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Wireless test report – 404987-1R1TRFWL

Applicant:

Eleven-X Inc.

Product type:

Parking Stall Sensor

Model:

PRK001001

FCC ID:

2A0X5PRK001001

IC Registration number:

22369-PRK001001

Specifications:

- FCC 47 CFR Part 15 Subpart C, §15.247

  Operation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz

- RSS-247, Issue 2, Feb 2017, Section 5

  Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

  5) Standard specifications for frequency hopping systems and digital transmission systems operating in the bands 902–928 MHz, 2400–2483.5 MHz and 5725–5850 MHz

Date of issue: November 24, 2020

Mark Libbrecht, EMC Specialist	*(signature)*
Tested by	Signature
Fahar A Sukkoor, EMC/Wireless Specialist	*(signature)*
Reviewed by	Signature

Test location(s)

Company name	Nemko Canada Inc.
Site name	Cambridge
Address	130 Saltsman Drive, Unit #1
City	Cambridge
Province	Ontario
Postal code	N3E 0B2
Country	Canada
Telephone	Tel: +1 519 680 4811
Website	www.nemko.com
Site number (3 m SAC)	FCC/IC: CA0101

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 contain in this report are within Nemko Canada's ISO/IEC 17025 accreditation.

Copyright notification

Table of contents

Section 1. Report summary

1.1 Applicant and manufacturer

Company name	Eleven-X Inc.
Address	375 Hagey Blvd., Suite 311
City	Waterloo
Province/State	Ontario
Postal/Zip code	N2L 6R5
Country	Canada

1.2 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

1.3 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.
DA 00-705, Released March 30, 2000	Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
RSS-Gen, Issue 5 Amendment 1, March 2019	General Requirements for Compliance of Radio Apparatus

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 1.5 below. 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 Exclusions

None

1.6 Test report revision history

Revision #	Date of issue	Details of changes made to test report
TRF	November 12, 2020	Original report issued
R1TRF	November 24, 2020	Update HVIN

Section 2. Summary of test results

2.1 FCC Part 15 Subpart C, general requirements test results

Table 2.1-1: *FCC general requirements results*

Part	Test description	Verdict
§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

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

2.2 FCC Part 15 Subpart C, intentional radiators test results for frequency hopping spread spectrum systems

Table 2.2-1: *FCC 15.247 results for FHSS*

Part	Test description	Verdict
§15.247(a)(1)(i)	Requirements for operation in the 902–928 MHz band	Pass
§15.247(a)(1)(ii)	Requirements for operation in the 5725–5850 MHz band	Not applicable
§15.247(a)(1)(iii)	Requirements for operation in the 2400–2483.5 MHz band	Not applicable
§15.247(b)(1)	Maximum peak output power in the 2400–2483.5 MHz band and 5725–5850 MHz band	Not applicable
§15.247(b)(2)	Maximum peak output power in the 902–928 MHz band	Pass
§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	Pass

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

Table 2.3-1: *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
§15.247(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(e)	Power spectral density	Pass
§15.247(f)	Time of occupancy for hybrid systems	Pass

2.4 ISED RSS-Gen, Issue 5, test results

Table 2.4-1: *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

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.

2.5 ISED RSS-247, Issue 2, test results for frequency hopping spread spectrum systems (FHSS)

Table 2.5-1: *RSS-247 results for FHSS*

Part	Test description	Verdict
5.1 (a)	Bandwidth of a frequency hopping channel	Pass
5.1 (b)	Minimum channel spacing	Pass
5.1 (c)	Systems operating in the 902–928 MHz band	Pass
5.1 (d)	Systems operating in the 2400–2483.5 MHz band	Not applicable
5.1 (e)	Systems operating in the 5725–5850 MHz band	Not applicable
5.3	Hybrid Systems	
5.3 (a)	Digital modulation turned off	Pass
5.3 (b)	Frequency hopping turned off	Pass
5.4	Transmitter output power and e.i.r.p. requirements	
5.4 (a)	Systems operating in the 902–928 MHz band	Pass
5.4 (b)	Systems operating in the 2400–2483.5 MHz band	Not applicable
5.4 (c)	Systems operating in the 5725–5850 MHz	Not applicable
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

Notes: None

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

Table 2.6-1: *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	Pass
5.3 (b)	Frequency hopping turned off	Pass
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

Notes: None

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	October 9, 2020
Nemko sample ID number	1

3.2 EUT information

Product type	Parking Stall Sensor
Model	PRK001001
Software Version	0.11.2
Model variant	1.0
Serial number	70B3B514900E0152

3.3 Technical information

Applicant IC company number	22369
IC UPN number	22369-PRK001001
All used IC test site(s) Reg. number	24676
RSS number and Issue number	RSS-247 Issue 2, Feb 2017
Frequency band	902-928 MHz
Frequency Min (MHz)	902.3 (FHSS) 903 (DTS)
Frequency Max (MHz)	914.9 (FHSS) 914.2 (DTS)
RF power Max (W), Conducted	0.204 (23.1 dBm) FHSS @ 902.3 MHz 0.195 (22.9 dBm) DTS @ 903 MHz
Field strength, dBµV/m @ 3 m	N/A
Measured BW (kHz), 99% OBW	146.3 kHz (FHSS) @ 902.3 MHz 503.9 kHz (DTS) @ 914.2 MHz
Type of modulation	LoRa
Emission classification (F1D, G1D, D1D)	X1D
Transmitter spurious, dBµV/m @ 3 m	55.4 (Peak), 53.7 (Average) @ 3634.7 MHz
Power requirements	Battery: 3.6V non-rechargeable Lithium Thionyl Chloride D-Cell
Antenna information	Peak gain = -1 dBi

3.4 Product description and theory of operation

The eleven smart parking sensor is an innovative patent-pending LoRaWAN®-based device that utilizes multiple technologies including magnetic sensing, Radar, and Bluetooth: The sensor sends parking events over LoRaWAN to the eleven-x SPS analytics platform where the data provides key analytics and insight to help parking manager understand the usage of the parking assets.

3.5 EUT exercise details

EUT was set to transmit continuously at 100% duty cycle.

3.6 EUT setup diagram

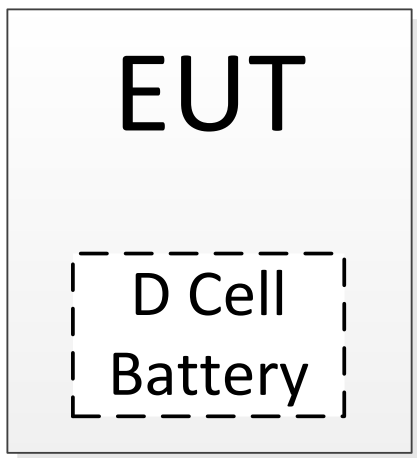


Figure 3.6-1: *Setup diagram*

3.7 EUT sub assemblies

Table 3.7-1: *EUT sub assemblies*

Description	Brand name	Model/Part number	Serial number
3.6 V_{DC} D Cell Battery	Tadiran	TL-4930	None

Section 4. Engineering considerations

4.1 Modifications incorporated in the EUT

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

4.2 Technical judgment

None

4.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 5. Test conditions

5.1 Atmospheric conditions

Temperature	15–30 °C
Relative humidity	20–75 %
Air pressure	860–1060 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.

5.2 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 6. Measurement uncertainty

6.1 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 6.1-1: *Measurement uncertainty*

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

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.
3 m EMI test chamber	TDK	SAC-3	FA003012	1 year	Oct. 10/21
Flush mount turntable	SUNAR	FM2022	FA003006	—	NCR
Controller	SUNAR	SC110V	FA002976	—	NCR
Antenna mast	SUNAR	TLT2	FA003007	—	NCR
Receiver/spectrum analyzer	Rohde & Schwarz	ESR26	FA002969	1 year	Dec. 4/20
Spectrum analyzer	Rohde & Schwarz	FSW43	FA002971	1 year	June 21/21
Horn antenna (1–18 GHz)	ETS Lindgren	3117	FA002911	1 year	Sept. 11/21
Preamp (1–18 GHz)	ETS Lindgren	124334	FA002956	1 year	Mar. 18/21
Bilog antenna (30–2000 MHz)	SUNAR	JB1	FA003010	1 year	Sept. 17/21
50 Ω coax cable	Huber + Suhner	None	FA003047	1 year	Sept. 30/21
50 Ω coax cable	Huber + Suhner	None	FA003044	1 year	Oct. 7/21
Notch filter 1.2 – 12 Ghz Highpass filter	Microwave circuits	H1G212G1	FA003031	1 year	Oct. 9/21

Note: NCR - no calibration required

Section 8. Testing data

8.1 FCC 15.31(e) Variation of power source

8.1.1 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 date

Start date	October 13, 2020

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.

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

8.2.1 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 date

Start date	October 9, 2020

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, 125 kHz FHSS*

Start of Frequency range, MHz	End of Frequency range, MHz	Frequency range bandwidth, MHz	Low channel, MHz	Mid channel, MHz	High channel, MHz
902	928	26	902.3	908.7	914.9

Table 8.2-3: *Test channels selection, 500 kHz DTS*

Start of Frequency range, MHz	End of Frequency range, MHz	Frequency range bandwidth, MHz	Low channel, MHz	Mid channel, MHz	High channel, MHz
902	928	26	903	907.8	914.2

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

8.3.1 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.

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 date

Start date	October 9, 2020

8.3.3 Observations, settings and special notes

None

8.3.4 Test data

Must the EUT be professionally installed?	☐ YES	☒ NO	
Does the EUT have detachable antenna(s)?	☐ YES	☒ NO	
If detachable, is the antenna connector(s) non-standard?	☐ YES	☐ NO	☒ N/A

8.4 FCC 15.247(a)(1) and RSS-247 5.1 Frequency Hopping Systems requirements, 900 MHz operation

8.4.1 Definitions and limits

FCC:

(1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(i) For frequency hopping systems operating in the 902–928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

(f) For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4. The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

ISED:

a) The bandwidth of a frequency hopping channel is the 20 dB emission bandwidth, measured with the hopping stopped. The system's radio frequency (RF) bandwidth is equal to the channel bandwidth multiplied by the number of channels in the hopset. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

c) For FHSs in the band 902–928 MHz: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping channels and the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 20-second period. If the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping channels and the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 10-second period. The maximum 20 dB bandwidth of the hopping channel shall be 500 kHz.

5.3 Hybrid systems

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

a With the digital transmission operation of the hybrid system turned off, the frequency hopping operation shall have an average time of occupancy on any frequency not exceeding 0.4 seconds within a duration in seconds equal to the number of hopping frequencies multiplied by 0.4.

8.4.2 Test date

Start date	October 13, 2020

8.4.3 Observations, settings and special notes

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

Resolution bandwidth	Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
Video bandwidth	≥ RBW
Frequency span	Wide enough to capture the peaks of two adjacent channels
Detector mode	Peak
Trace mode	Max Hold

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

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

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

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

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

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

8.4.4 Test data

***Table 8.4-1:** 20 dB bandwidth results*

Frequency, MHz	20 dB bandwidth, kHz
902.3	150.3
908.7	149.8
914.9	149.6

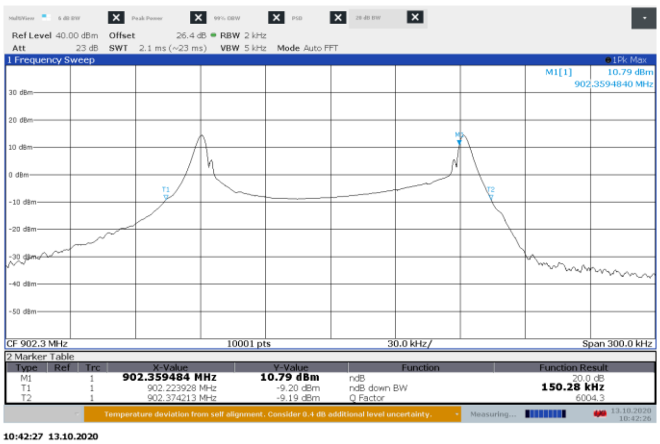


***Figure 8.4-1:** 20 dB bandwidth on low channel, 125 kHz BW*

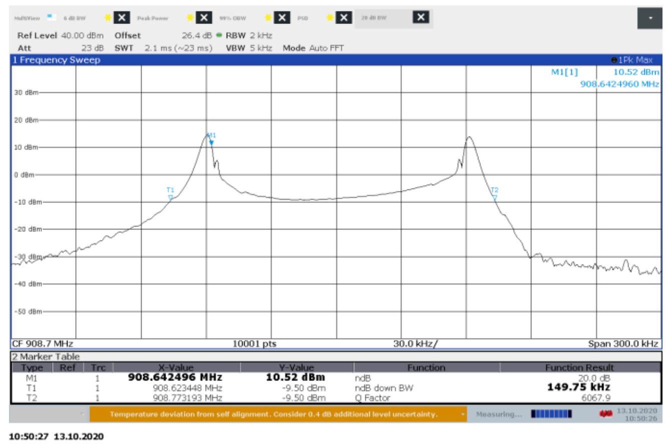


***Figure 8.4-2:** 20 dB bandwidth on mid channel, 125 kHz BW*

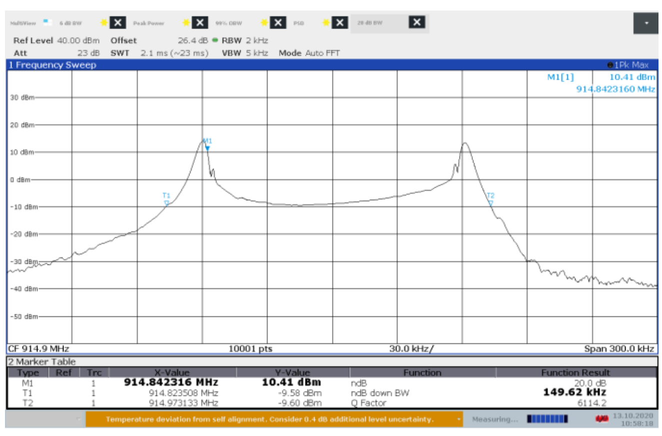


***Figure 8.4-3:** 20 dB bandwidth on high channel, 125 kHz BW*

8.4.5 Test data, continued

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

Frequency, MHz	99% occupied bandwidth, kHz
902.3	146.3
908.5	145.3
914.9	145.2

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

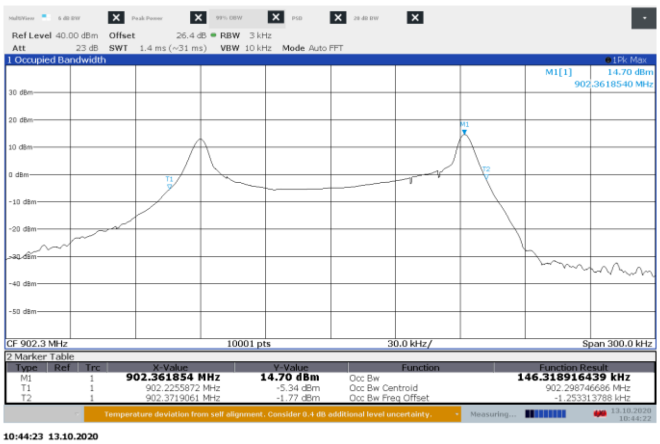


Figure 8.4-4: *99% OBW on low channel, 125 kHz BW*

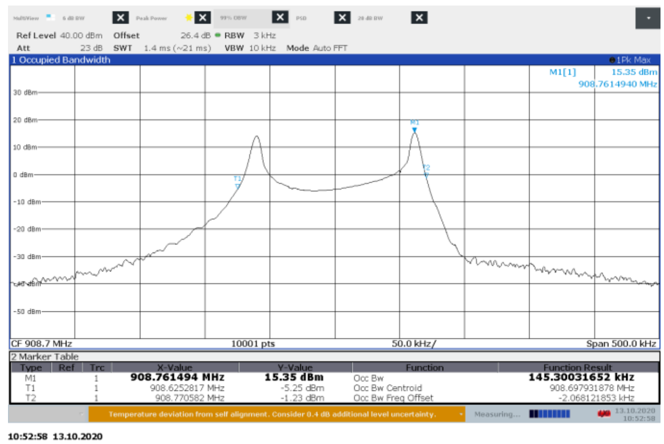


Figure 8.4-5: *99% OBW on mid channel, 125 kHz BW*

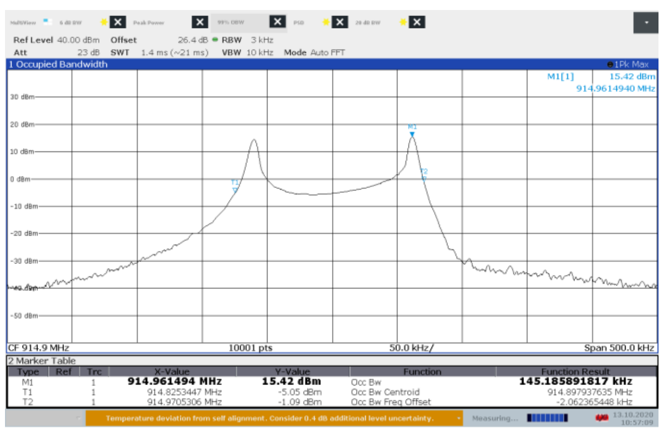


Figure 8.4-6: *99% OBW bandwidth on high channel, 125 kHz BW*

8.4.6 Test data, continued

Table 8.4-3: *Carrier frequency separation results*

Carrier frequency separation, kHz	Minimum limit, kHz	Margin, kHz
200	130	70

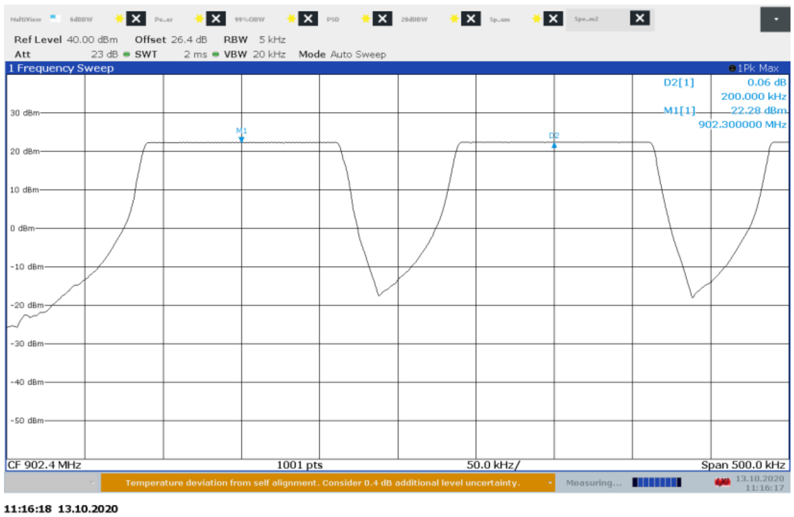


Figure 8.4-7: *Carrier frequency separation*

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

Number of hopping frequencies	Minimum limit	Margin
64	50	14

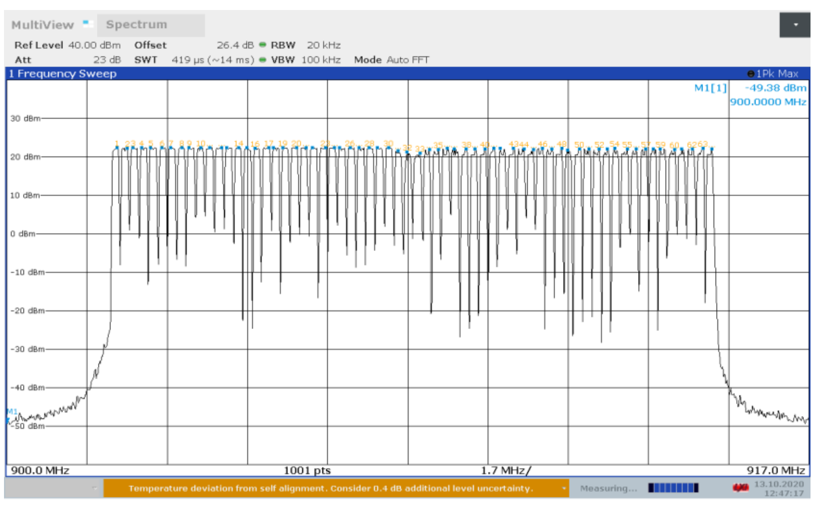


Figure 8.4-8: *Number of hopping channels = 64*

8.4.7 Test data, continued

Table 8.4-5: *Average time of occupancy results, Hybrid Mode*

Dwell time of each pulse, ms	Number of pulses within period	Total dwell time within period, ms	Limit, ms	Margin, ms
358	1	358	400	42

Measurement Period = 0.4 × 64 channels = 25.6 s

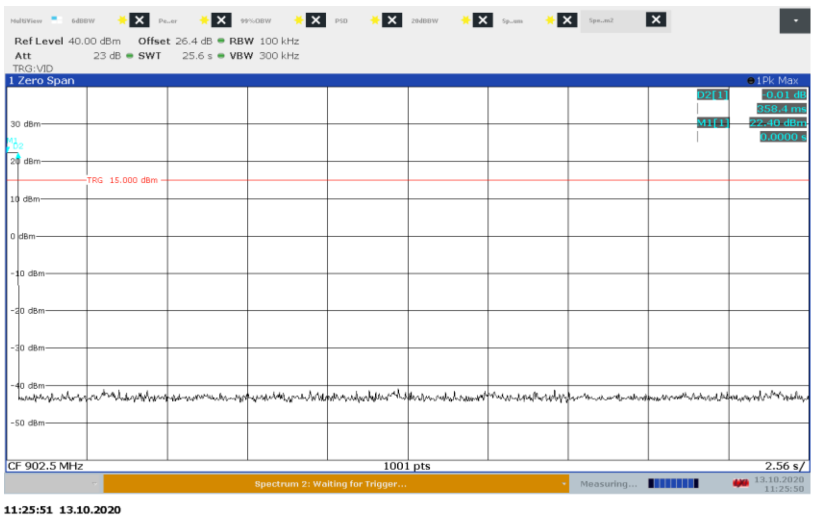


Figure 8.4-9: *Dwell time*

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

8.5.1 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.

8.5.1 Test date

Start date	October 13, 2020

8.5.2 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	100 kHz
Video bandwidth	≥3 × RBW
Frequency span	2 MHz
Detector mode	Peak
Trace mode	Max Hold

8.5.3 Test data

Table 8.5-1: *6 dB bandwidth results*

Frequency, MHz	6 dB bandwidth, kHz	Minimum limit, MHz	Margin, kHz
903.0	618.5	0.50	118.5
907.8	623.5	0.50	123.5
914.2	617.5	0.50	117.5

Table 8.5-2: *99% occupied bandwidth results*

Frequency, MHz	99% occupied bandwidth, kHz
903.0	498.9
907.8	503.3
914.2	503.9

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

8.5.4 Test data, continued

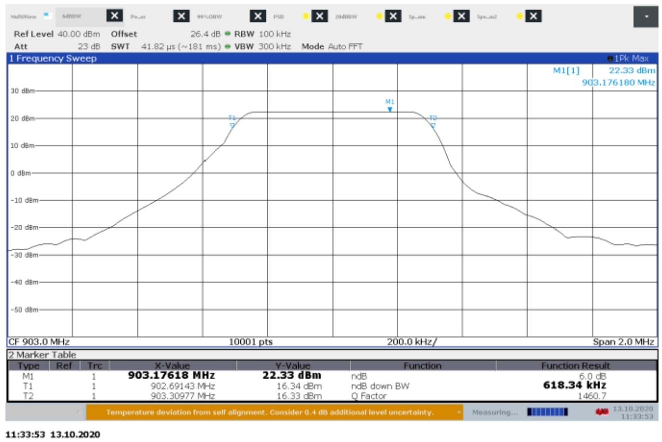


Figure 8.5-1: *6 dB bandwidth on low channel, 500 kHz BW*

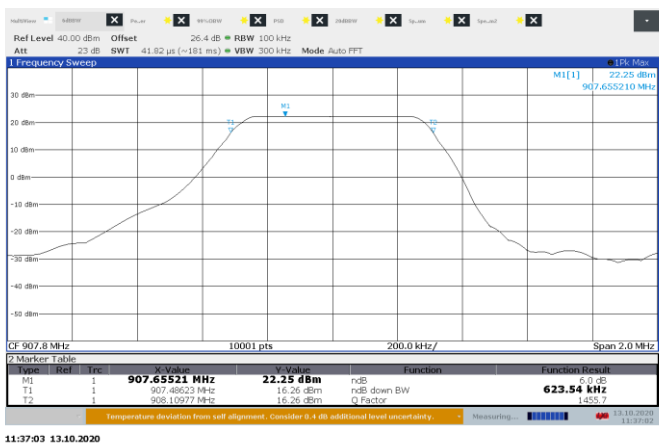


Figure 8.5-2: *6 dB bandwidth on mid channel, 500 kHz BW*

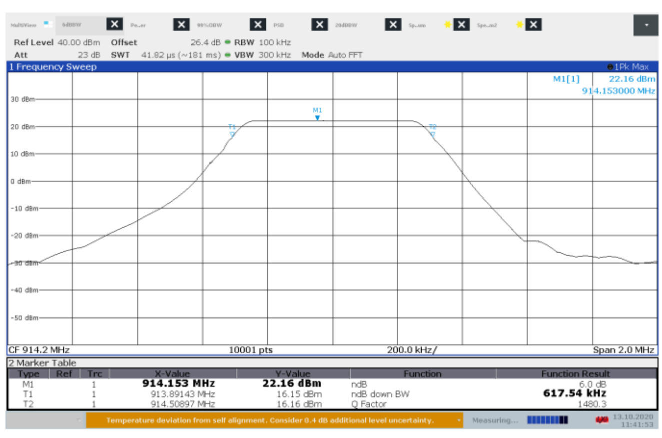


Figure 8.5-3: *6 dB bandwidth on high channel, 500 kHz BW*

8.5.5 Test data, continued

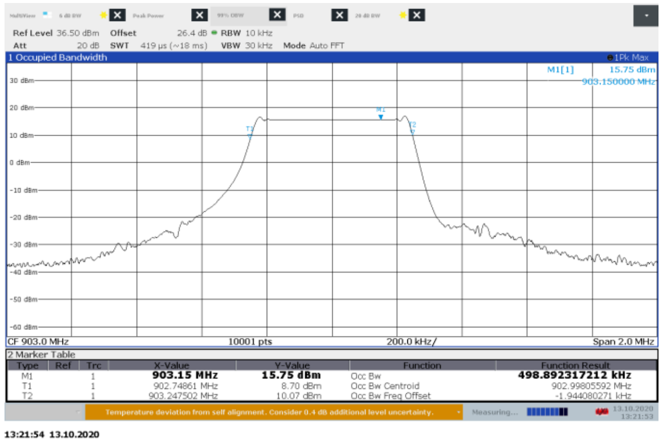


Figure 8.5-4: *99% OBW on low channel, 500 kHz BW*

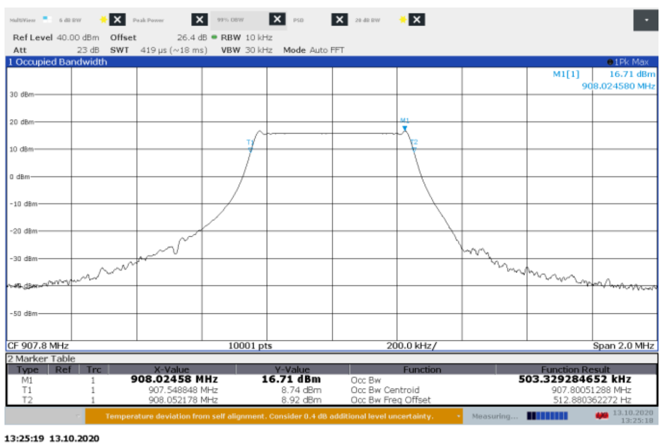


Figure 8.5-5: *99% OBW on mid channel, 500 kHz BW*

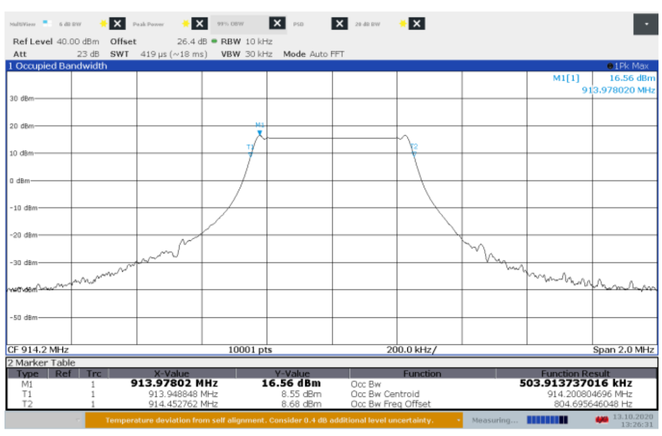


Figure 8.5-6: *99% OBW on high channel, 500 kHz BW*

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

8.6.1 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.

8.6.2 Test date

Start date	October 13, 2020

8.6.3 Observations, settings and special notes

The test was performed as per KDB 558074, section 8.3 with reference to ANSI C63.10 subclause 11.9.2.2 (average power)
Reported EUT antenna peak gain = -1 dBi. Per ANSI 63.10 (2013) clause 11.12.2.6 , 2 dBi gain used for all power calculations
The test was performed using method AVGSA-2 (trace averaging across on- and off-times of the EUT transmissions, followed by duty cycle correction).
Trace counts increased to 1000 to stabilize trace.
Spectrum analyser settings:

Resolution bandwidth	1-5 % OBW
Video bandwidth	≥3 × RBW
Frequency span	≥1.5 × OBW
Detector mode	RMS
Trace mode	Average
Trace count	> 100
Integration Bandwidth	> OBW

8.6.4 Test data

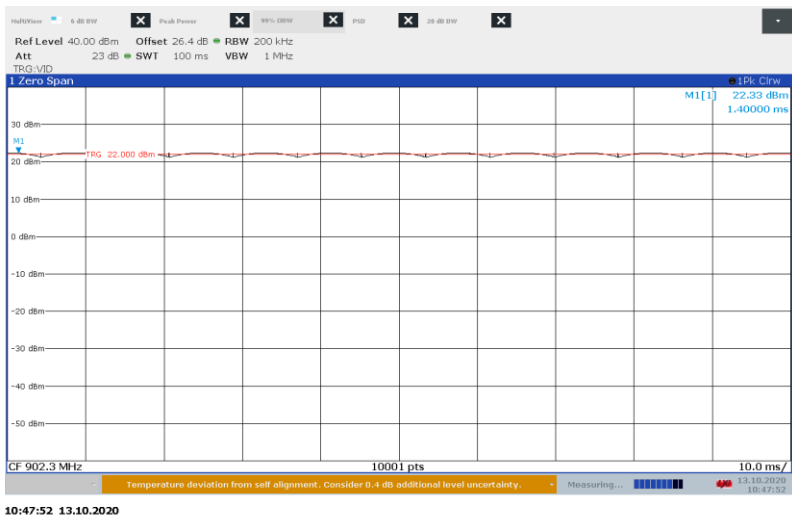


Figure 8.6-1: *Duty cycle on low channel, 125 kHz BW*

Frequency (MHz)	Bandwidth, kHz	ON Time, ms	Observation Time, ms	Duty Cycle	Duty Cycle Correction Factor (dB)
902.3	125	100	100	1.0	0.0

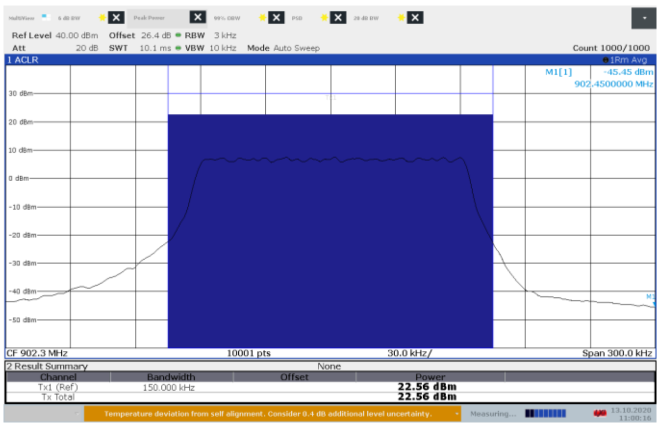
Notes: Duty cycle = On Time/Time, Duty cycle correction = 10 log(1/duty cycle)

8.6.5 Test data, continued

Table 8.6-1: *Output power measurements results, 125 kHz BW*

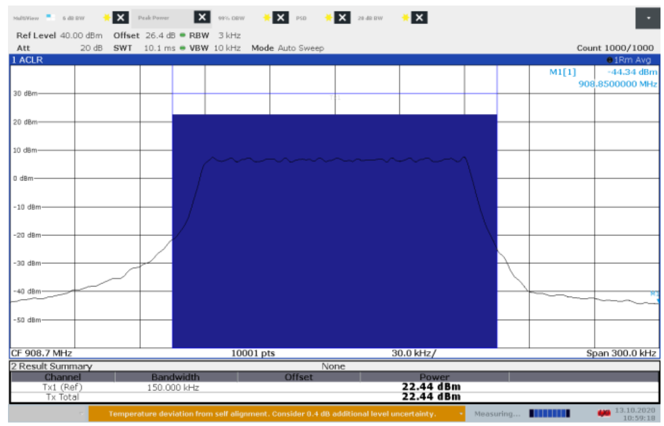
Frequency (MHz)	Conducted Output Power, dBm	Conducted Output limit, dBm	Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
902.3	23.1	30.0	6.9	2.0	25.1	36.0	10.9
908.7	22.9	30.0	7.1	2.0	24.9	36.0	11.1
914.9	22.7	30.0	7.3	2.0	24.7	36.0	11.3

Notes: EIRP = Output power + Antenna gain, Additional 0.5 dBm added to output power measurement to compensate for UFL to SMA connector



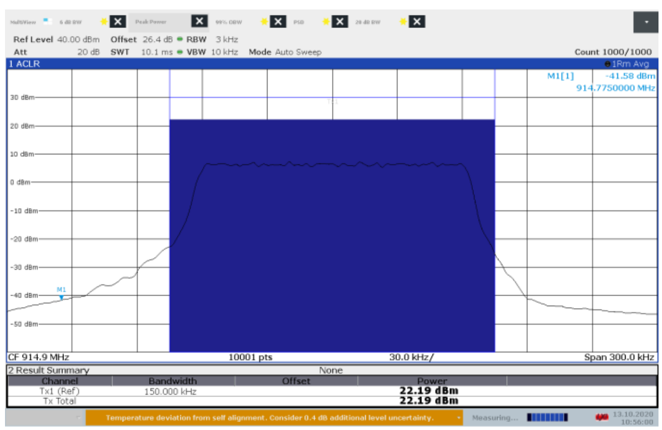
11:00:16 13.10.2020

Figure 8.6-2: *Output power on low channel, 125 kHz BW*



10:59:19 13.10.2020

Figure 8.6-3: *Output power on mid channel, 125 kHz BW*



10:56:01 13.10.2020

Figure 8.6-4: *Output power on high channel, 125 kHz BW*

8.6.1 Test data, continued

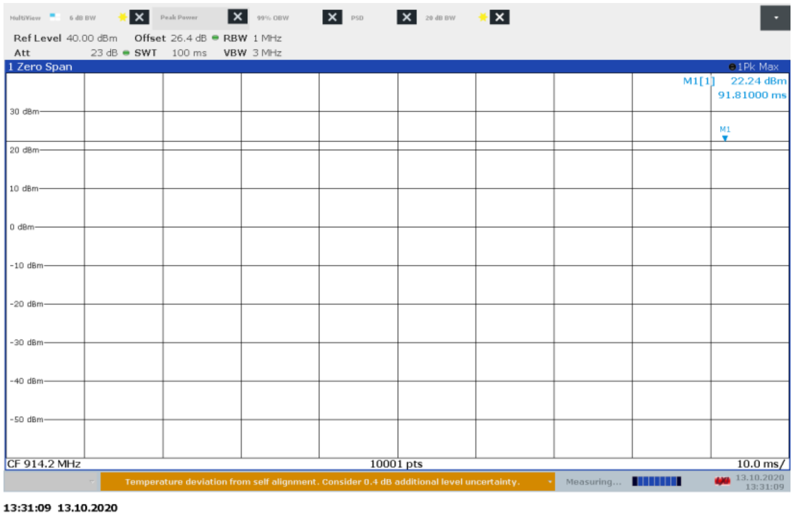


Figure 8.6-5: *Duty cycle on low channel, 500 kHz BW*

Frequency (MHz)	Bandwidth, kHz	ON Time, ms	Observation Time, ms	Duty Cycle	Duty Cycle Correction Factor (dB)
914.2	500	100	100	1.0	0.0

Notes: Duty cycle = On Time/Time, Duty cycle correction = 10 log(1/duty cycle)

8.6.2 Test data, continued

Table 8.6-2: *Output power measurements results, 500 kHz BW*

Frequency (MHz)	Conducted Output Power, dBm	Conducted Output limit, dBm	Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
903.0	22.9	30.0	7.1	2.0	24.9	36.0	11.1
907.8	22.8	30.0	7.2	2.0	24.8	36.0	11.2
914.2	22.7	30.0	7.3	2.0	24.7	36.0	11.3

Notes: EIRP = Output power + Antenna gain, Additional 0.5 dBm added to output power measurement to compensate for UFL to SMA connector

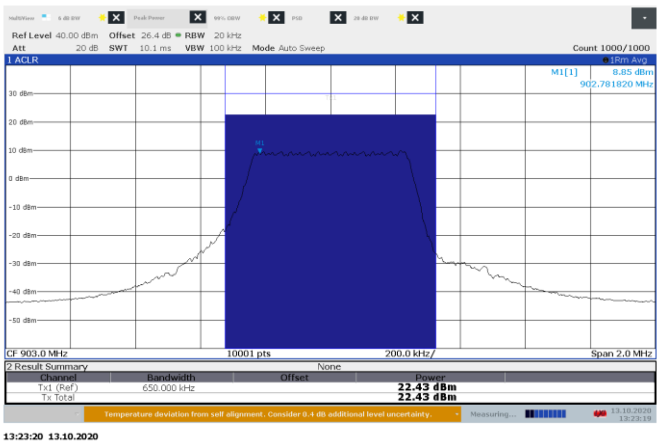


Figure 8.6-6: *Output power on low channel, 500 kHz BW*

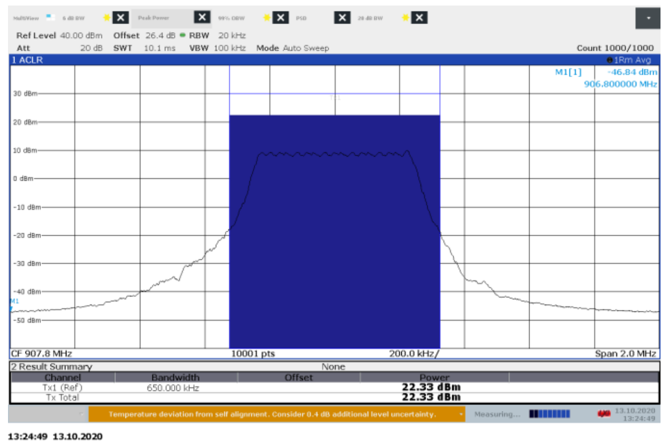


Figure 8.6-7: *Output power on mid channel, 500 kHz BW*

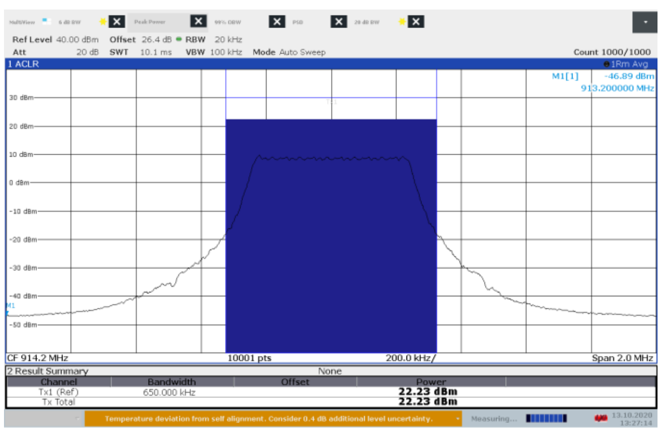


Figure 8.6-8: *Output power on high channel, 500 kHz BW*

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

8.7.1 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 8.7-1: *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 8.7-2: *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 8.7-2 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 8.7-3: *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			

8.7.1 Test date

Start date	October 13, 2020

8.7.2 Observations, settings and special notes

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

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

8.7.3 Test data, Conducted Band-edge, LoRa 125 kHz BW

Figure 8.7-1: *Conducted Band-edge low channel, 125 kHz BW*

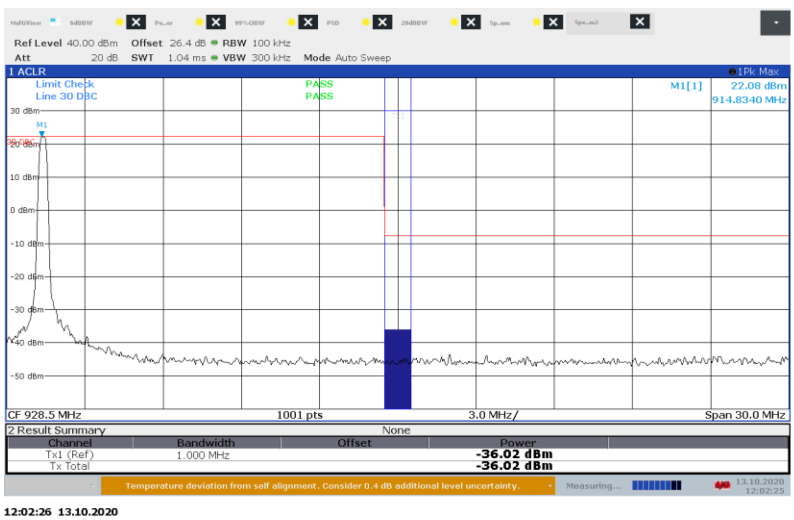


Figure 8.7-2: *Conducted Band-edge high channel, 125 kHz BW*

8.7.4 Test data, Conducted Spurious Emissions, LoRa 125 kHz BW

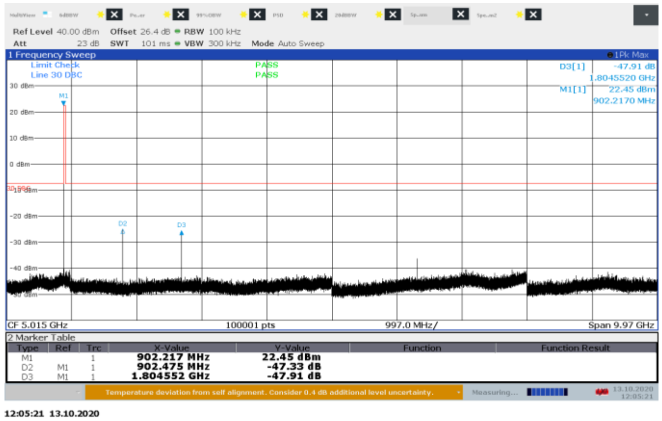


Figure 8.7-3: *Conducted spurious emissions on low channel, 125 kHz BW*

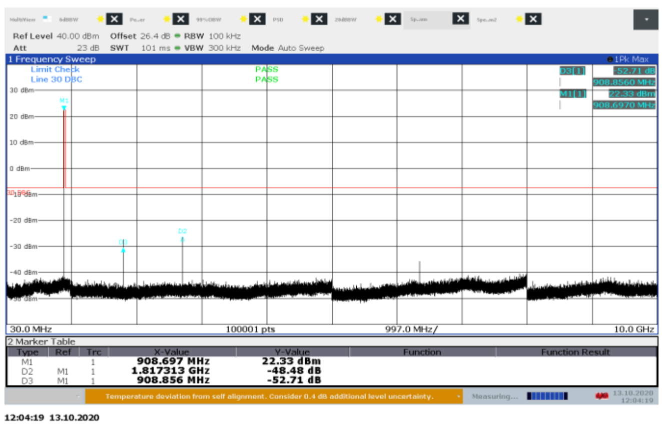


Figure 8.7-4: *Conducted spurious emissions on mid channel, 125 kHz BW*

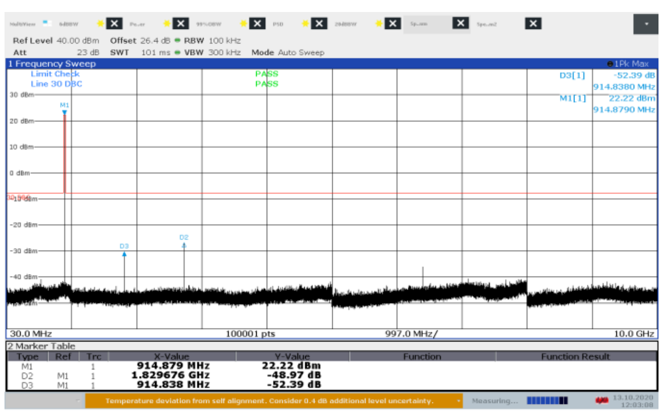


Figure 8.7-5: *Conducted spurious emissions on high channel, 125 kHz BW*

8.7.5 Test data, Radiated spurious 30 MHz – 1 GHz, LoRa 125 kHz BW

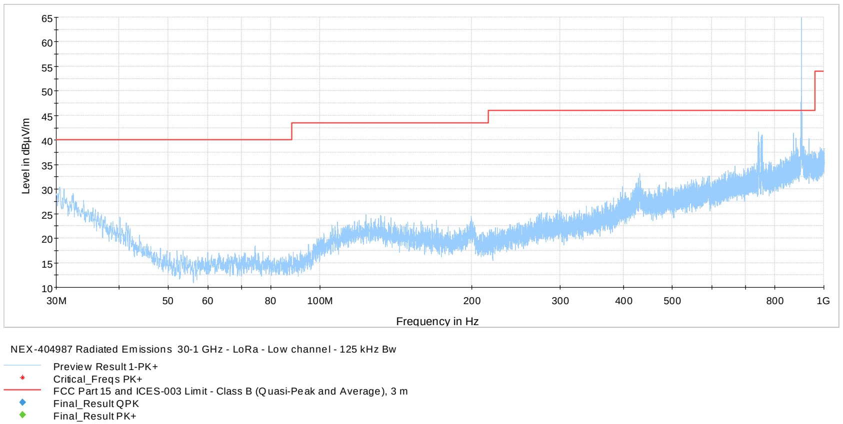


Figure 8.7-6: *Radiated spurious emissions 30 MHz – 1 GHz, 902.3 MHz LORA 125 kHz BW*

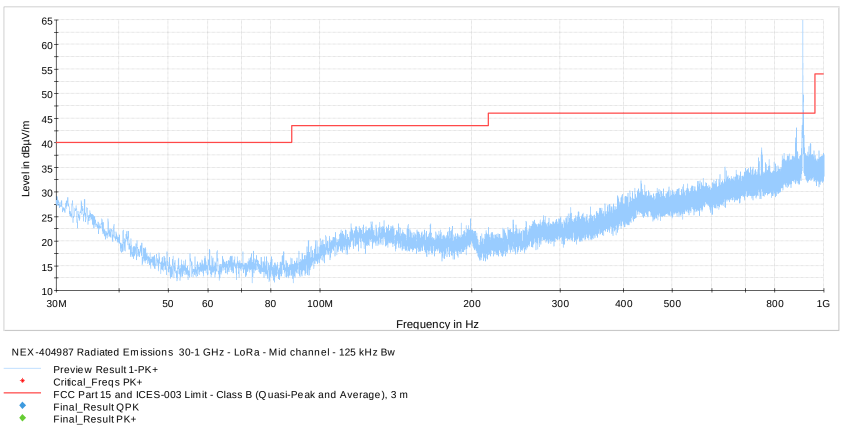


Figure 8.7-7: *Radiated spurious emissions 30 MHz – 1 GHz, 908.5 MHz LoRa 125 kHz BW*

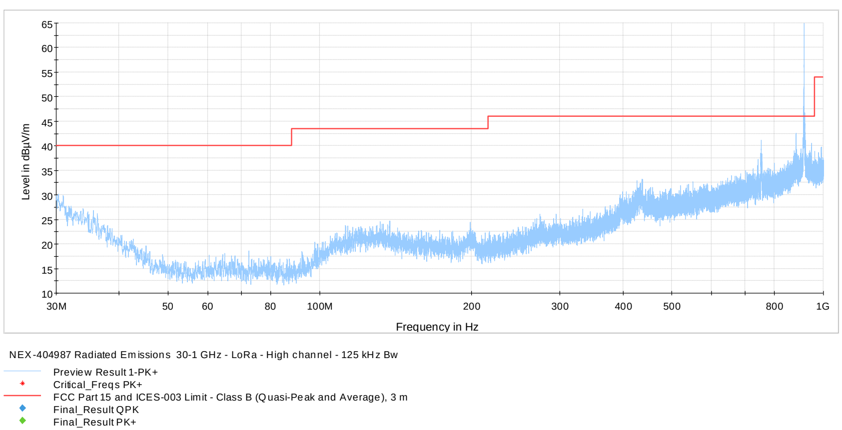


Figure 8.7-8: *Radiated spurious emissions 30 MHz – 1 GHz, 914.9 MHz LoRa 125 kHz BW*

8.7.6 Test data, Radiated spurious 1 – 10 GHz, LoRa 125 kHz BW

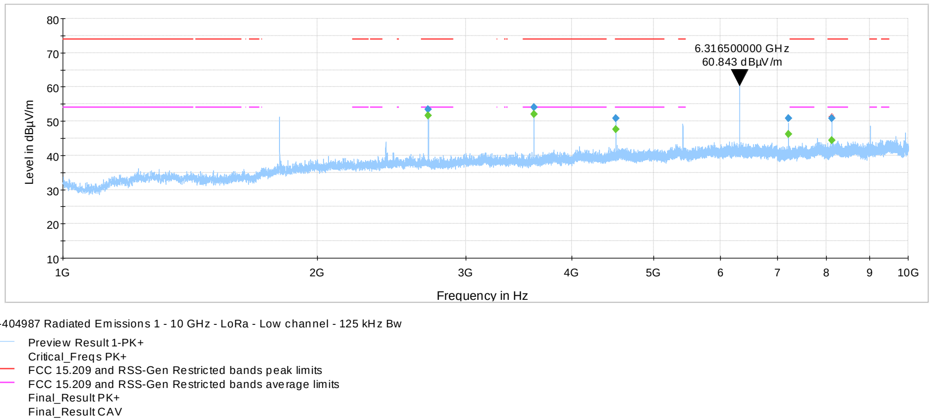


Figure 8.7-9: *Radiated spurious emissions 1 - 10 GHz, 902.3 MHz LoRa 125 kHz BW*

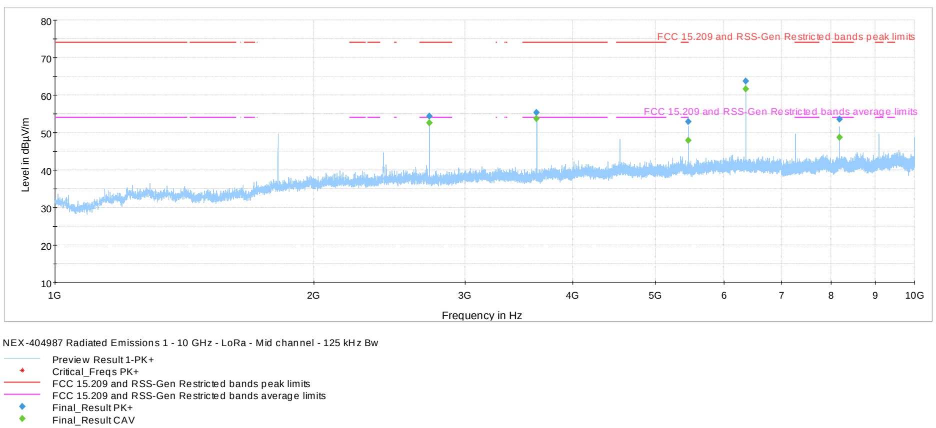


Figure 8.7-10: *Radiated spurious emissions 1 - 10 GHz, 908.5 MHz LoRa 125 kHz BW*

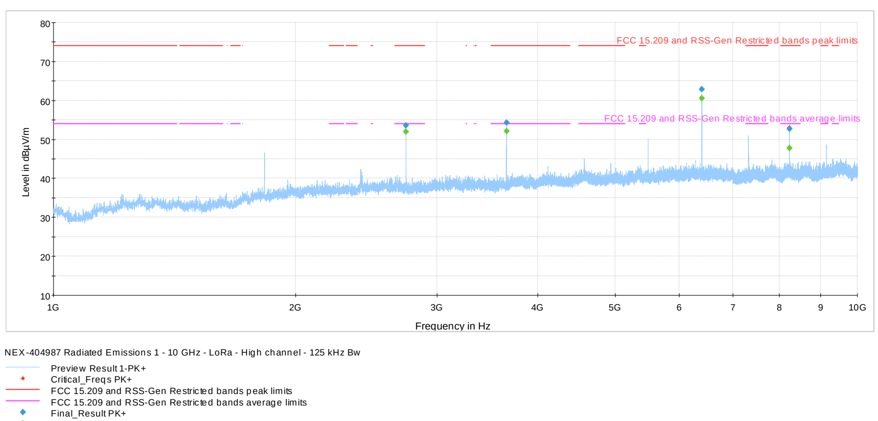


Figure 8.7-11: *Radiated spurious emissions 1 - 10 GHz, 914.9 MHz LoRa 125 kHz BW*

8.7.7 Test data, Radiated spurious 1 – 10 GHz, LoRa 125 kHz BW results

Table 8.7-4: *Radiated emissions results*

Frequency (MHz)	CAverage field strength[1 and 3] (dBμV/m)	CAverage limit (dBμV/m)	CAverage margin (dB)	Correction factor[2] (dB)
125 kHz BW Low channel: 902.3 MHz				
2706.803	51.5	54.0	2.5	-11.5
3609.082	52.0	54.0	2.0	-9.1
4511.546	47.5	54.0	6.5	-6.8
8120.993	44.5	54.0	9.5	-1.1
125 kHz BW Mid channel: 908.7 MHz				
2725.986	52.5	54.0	1.5	-11.6
3634.736	53.7	54.0	0.3	-9.1
5452.528	47.8	54.0	6.2	-6.4
8178.206	48.8	54.0	5.2	-0.8
125 kHz BW High channel: 914.9 MHz				
2744.639	51.9	54.0	2.1	-11.6
3659.748	52.2	54.0	1.8	-9.0
8233.933	47.8	54.0	6.2	-0.7

Frequency (MHz)	Peak field strength[1 and 3] (dBμV/m)	Peak limit (dBμV/m)	Peak margin (dB)	Correction factor[2] (dB)
125 kHz BW Low channel: 902.3 MHz				
2706.803	53.5	74.0	20.5	-11.5
3609.082	54.1	74.0	19.9	-9.1
4511.546	50.9	74.0	23.1	-6.8
8120.993	50.9	74.0	23.1	-1.1
2706.803	53.5	74.0	20.5	-11.5
125 kHz BW Mid channel: 908.7 MHz				
2725.986	54.3	74.0	19.7	-11.6
3634.736	55.4	74.0	18.6	-9.1
5452.528	52.9	74.0	21.1	-6.4
8178.206	53.5	74.0	20.5	-0.8
125 kHz BW High channel: 914.9 MHz				
2744.639	53.6	74.0	20.4	-11.6
3659.748	54.3	74.0	19.7	-9.0
8233.933	52.7	74.0	21.3	-0.7

Notes:
[1] Field strength (dBμV/m) = receiver/spectrum analyzer value (dBμV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB) − amplifier gain (dB)
[3] Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded.

Sample calculation: 51.5 dBμV/m (field strength) = 63.0 dBμV (receiver reading) + (-11.5 dB (Correction factor))

8.7.8 Test data, Conducted Band-edge, LoRa 500 kHz BW

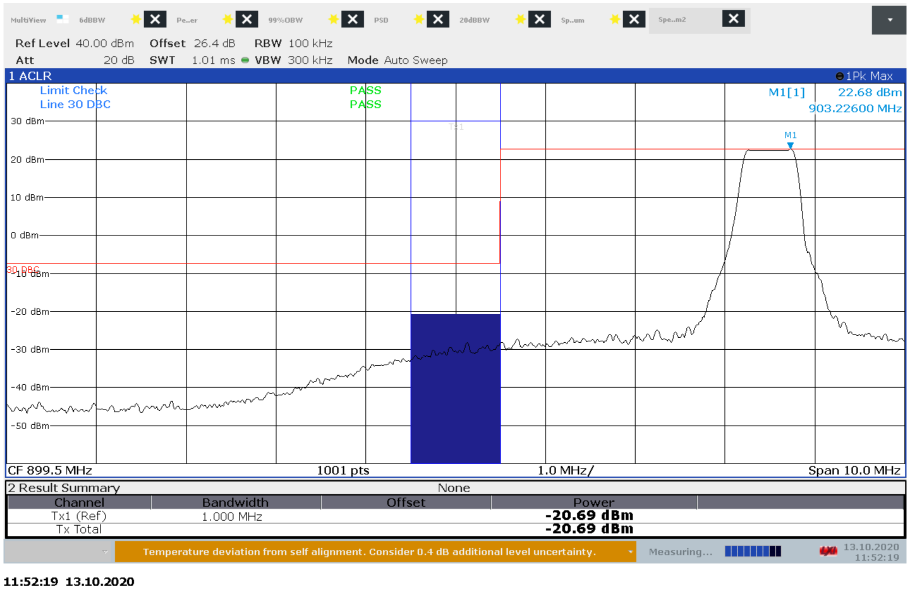


Figure 8.7-12: *Conducted Band-edge low channel, 500 kHz BW*

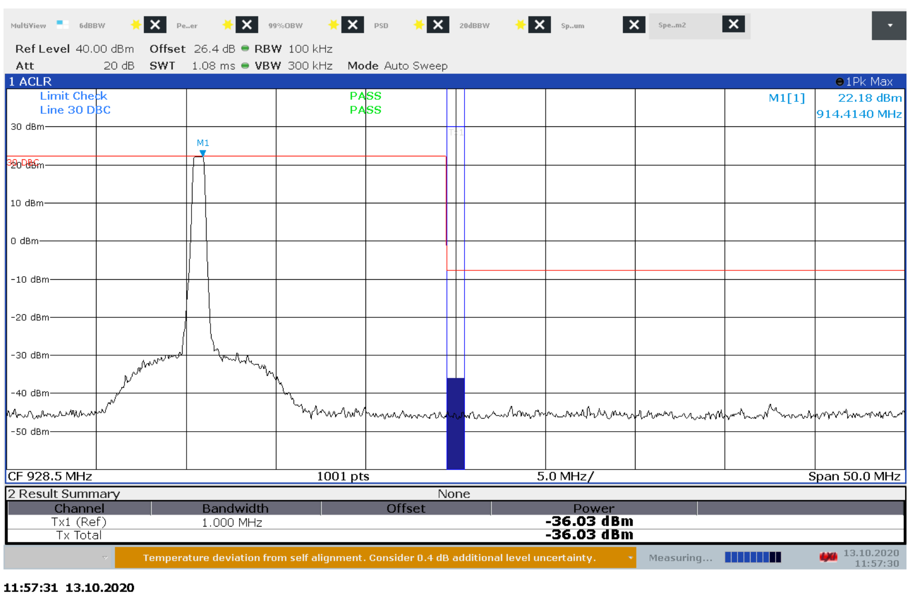


Figure 8.7-13: *Conducted Band-edge high channel, 500 kHz BW*

8.7.9 Test data, Conducted Spurious Emissions, LoRa 500 kHz BW

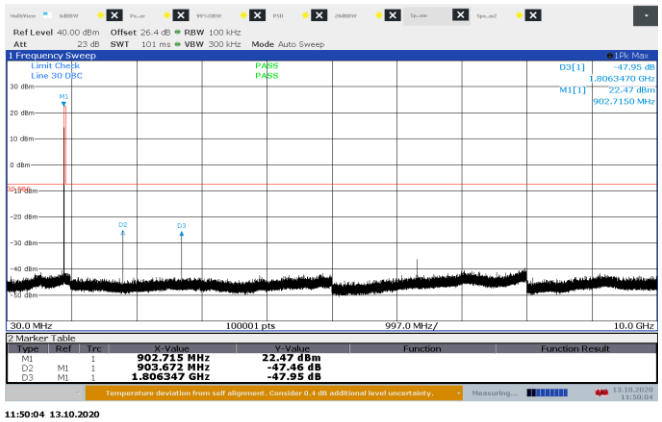


Figure 8.7-14: *Conducted spurious emissions on low channel, 500 kHz BW*

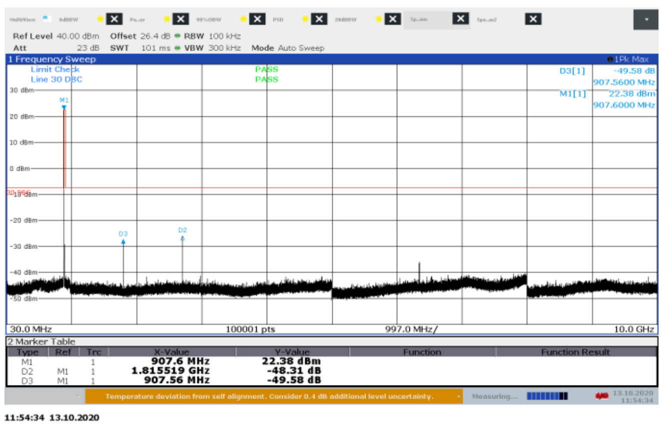
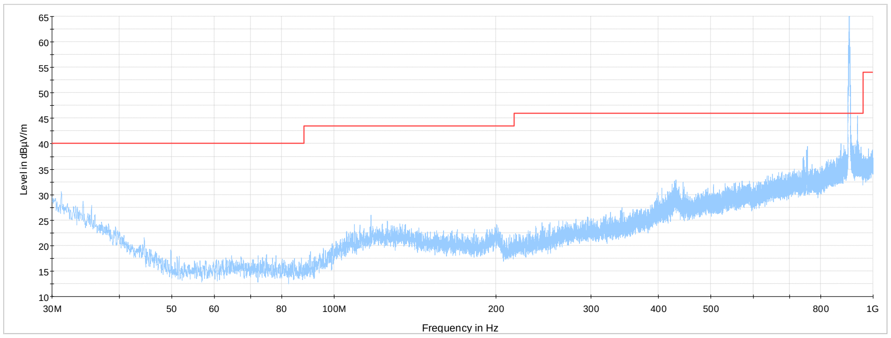


Figure 8.7-15: *Conducted spurious emissions on mid channel, 500 kHz BW*

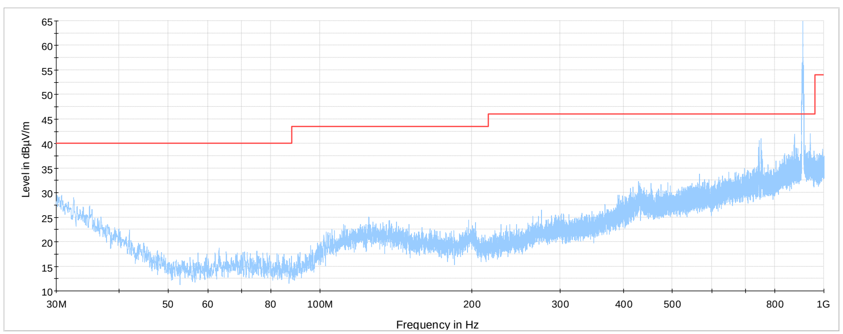
Figure 8.7-16: *Conducted spurious emissions on high channel, 500 kHz BW*

8.7.10 Test data, Radiated spurious 30 MHz – 1 GHz, LoRa 500 kHz BW



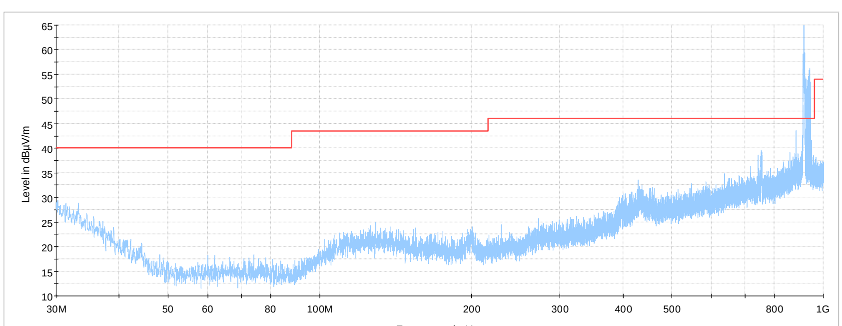
NEX-404987 Radiated Emissions 30-1 GHz - LoRa - Low channel - 500 kHz Bw
Preview Result 1-PK+
Critical_Freqs PK+
FCC Part 15 and ICES-003 Limit - Class B (Quasi-Peak and Average), 3 m
Final_Result QPK
Final_Result PK+

Figure 8.7-17: *Radiated spurious emissions 30 MHz – 1 GHz, 903 MHz LoRa 500 kHz BW*



NEX-404987 Radiated Emissions 30-1 GHz - LoRa - Mid channel - 500 kHz Bw
Preview Result 1-PK+
Critical_Freqs PK+
FCC Part 15 and ICES-003 Limit - Class B (Quasi-Peak and Average), 3 m
Final_Result QPK
Final_Result PK+

Figure 8.7-18: *Radiated spurious emissions 30 MHz – 1 GHz, 907.8 MHz LoRa 500 kHz BW*



NEX-404987 Radiated Emissions 30-1 GHz - LoRa - High channel - 500 kHz Bw
Preview Result 1-PK+
Critical_Freqs PK+
FCC Part 15 and ICES-003 Limit - Class B (Quasi-Peak and Average), 3 m
Final_Result QPK
Final_Result PK+

Figure 8.7-19: *Radiated spurious emissions 30 MHz – 1 GHz, 914.2 MHz LoRa 500 kHz BW*

8.7.11 Test data, Radiated spurious 1 - 10 GHz, LoRa 500 kHz BW

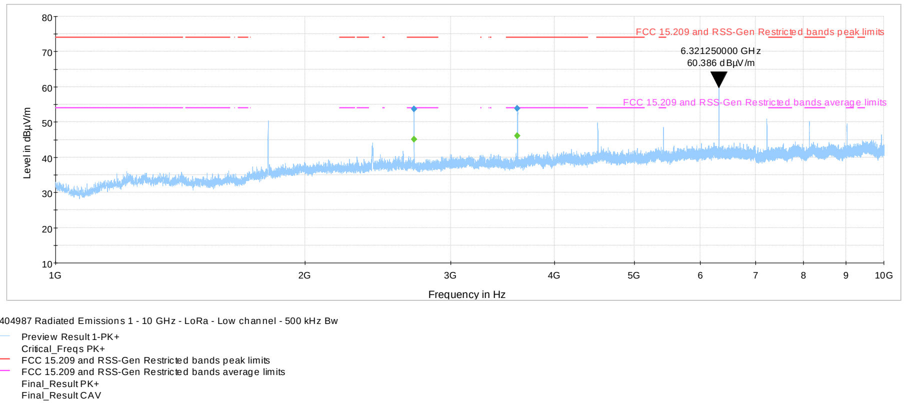


Figure 8.7-20: *Radiated spurious emissions 1 - 10 GHz, 903 MHz LoRa 500 kHz BW*

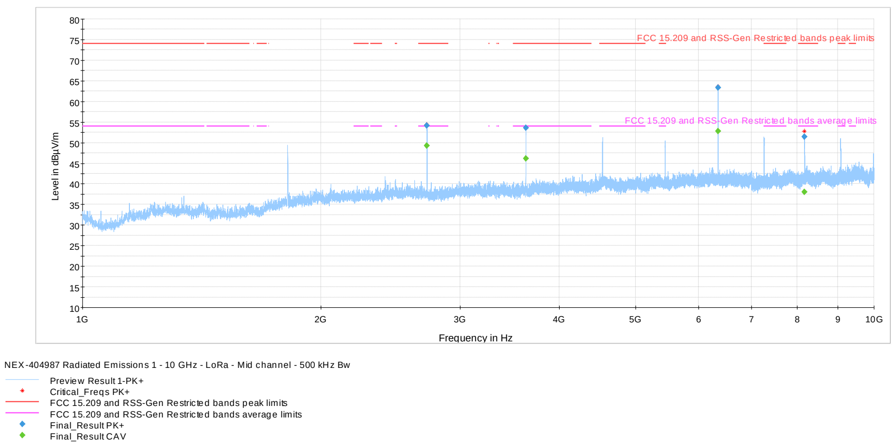


Figure 8.7-21: *Radiated spurious emissions 1 - 10 GHz, 907.8 MHz LoRa 500 kHz BW*

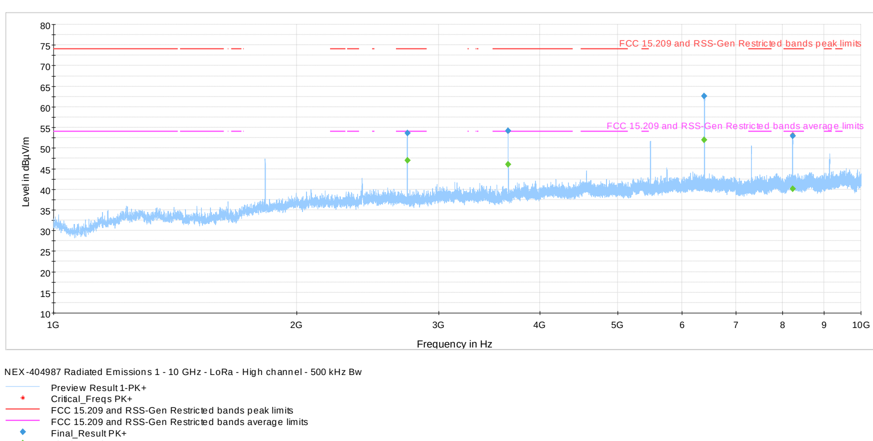


Figure 8.7-22: *Radiated spurious emissions 1 - 10 GHz, 914.2 MHz LoRa 500 kHz BW*

8.7.1 Test data, Radiated spurious 1 – 10 GHz, LoRa 500 kHz BW results

Table 8.7-5: *Radiated emissions results*

Frequency (MHz)	CAverage field strength[1 and 3] (dBµV/m)	CAverage limit (dBµV/m)	CAverage margin (dB)	Correction factor[2] (dB)
500 kHz BW Low channel: 903 MHz				
2708.354	45.1	54.0	8.9	-11.5
3611.505	46.1	54.0	7.9	-9.1
500 kHz BW Mid channel: 907.8 MHz				
2723.585	49.2	54.0	4.8	-11.6
3630.776	46.2	54.0	7.8	-9.1
8168.474	38.0	54.0	16.0	-0.9
500 kHz BW High channel: 914.2 MHz				
2742.128	47.0	54.0	7.0	-11.6
3656.193	46.0	54.0	8.0	-9.1
8226.978	40.1	54.0	13.9	-0.7
Frequency (MHz)	**Peak field strength[1 and 3] (dBµV/m)**	**Peak limit (dBµV/m)**	**Peak margin (dB)**	**Correction factor[2] (dB)**
500 kHz BW Low channel: 903 MHz				
2708.354	53.7	74.0	20.3	-11.5
3611.505	53.9	74.0	20.1	-9.1
500 kHz BW Mid channel: 907.8 MHz				
2723.585	54.2	74.0	19.8	-11.6
3630.776	53.6	74.0	20.4	-9.1
8168.474	51.5	74.0	22.5	-0.9
500 kHz BW High channel: 914.2 MHz				
2742.128	53.7	74.0	20.3	-11.6
3656.193	54.2	74.0	19.8	-9.1
8226.978	53.0	74.0	21.0	-0.7

Notes:
[1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB) − amplifier gain (dB)
[3] Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded.

Sample calculation: 45.1 dBµV/m (field strength) = 56.6 dBµV (receiver reading) + (-11.5 dB (Correction factor))

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

8.8.1 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:

a. 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.

8.8.1 Test date

Start date	October 13, 2020

8.8.2 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 AVGPSD-2 (trace averaging across on- and off-times of the EUT transmissions, followed by duty cycle correction).
Trace counts increased to 1000 to stabilize trace
Spectrum analyser settings:

Resolution bandwidth:	3 – 100 kHz
Video bandwidth:	≥3 × RBW
Frequency span:	2 times the DTS BW (Average)
Detector mode:	RMS
Trace mode:	Average
Trace count:	1000

8.8.3 Test data

Table 8.8-1: *PSD measurements results, 125 kHz BW*

Frequency, MHz	PSD, dBm/10 kHz	PSD limit, dBm/3 kHz	Margin, dB
902.3	5.0	8.00	3.0
908.5	5.3	8.00	2.7
914.9	5.6	8.00	2.4

Notes: Additional 0.5 dBm added to output PSD measurement to compensate for UFL to SMA connector

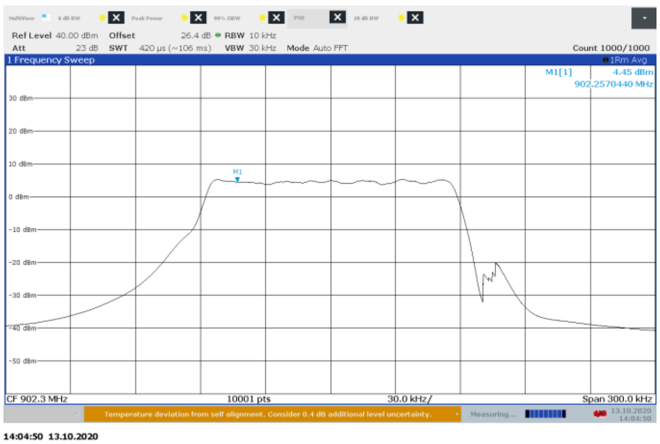


Figure 8.8-1: *PSD on low channel, 125 kHz BW*

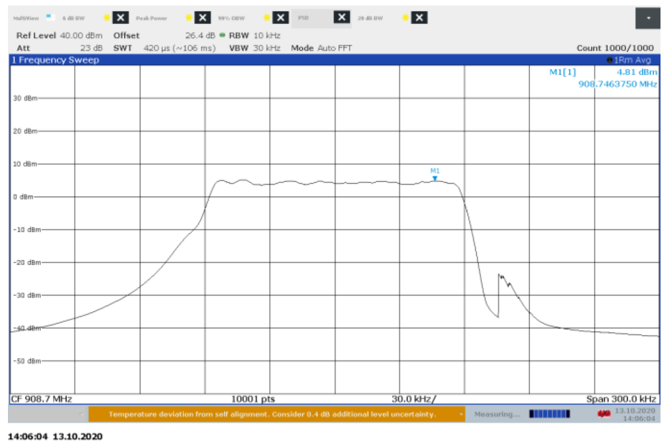


Figure 8.8-2: *PSD on mid channel, 125 kHz BW*

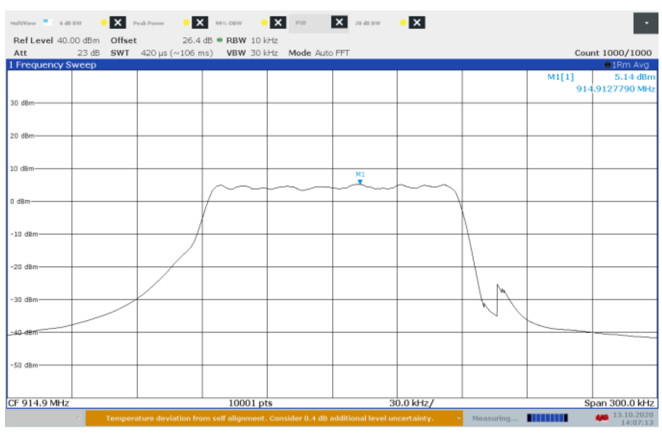


Figure 8.8-3: *PSD on high channel, 125 kHz BW*

Table 8.8-2: *PSD measurements results, 500 kHz BW*

Frequency, MHz	Measured PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
903.0	2.9	8.00	4.9
907.8	2.4	8.00	4.4
914.2	2.2	8.00	4.2

Notes: Additional 0.5 dBm added to output PSD measurement to compensate for SWG to SMA connector

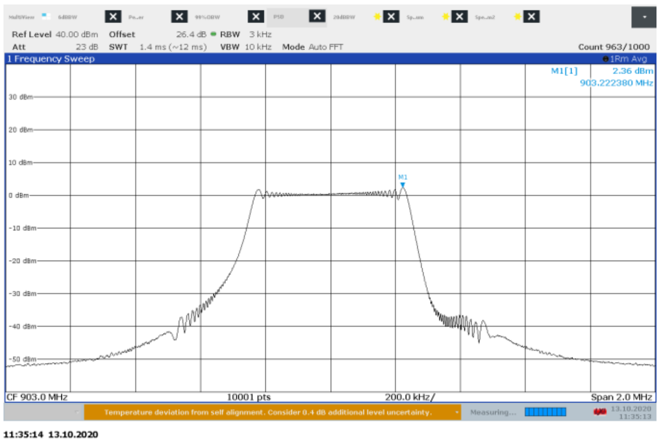


Figure 8.8-4: *PSD on low channel, 500 kHz BW*

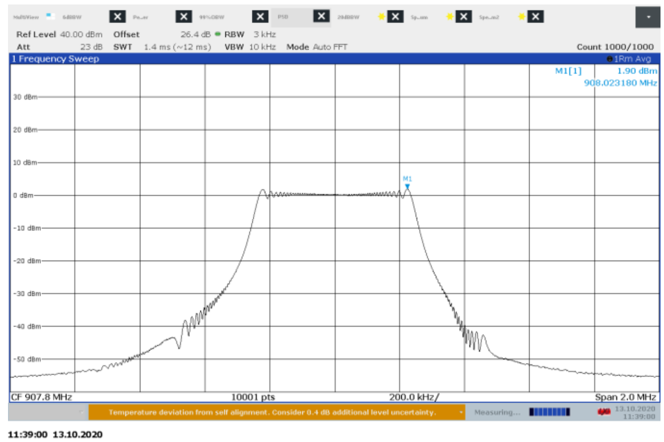


Figure 8.8-5: *PSD on mid channel, 500 kHz BW*

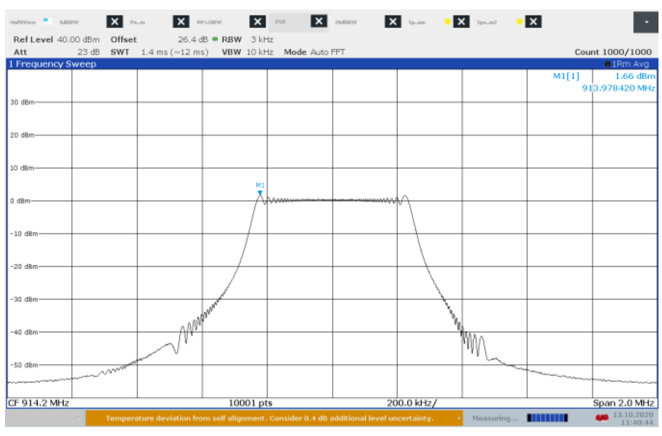
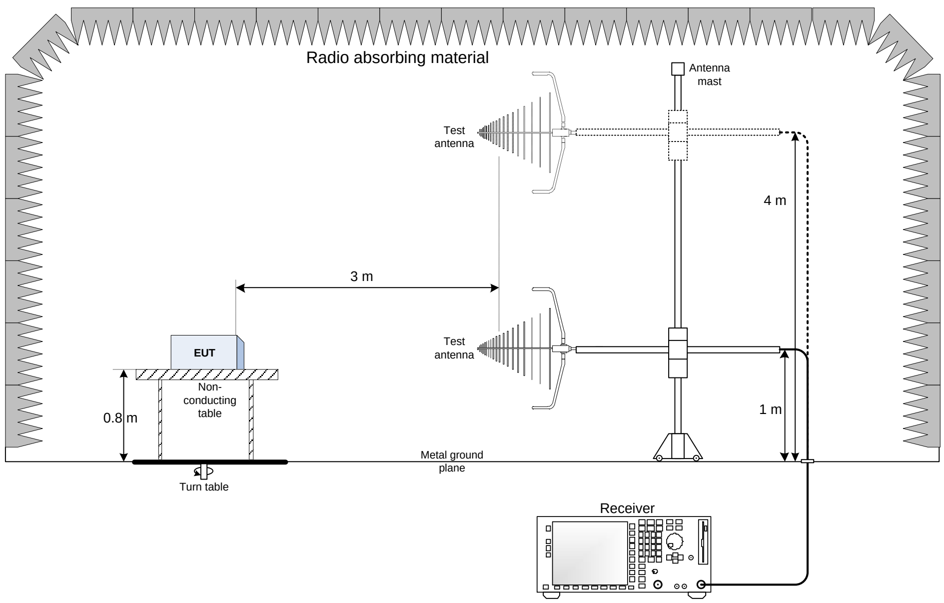


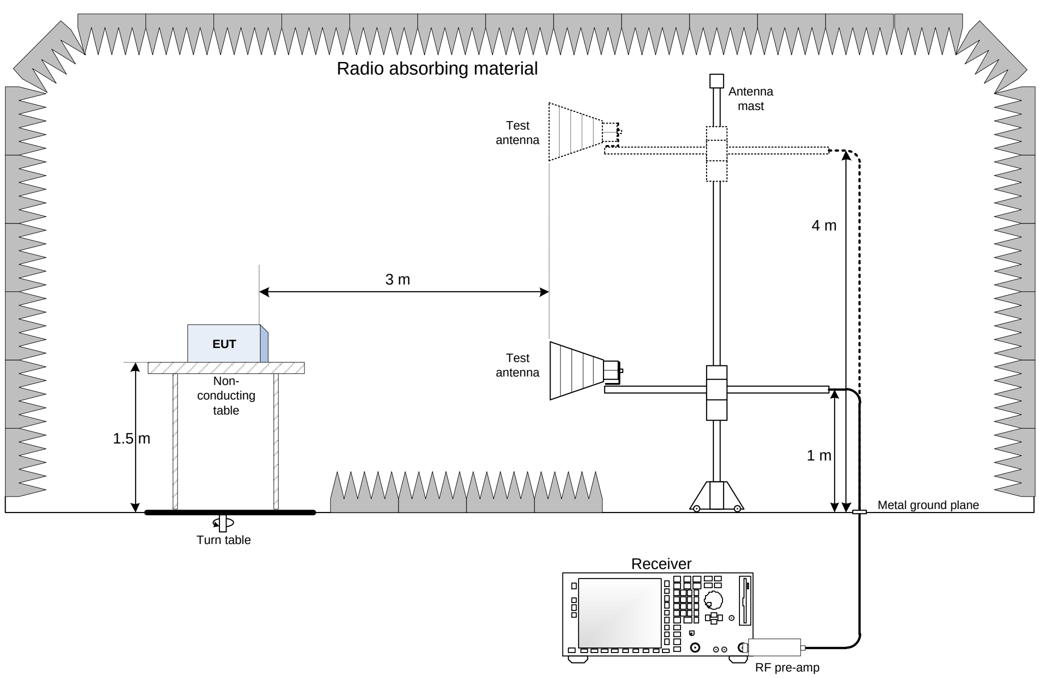
Figure 8.8-6: *PSD on high channel, 500 kHz BW*

Section 9. Block diagrams of test set-ups

9.1 Radiated emissions set-up for frequencies below 1 GHz



9.2 Radiated emissions set-up for frequencies above 1 GHz



9.3 Antenna port set-up