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RADIO TEST REPORT

Project ID
PRJ0024813

Report ID
REP009789

Type of assessment:

Original certification

Type of radio equipment:
Bluetooth Device

Equipment class:
DTS

Applicant:
Smartwave Technologies

Product marketing name (PMN):
Bell IQ Total Solutions

Model(s)/HVIN(s):
Pulse Rat IQ Total

Model/HVIN variant(s):
Pulse Mouse IQ Total, 24/7 IQ Total

FCC identifier:
FCC ID: 2ASYW-B01004

ISED certification number:
IC: 24934-B01004

Specifications:

- FCC 47 CFR Part 15 Subpart C, §15.247
- RSS-247, Issue 2, Feb 2017, Section 5
- AS/NZS 4268:2017

Date of issue: May 11, 2023

Ketav Jani, EMC/RF Specialist
Tested by


Signature

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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 5725–585 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
AS/NZS 4268:2017	Radio equipment and systems—Short range devices—Limits and methods of measurement
GURL SRD Notice 2019	Radiocommunications Regulations (General User Radio Licence for Short Range Devices) Notice 2019

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.
RSS-Gen, Issue 5, April 2018	General Requirements for Compliance of Radio Apparatus
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
REP009789	May 11, 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

None

2.3 Model variant declaration

As declared by the applicant, the EUT model Pulse Rat IQ Total has been chosen to be representative for all other models in the model family. The model family, and the description of the variations, are as follows: All models use the same PCBA (B01-004-01). The model variants are due to different plastic enclosure the PCBA is housed in. Pulse Mouse IQ Total and Pulse Rat IQ Total are essentially the same except Pulse Rat is a larger version of Pulse Mouse. Both the Pulse Mouse and the Pulse Rat can be installed as bait and/or snap trap. The 24/7 enclosure is a different type of bait station which contains the same B01-004-01 PCBA but the enclosure is constructed in a way that uses bait to attract rodents but once the rodent enters the trap they can not leave.

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, TIA-603 and ETSI TR 100 028-1/2 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*

Measurement	Measurement uncertainty, ±dB
Radiated spurious emissions (30 MHz to 1 GHz)	5.7
Radiated spurious emissions (1 GHz to 6 GHz)	4.7
Radiated spurious emissions (6 GHz to 18 GHz)	5.0
Radiated spurious emissions (18 GHz to 26 GHz)	5.0
RF Output power measurement using Spectrum Analyzer	0.85
RF Output power measurement using Power Meter	0.73
Conducted spurious emissions	1.13
Other antenna port measurements	0.94

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	Smartwave Technologies
Applicant address	1 Marmac Drive, Toronto, ON, M9W 1E7, Canada
Manufacturer name	Same as applicant
Manufacturer address	Same as applicant

5.3 EUT information

Product description	Bell IQ Total Solutions
Model / HVIN	Pulse Rat IQ Total
Model variant(s)	Pulse Mouse IQ Total, 24/7 IQ Total
Serial number	Prototype
Power supply requirements	Battery: 3.6 V(DC)
Product description and theory of operation	Product can be installed as bait and/or snap trap. The unit is powered on continuously and run production firmware. After manufacturing and final assembly, the unit enters a deep sleep state until installation. After installation the unit will continuously advertise trap activity over BLE.
Software Details	Firmware Version: 154.8
Hardware Version	B01-004-01

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	2400–2483.5 MHz
Frequency Min	2402 MHz (1 MHz bandwidth)
Frequency Max	2480 MHz (1 MHz bandwidth)
RF power Max (W), Conducted	0.00047 W (-3.3 dBm)
Measured BW (kHz), 99% OBW	1.04 (1 MHz)
Type of modulation	BLE (GFSK)
Emission classification	F1D
Transmitter spurious, dBµV/m @ 3 m	61.7 (pk) @2440 MHz channel and 52.9 (avg) @ 2480 MHz channel 1 MHz BW
Antenna information	Type: Helical antenna with connector style PCB-mount base Manufacturer: Linx Technologies Model: ANT-915-VHETH Peak gain: 1.8 dBi

5.5 EUT setup details

5.5.1 Radio exercise details

Operating conditions	The EUT was powered on and the product was preloaded with the appropriate test firmware to transmit continuously the specific BLE channel.
Transmitter state	Transmit at 100% duty cycle & BLE duty cycle, Transmit at maximum power level -3 dBm

EUT setup configuration

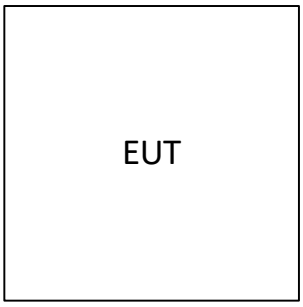

Figure 5.5-1: *Radiated testing block diagram*

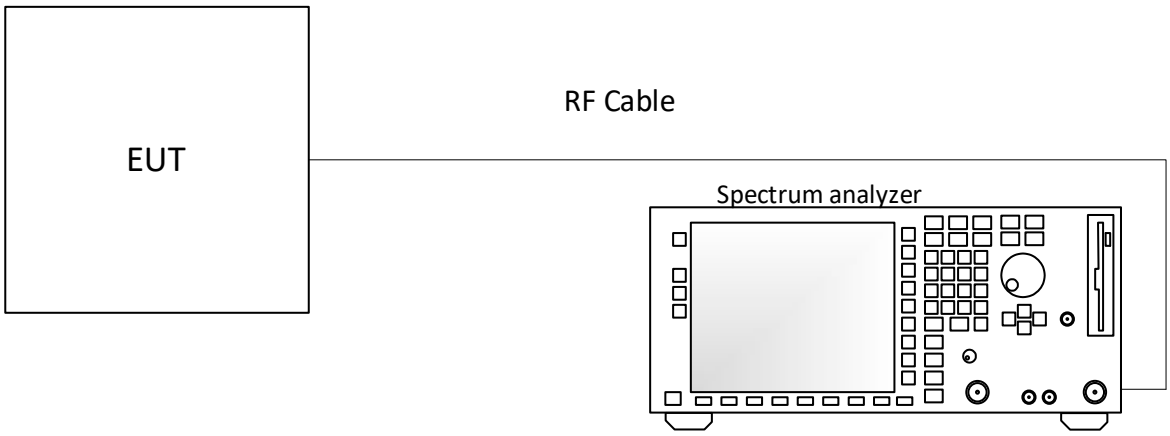

Figure 5.5-2: *Antenna port testing block diagram*

Section 6 Summary of test results

6.1 location

Test location (s)	Cambridge

6.2 Testing period

Test start date	November 21, 2022	Test end date	April 11, 2023

6.3 Sample information

Receipt date	November 16, 2022	Nemko sample ID number(s)	1,2,3 (Radiated) 4,5,6 (Conducted)

6.4 FCC test results

Table 6.4-1: *FCC requirements results*

Part	Test description	Verdict
Generic requirements		
§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
DTS specific requirements		
§15.247(a)(2)	Minimum 6 dB bandwidth	Pass
§15.247(b)(3)	Maximum peak output power	Pass
§15.247(e)	Power spectral density	Pass

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
Generic requirements		
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
DTS specific requirements		
RSS-247, 5.2 (a)	Minimum 6 dB bandwidth	Pass
RSS-247, 5.2 (b)	Maximum power spectral density	Pass
RSS-247, 5.4 (d)	Transmitter output power and e.i.r.p. requirements for systems employing digital modulation techniques	Pass
RSS-247, 5.4 (e)	Transmitter e.i.r.p. requirements for point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band	Not applicable
RSS-247, 5.4 (f)	Transmitter requirements for operation in the 2400–2483.5 MHz band with multiple directional beams	Not applicable

Notes: [1]According to sections 5.2 and 5.3 of RSS-Gen, Issue 5 the EUT does not have a stand-alone receiver neither scanner receiver, therefore exempt from receiver requirements.
EUT is a battery-operated device, the testing was performed using fresh batteries.

6.6 AS/NZS 4268 Test results

Transmitter parameters

Evidence of transmitter compliance to this standard may be demonstrated by testing to FCC generic standards listed in Clause 6.2.2. of AS/NZS 4268: 2017. Australian and New Zealand requirements, for example, frequency assignments or transmitter power levels, may be different to international requirements and compliance with any differences were addressed and documented.

Transmitter requirements

Testing of the transmitter parameters specified in this Clause 6 were conducted using the appropriate generic product standard for FCC listed in Clause 6.2.2 of AS/NZS 4268: 2017 unless a specific product standard is listed in Table 1 AS/NZS 4268: 2017 for Australia, in which case that shall be used.

Table 6.6-1: *Test results for AS/NZS*

FCC part	AS/NZS part	Test description	Verdict
Generic requirements			
§15.207(a)	6.2	Conducted limits	Not applicable
§15.31(e)	6.2	Variation of power source	Pass
§15.31(m)	6.2	Number of tested frequencies	Pass
§15.203	6.2	Antenna requirement	Pass
§15.109	7.2	Receiver emissions	Not applicable
DTS requirements			
§15.247(a)(2)	6.5	Minimum 6 dB bandwidth	Pass
§15.247(b)(3)	6.3	Maximum peak output power in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands	Pass
§15.247(c)(1)	6.2	Fixed point-to-point operation with directional antenna gains greater than 6 dBi	Not applicable
§15.247(c)(2)	6.2	Transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams	Not applicable
§15.247(d)	6.4	Spurious emissions	Pass
§15.247(e)	6.2	Power spectral density	Pass
§15.247(f)	6.2	Time of occupancy for hybrid systems	Not applicable

Notes: 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.	Cal cycle	Next cal.
Receiver/spectrum analyzer	Rohde & Schwarz	ESR26	FA002969	1 year	February 10, 2024
Spectrum analyzer	Rohde & Schwarz	FSW43	FA002971	1 year	December 31, 2023
3 m EMI test chamber	TDK	SAC-3	FA003012	1 year	January 30, 2024
Flush mount turntable	SUNAR	FM2022	FA003006	—	NCR
Controller	SUNAR	SC110V	FA002976	—	NCR
Antenna mast	SUNAR	TLT2	FA003007	—	NCR
Bilog antenna (30–2000 MHz)	SUNAR	JB1	FA003010	1 year	June 21, 2023
Horn antenna (1–18 GHz)	ETS-Lindgren	3117	FA002911	1 year	May 11, 2023
Preamp (1–18 GHz)	ETS-Lindgren	124334	FA002956	1 year	March 27, 2024
50 Ω coax cable	Huber + Suhner	None	FA003046	1 year	January 18, 2024
50 Ω coax cable	Huber + Suhner	None	FA003047	1 year	January18, 2024
50 Ω coax cable	Huber + Suhner	None	FA003402	1 year	January18, 2024
Vector signal Generator	Rohde & Schwarz	SMW200A	FA002970	1 year	December 31 2023
Preamp 18-40 GHz	None	None	FA003323	1 year	March 27, 2024
Horn antenna (18–40 GHz)	EMCO	3116B	FA002948	1 year	March 27, 2024

Notes: NCR - no calibration required

Table 7.1-2: *Automation software details*

Test description	Manufacturer of Software	Details
Spurious Emissions	Rohde & Schwarz	EMC32, Software for EMC Measurements, Version 10.60.00

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	Ketav Jani	Test date	November 21, 2022

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

8.1.4 Test data

EUT Power requirements:	☐ AC	☐ DC	☒ Battery
If EUT is an AC or a DC powered, was the noticeable output power variation observed?	☐ YES	☐ NO	☒ N/A
If EUT is battery operated, was the testing performed using fresh batteries?	☒ YES	☐ NO	☐ N/A
If EUT is rechargeable battery operated, was the testing performed using fully charged batteries?	☐ YES	☐ NO	☒ N/A

8.2 Number of frequencies

8.2.1 References, definitions, and limits

FCC §15.31:

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

RSS-Gen, Clause 6.9:

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

Table 8.2-1: *Frequency Range of Operation*

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

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

8.2.2 Test summary

Verdict	Pass		
Tested by	Ketav Jani	Test date	November 21, 2022

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:

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.

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:

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
2400	2483.5	83.5	2402	2440	2480

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	Ketav Jani	Test date	November 21, 2022

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
Helical	Linx technologies	ANT-915-VHETH	1.8	Direct PCB attachment

8.4 Minimum 6 dB bandwidth for DTS systems

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:

(2) 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.

RSS-247, Clause 5.2:

DTSs include systems that employ digital modulation techniques resulting in spectral characteristics similar to direct sequence systems. The following applies to the bands 902-928 MHz and 2400-2483.5 MHz:

a. The minimum 6 dB bandwidth shall be 500 kHz.

RSS-Gen, Clause 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).

AS/NZS 4268, Clause 6.5:

The upper and lower frequency limits of the transmitter 99% emission power bandwidth shall at all times remain within the operating frequency limits.

Some transmitter categories require a specific limit for emission bandwidth. In such cases, the emission bandwidth shall be established by testing in accordance with the relevant specified Standard

8.4.2 Test summary

Verdict	Pass		
Tested by	Ketav Jani	Test date	March 31, 2023

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:

Resolution bandwidth	6 dB BW: 100 kHz; 99% OBW: 1–5% of OBW
Video bandwidth	≥3 × RBW
Frequency span	3 MHz for 1 MHz channel
Detector mode	Peak
Trace mode	Max Hold

8.4.4 Test data

Table 8.4-1: *99% occupied bandwidth results – 1 MHz*

Frequency, MHz	99% occupied bandwidth, MHz
2402	1.04
2440	1.04
2480	1.04

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

Table 8.4-2: *6 dB bandwidth results – 1 MHz*

Frequency, MHz	6 dB bandwidth, MHz	Minimum limit, MHz	Margin, MHz
2402	0.65	0.50	0.15
2440	0.65	0.50	0.15
2480	0.64	0.50	0.14

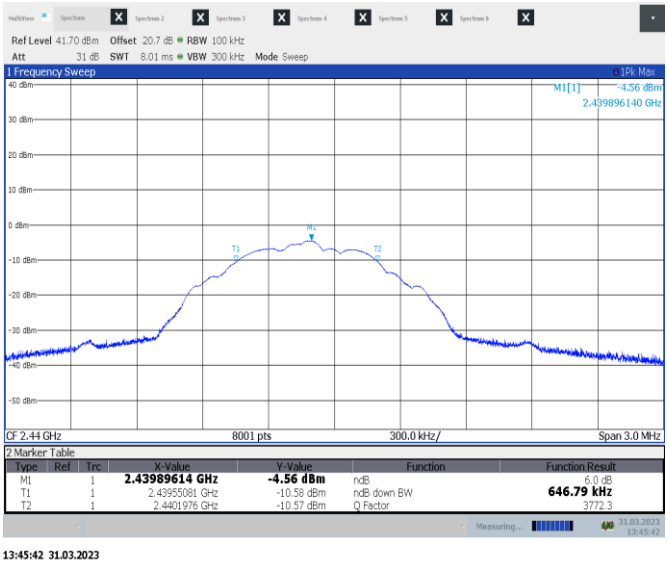

Figure 8.4-1: *6 dB bandwidth, sample plot Mid channel, 1 MHz BW*

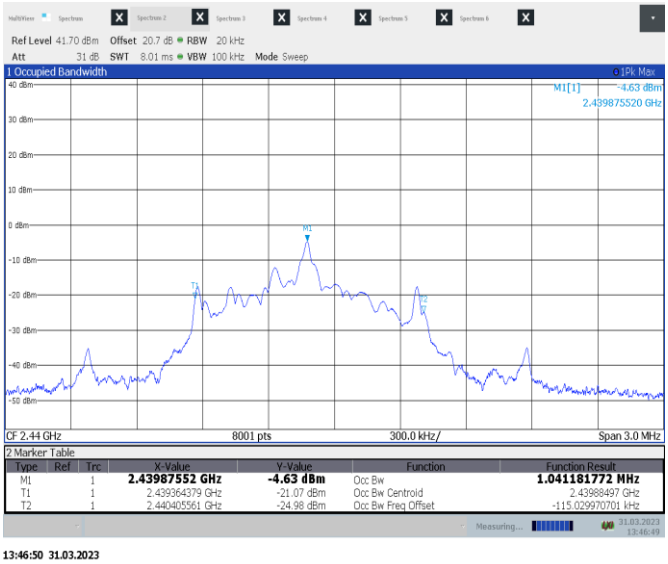

Figure 8.4-2: *99% bandwidth, sample plot Mid channel, 1 MHz BW*

8.5 Transmitter output power and e.i.r.p. requirements for DTS in 2.4 GHz

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:

(3) For systems using digital modulation in the 2400–2483.5 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:

(i) Systems operating in the 2400–2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

(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.

(2) In addition to the provisions in paragraphs (b)(1), (b)(3), (b)(4) and (c)(1)(i) of this section, transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams, simultaneously or sequentially, for the purpose of directing signals to individual receivers or to groups of receivers provided the emissions comply with the following:

(i) Different information must be transmitted to each receiver.

(ii) If the transmitter employs an antenna system that emits multiple directional beams but does not do emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device, i.e., the sum of the power supplied to all antennas, antenna elements, staves, etc. and summed across all carriers or frequency channels, shall not exceed the limit specified in paragraph (b)(1) or (b)(3) of this section, as applicable. However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as follows:

(A) The directional gain shall be calculated as the sum of 10 log (number of array elements or staves) plus the directional gain of the element or stave having the highest gain.

(B) A lower value for the directional gain than that calculated in paragraph (c)(2)(ii)(A) of this section will be accepted if sufficient evidence is presented, e.g., due to shading of the array or coherence loss in the beamforming.

(iii) If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the power limit specified in paragraph (c)(2)(ii) of this section. If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the limit specified in paragraph (c)(2)(ii) of this section. In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the limit specified in paragraph (c)(2)(ii) of this section by more than 8 dB.

(iv) Transmitters that emit a single directional beam shall operate under the provisions of paragraph (c)(1) of this section.

References, definitions, and limits, continued

RSS-247, Clause 5.4:

Devices shall comply with the following requirements, where applicable:

d. For DTSs employing digital modulation techniques operating in the 2400–2483.5 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.

e. Fixed point-to-point systems in the 2400–2483.5 MHz band are permitted to have an e.i.r.p. higher than 4 W provided that the higher e.i.r.p. is achieved by employing higher gain directional antennas and not higher transmitter output powers. Point-to-multipoint systems, omnidirectional applications and multiple co-located transmitters transmitting the same information are prohibited from exceeding an e.i.r.p. of 4 W.

f. Transmitters operating in the band 2400–2483.5 MHz, may employ antenna systems that emit multiple directional beams simultaneously or sequentially, for the purpose of directing signals to individual receivers or to groups of receivers, provided that the emissions comply with the following:

i. Different information must be transmitted to each receiver.

ii. If the transmitter employs an antenna system that emits multiple directional beams, but does not emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device (i.e. the sum of the power supplied to all antennas, antenna elements, staves, etc., and summed across all carriers or frequency channels) shall not exceed the applicable output power limit specified in sections 5.4(b) and 5.4(d). However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as the sum of 10 log (number of array elements or staves) plus the directional gain of the element or stave having the highest gain.

iii. If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the applicable power limit specified in sections 5.4(b) and 5.4(d). If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the applicable limit specified in sections 5.4(b) and 5.4(d). In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the applicable limit specified in sections 5.4(b) and 5.4(d) by more than 8 dB.

iv. Transmitters that transmit a single directional beam shall operate under the provisions of sections 5.4(b), 5.4(d) and 5.4(e).

AS/NZS 4268, Clause 6.3:

6.3.1 Australian limits
In Australia, refer to Table 1
Table 1 Australian requirements
Row 59 Digital modulation transmitters within 2400–2483.5 MHz
Maximum EIRP limit: 4 W (36 dBm)
6.3.2 New Zealand limits
In New Zealand, refer to the General User Radio Licence (GURL) for SRD.
GURL Radiocommunications Regulations (General User Radio Licence for Short Range Devices) Notice 2019
3. Spectrum
Maximum power within 2400–2483.5 MHz is 6 dBW EIRP (36 dBm)

8.5.2 Test summary

Verdict	Pass		
Tested by	Ketav Jani	Test date	April 11, 2023

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 11.9.1 (peak power) using method RBW≥DTS bandwidth (Maximum peak conducted output power)
Spectrum analyser settings:

Resolution bandwidth	3 MHz
Video bandwidth	≥3 × RBW
Frequency span	10 MHz for 1 MHz channel
Detector mode	Peak
Trace mode	Max Hold

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
2402	-3.3	30.0	33.3	1.8	-1.5	36.0	37.5
2440	-3.6	30.0	33.6	1.8	-1.8	36.0	37.8
2480	-4.1	30.0	34.1	1.8	-2.3	36.0	38.3

Note: EIRP [dBm] = Conducted output power [dBm] + Antenna gain [dBi]

Test data, continued

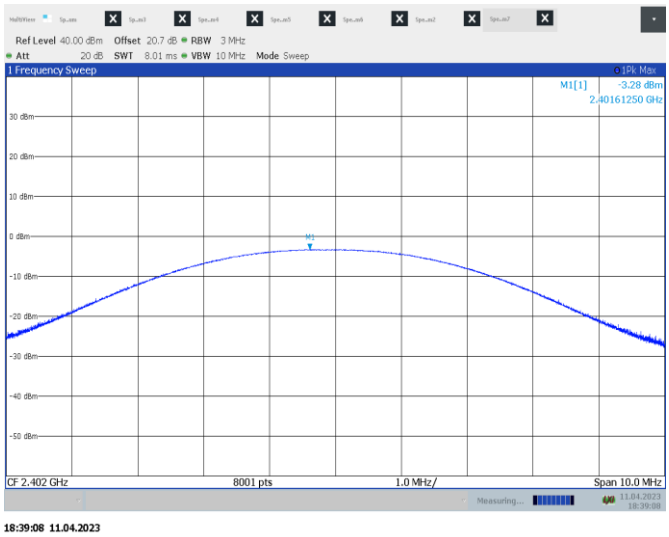

Figure 8.5-1: *Output power on low channel, 1 MHz BW*

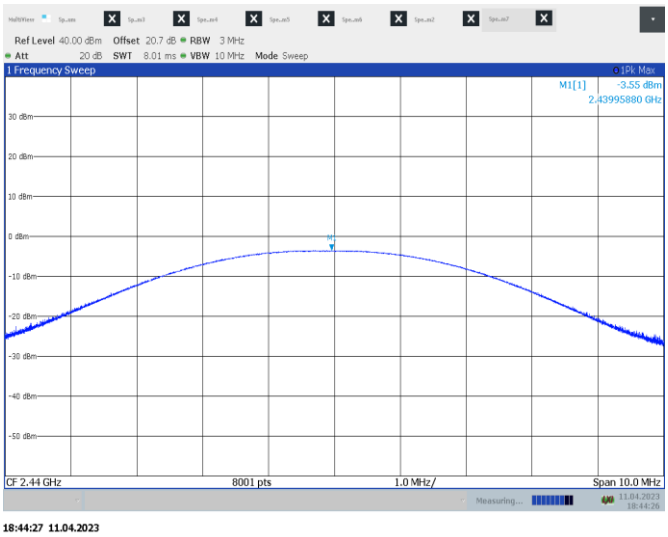

Figure 8.5-2: *Output power on mid channel, 1 MHz BW*

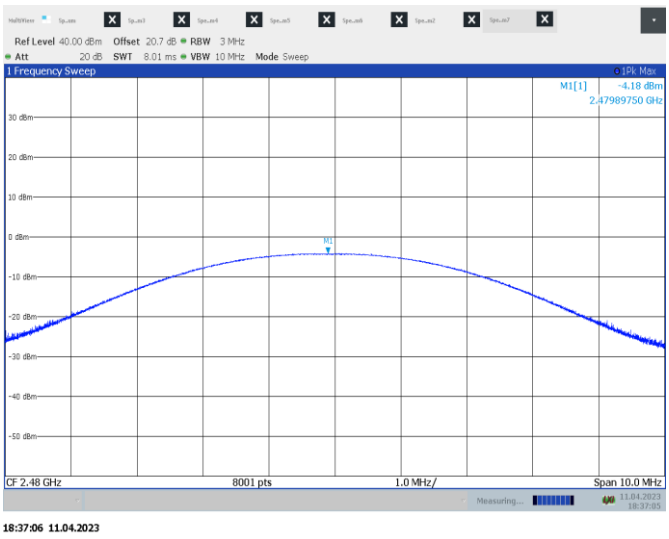

Figure 8.5-3: *Output power on high channel, 1 MHz BW*

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.

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.

AS/NZS 4268, Clause 6.4:

6.4.1 Australian limits

In Australia, refer to the limits in Standards referenced in Clause 6.2.2, Table 1

6.2.2 Methods and limits are in 47 CFR Part 15.247

6.4.2 New Zealand limits

In New Zealand, refer to the General User Radio Licence (GURL) for SRD.

GURL Radiocommunications Regulations (General User Radio Licence for Short Range Devices) Notice 2019

23 Special condition:

Transmissions must not exceed the following unwanted emission limits: −79 dBW (−49 dBm or 46.23 dBµV/m) e.i.r.p. within 800–915 MHz and −63 dBW (−33 dBm or 62.23 dBµV/m) e.i.r.p. within 928–1000 GHz. The reference bandwidth for emissions is 100 kHz.

Outside the band 0.8–1 GHz, the limits prescribed in applicable standards prescribed in the Radiocommunications (Radio Standards) Notice 2016 apply. In the absence of applicable standards, the limits prescribed in Table 2 of the notice apply.

References, definitions, and limits, continued

Table 8.6-1: *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.

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	Above 38.6
8.41425–8.41475	167.72–173.2	3500–4400	
12.29–12.293	240–285	4500–5150	
12.51975–12.52025	322–335.4	5350–5460	

Note: Certain frequency bands listed in 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.

References, definitions, and limits, continued

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	Tarek Elkholy	Test date	April 3, 2023

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 the maximum peak conducted output power procedure to demonstrate compliance, the spurious emissions limit is −20 dBc/100 kHz.
- DTS emissions in restricted frequency bands test was performed as per KDB 558074, section 8.6 with reference to ANSI C63.10 subclause 11.12.
- DTS band-edge emission measurements test was performed as per KDB 558074, section 8.7 with reference to ANSI C63.10 subclause 11.13.

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 conducted spurious emissions measurements:

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

8.6.4 Test data

Table 8.6-4: *Radiated field strength measurement results*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2390.0	60.0	74.0	14.0	42.4	54.0	11.6
High	2483.5	61.1	74.0	12.9	42.6	54.0	11.4
Low	12008.9	57.7	74.0	16.3	48.1	54.0	5.9
Mid	7320.4	61.7	74.0	12.3	52.1	54.0	1.9
High	7440.0	60.1	74.0	13.9	52.9	54.0	1.1

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

Test data, continued

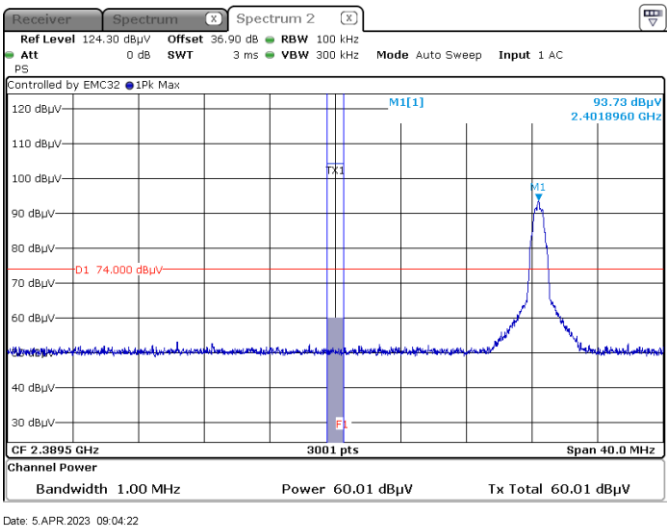

Figure 8.6-1: *Band edge spurious emissions at 2390 MHz, Peak, 1MHz*

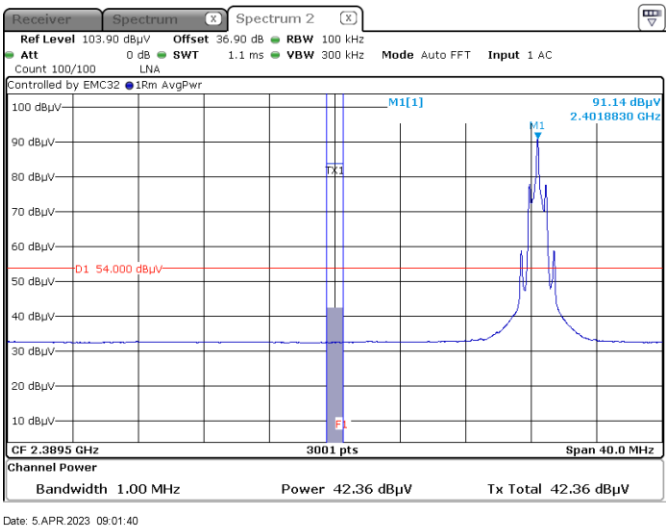

Figure 8.6-2: *Band edge spurious emissions at 2390 MHz, Average, 1MHz*

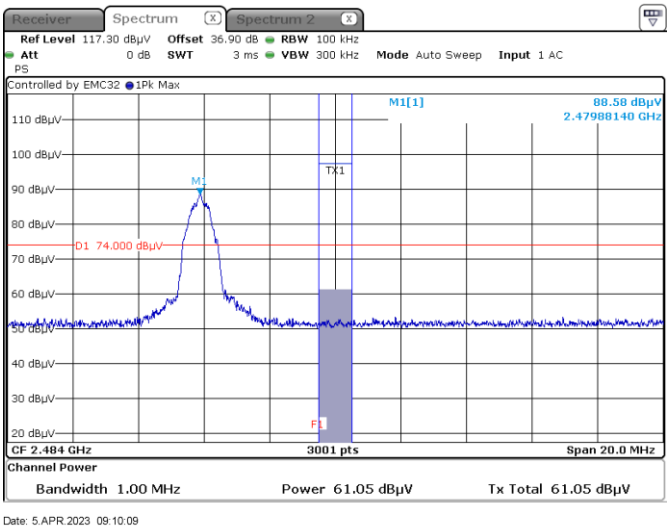

Figure 8.6-3: *Band edge spurious emissions at 2483.5 MHz, Peak, 1MHz*

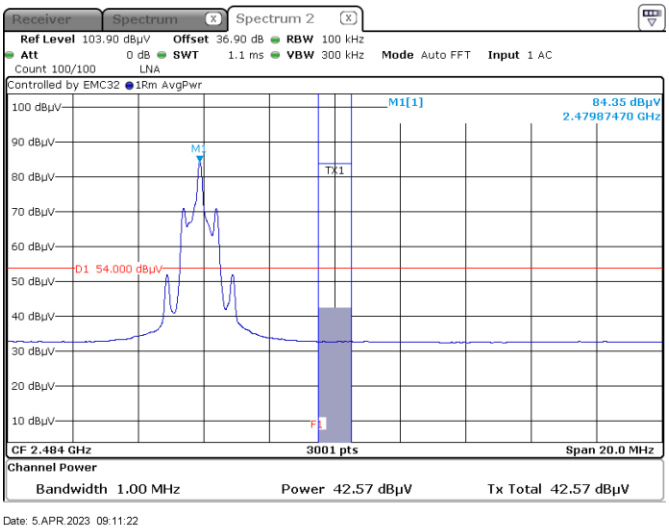

Figure 8.6-4: *Band edge spurious emissions at 2483.5 MHz, Average, 1MHz*

Test data, continued

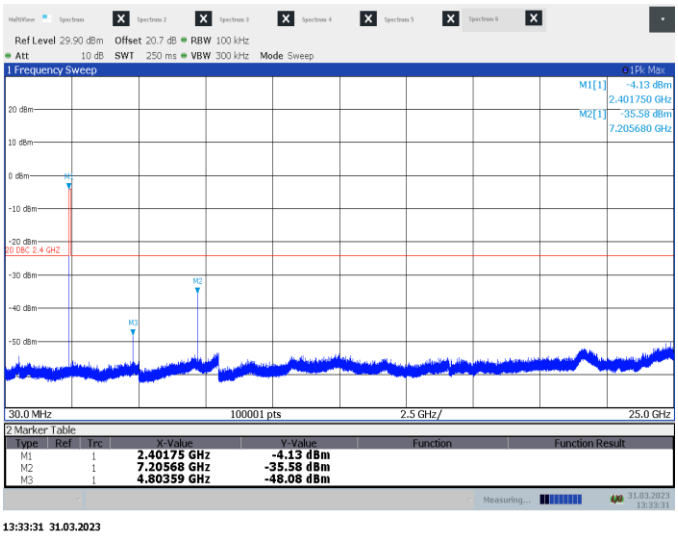

Figure 8.6-5: *Conducted spurious emissions on low channel, 1 MHz BW*

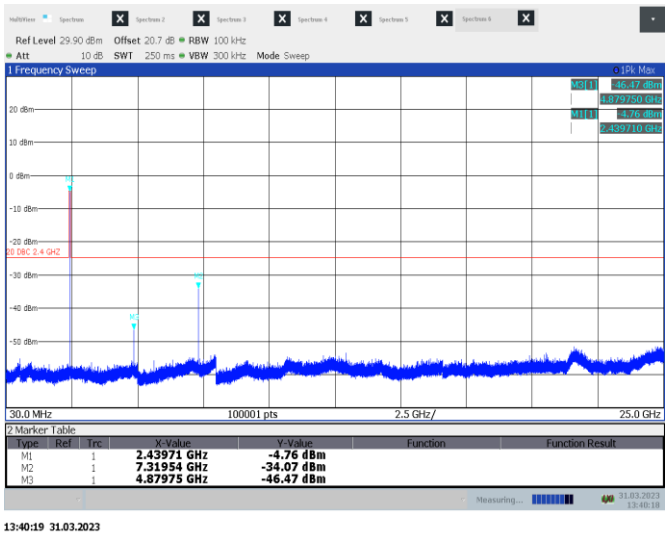

Figure 8.6-6: *Conducted spurious emissions on mid channel, 1 MHz BW*

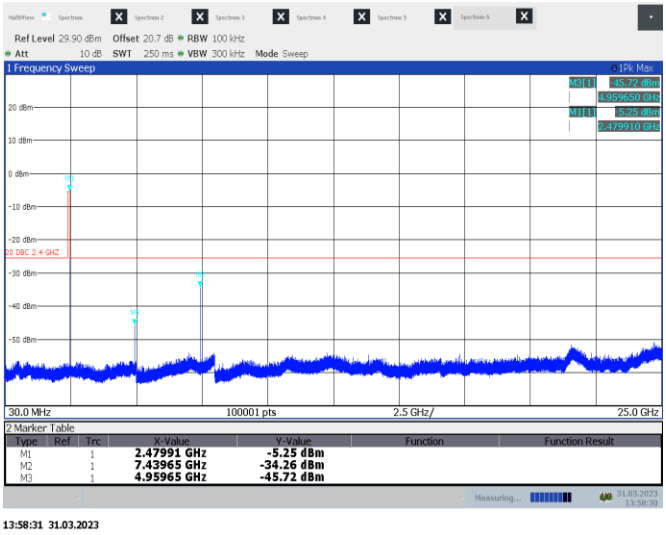

Figure 8.6-7: *Conducted spurious emissions on high channel, 1 MHz BW*

Test data, continued

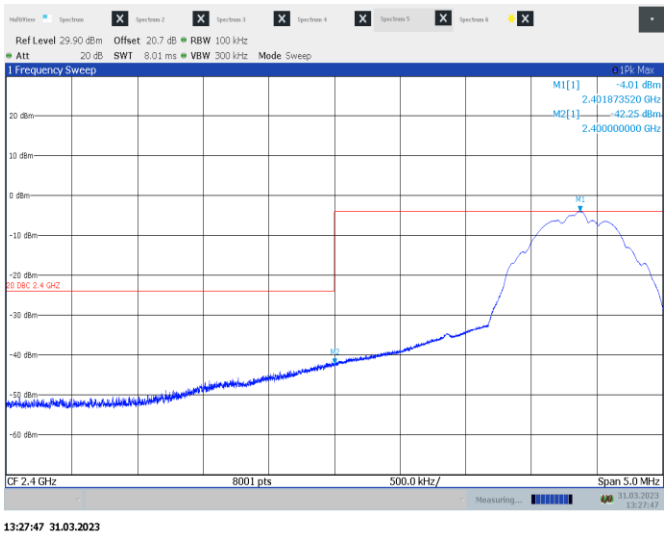

Figure 8.6-8: *Conducted Band edge on low channel, 1 MHz BW*

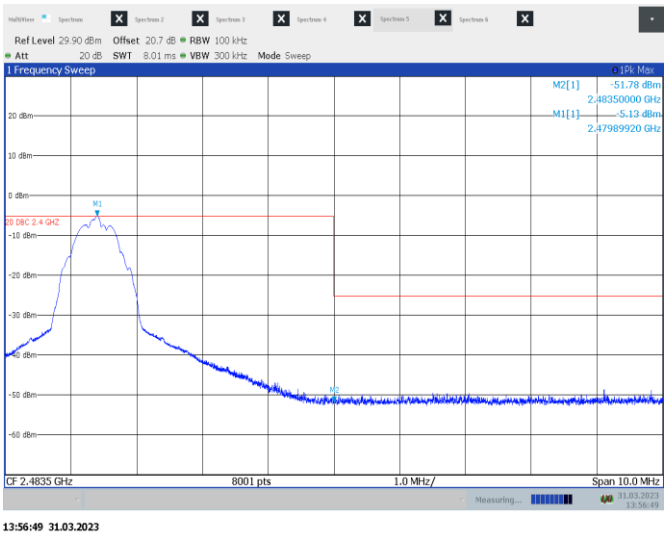

Figure 8.6-9: *Conducted Band edge on high channel, 1 MHz BW*

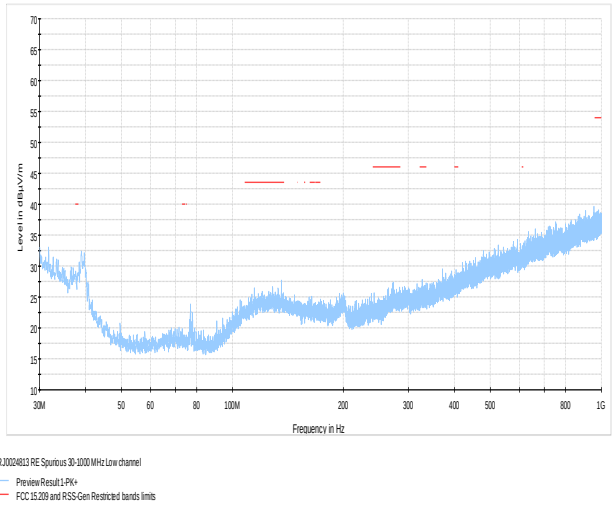

Figure 8.6-10: *Radiated spurious emissions 30-1000 MHz on low channel – 1MHz*

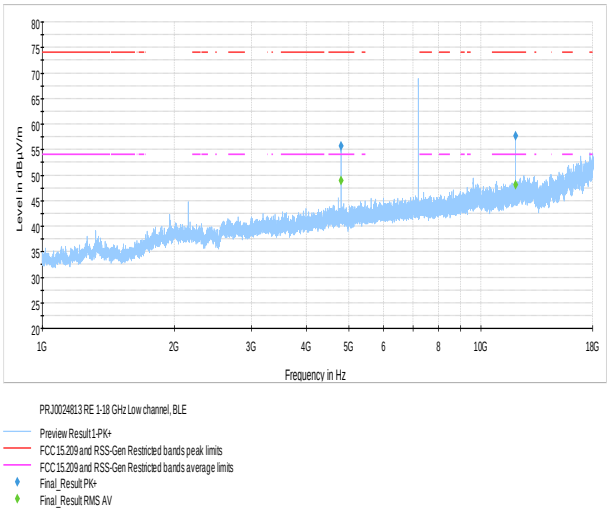

Figure 8.6-11: *Radiated spurious emissions 1-18 GHz on low channel – 1MHz*

Test data, continued

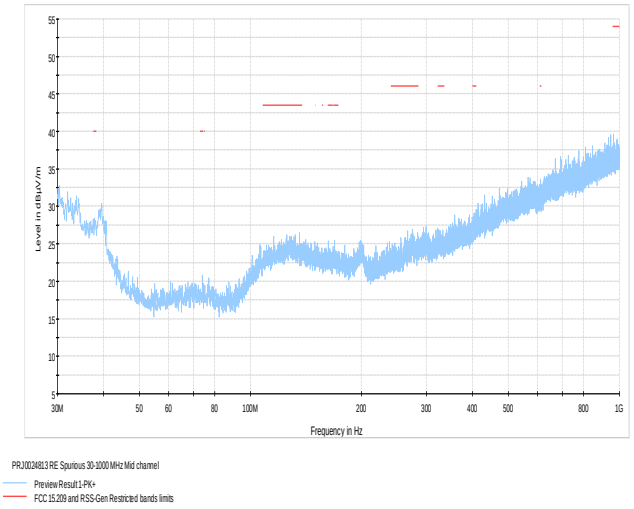

Figure 8.6-12: *Radiated spurious emissions 30-1000 MHz on mid channel – 1MHz*

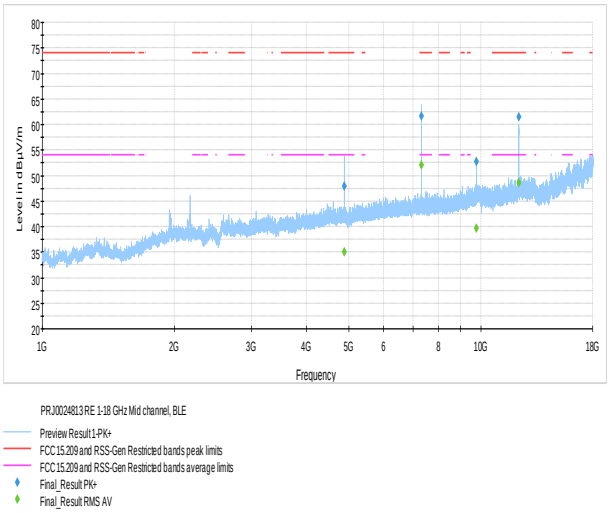

Figure 8.6-13: *Radiated spurious emissions 1-18 GHz on mid channel – 1MHz*

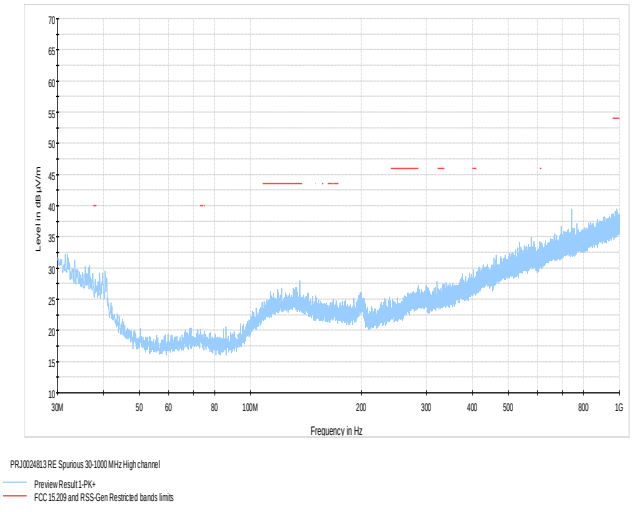

Figure 8.6-14: *Radiated spurious emissions 30-1000 MHz on high channel – 1MHz*

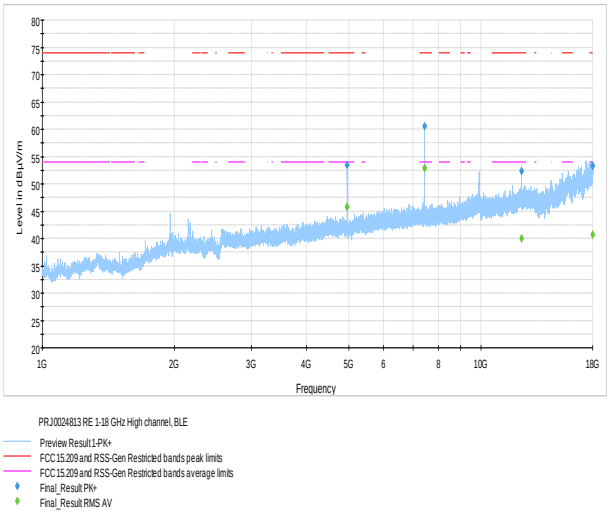

Figure 8.6-15: *Radiated spurious emissions 1-18 GHz on high channel – 1MHz*

Test data, continued

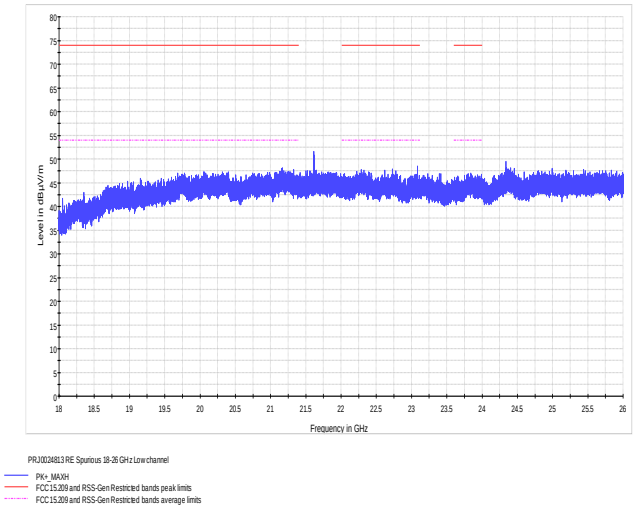

Figure 8.6-16: *Radiated spurious emissions 18-26 GHz on low channel – 1MHz*

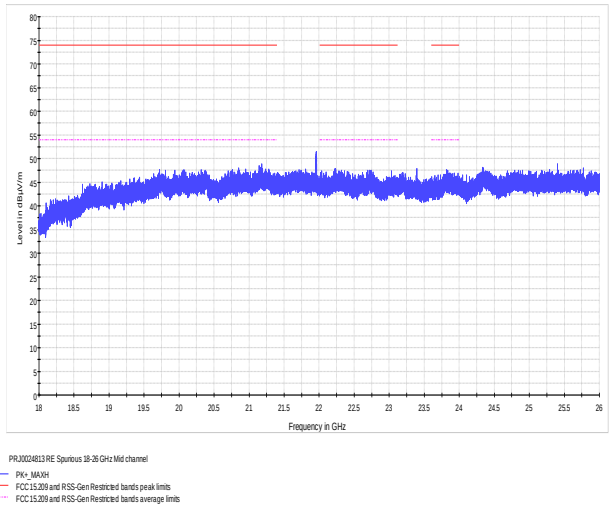

Figure 8.6-17: *Radiated spurious emissions 18-26 GHz on mid channel – 1MHz*

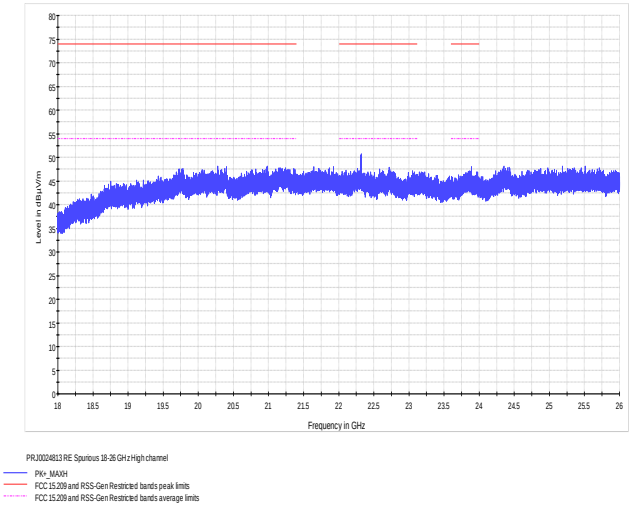

Figure 8.6-18: *Radiated spurious emissions 18-26 GHz on high channel – 1MHz*

8.7 Power spectral density for digitally modulated devices

8.7.1 References, definitions, and limits

FCC §15.247:

(e) 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.

RSS-247, Clause 5.2:

DTSs include systems that employ digital modulation techniques resulting in spectral characteristics similar to direct sequence systems. The following applies to the bands 902-928 MHz and 2400-2483.5 MHz:

b. 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).

RSS-247, Clause 5.3:

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

b. 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.

AS/NZS 4268, Clause 6.3:

6.3.1 Australian limits
In Australia, refer to Table 1
Table 1 Australian requirements
Note 2 The radiated peak power spectral density in any 3 kHz is limited to 25 mW (8 dBm) per 3 kHz.

6.3.2 New Zealand limits
In New Zealand, refer to the General User Radio Licence (GURL) for SRD.
GURL Radiocommunications Regulations (General User Radio Licence for Short Range Devices) Notice 2019
No specific limits

8.7.2 Test summary

Verdict	Pass		
Tested by	Ketav Jani	Test date	March 31, 2023

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 PKPSD (peak PSD).
Spectrum analyser settings:

Resolution bandwidth:	3 kHz
Video bandwidth:	≥3 × RBW
Frequency span:	1.5 times the DTS BW (Peak)
Detector mode:	Peak
Trace mode:	Max hold

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
2402	-5.0	8.0	13.0
2440	-5.7	8.0	13.7
2480	-6.2	8.0	14.2

Test data, continued

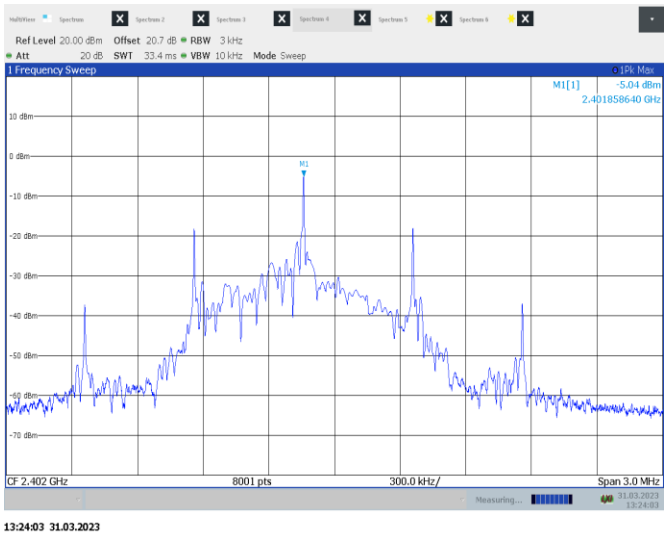

Figure 8.7-1: *PSD on low channel*

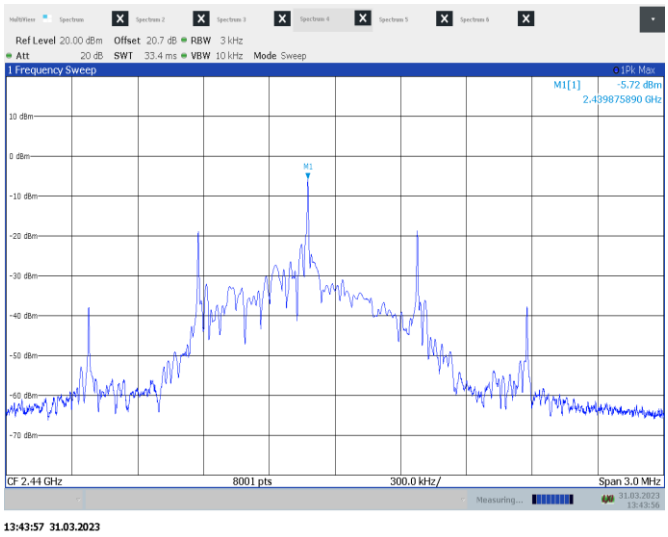

Figure 8.7-2: *PSD on mid channel*

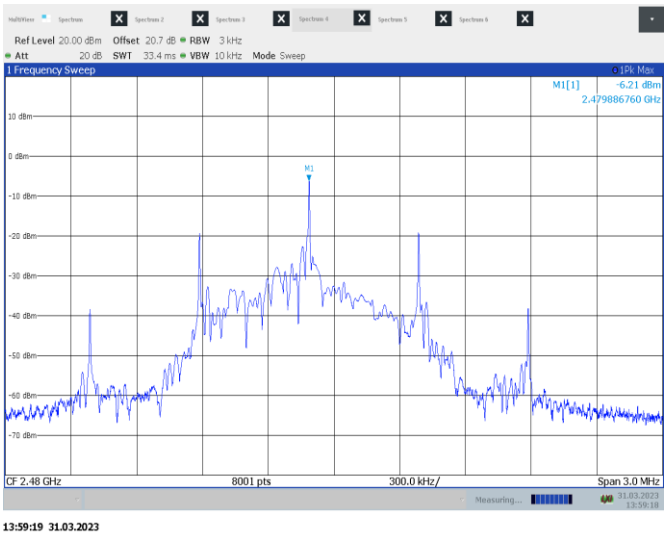

Figure 8.7-3: *PSD on high channel*

End of the test report