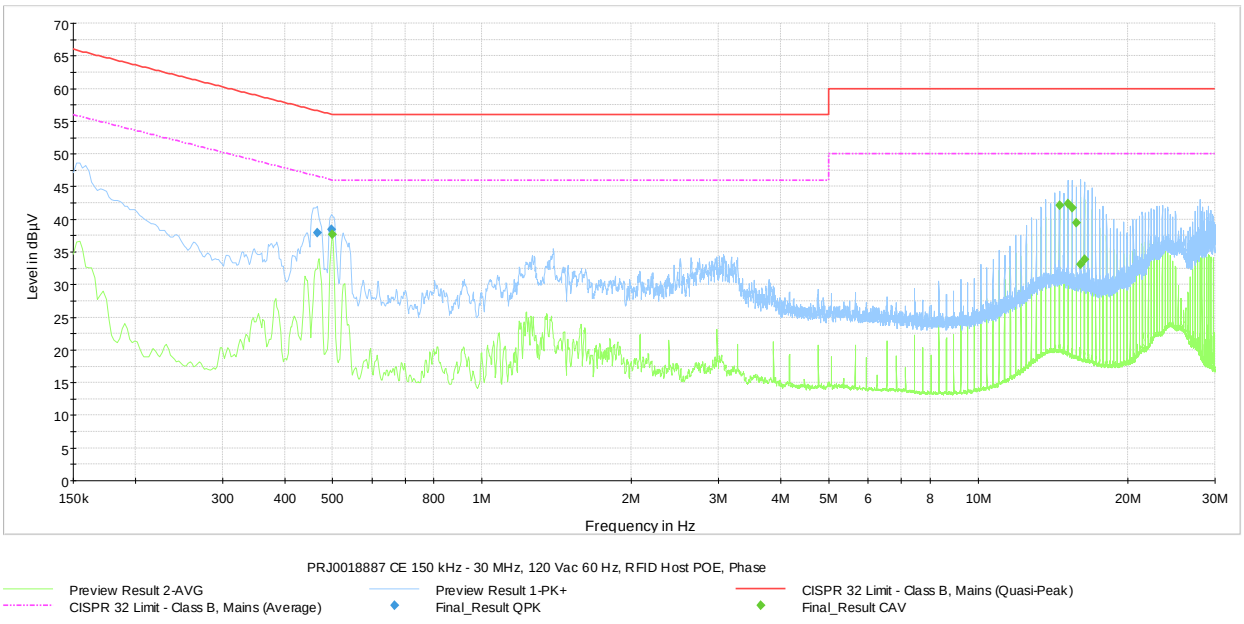
Table 8.1-2: *Conducted emissions results on phase line*

Frequency, MHz	CAverage result, dBµV	CAverage limit, dBµV	CAverage margin, dB	Correction factor, dB
0.499	37.7	46.0	8.3	15.8
14.573	42.1	50.0	7.9	15.8
15.167	42.4	50.0	7.6	15.9
15.464	41.7	50.0	8.3	15.9

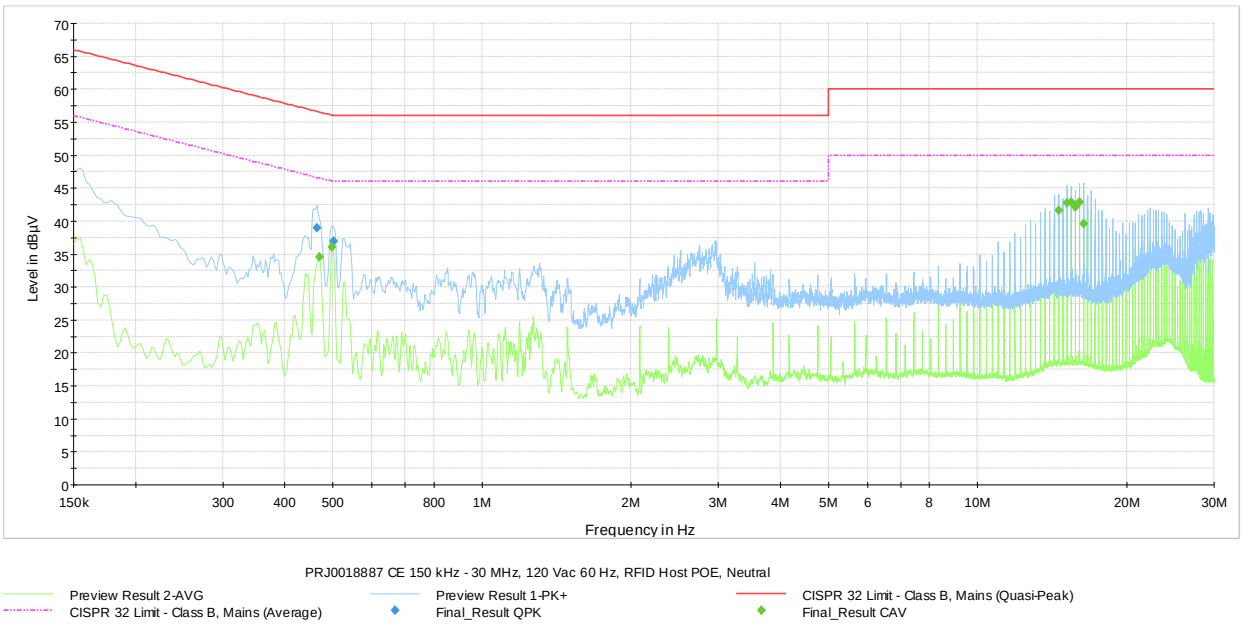
Table 8.1-3: *Conducted emissions results on neutral line*

Frequency, MHz	CAverage result, dBµV	CAverage limit, dBµV	CAverage margin, dB	Correction factor, dB
0.499	36.1	46.0	9.9	15.8
14.575	41.7	50.0	8.3	15.8
15.169	42.8	50.0	7.2	15.9
15.466	42.9	50.0	7.1	15.9
15.765	42.2	50.0	7.9	15.9
16.062	42.9	50.0	7.1	15.9

Test data, continued



Plot 8.1-1: *Conducted emissions on phase line*



Plot 8.1-2: *Conducted emissions on neutral line*

8.2 Transmitter output power and e.i.r.p. requirements

8.2.1 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 FHSs 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.

8.2.2 Test summary

Verdict	Pass		
Tested by	Alvin Liu	Test date	December 20, 2022

8.2.3 Observations, settings and special notes

Conducted output power was tested per ANSI C63.10 subclause 7.8.5. The hopping was disabled for this test.
Output power setting 28 dBm

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

8.2.4 Test data

Table 8.2-1: *Output power and EIRP results – Port 1*

Frequency, MHz	Output power, dBm	Output power limit[1], dBm	Margin, dB	Antenna gain, dBi	EIRP[2], dBm	EIRP limit, dBm	EIRP margin, dB
902.5	28.50	29.00	0.50	7.00	35.50	36.00	0.50
915.0	27.98	29.00	1.02	7.00	34.98	36.00	1.02
927.5	28.09	29.00	0.91	7.00	35.09	36.00	0.91

Notes: [1] Output power limit was reduced by 1.0 dB as antenna gain 7 dBi is 1 dB higher than 6 dBi
[2] EIRP = Output power + Antenna gain

Table 8.2-2: *Output power and EIRP results – Port 2*

Frequency, MHz	Output power, dBm	Output power limit[1], dBm	Margin, dB	Antenna gain, dBi	EIRP[2], dBm	EIRP limit, dBm	EIRP margin, dB
902.5	28.61	29.00	0.39	7.00	35.61	36.00	0.39
915.0	27.97	29.00	1.03	7.00	34.97	36.00	1.03
927.5	28.22	29.00	0.78	7.00	35.22	36.00	0.78

Notes: [1] Output power limit was reduced by 1.0 dB as antenna gain 7 dBi is 1 dB higher than 6 dBi
[2] EIRP = Output power + Antenna gain

Table 8.2-3: *Output power and EIRP results – Port 3*

Frequency, MHz	Output power, dBm	Output power limit[1], dBm	Margin, dB	Antenna gain, dBi	EIRP[2], dBm	EIRP limit, dBm	EIRP margin, dB
902.5	28.43	29.00	0.57	7.00	35.43	36.00	0.57
915.0	27.74	29.00	1.26	7.00	34.74	36.00	1.26
927.5	28.27	29.00	0.73	7.00	35.27	36.00	0.73

Notes: [1] Output power limit was reduced by 1.0 dB as antenna gain 7 dBi is 1 dB higher than 6 dBi
[2] EIRP = Output power + Antenna gain

Table 8.2-4: *Output power and EIRP results – Port 4*

Frequency, MHz	Output power, dBm	Output power limit[1], dBm	Margin, dB	Antenna gain, dBi	EIRP[2], dBm	EIRP limit, dBm	EIRP margin, dB
902.5	28.95	29.00	0.05	7.00	35.95	36.00	0.05
915.0	28.01	29.00	0.99	7.00	35.01	36.00	0.99
927.5	28.28	29.00	0.72	7.00	35.28	36.00	0.72

Notes: [1] Output power limit was reduced by 1.0 dB as antenna gain 7 dBi is 1 dB higher than 6 dBi
[2] EIRP = Output power + Antenna gain

Test data, continued

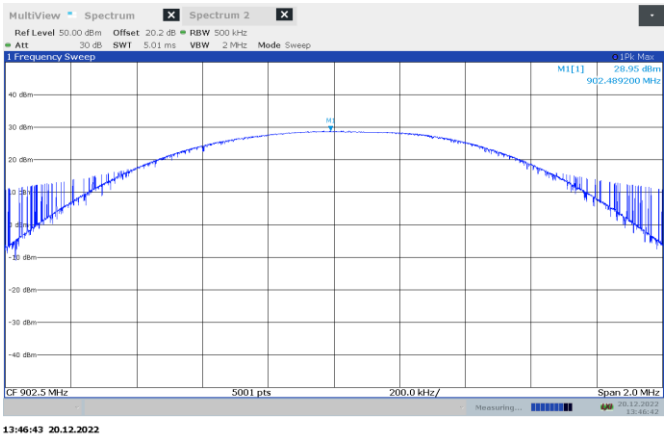


Figure 8.2-1: *Output power on low channel (sample plot)*

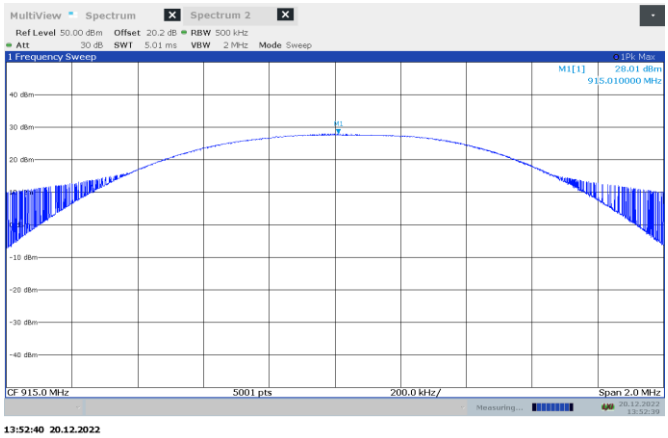


Figure 8.2-2: *Output power on mid channel (sample plot)*

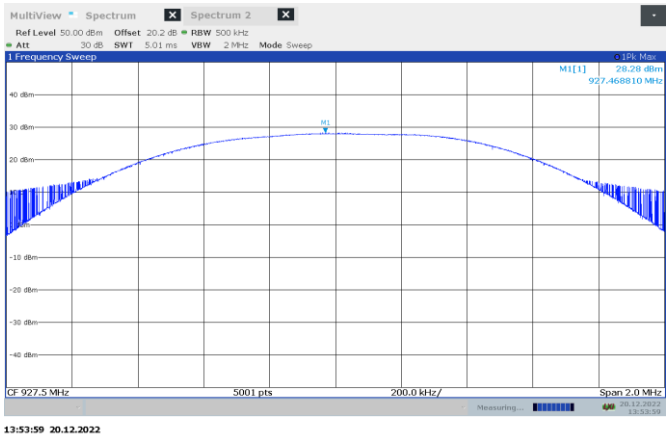


Figure 8.2-3: *Output power on high channel (sample plot)*

8.3 Spurious (out-of-band) unwanted emissions

8.3.1 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.

RSS-Gen:

8.9 Except where otherwise indicated in the applicable RSS, radiated emissions shall comply with the field strength limits shown in table below.

8.10 Restricted frequency bands are designated primarily for safety-of-life services (distress calling and certain aeronautical activities), certain satellite downlinks, radio astronomy and some government uses. The following conditions related to the restricted frequency bands apply:

a The transmit frequency, including fundamental components of modulation, of licence-exempt radio apparatus shall not fall within the restricted frequency bands.

b Unwanted emissions that fall into restricted frequency bands listed in table 7 shall comply with the limits specified in table below.

c Unwanted emissions that do not fall within the restricted frequency bands shall comply either with the limits specified in the applicable RSS or with those specified in table below.

Table 8.3-1: *FCC §15.209 and RSS-Gen – Radiated emission limits*

	Field strength of emissions		
Frequency, MHz	**µV/m**	**dBµV/m**	**Measurement distance, 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 8.3-2: *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 8.3-2 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 8.3-3: *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			

8.3.2 Test summary

Verdict	Pass		
Tested by	Alvin Liu	Test date	December 20, 2022 – February 1, 2023

8.3.3 Observations, settings and special notes

- Only radiated spurious emissions within restricted bands were evaluated.
- As part of the current assessment, the test range of 9 kHz to 10th 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.
- 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 measurements were performed at a distance of 3 m.
- Output power setting 26 dBm
- The port 4 which has the highest output power was connected with the antenna, other ports were terminated.
- The spectrum was searched from 30 MHz to 10 GHz.

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

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

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

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

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

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

8.3.4 Test data

Table 8.3-4: *Radiated field strength measurement results*

Channel	Frequency, MHz	Field strength result, dBµV/m	Field strength limit, dBµV/m	Margin, dB
Low	250.003	42.9	46.0	3.1
Low	960.022	53.0	54.0	1.0
Low	989.028	52.0	54.0	2.0
Low	998.495	52.5	54.0	1.5
Mid	249.991	43.7	46.0	2.3
Mid	960.017	53.6	54.0	0.4
High	249.998	41.3	46.0	4.7
High	323.476	42.4	46.0	3.6
High	960.054	49.9	54.0	4.1

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

Test data, continued

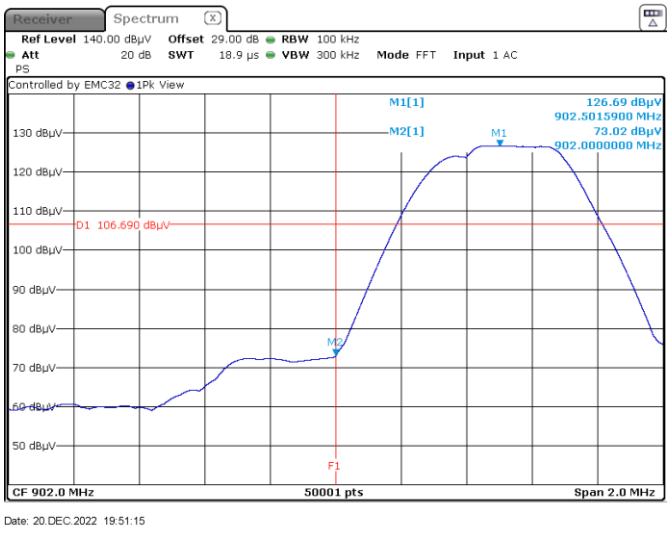


Figure 8.3-1: *Radiated spurious emissions on lower band edge*

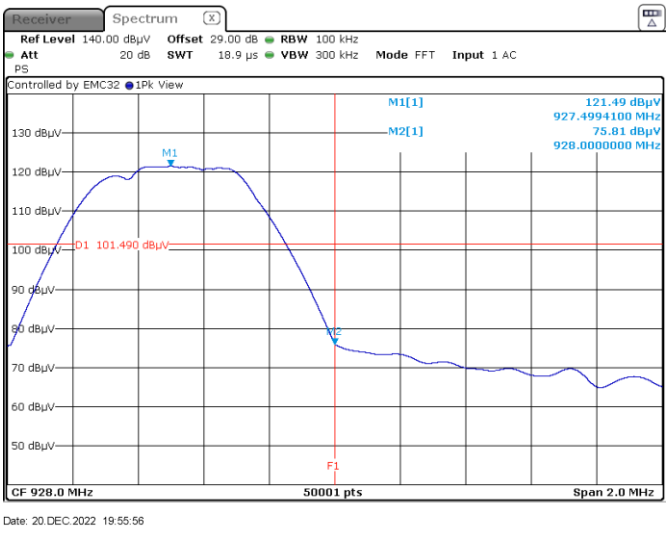


Figure 8.3-2: *Radiated spurious emissions on upper band edge*

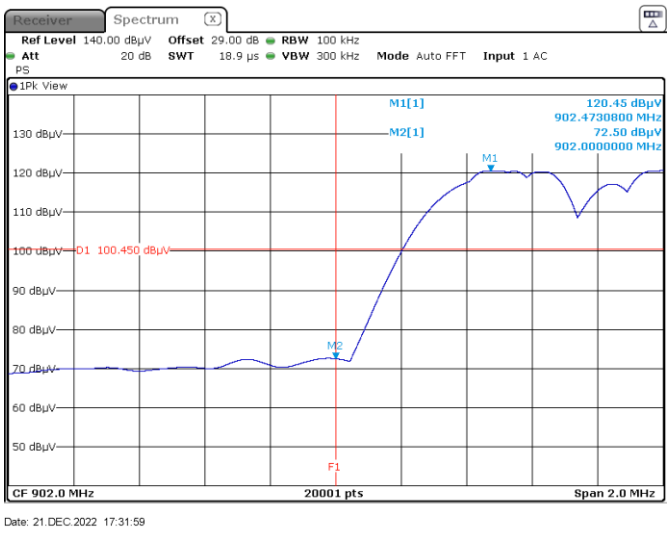


Figure 8.3-3: *Radiated spurious emissions on lower band edge, Hopping*

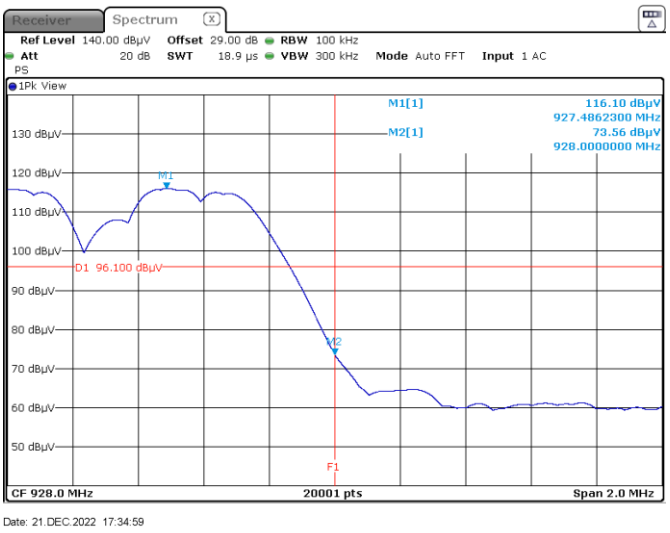


Figure 8.3-4: *Radiated spurious emissions on upper band edge, Hopping*

Test data, continued

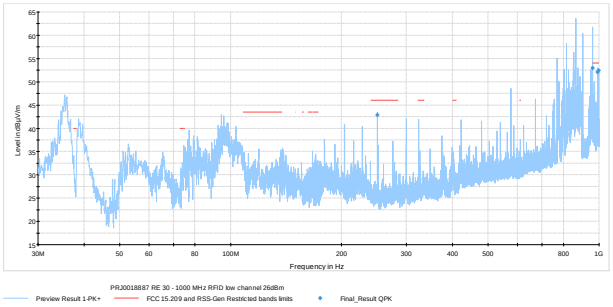


Figure 8.3-5: *Radiated spurious emissions on low channel, 30–1000 MHz*

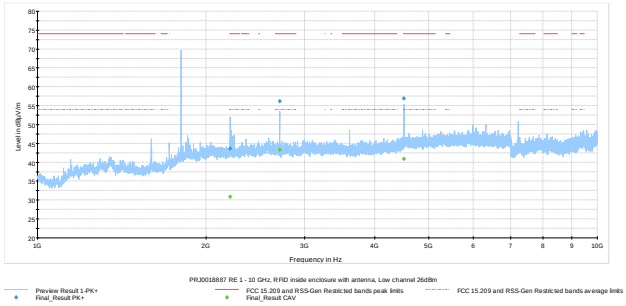


Figure 8.3-6: *Radiated spurious emissions on low channel, 1–10 GHz*

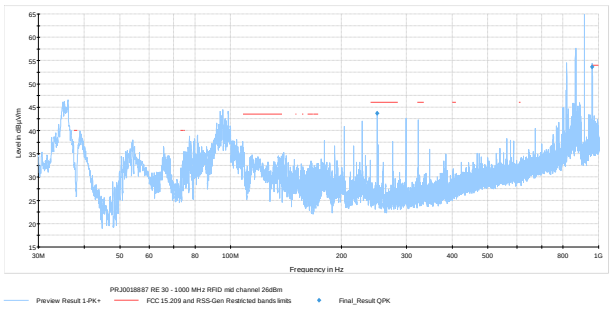


Figure 8.3-7: *Radiated spurious emissions on mid channel, 30–1000 MHz*

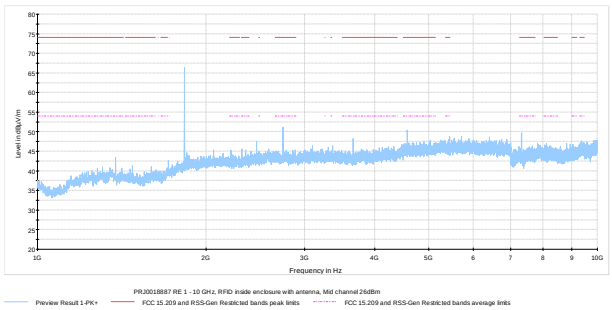


Figure 8.3-8: *Radiated spurious emissions on mid channel, 1–10 GHz*

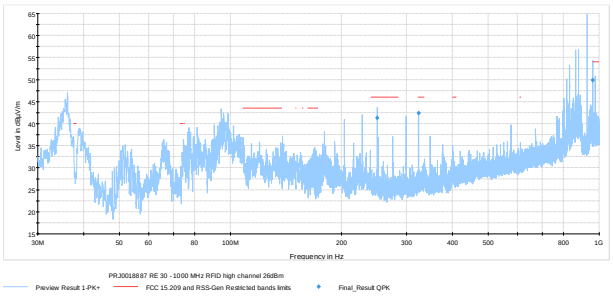


Figure 8.3-9: *Radiated spurious emissions on high channel, 30–1000 MHz*

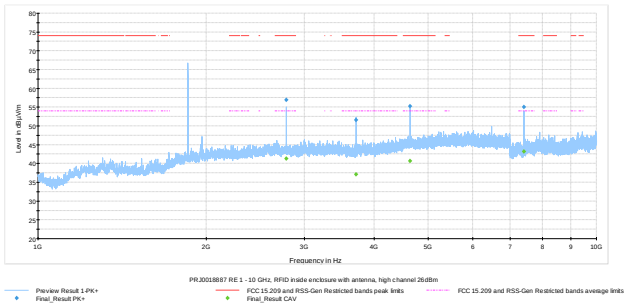


Figure 8.3-10: *Radiated spurious emissions on high channel, 1–10 GHz*

Test data, continued

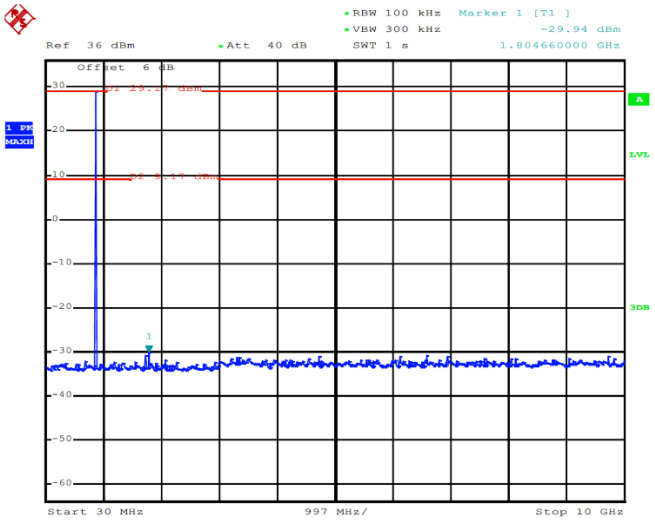


Figure 8.3-11: *Conducted spurious emissions on lower channel*

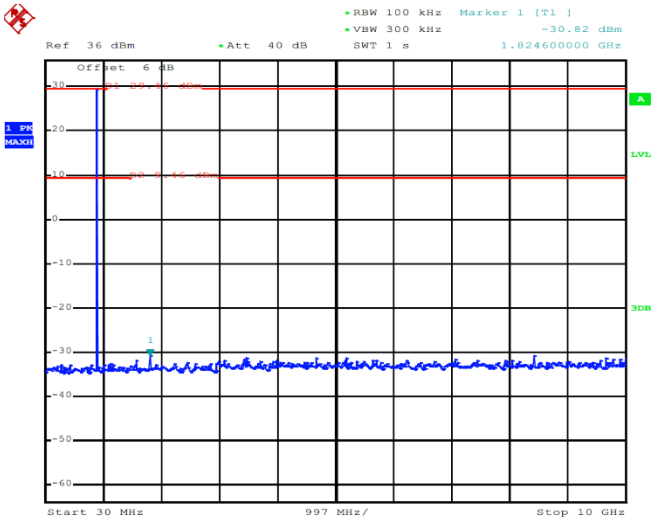


Figure 8.3-12: *Conducted spurious emissions on middle channel*

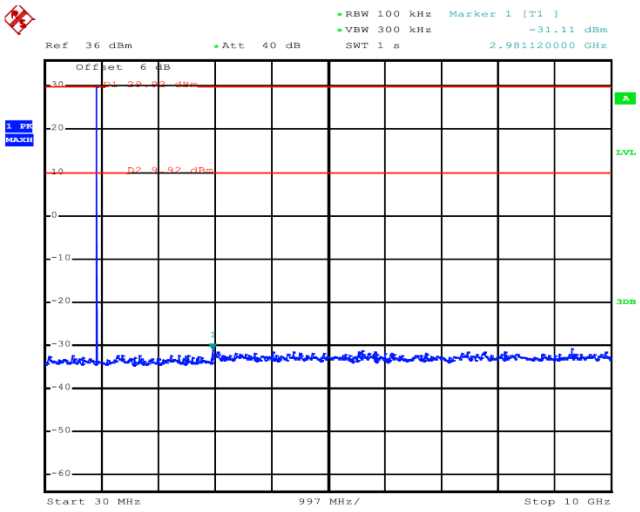


Figure 8.3-13: *Conducted spurious emissions on upper channel*

8.4 Frequency Hopping Systems requirements, 900 MHz operation

8.4.1 References, definitions and limits

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.

b. FHSs 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.

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.

8.4.2 Test summary

Verdict	Pass		
Tested by	Alvin Liu	Test date	February 17, 2023

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	Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
Video bandwidth	≥ 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	≥ 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 ≤ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.
Video bandwidth	≥ 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	≥ 1–5% of the 20 dB bandwidth
Video bandwidth	≥ 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 8.4-1: *20 dB bandwidth results*

Frequency, MHz	20 dB bandwidth, kHz	20 dB bandwidth limit, kHz	Margin, kHz
902.5	136	500	364
915.0	140	500	360
927.5	175	500	325

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

Frequency, MHz	99% occupied bandwidth, kHz
902.5	300.6
915.0	375.3
927.5	356.0

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

Table 8.4-3: *Carrier frequency separation results*

Carrier frequency separation, kHz	Minimum limit, kHz	Margin, kHz
502	175	327

Table 8.4-4: *Number of hopping frequencies results*

Number of hopping frequencies	Minimum limit	Margin
50	50	0

Table 8.4-5: *Average time of occupancy results*

Dwell time of each pulse, s	Number of pulses within period	Total dwell time within period, s	Limit, s	Margin, s
0.01644	17	0.279	0.400	0.121

Notes: Measurement Period is 20 s

Test data, continued

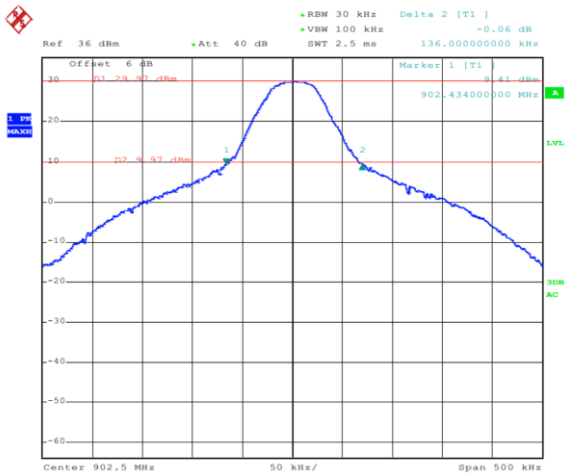


Figure 8.4-1: *20 dB bandwidth on low channel*

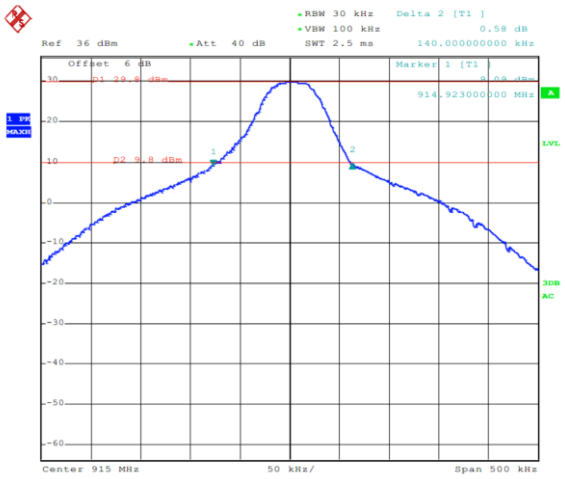


Figure 8.4-2: *20 dB bandwidth on mid channel*

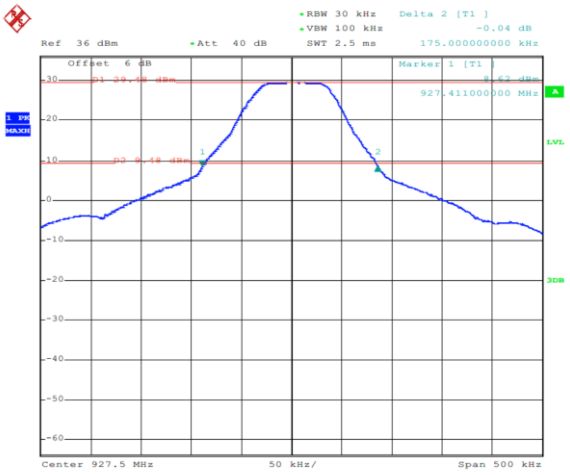


Figure 8.4-3: *20 dB bandwidth on high channel*

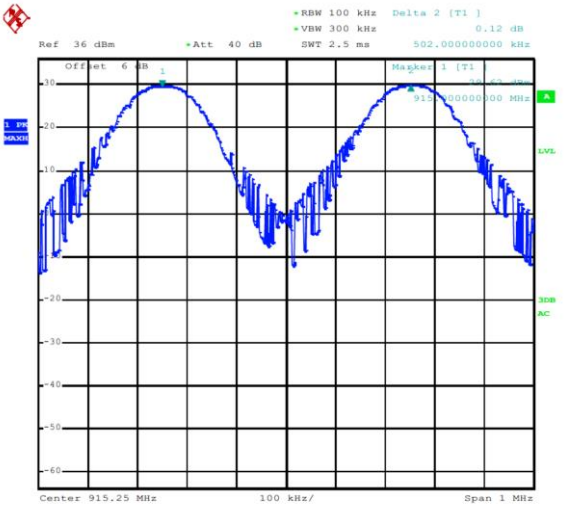


Figure 8.4-4: *Carrier frequency separation*

Test data, continued

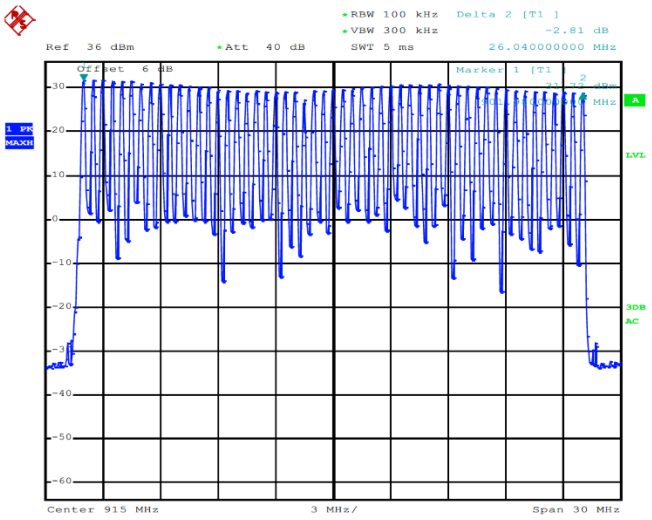


Figure 8.4-5: *Number of hopping channels*

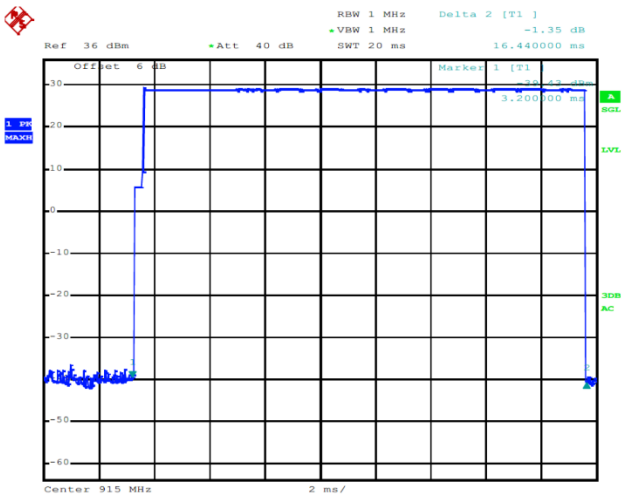


Figure 8.4-6: *Dwell time (pulse width)*

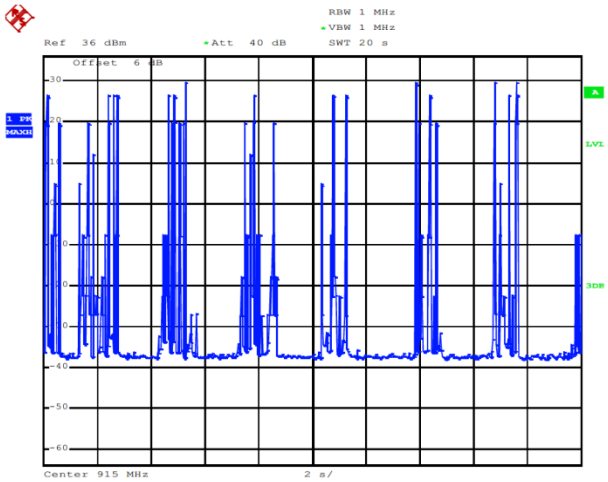


Figure 8.4-7: *Dwell time (number of pulses)*

Test data, continued

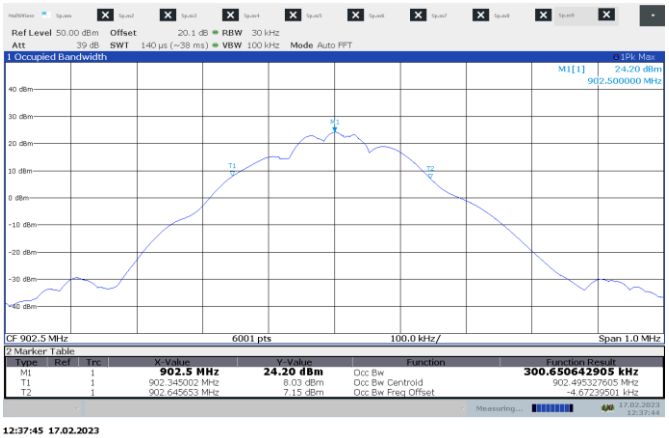


Figure 8.4-8: *99% OBW on low channel*

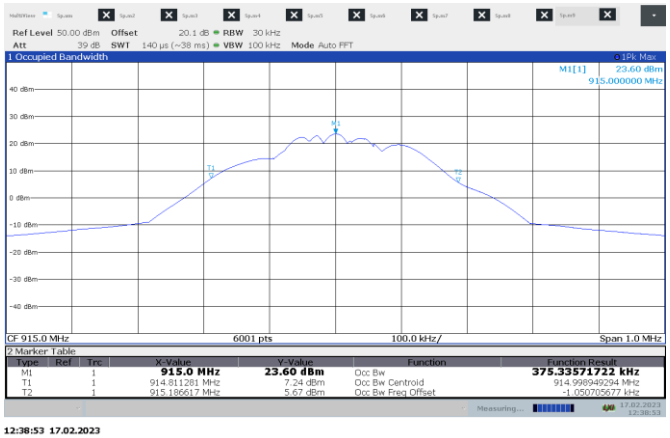


Figure 8.4-9: *99% OBW on mid channel*

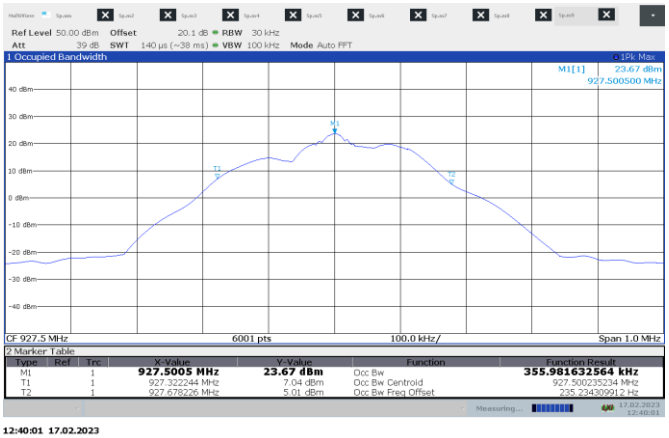
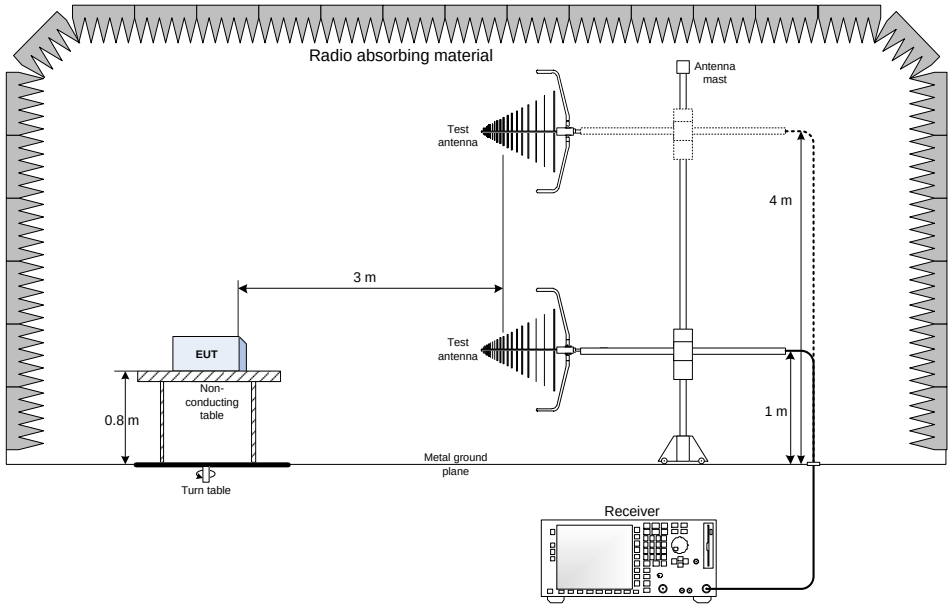


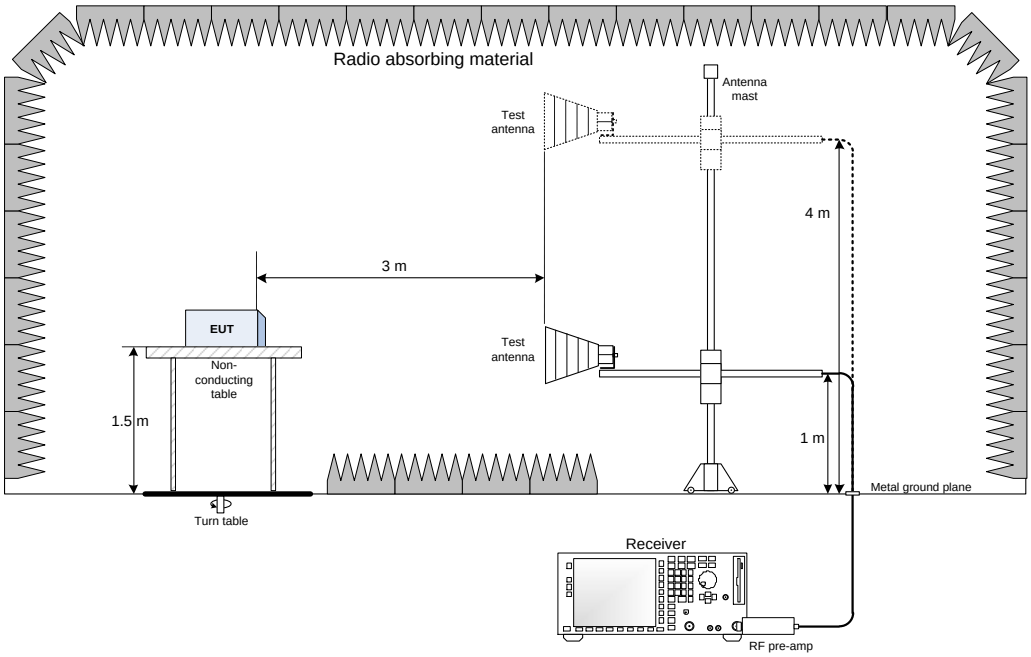
Figure 8.4-10: *99% OBW on high channel*

Section 9 Test setup diagrams

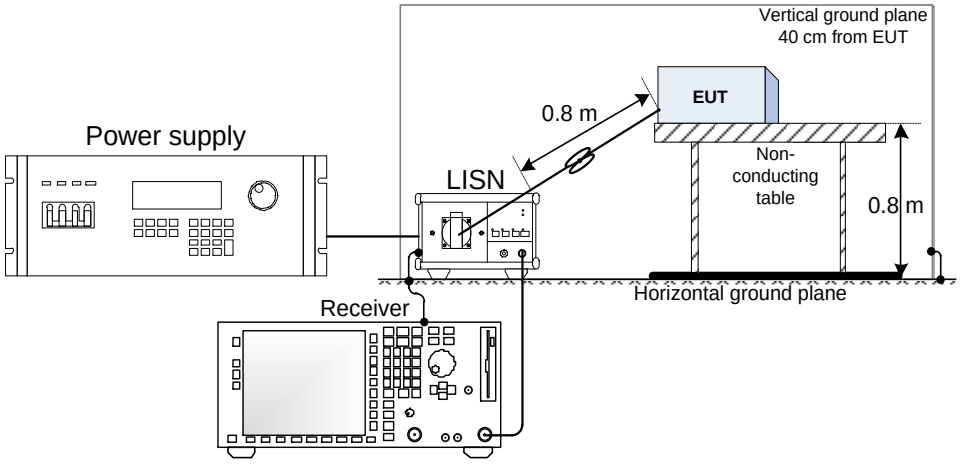
9.1 Radiated emissions set-up for frequencies below 1 GHz



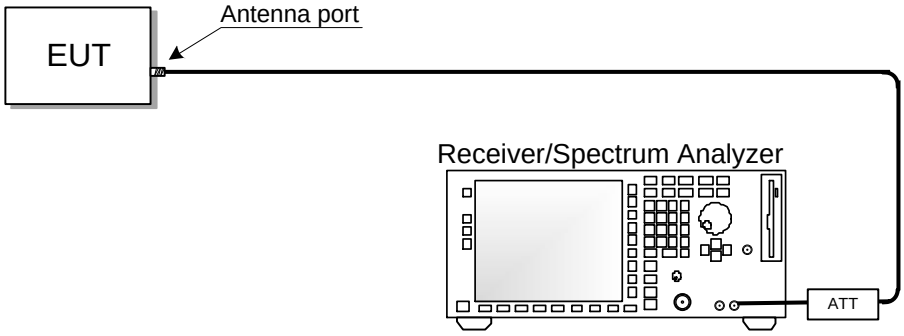
9.2 Radiated emissions set-up for frequencies above 1 GHz



9.3 AC mains conducted emissions set-up



9.4 Antenna port set-up



End of the test report