

RADIO TEST REPORT – 455912-1TRFWL

Type of assessment:

Class 2 Permissive Change

Applicant:

Alert Labs Inc.

Product name (type):

**Alert Labs ALRM001 Sub-1GHz Radio
Module**

Model:

ALRM001

FCC ID:

2AKXF-ALB080

IC Registration number:

22365-ALB080

Specifications:

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

Date of issue: January 17, 2022

Mark Libbrecht, EMC/RF Specialist

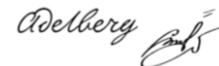
Tested by



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Andrey Adelberg, Senior EMC/RF Specialist

Reviewed by



Signature



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Company name	Nemko Canada Inc.			
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	Test site registration	Organization FCC/ISED	Recognition numbers and location 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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Report summary

1.1 Test specifications

Se FCC 47 CFR Part 15, Subpart C, Clause 15.247	Operation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–585 MHz
RSS-247, Issue 2, Feb 2017, Section 5	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

1.2 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.
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

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 17, 2022	Original report issued

Engineering considerations

2.1 Modifications incorporated in the EUT for compliance

There were no modifications performed to the EUT during this assessment.
Section 2

2.2 Technical judgment

None

2.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

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.

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 for Radio

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

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

Company name	Alert Labs Inc.
Address	132 Queen Street South, Unit #2, Kitchener, Ontario, Canada N2G 1V9

5.3 Manufacturer

Company name	Alert Labs Inc.
Address	132 Queen Street South, Unit #2, Kitchener, Ontario, Canada N2G 1V9

5.4 EUT information

Product name	Alert Labs ALRM001 Sub-1GHz Radio Module
Model	ALRM001
Serial number	None
Part number	SOM-000014-001
Operating conditions	Test software transmits data on one of 3 channels: 903 MHz, 915 MHz, 927.5 MHz
Product description and theory of operation	ALRM001 is a radio module that operates in the 902 to 928 MHz band using chirp spread spectrum modulation. Maximum RF power is approx. 20 dBm

5.5 Technical information

Applicant IC company number	22365
IC UPN number	ALB080
All used IC test site(s) Reg. number	24676
RSS number and Issue number	RSS-247 Issue 2, Feb 2017
Category of Wideband Data Transmission equipment	<input type="checkbox"/> Frequency Hopping Spread Spectrum (FHSS) equipment <input checked="" type="checkbox"/> Other types of Wideband Data Transmission equipment (e.g. DSSS, OFDM, etc.).
Frequency band	902–928 MHz
Frequency Min (MHz)	903.0
Frequency Max (MHz)	927.5
RF power Max (W), Conducted	0.0583 W (17.66 dBm)
Field strength, dB μ V/m @ 3 m	N/A
Measured BW (kHz), 99% OBW	638.4
Type of modulation	CSS: Chirp Spread Spectrum
Emission classification	X1D
Transmitter spurious, dB μ V/m @ 3 m	48.1 @ 10 GHz
Power supply requirements	2.4-3.6 V _{DC} ; Nominal 3.3 V _{DC}
Antenna information	type: PCB trace antenna, manufacturer: Alert Labs, model: None, gain: 0.01 dBi

5.6 EUT setup details

5.6.1 EUT Exercise and monitoring

Methods used to exercise the EUT and all relevant ports:

- The EUT powers up and begins transmitting on 903 MHz at approx. 20 dBm, with a > 500 kHz bandwidth
- The EUT contains a push-button that is used to toggle through the transmit frequencies in the following sequence: 903 MHz, 915 MHz, 927.5 MHz.

Configuration details:

- The EUT setup in a configuration that was expected to produce the highest amplitude emissions relative to the limit and that satisfy normal operation/installation practice by the end user.
- The type and construction of cables used in the measurement set-up were consistent with normal or typical use. Cables with mitigation features (for example, screening, tighter/more twists per length, ferrite beads) have been noted below:
 - The following deviations were:
 - None
- The EUT was setup in a manner that was consistent with its typical arrangement and use. The measurement arrangement of the EUT, local AE and associated cabling was representative of normal practice. Any deviations from typical arrangements have been noted below:
 - The following deviations were:
 - None

Monitoring details:

- The EUT contains an LED to show what the current transmit frequency is: Green = 903 MHz, Blue = 915 MHz, Red = 927.5 MHz

5.6 EUT setup details, continued

5.6.2 EUT test configuration

Table 5.6-1: EUT sub assemblies

Description	Brand name	Model, Part number, Serial number, Revision level
Alert Labs ALRM001 Sub-1GHz Radio Module	Alert Labs	MN: ALRM001, PN: SOM-000014-001, SN: None, Rev. N/A

Table 5.6-2: EUT interface ports

Description	Qty.
DC Power input	2

Table 5.6-3: Support equipment

Description	Brand name	Model, Part number, Serial number, Revision level
DC Power Supply	GWInstek	MN: GPR-3060D, SN: None

Table 5.6-4: Inter-connection cables

Cable description	From	To	Length (m)
DC Power cable	EUT	DC Power Supply	> 1
AC Power Cable	DC Power supply	AC Mains	> 1

5.6 EUT setup details, continued

5.6.2 EUT test configuration, continued

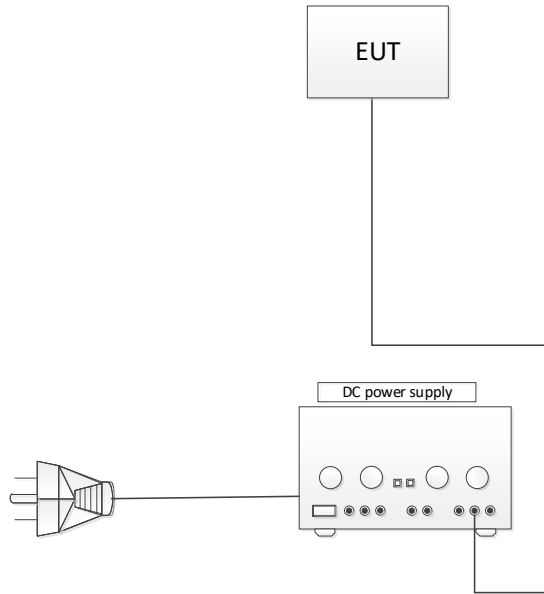


Figure 5.6-1: Radiated testing block diagram

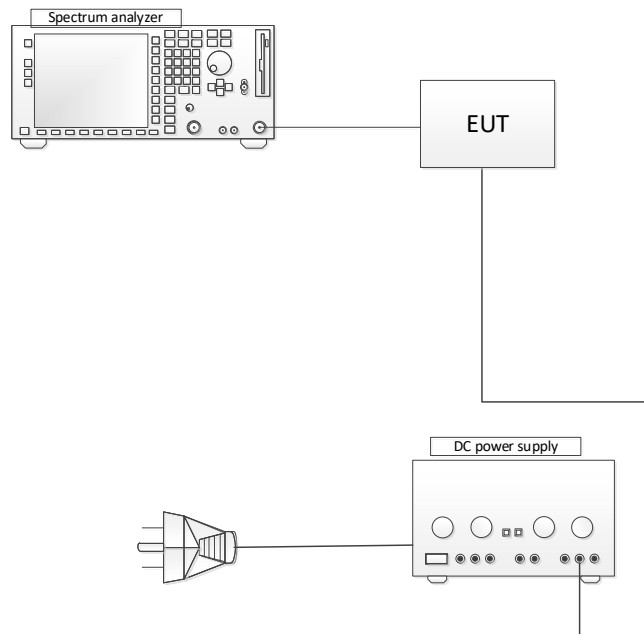


Figure 5.6-2: Antenna port testing block diagram

Summary of test results

6.1 Testing location

Test location (s)	Cambridge
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Section b

6.2 Testing period

Test start date	December 13, 2021	Test end date	December 17, 2021
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6.3 Sample information

Receipt date	December 13, 2021	Nemko sample ID number(s)	1(Conducted),2(Radiated)
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6.4 FCC Part 15 Subpart C, general requirements test results

Table 6.4-1: FCC general requirements results

Part	Test description	Verdict
§15.207(a)	Conducted limits	Not applicable ¹
§15.31l	Variation of power source	Pass
§15.31(m)	Number of tested frequencies	Pass
§15.203	Antenna requirement	Pass

Notes:¹ EUT is an DC powered device.

6.5 FCC Part 15 Subpart C, intentional radiators test results for digital transmission systems (DTS)

Table 6.5-1: FCC 15.247 results for DTS

Part	Test description	Verdict
§15.247(a)(2)	Minimum 6 dB bandwidth	Pass
§15.247(b)(3)	Maximum peak output power in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands	Pass
§15.247l(1)	Fixed point-to-point operation with directional antenna gains greater than 6 dBi	Not applicable
§15.247l(2)	Transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams	Not applicable
§15.247(d)	Spurious emissions	Pass
§15.247l	Power spectral density	Pass
§15.247(f)	Time of occupancy for hybrid systems	Not applicable

6.6 ISED RSS-Gen, Issue 5, test results

Table 6.6-1: RSS-Gen results

Part	Test description	Verdict
7.3	Receiver radiated emission limits	Not applicable
7.4	Receiver conducted emission limits	Not applicable
6.9	Operating bands and selection of test frequencies	Pass
8.8	AC power-line conducted emissions limits	Not applicable ²

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.

²EUT is an DC powered device.

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

Table 6.7-1: RSS-247 results for DTS

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

Test equipment

7.1 Test equipment list

Section 7

Table 7.1-1: Equipment list

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
3 m EMI test chamber	TDK	SAC-3	FA003012	1 year	April 12, 2022
Flush mount turntable	SUNAR	FM2022	FA003006	—	NCR
Controller	SUNAR	SC110V	FA002976	—	NCR
Antenna mast	SUNAR	TLT2	FA003007	—	NCR
DC Power source	GWInstek			—	VOU
Receiver/spectrum analyzer	Rohde & Schwarz	ESR26	FA002969	1 year	November 30, 2022
Spectrum analyzer	Rohde & Schwarz	FSW43	FA002971	1 year	November 30, 2022
Horn antenna (1–18 GHz)	ETS Lindgren	3117	FA002911	1 year	April 21, 2022
Preamp (1–18 GHz)	ETS Lindgren	124334	FA002956	1 year	April 5, 2022
Bilog antenna (20–2000 MHz)	Sun AR	JB1	FA003009	1 year	February 2, 2022
Horn antenna (18–40 GHz)	EMCO	3116B	FA002948	1 year	January 22, 2022
50 Ω coax cable	Huber + Suhner	None	FA003047	1 year	July 13, 2022
50 Ω coax cable	Huber + Suhner	None	FA003043	1 year	July 13, 2022
900 – 928 MHz notch filter	Microwave Circuits	N03916M1	FA003032	1 year	April 23, 2022
3-18 GHz Highpass filter	Microwave Circuits	H3G020G8	FA003026	1 year	April 23, 2022
50 Ω coax cable	Huber + Suhner	None	FA003054	1 year	August 31, 2022
50 Ω coax cable	Huber + Suhner	None	FA003056	1 year	August 31, 2022

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

Testing data

8.1 FCC 15.31(e) Variation of power source

8.1.1 References, definitions and limits

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

8.1.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	December 17, 2021

8.1.3 Observations, settings and special notes

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

- 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.
- 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.
- 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.
- 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.

The manufacturer has declared the upper voltage supply is 3.6V_{DC}, and lower supply voltage is 2.4 V_{DC}

8.1.4 Test data

EUT Power requirements:

	<input type="checkbox"/> AC	<input checked="" type="checkbox"/> DC	<input type="checkbox"/> Battery
If EUT is an AC or a DC powered, was the noticeable output power variation observed?	<input type="checkbox"/> YES	<input checked="" type="checkbox"/> NO	<input type="checkbox"/> N/A
If EUT is battery operated, was the testing performed using fresh batteries?	<input type="checkbox"/> YES	<input type="checkbox"/> NO	<input checked="" type="checkbox"/> N/A
If EUT is rechargeable battery operated, was the testing performed using fully charged batteries?	<input type="checkbox"/> YES	<input type="checkbox"/> NO	<input checked="" type="checkbox"/> N/A

8.2 FCC 15.31(m) and RSS-Gen 6.9 Number of frequencies

8.2.1 References, definitions and limits

FCC:

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.

ISED:

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

Note: “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 15, 2021

8.2.3 Observations, settings and special notes

Per ANSI C63.10 Subclause 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:

- a) 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.
- b) 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.
- c) 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.

Per ANSI C63.10 Subclause 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:

- a) 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).
- b) 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).
- c) 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
902.0	928.0	26.0	903.0	915.0	927.5

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

8.3.1 References, definitions and limits

FCC:

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

FCC 15.247(b)(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.

ISED:

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

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

8.3.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	December 15, 2021

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
PCB Trace	Alert Labs Inc.	N/A	0.01 dBi	N/A

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

8.4.1 References, definitions and limits

FCC:

Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

ISED:

The minimum 6 dB bandwidth shall be 500 kHz.

RSS-GEN, Section 6.7:

6 dB bandwidth is defined as the frequency range between two points, one at the lowest frequency below and one at the highest frequency above the carrier frequency, at which the maximum power level of the transmitted emission is attenuated 6 dB below the maximum in-band power level of the modulated signal, where the two points are on the outskirts of the in-band emission.

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).

8.4.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	December 17, 2021

8.4.3 Observations, settings and special notes

The test was performed as per KDB 558074, section 8.2 with reference to ANSI C63.10 subclause 11.8.

Spectrum analyser settings:

6 dB Bandwidth

Resolution bandwidth	100 kHz
Video bandwidth	300 kHz
Frequency span	2 –5 × OBW
Detector mode	Peak
Trace mode	Max Hold

99% Occupied Bandwidth

Resolution bandwidth	1–5% of OBW
Video bandwidth	≥3 × RBW
Frequency span	1.5 –5 × OBW
Detector mode	Peak
Trace mode	Max Hold

8.4.4 Test data

Table 8.4-1: 6 dB bandwidth results

Frequency, MHz	6 dB bandwidth, kHz	Minimum limit, kHz	Margin, kHz
903.0	781.2	500.0	281.2
915.0	773.2	500.0	273.2
927.5	761.2	500.0	261.2

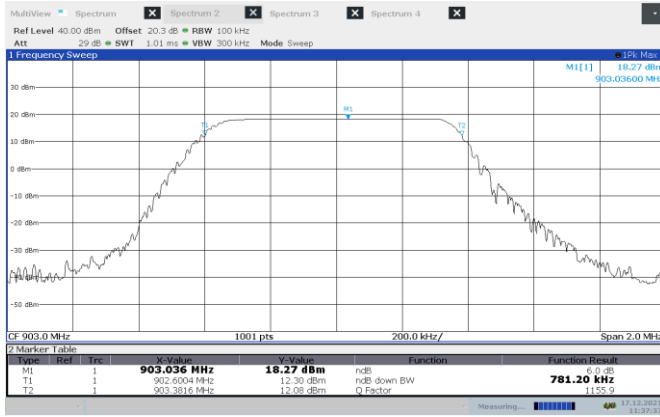


Figure 8.4-1: 6 dB bandwidth - Low channel

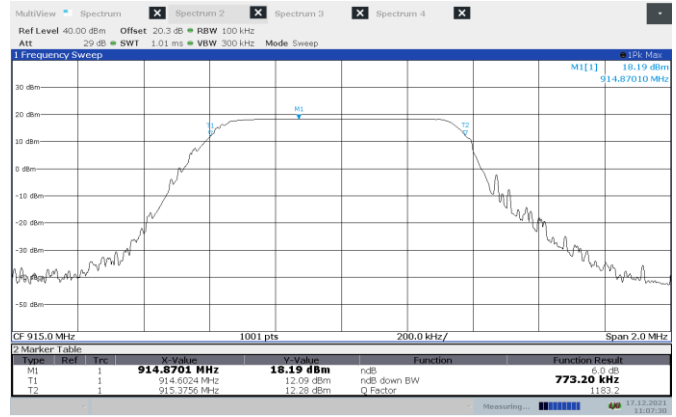


Figure 8.4-2: 6 dB bandwidth - Mid channel

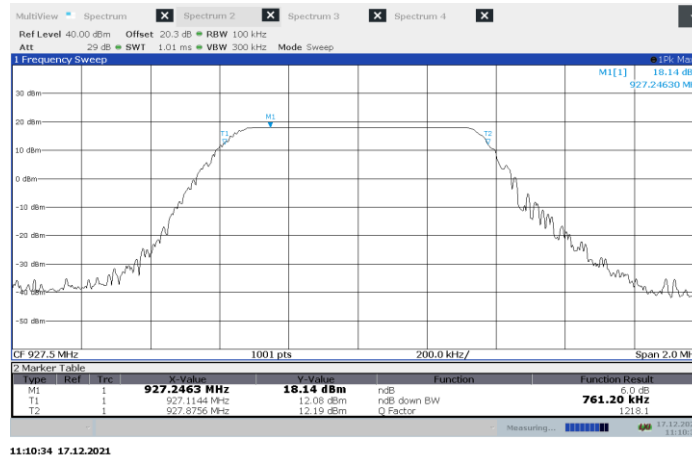


Figure 8.4-3: 6 dB bandwidth - High channel

Test data, continued

Table 8.4-2: 99% occupied bandwidth results

Frequency, MHz	99% occupied bandwidth, kHz
903.0	638.4
915.0	636.4
927.5	632.2

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

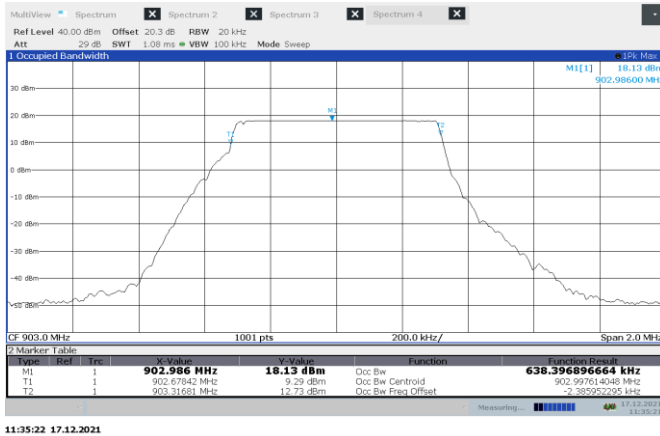


Figure 8.4-4: 99% occupied bandwidth on 802.11b, sample plot

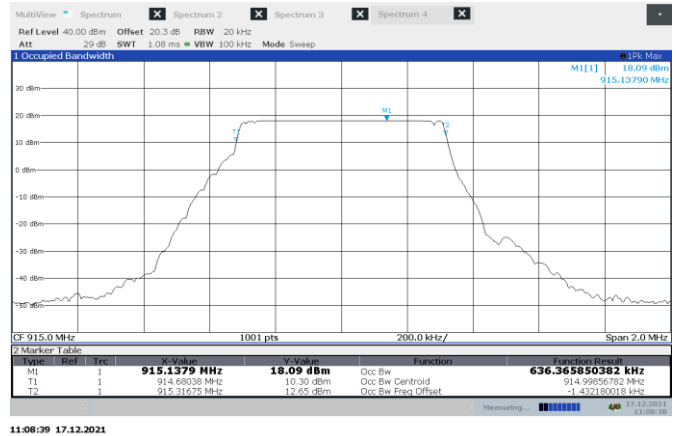


Figure 8.4-5: 99% occupied bandwidth on 802.11g, sample plot



Figure 8.4-6: 99% occupied bandwidth on 802.11n HT20, sample plot

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

8.5.1 References, definitions and limits

FCC:

- (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:
- (3) For systems using digital modulation in the 902–928 MHz band: 1 W (30 dBm). As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.
 - (4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.
- (c) Operation with directional antenna gains greater than 6 dBi.
- (1) Fixed point-to-point operation:
- (iii) Fixed, point-to-point operation, as used in paragraphs (c)(1)(i) and (c)(1)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum or digitally modulated intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

ISED:

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

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



8.5.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	December 17, 2021

8.5.3 Observations, settings and special notes

The test was performed as per KDB 558074, section 8.3 with reference to ANSI C63.10 subclause 11.9.2 (average power) using method AVGSA-1 (trace averaging with the EUT transmitting at full power throughout each sweep).

Spectrum analyser settings:

Resolution bandwidth	100 kHz
Video bandwidth	$\geq 3 \times \text{RBW}$
Frequency span	$> 1.5 \times \text{OBW}$
Detector mode	RMS
Trace mode	Power Average
Averaging sweeps number:	1000
Integration Bandwidth	650 kHz

8.5.4 Test data

Table 8.5-1: Output power and EIRP results (antenna port measurement)

Frequency, MHz	Conducted output power, dBm	Output power limit, dBm	Output power margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
903.0	17.66	30.00	12.34	0.01	17.67	36.00	18.33
915.0	17.66	30.00	12.34	0.01	17.67	36.00	18.33
927.5	17.51	30.00	12.49	0.01	17.52	36.00	18.48

Note: EIRP [dBm] = Conducted output power [dBm] + Antenna gain [dBi] + w.FL to SMA cable (0.3 dB)

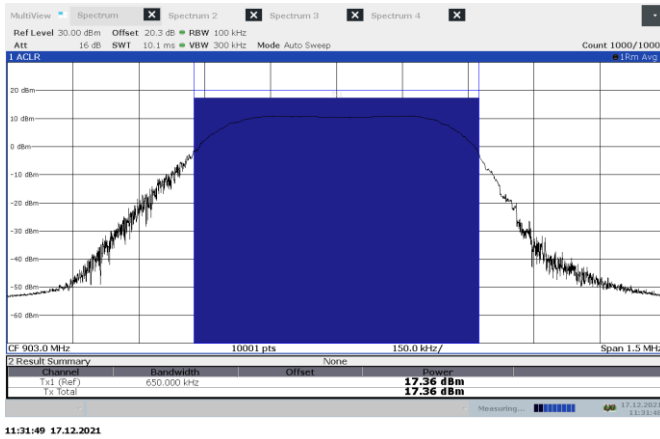


Figure 8.5-1: Output power on low channel

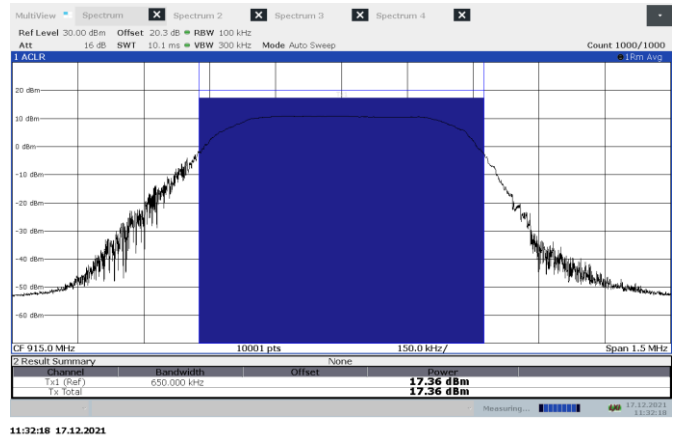


Figure 8.5-2: Output power on mid channel

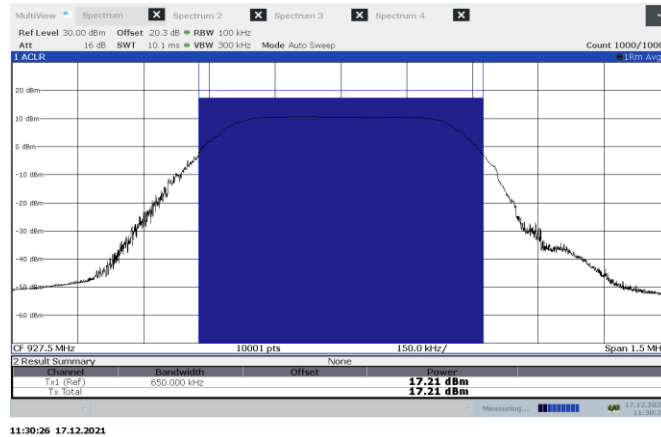


Figure 8.5-3: Output power on high channel

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

8.6.1 References, definitions and limits

FCC:

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

ISED:

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

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

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

Notes: In the emission table above, the tighter limit applies at the band edges.

For frequencies above 1 GHz the limit on peak RF emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test

Table 8.6-2: ISED restricted frequency bands

MHz	MHz	MHz	GHz
0.090–0.110	12.57675–12.57725	399.9–410	7.25–7.75
0.495–0.505	13.36–13.41	608–614	8.025–8.5
2.1735–2.1905	16.42–16.423	960–1427	9.0–9.2
3.020–3.026	16.69475–16.69525	1435–1626.5	9.3–9.5
4.125–4.128	16.80425–16.80475	1645.5–1646.5	10.6–12.7
4.17725–4.17775	25.5–25.67	1660–1710	13.25–13.4
4.20725–4.20775	37.5–38.25	1718.8–1722.2	14.47–14.5
5.677–5.683	73–74.6	2200–2300	15.35–16.2
6.215–6.218	74.8–75.2	2310–2390	17.7–21.4
6.26775–6.26825	108–138	2483.5–2500	22.01–23.12
6.31175–6.31225	149.9–150.05	2655–2900	23.6–24.0
8.291–8.294	156.52475–156.52525	3260–3267	31.2–31.8
8.362–8.366	156.7–156.9	3332–3339	36.43–36.5
8.37625–8.38675	162.0125–167.17	3345.8–3358	
8.41425–8.41475	167.72–173.2	3500–4400	
12.29–12.293	240–285	4500–5150	Above 38.6
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		
Tested by	Mark Libbrecht	Test date	December 17, 2021



8.6.3 Observations, settings and special notes

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.

EUT was set to transmit with 100 % duty cycle.

Radiated measurements were performed at a distance of 3 m.

DTS emissions in non-restricted frequency bands test was performed as per KDB 558074, section 8.5 with reference to ANSI C63.10 subclause 11.11.

Since fundamental power was tested using maximum conducted (average) output power procedure to demonstrate compliance, the spurious emissions limit is -30 dBc/100 kHz.

DTS band-edge emission measurements test was performed as per KDB 558074, section 8.7 with reference to ANSI C63.10 subclause 11.13.

All radiated spurious measurements 30 MHz – 3 GHz were measured with a 902-928 MHz notch filter identified in the equipment list.

All radiated spurious measurements 3 - 10 GHz were measured with a 3-18 GHz Highpass filter identified in the equipment list.

Spectrum analyser settings for radiated measurements below 1 GHz:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak(preview), Quasi-peak(final)
Trace mode:	Max Hold

Spectrum analyser settings for radiated measurements above 1 GHz:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak(preview), Peak(final), Average(final)
Trace mode:	Max Hold

Spectrum analyser settings for conducted band edge and spurious emissions measurements:

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

8.6.1 Test data

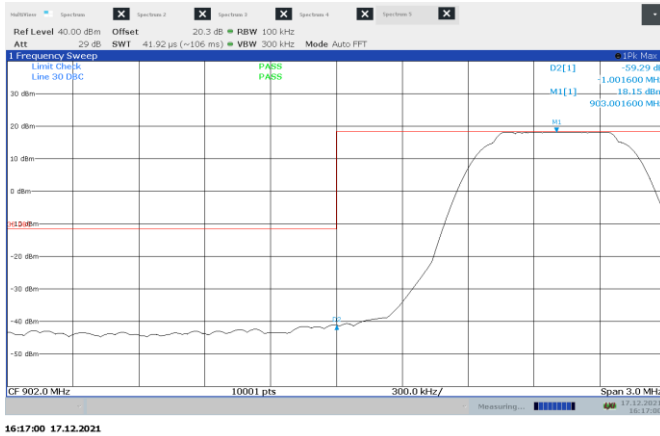


Figure 8.6-1: Conducted band edge spurious emissions at 902 MHz

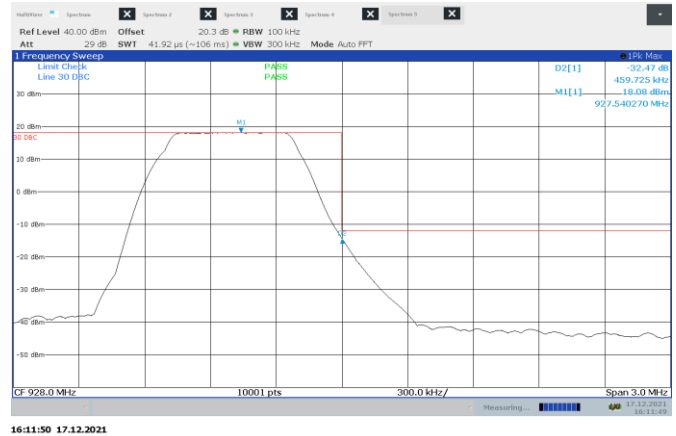


Figure 8.6-2: Conducted band edge spurious emissions at 928 MHz

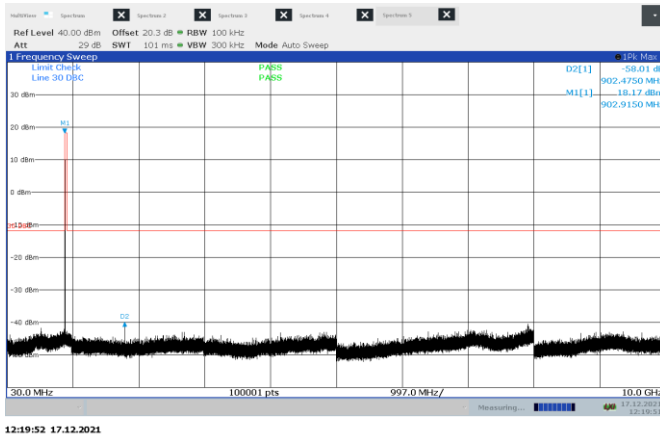


Figure 8.6-3: Conducted spurious emissions on low channel

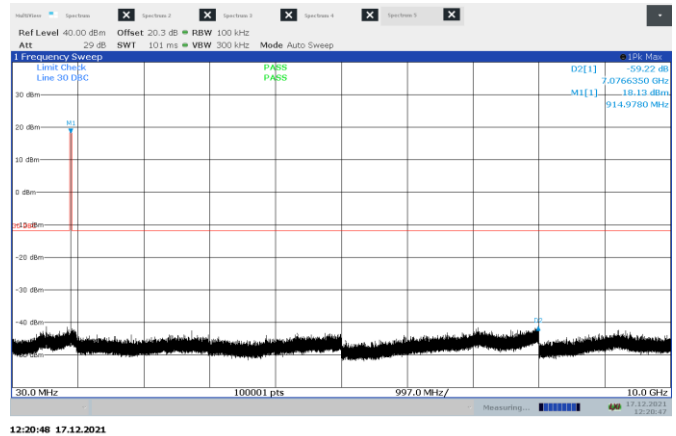


Figure 8.6-4: Conducted spurious emissions on mid channel

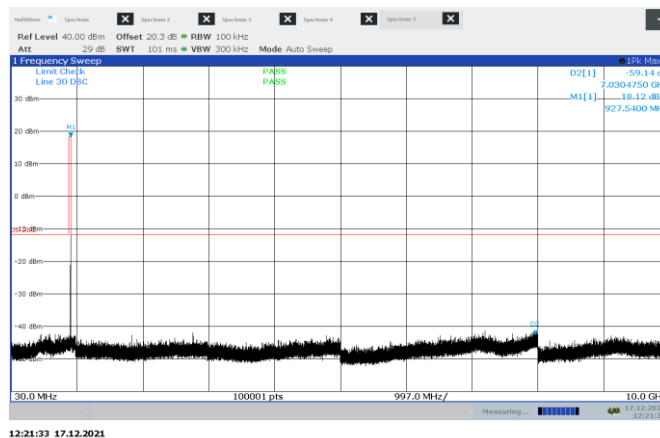
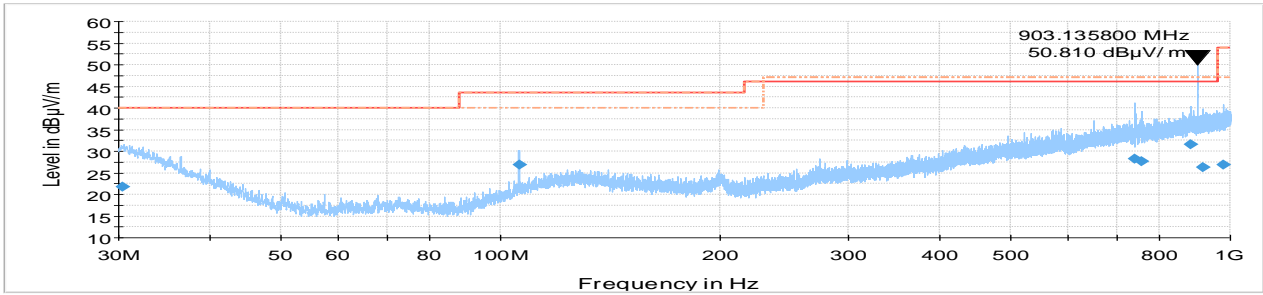


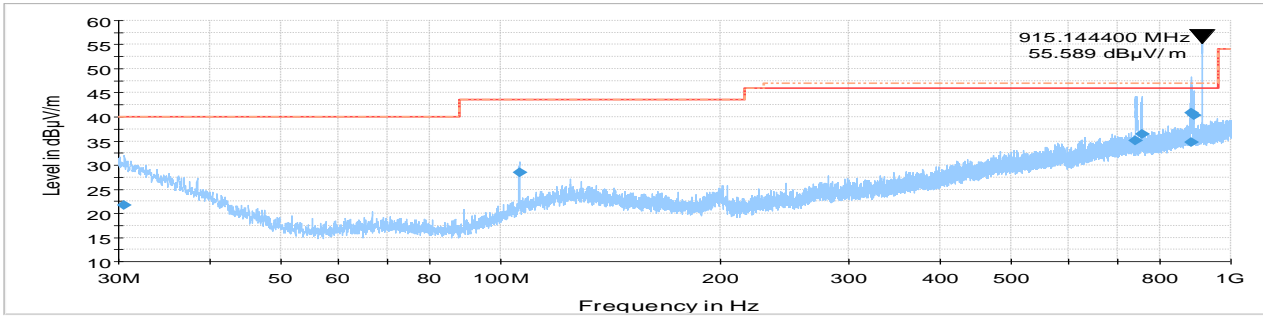
Figure 8.6-5: Conducted spurious emissions on high channel

Test data, continued



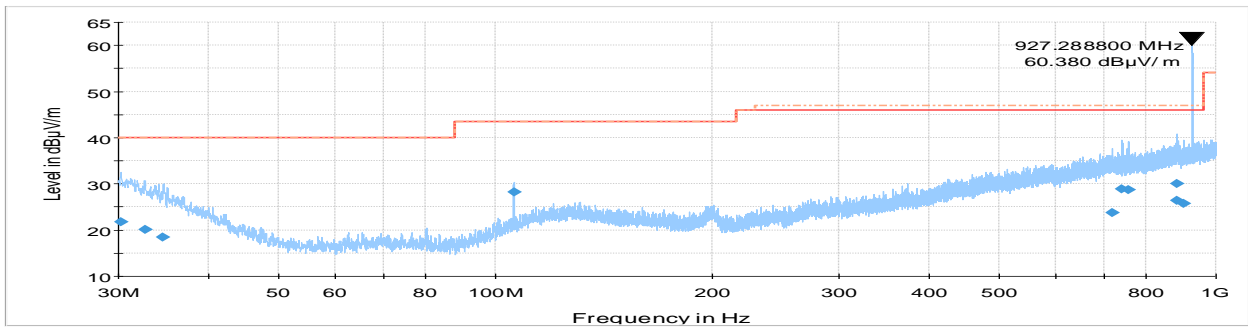
- NEX455912 RE, 30-1000 MHz, Low
- Preview Result 1-PK+
- FCC Part 15 Limit - Class B (Quasi-Peak), 3 m
- - - CISPR 32 Limit - Class B, Quasi-Peak, 3 m
- - - ICES-003 Limit - Class B (Quasi-Peak), 3 m
- ◆ Final_Result QPK

Figure 8.6-6: Radiated spurious emissions 30 – 1000 MHz, Low Channel



- NEX455912 RE, 30-1000 MHz, Mid
- Preview Result 1-PK+
- FCC Part 15 Limit - Class B (Quasi-Peak), 3 m
- - - CISPR 32 Limit - Class B, Quasi-Peak, 3 m
- - - ICES-003 Limit - Class B (Quasi-Peak), 3 m
- ◆ Final_Result QPK

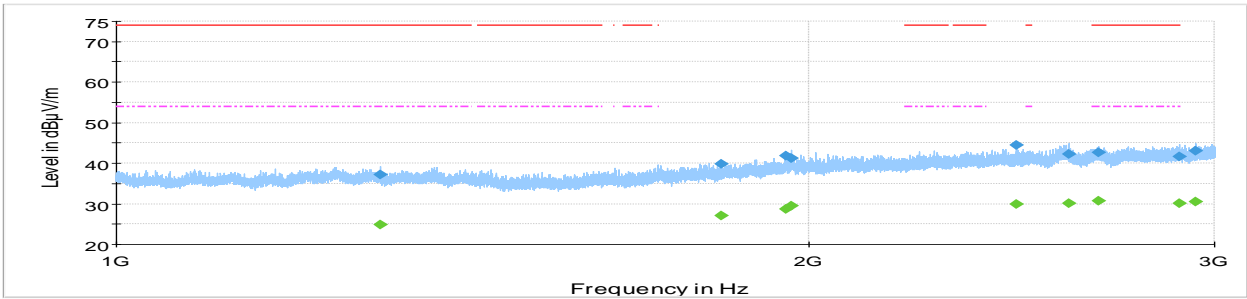
Figure 8.6-7: Radiated spurious emissions 30 – 1000 MHz, Mid Channel



- NEX455912 RE, 30-1000 MHz, High
- Preview Result 1-PK+
- FCC Part 15 Limit - Class B (Quasi-Peak), 3 m
- - - CISPR 32 Limit - Class B, Quasi-Peak, 3 m
- - - ICES-003 Limit - Class B (Quasi-Peak), 3 m
- ◆ Final_Result QPK

Figure 8.6-8: Radiated spurious emissions 30 – 1000 MHz, High Channel

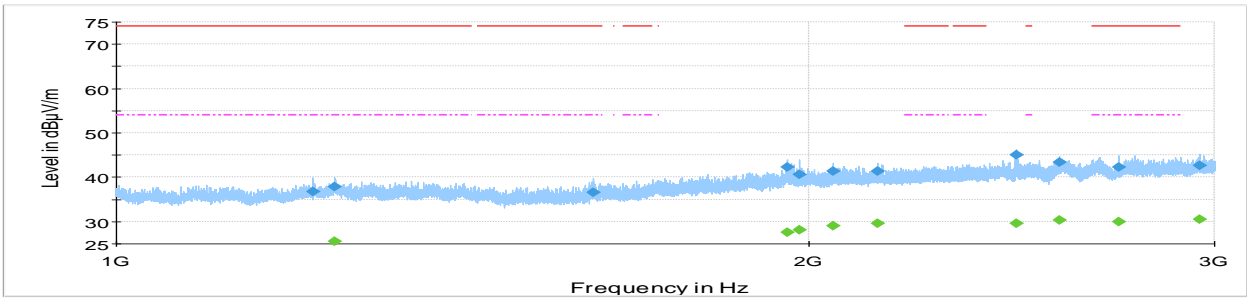
Test data, continued



NEX455912 RE, 1-3 GHz, Low

- Preview Result 1-PK+
- FCC 15.209 and RSS-Gen Restricted bands peak limits
- FCC 15.209 and RSS-Gen Restricted bands average limits
- Final_Result PK+
- Final_Result CAV

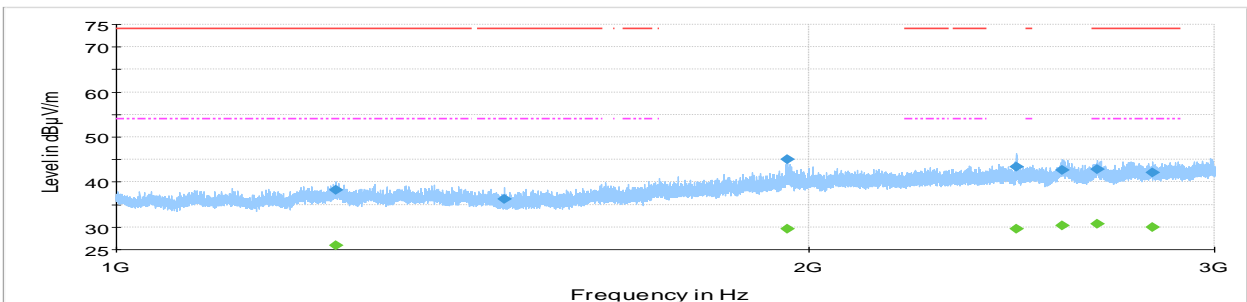
Figure 8.6-9: Radiated spurious emissions 1 - 3 GHz, Low Channel



NEX455912 RE, 1-3 GHz, Mid

- Preview Result 1-PK+
- FCC 15.209 and RSS-Gen Restricted bands peak limits
- FCC 15.209 and RSS-Gen Restricted bands average limits
- Final_Result PK+
- Final_Result CAV

Figure 8.6-10: Radiated spurious emissions 1 - 3 GHz, Mid Channel

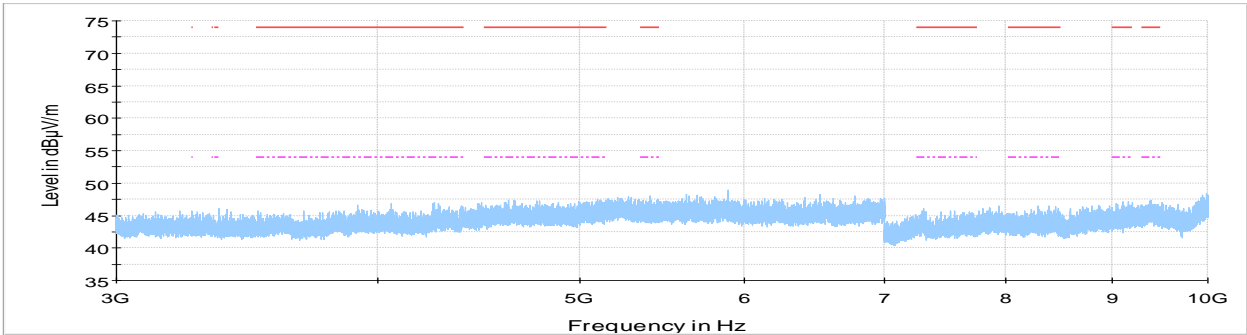


NEX455912 RE, 1-3 GHz, High

- Preview Result 1-PK+
- FCC 15.209 and RSS-Gen Restricted bands peak limits
- FCC 15.209 and RSS-Gen Restricted bands average limits
- Final_Result PK+
- Final_Result CAV

Figure 8.6-11: Radiated spurious emissions 1 - 3 GHz, High Channel

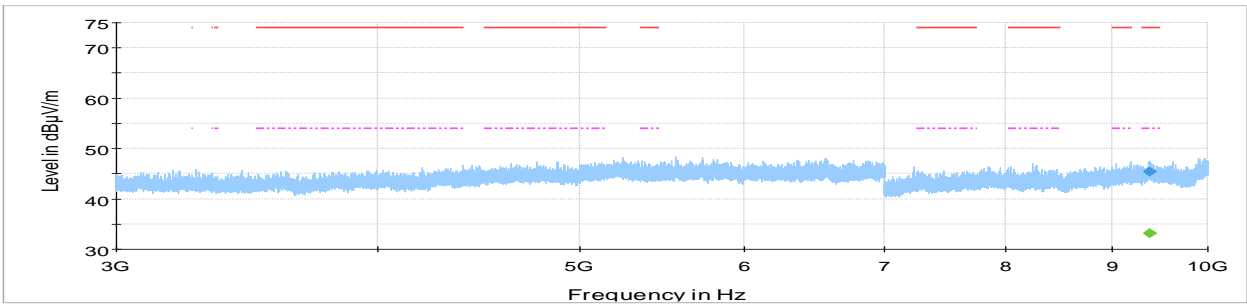
Test data, continued



NEX455912 RE, 3-10GHz, Low

- Preview Result 1-PK+
- FCC 15.209 and RSS-Gen Restricted bands peak limits
- - - FCC 15.209 and RSS-Gen Restricted bands average limits

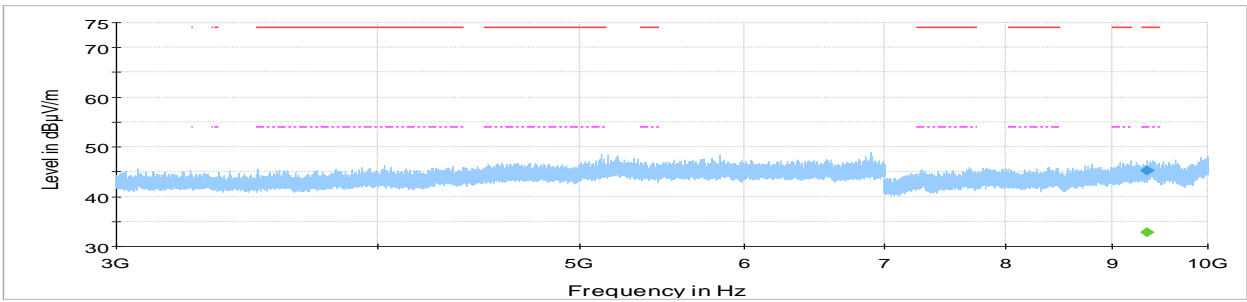
Figure 8.6-12: Radiated spurious emissions 3 - 10 GHz, Low Channel



NEX455912 RE, 3-10 GHz, Mid

- Preview Result 1-PK+
- FCC 15.209 and RSS-Gen Restricted bands peak limits
- - - FCC 15.209 and RSS-Gen Restricted bands average limits
- ◆ Final_Result PK+
- ◆ Final_Result CAV

Figure 8.6-13: Radiated spurious emissions 3 - 10 GHz, Mid Channel



NEX455912 RE, 3-10 GHz, High

- Preview Result 1-PK+
- FCC 15.209 and RSS-Gen Restricted bands peak limits
- - - FCC 15.209 and RSS-Gen Restricted bands average limits
- ◆ Final_Result PK+
- ◆ Final_Result CAV

Figure 8.6-14: Radiated spurious emissions 3 - 10 GHz, High Channel

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

8.7.1 References, definitions and limits

FCC:

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

(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.

ISED:

The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of section 5.4(d), (i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

5.3 Hybrid systems

Hybrid systems employ a combination of both frequency hopping and digital transmission techniques and shall comply with the following:

With the frequency hopping turned off, the digital transmission operation shall comply with the power spectral density requirements for digital modulation systems set out in of section 5.2(b) or section 6.2.4 for hybrid devices operating in the band 5725–5850 MHz.

8.7.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	December 17, 2021

8.7.3 Observations, settings and special notes

Power spectral density test was performed as per KDB 558074, section 8.4 with reference to ANSI C63.10 subclause 11.10. The test was performed using method AVGPS-1 (trace averaging with EUT transmitting at full power throughout each sweep). Spectrum analyser settings:

Resolution bandwidth:	3 kHz
Video bandwidth:	$\geq 3 \times \text{RBW}$
Frequency span:	$1.5 \times \text{DTS BW}$
Detector mode:	RMS
Trace mode:	Power Average
Averaging sweeps number:	1000

8.7.4 Test data

Table 8.7-1: PSD results (antenna port measurement)

Frequency, MHz	PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
903.0	-3.0	8.0	11.0
915.0	-3.2	8.0	11.2
927.5	-3.9	8.0	11.9

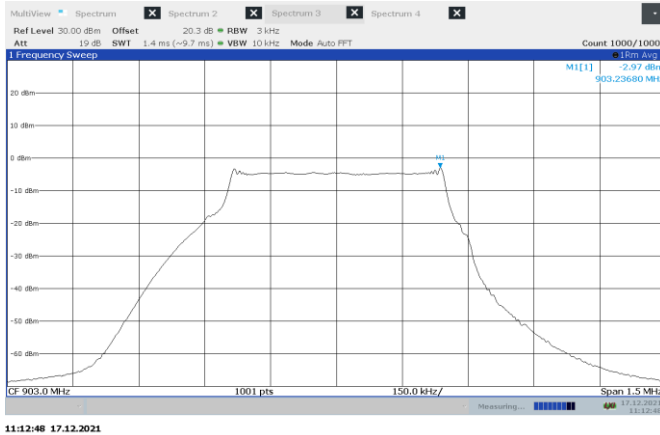


Figure 8.7-1: PSD on low channel

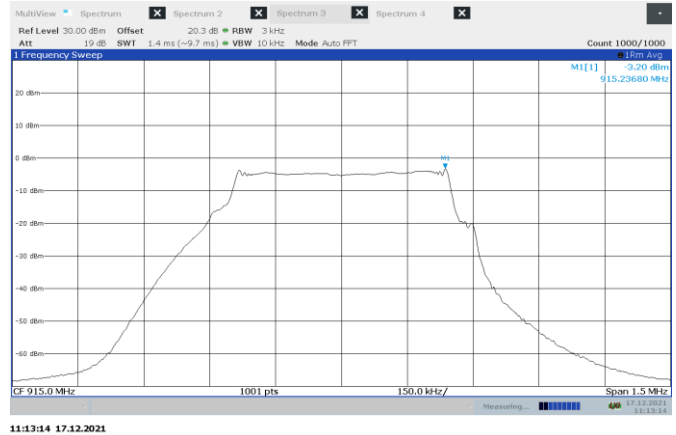


Figure 8.7-2: PSD on mid channel

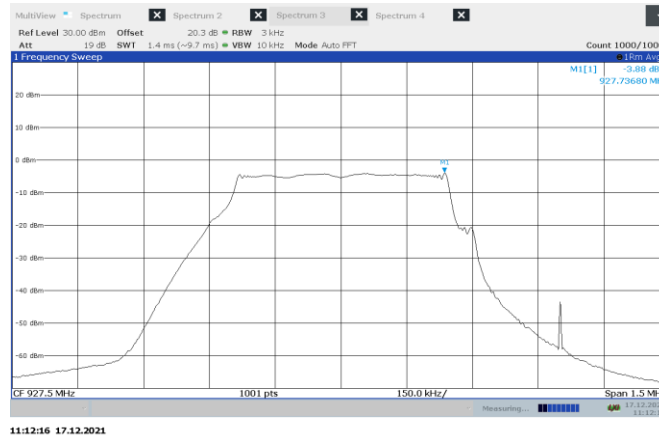


Figure 8.7-3: PSD on high channel

End of the test report