Nemko

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RADIO TEST REPORT – 401220-1R3TRFWL

Type of assessment:

Final product testing

Applicant:	Product name (type):
3D-P	OSPREY
Model:	Model variant(s):
OSP-R5	OSP-R5L01, OSP-R5L01E25, OSP-R5L01W04, OSP-R5L02, OSP-R5L02E25, OSP-R5L02W04, OSP-R5L03, OSP-R5L03E25, OSP-R5L03W04, OSP-R5L04, OSP-R5L04E25, OSP-R5L04W04
FCC ID:	IC Registration number:
2AXB9-OSPR5	26409-OSPR5

Specifications:

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

Date of issue: December 9, 2020

Kevin Rose, EMC/RF Lab Manager

Tested by — Signature

Mark Libbrecht, EMC/RF Specialist

Reviewed by — Signature

Lab locations

Company name	Nemko Canada Inc.	
Facilities	*Cambridge site:* 1-130 Saltsman Drive Cambridge, Ontario Canada N3E 0B2 Tel: +1 519 650 4811	
Test site registration	**Organization**	**Recognition numbers and location**
	FCC/ISED	CA0101 (Cambridge)
Website	www.nemko.com	

Limits of responsibility

Note that the results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.
This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contained in this report are within Nemko Canada's ISO/IEC 17025 accreditation.

Copyright notification

Table of Contents

Section 1 Report summary

1.1 Test specifications

FCC 47 CFR Part 15, Subpart C, Clause 15.247	Operation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz
RSS-247, Issue 2, Feb 2017, Section 5	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

1.2 Test methods

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

1.3 Exclusions

None

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was performed against all relevant requirements of the test standard except as noted in section 1.3 above. Results obtained indicate that the product under test complies In full with the requirements tested. The test results relate only to the items tested.

See "Summary of test results" for full details.

1.5 Test report revision history

Table 1.5-1: *Test report revision history*

Revision #	Date of issue	Details of changes made to test report
TRF	August 31, 2020	Original report issued
R1TRF	October 23, 2020	Update section 5.5, update NEX number
R2TRF	November 13, 2020	Update section 5.4 and 5.5
R3TRF	December 9, 2020	Update model variants

Section 2 Engineering considerations

2.1 Modifications incorporated in the EUT for compliance

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

2.2 Technical judgment

The OSP-R5 variants are described in the table below:

Variant	Description	Functional	Transmitter(s)
OSP-R5L**xx**E25	If **xx** = 01 LTE radio configured for North America bands If **xx** = 02 LTE radio configured for Asia Pacific bands If **xx** = 03 LTE radio configured for EU bands If **xx** = 04 LTE radio configured for CBRS bands	Provides LTE radio & 802.11 radio for wireless connectivity	**Sierra Wireless EM7565** FCC: *N7MEM75* ICES: *2417C-EM75* **Rajant 2.4Ghz** Testing completed by Nemko **Rajant 5Ghz** FCC: *VJA-RJ1701* ICES: *7382A-RJ1701*
OSP-R5L**xx**W04	If **xx** = 01 LTE radio configured for North America bands If **xx** = 02 LTE radio configured for Asia Pacific bands If **xx** = 03 LTE radio configured for EU bands If **xx** = 04 LTE radio configured for CBRS bands	Provides LTE radio & 2.4 & 5 integrated 802.11 radio for wireless connectivity	**Sierra Wireless EM7565** FCC: *N7MEM75* ICES: *2417C-EM75* **Doodle Labs** FCC: *2AG87NM-DB-3N* ICES: *21411-NMDB3*
OSP-R5L**xx**	If **xx** = 01 LTE radio configured for North America bands If **xx** = 02 LTE radio configured for Asia Pacific bands If **xx** = 03 LTE radio configured for EU bands If **xx** = 04 LTE radio configured for CBRS bands	Provides LTE radio for wireless connectivity	**Sierra Wireless EM7565** FCC: *N7MEM75* ICES: *2417C-EM75*

2.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 3 Test conditions

3.1 Atmospheric conditions

Temperature	15 °C – 35 °C
Relative humidity	20 % – 75 %
Air pressure	86 kPa (860 mbar) – 106 kPa (1060 mbar)

When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.

3.2 Power supply range

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages ±5 %, for which the equipment was designed.

Section 4 Measurement uncertainty

4.1 Uncertainty of measurement

UKAS Lab 34 and TIA-603-B have been used as guidance for measurement uncertainty reasonable estimations with regards to previous experience and validation of data. Nemko Canada, Inc. follows these test methods in order to satisfy ISO/IEC 17025 requirements for estimation of uncertainty of measurement for wireless products.

Measurement uncertainty budgets for the tests are detailed below. Measurement uncertainty calculations assume a coverage factor of K = 2 with 95% certainty.

Table 4.1-1: *Measurement uncertainty calculations for Radio*

Test name	Measurement uncertainty, ±dB
All antenna port measurements	0.55
Occupied bandwidth	4.45
Conducted spurious emissions	1.13
Radiated spurious emissions	3.78
AC power line conducted emissions	3.55

Section 5 Information provided by the applicant

5.1 Disclaimer

This section contains information provided by the applicant and has been utilized to support the test plan. Inaccurate information provided by the applicant can affect the validity of the results contained within this test report. Nemko accepts no responsibility for the information contained within this section and the impact it may have on the test plan and resulting measurements.

5.2 Applicant

Company name	3D-P
Address	200 8 Manning Close NE, Calgary, Alberta, T2E 7N5, Canada

5.3 Manufacturer

Company name	3D-P
Address	200 8 Manning Close NE, Calgary, Alberta, T2E 7N5, Canada

5.4 EUT information

Product name	OSPREY
Model	OSP-R5
Model variant(s)	OSP-R5L01, OSP-R5L01E25, OSP-R5L01W04, OSP-R5L02, OSP-R5L02E25, OSP-R5L02W04, OSP-R5L03, OSP-R5L03E25, OSP-R5L03W04, OSP-R5L04, OSP-R5L04E25, OSP-R5L04W04
Serial number	ES1-2450RE-74124
Firmware revision	11.22.3
Software revision	BCC (BC|Commander) version 11.22.1
Operating conditions	Power settings:

		Low channel	Middle channel	High channel
b	Frequency (MHz)	2412	2442	2462
	power (dBm)	16	22	15
	Multicast Rate (Mbps)	1	1	1
g	Frequency (MHz)	2412	2442	2462
	power (dBm)	13	20	15
	Multicast Rate (Mbps)	6	6	6
n 20	Frequency (MHz)	2412	2442	2462
	power (dBm)	13	19	15
	Multicast Rate (Mbps)	13	13	13
n 40	Frequency (MHz)	2422	2442	2452
	power (dBm)	11	14	11
	Multicast Rate (Mbps)	13	13	13

Product description and theory of operation	Wireless Module operating in the (2400–2483.5 MHz) utilizing 802.11 b/g/n.

5.5 Technical information

Applicant IC company number	2AXB9
IC UPN number	OSPR5
All used IC test site(s) Reg. number	24676
RSS number and Issue number	RSS-247 Issue 2, Feb 2017
Category of Wideband Data Transmission equipment	☐ 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 (MHz)	2412 (20 MHz BW), 2422 (40 MHz BW)
Frequency Max (MHz)	2462 (20 MHz BW), 2452 (40 MHz BW)
Channel numbers	1–11
RF power Max (W), Conducted	0.2512 W (20 MHz BW), 0.3162 W (40 MHz BW)
Field strength, dBµV/m @ 3 m	N/A
Measured BW (MHz), 99% OBW	16.6 MHz (20 MHz BW), 36.8 MHz (40 MHz BW)
Type of modulation	802.11b: DSSS, 802.11g/n(HT20, HT40): OFDM
Emission classification	W7D
Transmitter spurious, dBµV/m @ 3 m	66.1 dBµV/m (Peak), 50.6 dBµV/m (Average), @ 2390 MHz
Power supply requirements	12-36 V_{DC}
Antenna information	Manufacturer: Rajant, Model: KMA-2400-5-NM, Peak gain: 5.0 dBi, Directional gain (2 × 2 MIMO) = 5+10log(2) = 8 dBi EUT is designed so that the end user may replace a broken antenna. (The EUT has a non-standard antenna jack or electrical connector.)

5.6 EUT setup details

5.6.1 EUT Exercise and monitoring

Methods used to exercise the EUT and all relevant ports:

- Inactive RF ports terminated into 50 Ω Load
- Activate "mesh" mode for MIMO operation
- EUT configured to transmit continuously at 99% duty cycle

Configuration details:

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

Monitoring details:

- Ensure transmitter is connected via GUI interface
- Monitor fundamental power level
- Monitor LED indicators on EUT

5.6 EUT setup details, continued

5.6.2 EUT test configuration

Table 5.6-1: *EUT sub assemblies*

Description	Brand name	Model, Part number, Serial number, Revision level
50 Ω Load (Qty. 3)	Mini-circuits	KARN-50+
AC/DC Adapter	Mean Well	MDR-60-24

Table 5.6-2: *EUT interface ports*

Description	Qty.
Power/communication distribution cable	1
WIFI 2.4 GHz N-Type	2
LTE N-Type	2
GPS BNC	1

Table 5.6-3: *Support equipment*

Description	Brand name	Model, Part number, Serial number, Revision level
Laptop	Dell	Latitude 5490

Table 5.6-4: *Inter-connection cables*

Cable description	From	To	Length (m)
Lmr 400 (2)	Eut	Antenna	1

5.6 EUT setup details, continued

5.6.2 EUT test configuration, continued

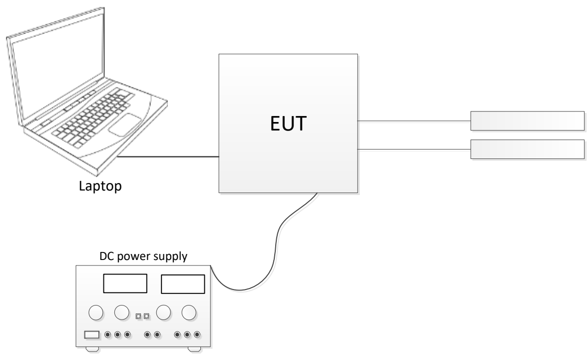


Figure 5.6-1: *Radiated testing block diagram*

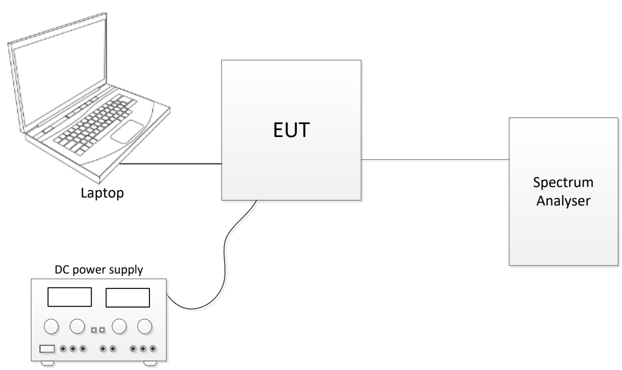


Figure 5.6-2: *Antenna port testing block diagram*

Section 6 Summary of test results

6.1 Testing location

Test location (s)	Cambridge

6.2 Testing period

Test start date	June 26, 2020	Test end date	July 28, 2020

6.3 Sample information

Receipt date	June 23, 2020	Nemko sample ID number(s)	1

6.4 FCC Part 15 Subpart C, general requirements test results

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

Part	Test description	Verdict
§15.207(a)	Conducted limits	Pass
§15.31I	Variation of power source	Pass
§15.31(m)	Number of tested frequencies	Pass
§15.203	Antenna requirement	Pass

Notes: Choose an item.

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

***Table 6.5-1:** FCC 15.247 results for DTS*

Part	Test description	Verdict
§15.247(a)(2)	Minimum 6 dB bandwidth	Pass
§15.247(b)(3)	Maximum peak output power in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands	Pass
§15.247I(1)	Fixed point-to-point operation with directional antenna gains greater than 6 dBi	Pass
§15.247I(2)	Transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams	Pass
§15.247(d)	Spurious emissions	Pass
§15.247I	Power spectral density	Pass
§15.247(f)	Time of occupancy for hybrid systems	Pass
§15.247(i)	Radiofrequency radiation exposure evaluation	Pass

6.6 ISED RSS-Gen, Issue 5, test results

Table 6.6-1: *RSS-Gen results*

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

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.

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

Table 6.7-1: *RSS-247 results for DTS*

Part	Test description	Verdict
5.2 (a)	Minimum 6 dB bandwidth	Pass
5.2 (b)	Maximum power spectral density	Pass
5.3	Hybrid Systems	
5.3 (a)	Digital modulation turned off	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	Pass
5.4 (f)	Transmitters which operate in the 2400–2483.5 MHz band with multiple directional beams	Pass
5.5	Unwanted emissions	Pass

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, 2020
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, 2020
Spectrum analyzer	Rohde & Schwarz	FSW43	FA002971	1 year	Dec 21, 2020
Horn antenna (1–18 GHz)	ETS Lindgren	3117	FA002911	1 year	Sep 11, 2020
Horn antenna (18–40 GHz)	ETS Lindgren	3116B	FA002948	1 year	Dec. 9, 2020
Bilog antenna (30–2000 MHz)	SUNAR	JB1	FA003010	1 year	Sep 17, 2020
Power sensor	Rohde & Schwarz	NRP-6A	FA002962	1 year	Dec 20, 2020
Temperature chamber	Espec	EPX-4H	FA003033	—	VOU
Vector Signal Generator	Rohde & Schwarz	SMW200A	FA002970	1 year	Dec. 16, 2020
50 Ω coax cable	Huber + Suhner	None	FA003044	1 year	Oct. 7, 2020
50 Ω coax cable	Huber + Suhner	None	FA003047	1 year	Sep 30, 2020

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

Section 8 Testing data

8.1 FCC 15.31(e) Variation of power source

8.1.1 References, definitions and limits

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

8.1.2 Test summary

Verdict	Pass		
Tested by	Kevin Rose	Test date	June 25, 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 References, definitions and limits

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

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

Table 8.2-1: *Frequency Range of Operation*

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

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

8.2.2 Test summary

Verdict	Pass		
Tested by	Kevin Rose	Test date	June 25, 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, 802.11 b*

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	2412	2442	2462

Table 8.2-3: *Test channels selection, 802.11 g*

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	2412	2442	2462

Table 8.2-4: *Test channels selection, 802.11 NT20*

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	2412	2442	2462

Table 8.2-5: *Test channels selection, 802.11 NT40*

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	2422	2442	2452

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

8.3.1 References, definitions and limits

FCC:
An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.
FCC 15.247(b)(4)
The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

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

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

8.3.2 Test summary

Verdict	Pass		
Tested by	Kevin Rose	Test date	June 30, 2020

8.3.3 Observations, settings and special notes

The EUT antenna is professionally installed.

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
Rod	Rajant	KMA-2400-5-NM	5 dBi	N type

8.4 FCC 15.207(a) and RSS-Gen 8.8 AC power line conducted emissions limits

8.4.1 References, definitions and limits

FCC:
Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 µH/50 Ω line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

ANSI: C63.10 subclause 6.2
If the EUT normally receives power from another device that in turn connects to the public utility ac power lines, measurements shall be made on that device with the EUT in operation to demonstrate that the device continues to comply with the appropriate limits while providing the EUT with power. If the EUT is
operated only from internal or dedicated batteries, with no provisions for connection to the public utility ac power lines (600 VAC or less) to operate the EUT (such as an adapter), then ac power-line conducted measurements are not required.
For direct current (dc) powered devices where the ac power adapter is not supplied with the device, an “off-the-shelf” unmodified ac power adapter shall be used. If the device is supposed to be installed in a host (e.g., the device is a module or PC card), then it is tested in a typical compliant host.

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

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

Table 8.4-1: *Conducted emissions limit*

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

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

8.4.2 Test summary

Verdict	Pass		
Tested by	Kevin Rose	Test date	June 25, 2020

8.4.3 Observations, settings and special notes

The EUT was set up as tabletop configuration per ANSI C63.10-2013 measurement procedure.

The spectral scan has been corrected with transducer factors (i.e. cable loss, LISN factors, and attenuators) for determination of compliance.

A preview measurement was generated with the receiver in continuous scan mode. Emissions detected within 6 dB or above limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement.

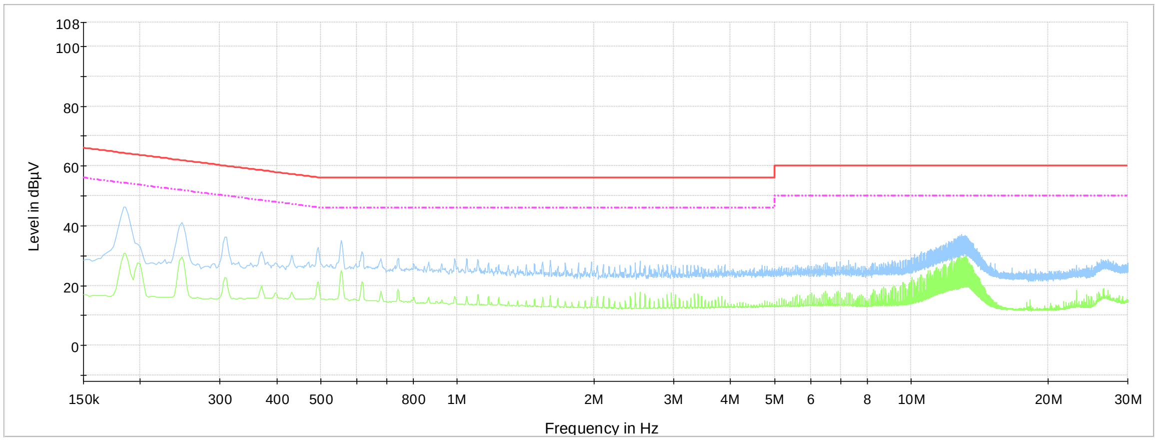
EMI Receiver settings for preview measurements:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Peak and Average
Trace mode	Max Hold
Measurement time	1000 ms

Receiver settings for final measurements:

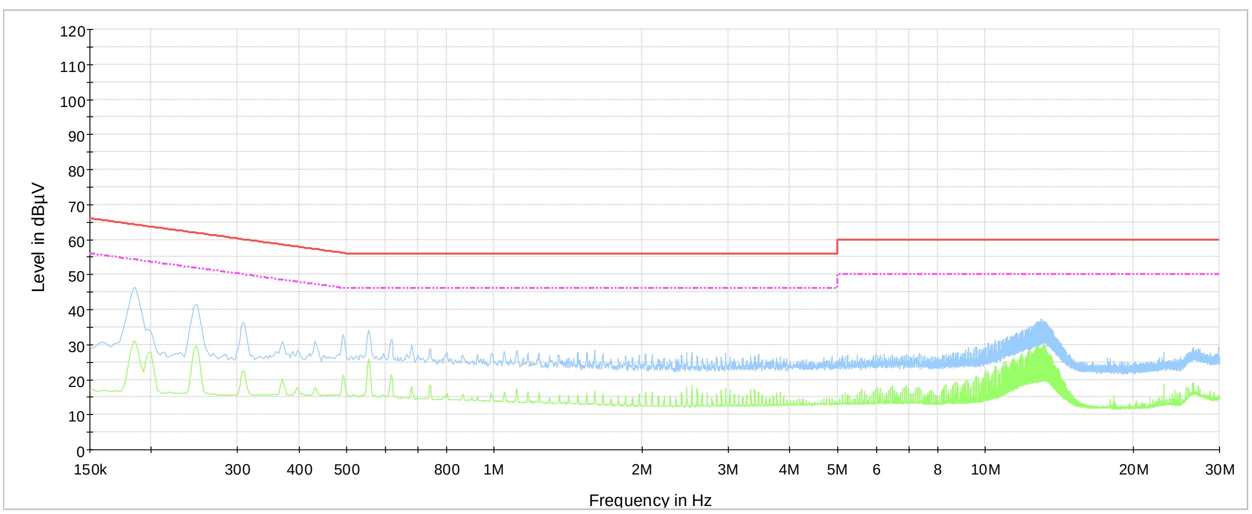
Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Quasi-Peak and Average
Trace mode	Max Hold
Measurement time	1000 ms

8.4.4 Test data



NEX-401220 CE scan 120 Vac 60 Hz Phase ES1-2450RE-74124
Preview Result 2-AVG
Preview Result 1-PK+
PK+
AVG
CISPR 22 Limit - Class B, Mains (Quasi-Peak)
CISPR 22 Limit - Class B, Mains (Average)
Final_Result QPK
Final_Result CAV

***Plot 8.4-1:** Conducted emissions on phase line – ES1-2450RE-74124 – 120Vac 60Hz*



NEX-401220 CE scan 120 Vac 60 Hz Neutral ES1-2450RE-74124
Preview Result 2-AVG
Preview Result 1-PK+
CISPR 22 Limit - Class B, Mains (Quasi-Peak)
CISPR 22 Limit - Class B, Mains (Average)
Final_Result QPK
Final_Result CAV

***Plot 8.4-2:** Conducted emissions on neutral line- ES1-2450RE-74124– 120Vac 60Hz*

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

8.5.1 References, definitions and limits

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

ISED:
The minimum 6 dB bandwidth shall be 500 kHz.
RSS-GEN, Section 6.7:
6 dB bandwidth is defined as the frequency range between two points, one at the lowest frequency below and one at the highest frequency above the carrier frequency, at which the maximum power level of the transmitted emission is attenuated 6 dB below the maximum in-band power level of the modulated signal, where the two points are on the outskirts of the in-band emission.
For the 99% emission bandwidth, the trace data points are recovered and directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached, and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded. The difference between the two recorded frequencies is the occupied bandwidth (or the 99% emission bandwidth).

8.5.2 Test summary

Verdict	Pass		
Tested by	Kevin Rose	Test date	June 25, 2020

8.5.3 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	30 MHz for 20 MHz channel; 100 MHz for 40 MHz channel
Detector mode	Peak
Trace mode	Max Hold

8.5.4 Test data

Table 8.5-1: *6 dB bandwidth results*

Modulation	Frequency, MHz	6 dB bandwidth, MHz CH0	Minimum limit, MHz	Margin, MHz
802.11b	2412	10.14	0.500	9.64
	2442	10.08	0.500	9.58
	2462	12.48	0.500	11.98
802.11g	2412	16.56	0.500	16.06
	2442	16.32	0.500	15.82
	2462	16.32	0.500	15.82
802.11n HT20	2412	16.41	0.500	15.91
	2442	16.41	0.500	15.91
	2462	16.26	0.500	15.76
802.11n HT40	2422	36.54	0.500	36.04
	2442	36.68	0.500	36.18
	2452	36.05	0.500	35.55

Table 8.5-2: *99% bandwidth results*

Modulation	Frequency, MHz	Bandwidth, MHz
802.11b	2412	13.98
	2442	13.68
	2462	14.28
802.11g	2412	16.56
	2442	16.47
	2462	16.53
802.11n HT20	2412	16.47
	2442	16.32
	2462	16.50
802.11n HT40	2422	36.47
	2442	36.61
	2452	36.75

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

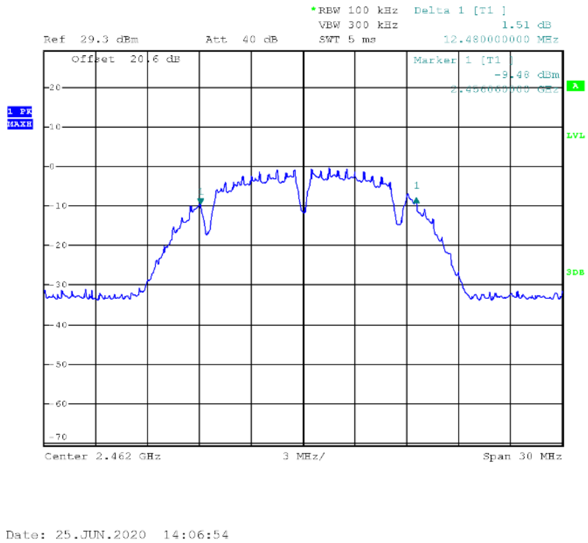


Figure 8.5-1: *6 dB bandwidth on 802.11b, sample plot*

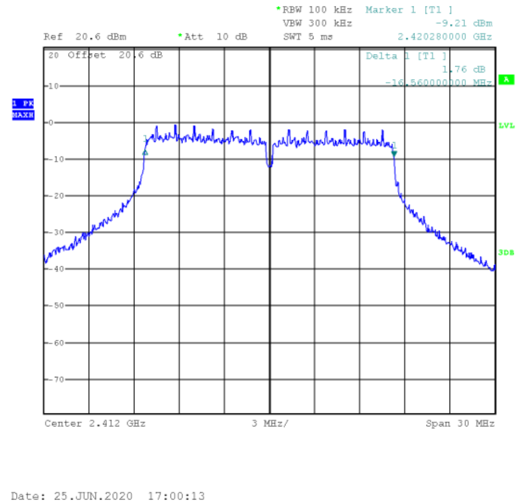


Figure 8.5-2: *6 dB bandwidth on 802.11g, sample plot*

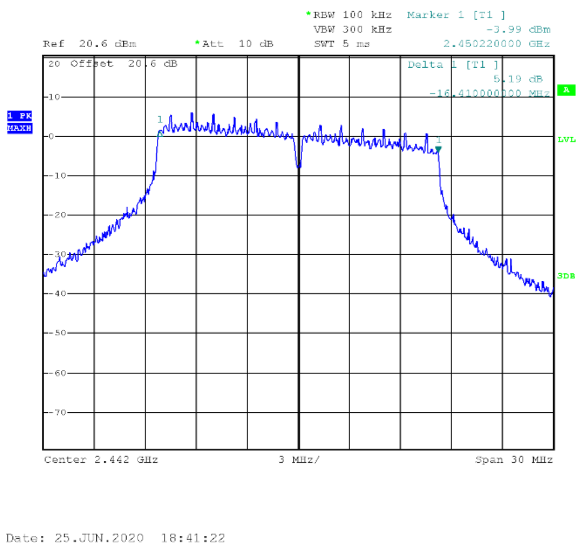


Figure 8.5-3: *6 dB bandwidth on 802.11n HT20, sample plot*

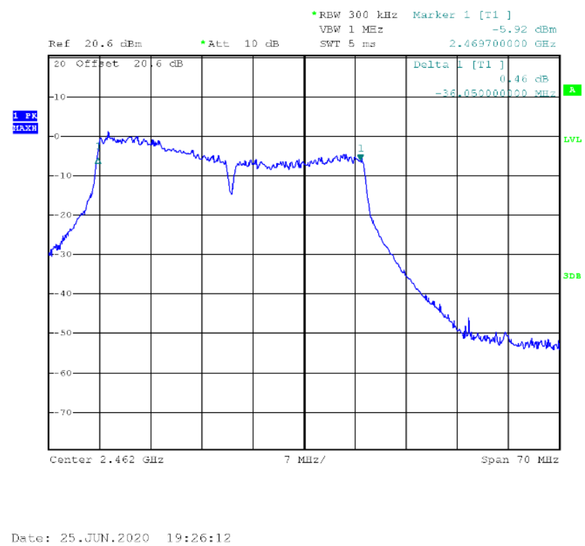


Figure 8.5-4: *6 dB bandwidth on 802.11n HT40, sample plot*

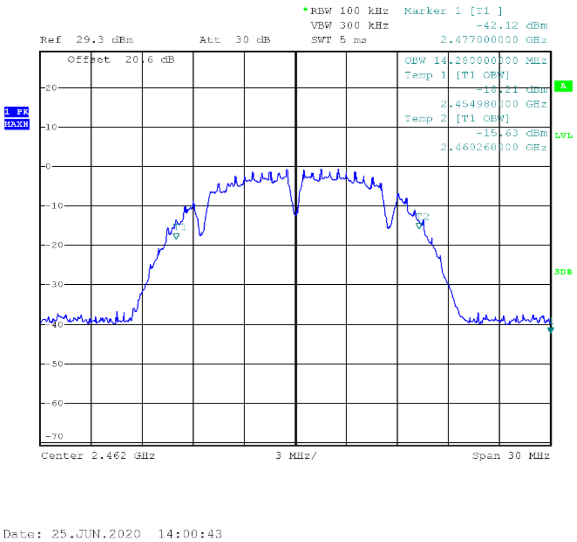


Figure 8.5-5: *99% occupied bandwidth on 802.11b, sample plot*

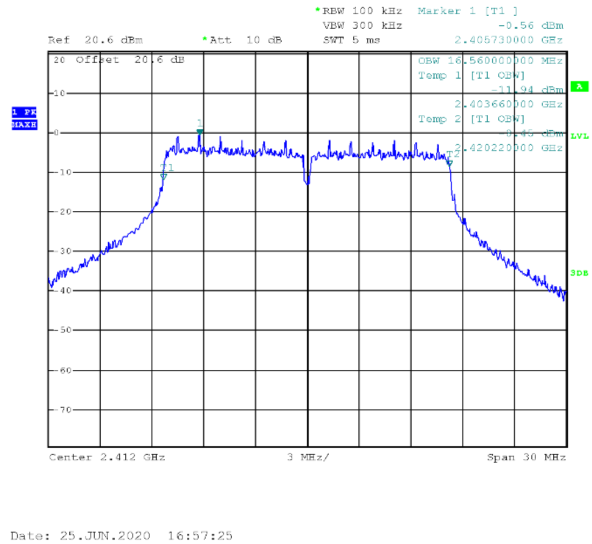


Figure 8.5-6: *99% occupied bandwidth on 802.11g, sample plot*

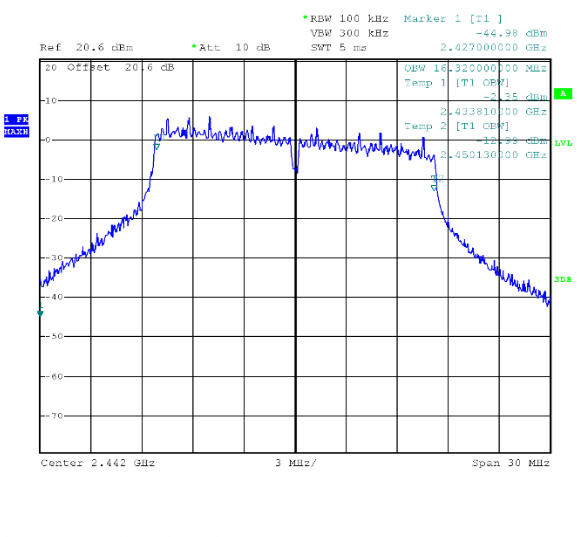


Figure 8.5-7: *99% occupied bandwidth on 802.11n HT20, sample plot*

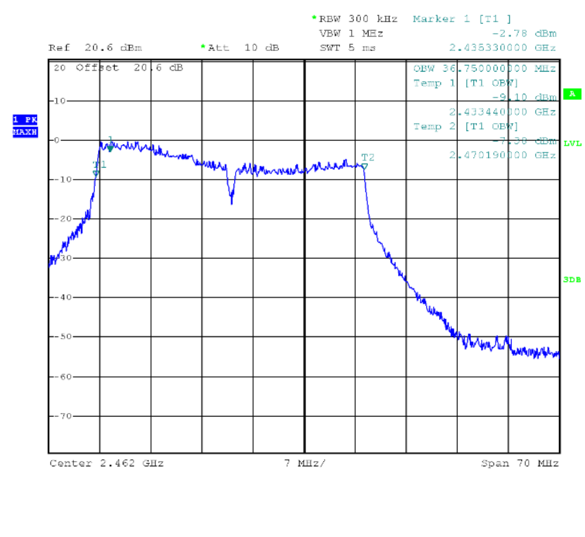


Figure 8.5-8: *99% occupied bandwidth on 802.11n HT40, sample plot*

8.6 FCC 15.247(b) and RSS-247 5.4(d) Transmitter output power and e.i.r.p. requirements for DTS in 2.4 GHz

8.6.1 References, definitions and limits

FCC:

(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

(3) For systems using digital modulation in the 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.

ISED:

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).

8.6.2 Test summary

Verdict	Pass		
Tested by	Kevin Rose	Test date	July 28, 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)

The EUT uses 1 meter of LMR 400 from the EUT to the antenna with 0.5 dB of loss the measurements were made from the end of the LMR 400 cable.

Resolution bandwidth	1 MHz
Video bandwidth	≥3 × RBW
Frequency span	30 MHz for 20 MHz channel; 70 MHz for 40 MHz channel
Detector mode	RMS
Trace mode	Power Average
Sweep count	100

Combined average output power for MIMO 2 × 2 application was calculated as follows: $P_{combined} = 10 \times log_{10}\left(\left(10^{P_{ch0}/10}\right) + \left(10^{P_{ch1}/10}\right)\right)$
Directional gain for MIMO Correlated 2 × 2 (CDD/TXBF) = XXX dBi + 10 × $\log_{10}$ (N) dB = XXX dBi + 3 dB = ZZZZ dBi, where "N" is number of antennae.
Output power limit was calculated as follows: 30 – (ZZZ – 6) = WWW dBm

8.6.4 Test data

Table 8.6-1: *Average output power and EIRP results (antenna port measurement)*

Modulation	Frequency, MHz	Conducted output power, dBm CH0	Conducted output power, dBm CH1	Combined output, dBm	Output power limit, dBm	Output power margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
b	2412	14.2	12.6	16.5	30	13.5	5	21.5	36	14.5
b	2442	20.6	21.3	24.0	30	6.0	5	29.0	36	7.0
b	2462	14.0	12.7	16.4	30	13.6	5	21.4	36	14.6
g	2412	11.0	11.1	14.1	30	15.9	5	19.1	36	16.9
g	2442	19.2	17.7	21.5	30	8.5	5	26.5	36	9.5
g	2462	14.1	12.0	16.2	30	13.8	5	21.2	36	14.8
nt20	2412	11.0	10.9	14.0	30	16.0	5	19.0	36	17.0
nt20	2442	17.9	16.3	20.2	30	9.8	5	25.2	36	10.8
nt20	2462	13.9	12.2	16.1	30	13.9	5	21.1	36	14.9
nt40	2422	10.2	9.2	12.7	30	17.3	5	17.7	36	18.3
nt40	2442	22.5	21.4	25.0	30	5.0	5	30.0	36	6.0
nt40	2452	10.5	9.6	13.1	30	16.9	5	18.1	36	17.9

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

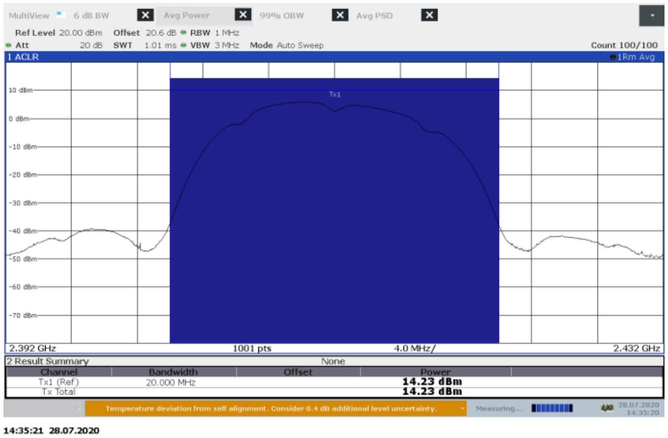


Figure 8.6-1: *Output power on b sample plot*

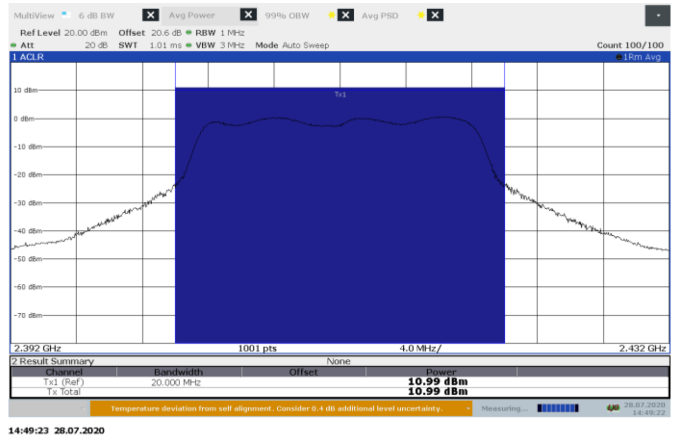


Figure 8.6-2: *Output power on g sample plot*

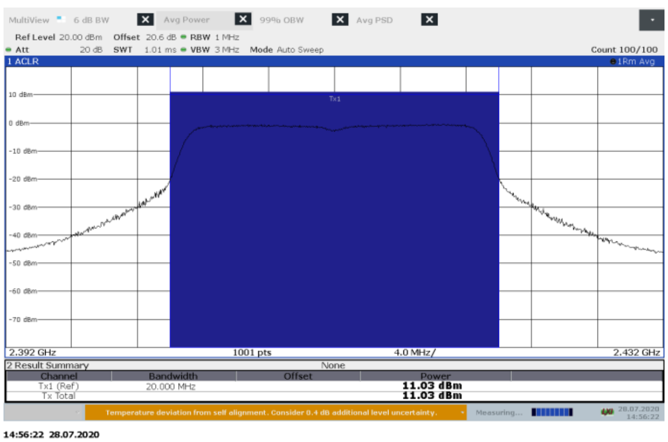


Figure 8.6-3: *Output power on NT20 sample plot*

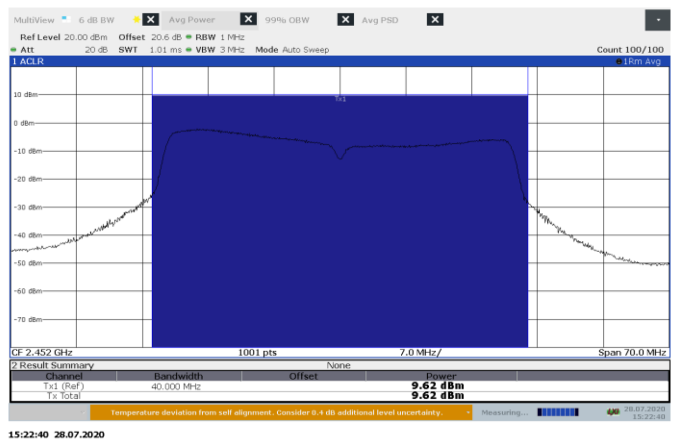


Figure 8.6-4: *Output power on NT40 sample plot*

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

8.7.1 References, definitions and limits

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

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

Table 8.7-1: *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			

8.7.2 Test summary

Verdict	Pass		
Tested by	Kevin Rose	Test date	June 26, 2020

8.7.3 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 >98 % duty cycle. The EUT was transmitting on both MIMO chains simultaneously
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.
Limit lines for conducted bandedge and spurious plots are incorrect for average power measurements (should be -30 dBc). No emissions were observed within -40 dBc relative to the carrier amplitude.
Radiated spurious emissions evaluated for 802.11b modulation only per ANSI 63.10 (2013) Clause 5.6.2.2 b), as this modulation exhibits the highest output power and power spectral density of the modulation family.

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

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

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

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

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

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

Spectrum analyser settings for conducted spurious emissions measurements:

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

8.7.4 Test data

Table 8.7-4: *Radiated field strength measurement results b*

Channel	Frequency, MHz	Peak Field strength, dBμV/m		Margin, dB	Average Field strength, dBμV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2390.0	66.08	74.00	7.92	50.62	54.00	3.38
High	2483.5	61.03	74.00	12.97	42.67	54.00	11.33

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

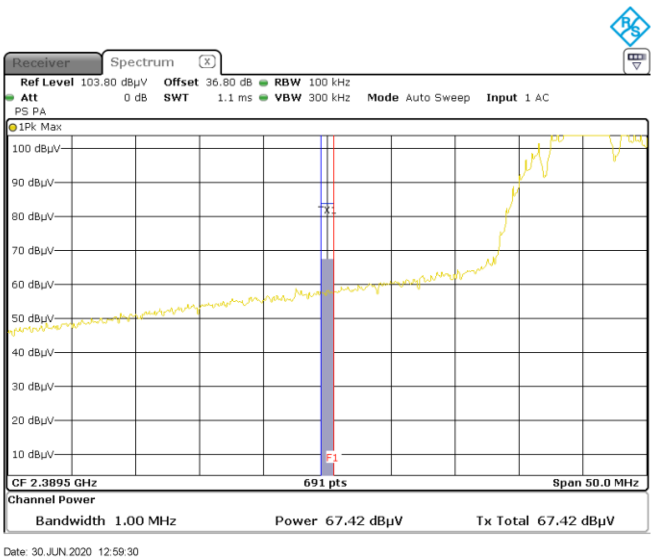


Figure 8.7-1: *Band edge spurious emissions at 2390 MHz on b peak*

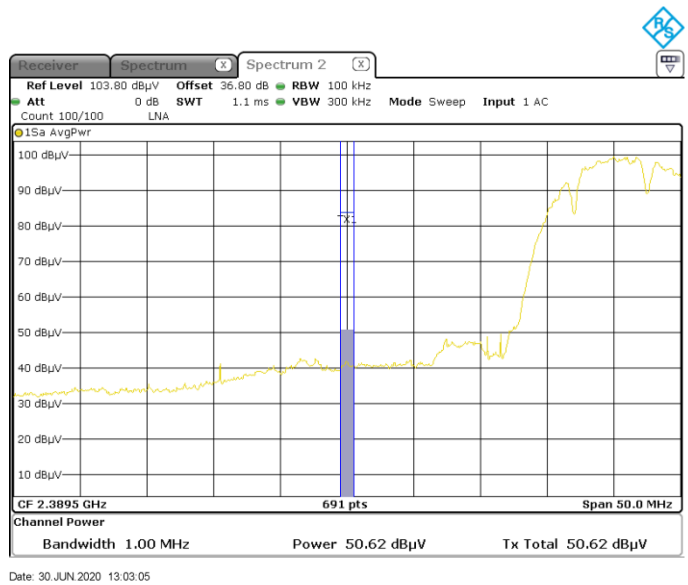


Figure 8.7-2: *Band edge spurious emissions at 2390 MHz on b avg*

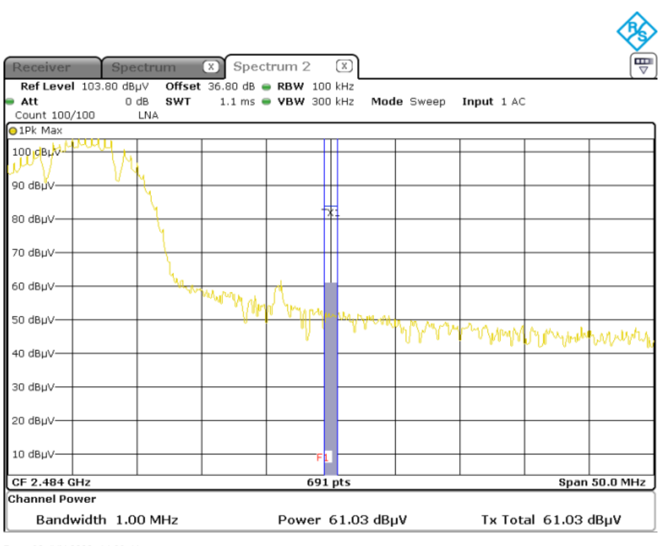


Figure 8.7-3: *Band edge spurious emissions at 2483.5 MHz on b peak*

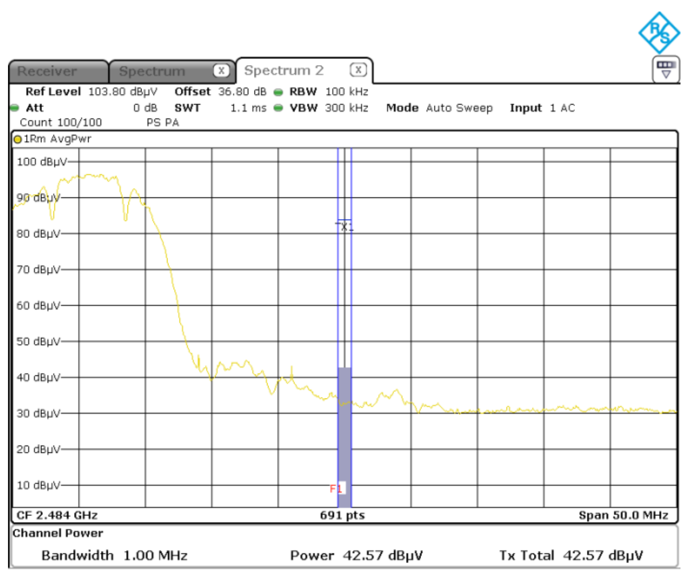


Figure 8.7-4: *Band edge spurious emissions at 2483.5 MHz on b avg*

Table 8.7-5: *Radiated field strength measurement results g*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2390.0	61.54	74.00	12.46	52.85	54.00	1.15
High	2483.5	61.10	74.00	12.9	51.79	54.00	2.21

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

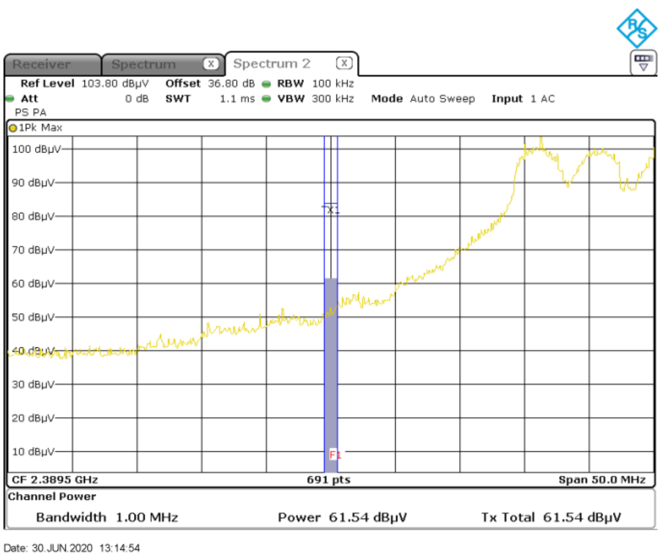


Figure 8.7-5: *Band edge spurious emissions at 2390 MHz peak*

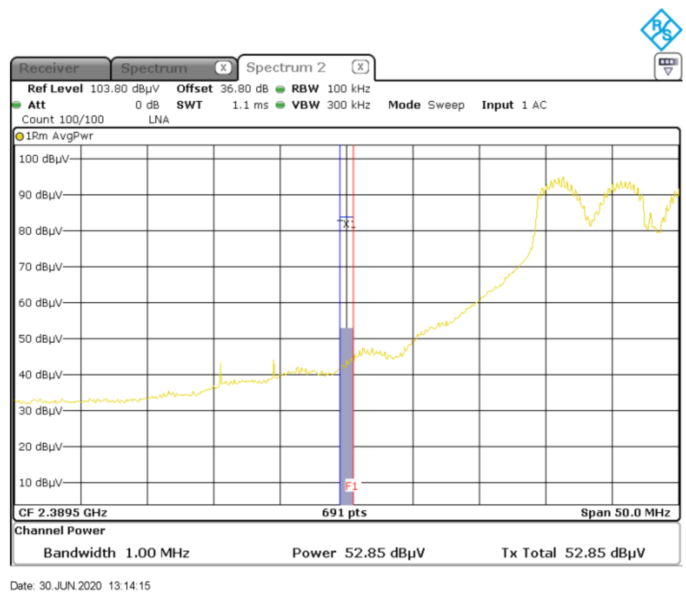


Figure 8.7-6: *Band edge spurious emissions at 2390 MHz avg*

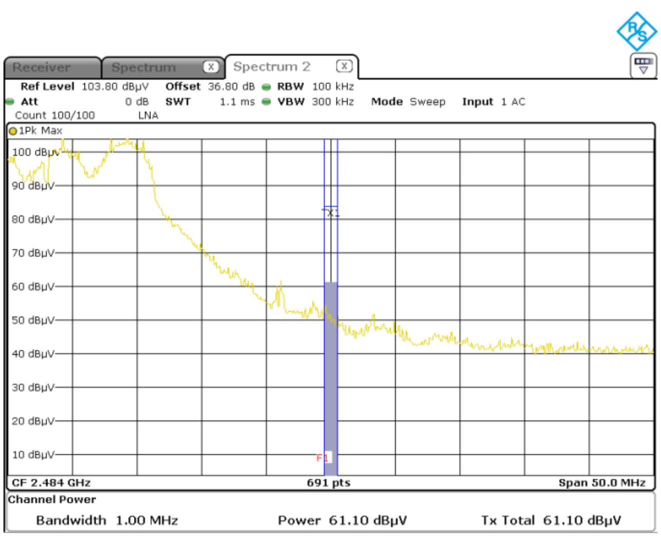


Figure 8.7-7: *Band edge spurious emissions at 2483.5 MHz peak*

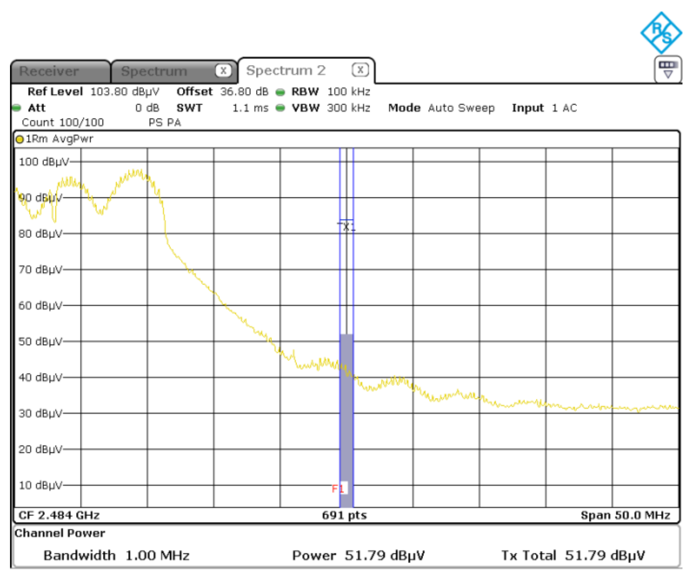


Figure 8.7-8: *Band edge spurious emissions at 2483.5 MHz avg*

Table 8.7-6: *Radiated field strength measurement results NT20*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2390.0	61.79	74.00	12.21	53.29	54.00	0.71
High	2483.5	57.15	74.00	16.85	51.42	54.00	2.58

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

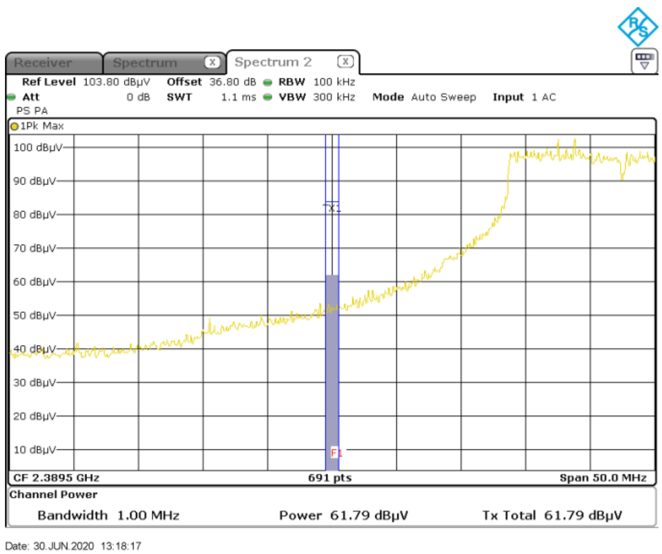


Figure 8.7-9: *Band edge spurious emissions at 2390 MHz peak*

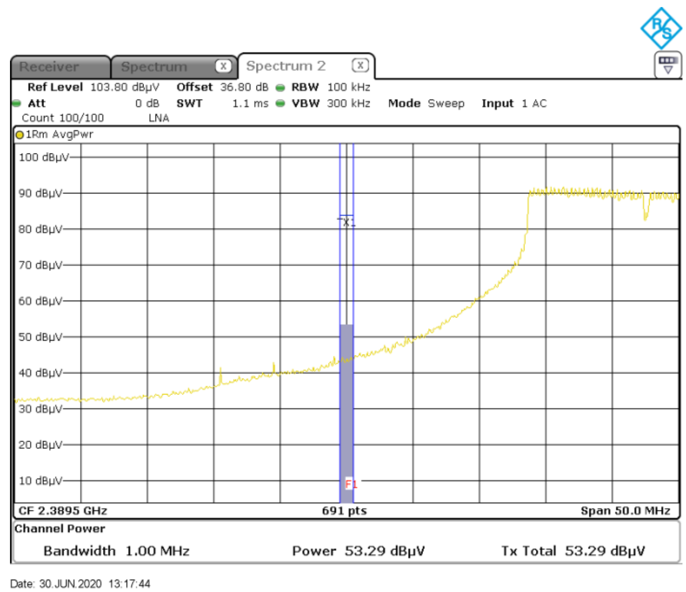


Figure 8.7-10: *Band edge spurious emissions at 2390 MHz avg*

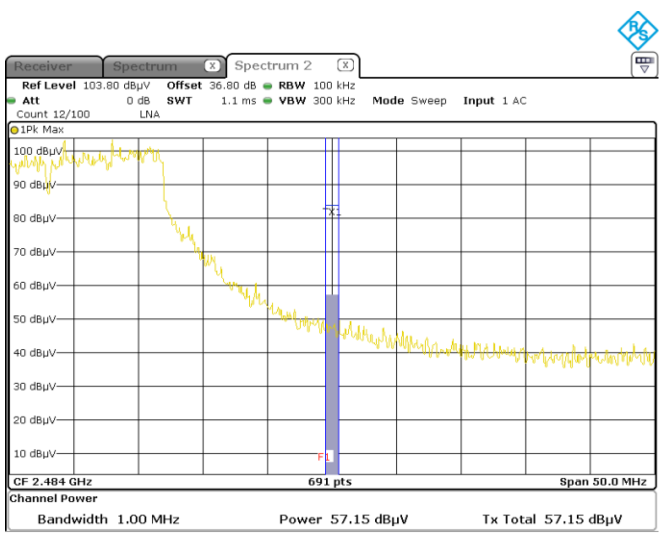


Figure 8.7-11: *Band edge spurious emissions at 2483.5 MHz peak*

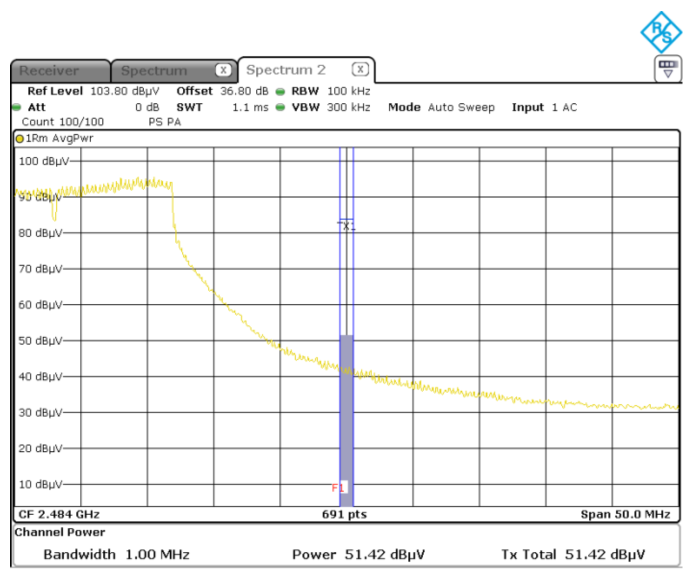


Figure 8.7-12: *Band edge spurious emissions at 2483.5 MHz avg*

Table 8.7-7: *Radiated field strength measurement results NT40*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2390.0	62.91	74.00	11.09	53.68	54.00	0.32
High	2483.5	59.11	74.00	14.89	50.89	54.00	3.11

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

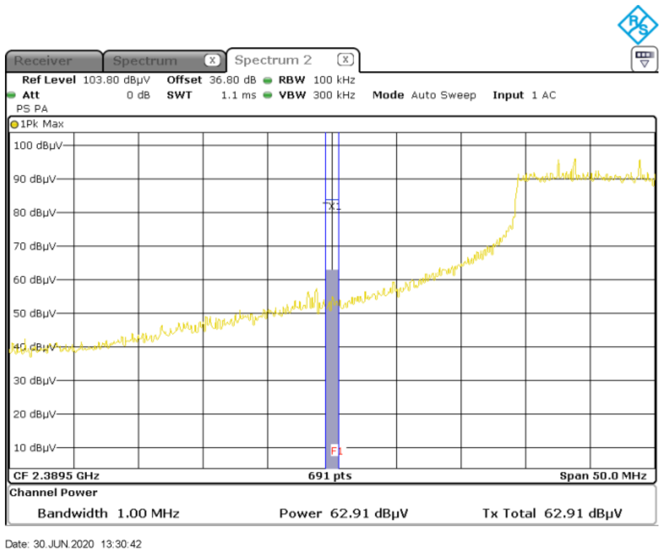


Figure 8.7-13: *Band edge spurious emissions at 2390 MHz peak*

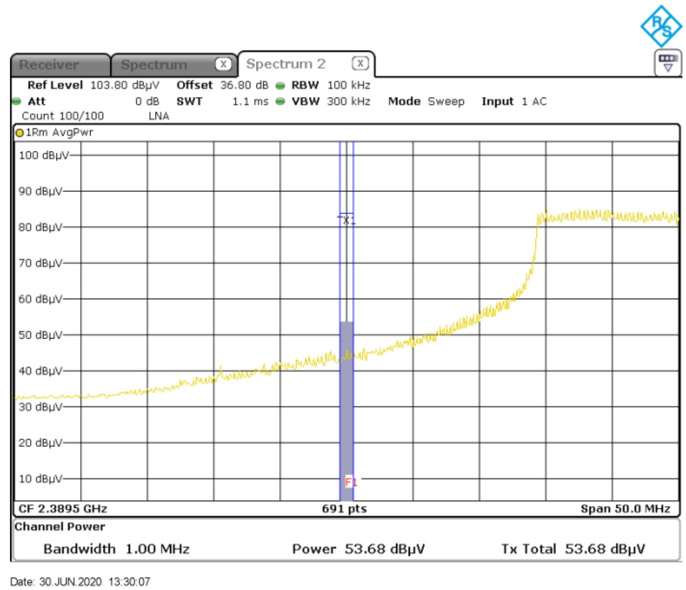


Figure 8.7-14: *Band edge spurious emissions at 2390 MHz avg*

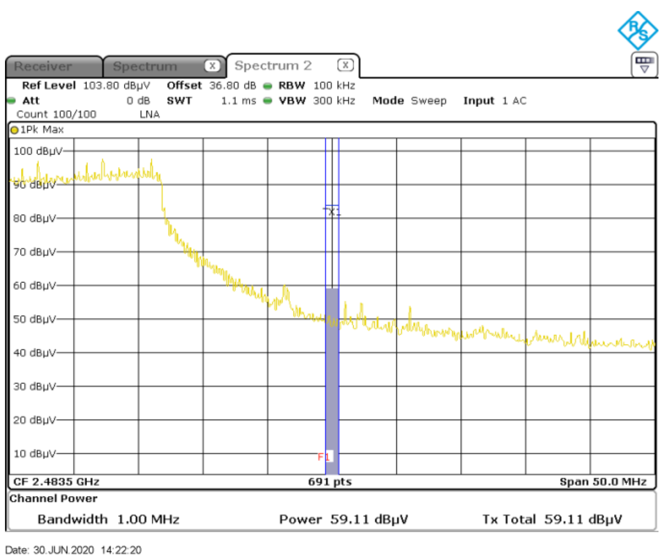


Figure 8.7-15: *Band edge spurious emissions at 2483.5 MHz peak*

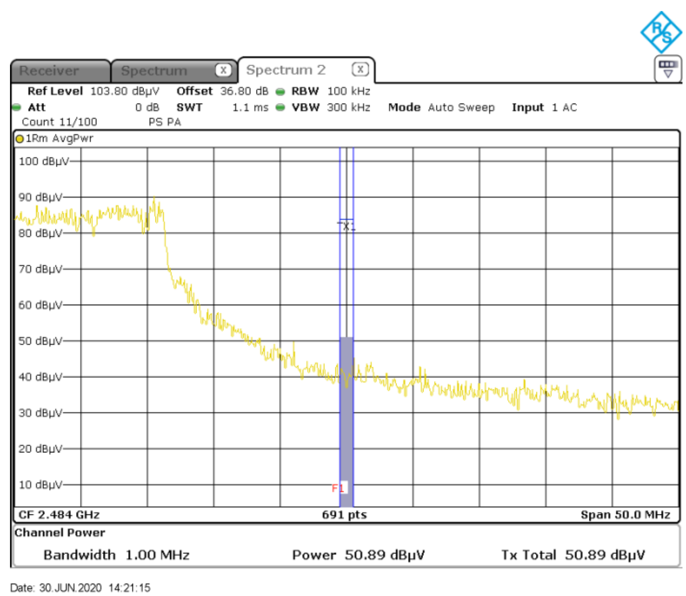
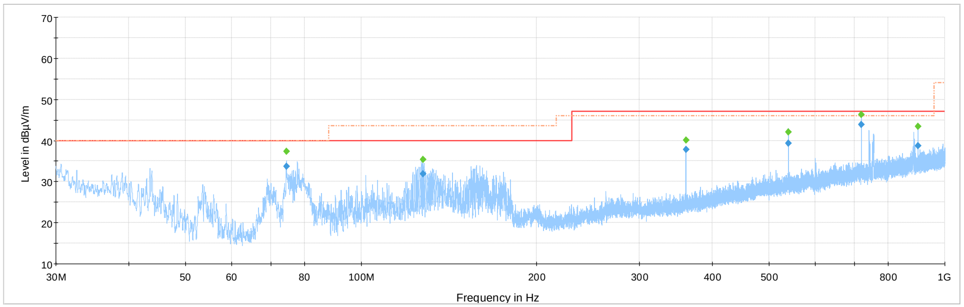


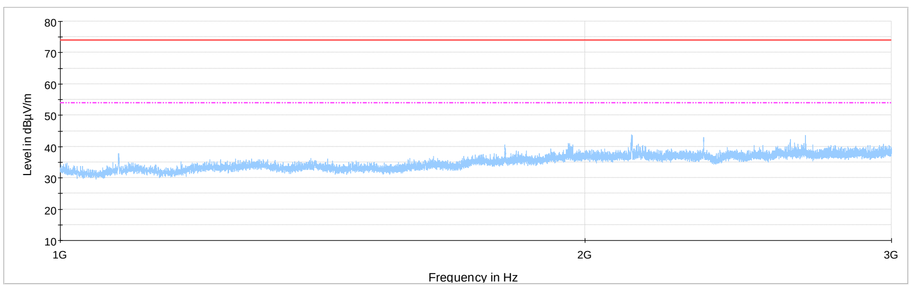
Figure 8.7-16: *Band edge spurious emissions at 2483.5 MHz avg*



NEX-410220 REscan 30-1000 MHz ES1-2450RE-74124

Preview Result 1-PK+
CISPR 32 Limit - Class B, Quasi-Peak, 3 m
FCC Part 15 and ICES-003 Limit - Class B (Quasi-Peak), 3 m
Final_Result QPK
Final_Result PK+

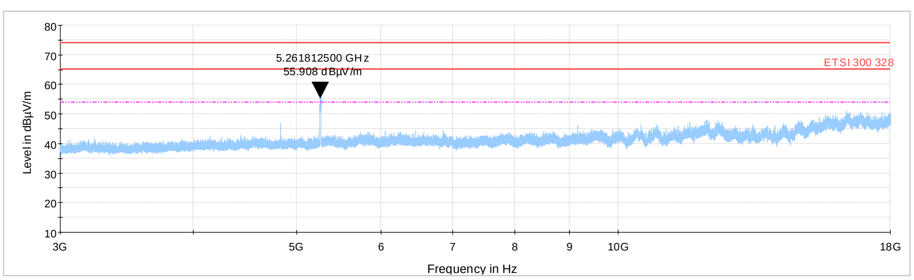
Figure 8.7-17: *Radiated spurious emissions at 30-1000 MHz, 802.11b low channel*



NEX-401220 b low channel

Preview Result 1-PK+
Critical_Freqs PK+
FCC Part 15 and ICES-003 Limit - Class B (Peak) above 1 GHz, 3 m
FCC Part 15 and ICES-003 Limit - Class B (Quasi-Peak and Average), 3 m
Final_Result PK+
Final_Result CAV

Figure 8.7-18: *Radiated spurious emissions at 1-3 GHz, 802.11b low channel*



NEX-401220 b low channel 3-18 GHz

Preview Result 1-PK+
Critical_Freqs PK+
ETSI 300 328
FCC Part 15 and ICES-003 Limit - Class B (Peak) above 1 GHz, 3 m
FCC Part 15 and ICES-003 Limit - Class B (Quasi-Peak and Average), 3 m
Final_Result PK+
Final_Result CAV

Figure 8.7-19: *Radiated spurious emissions at 3-18 GHz, 802.11b low channel*

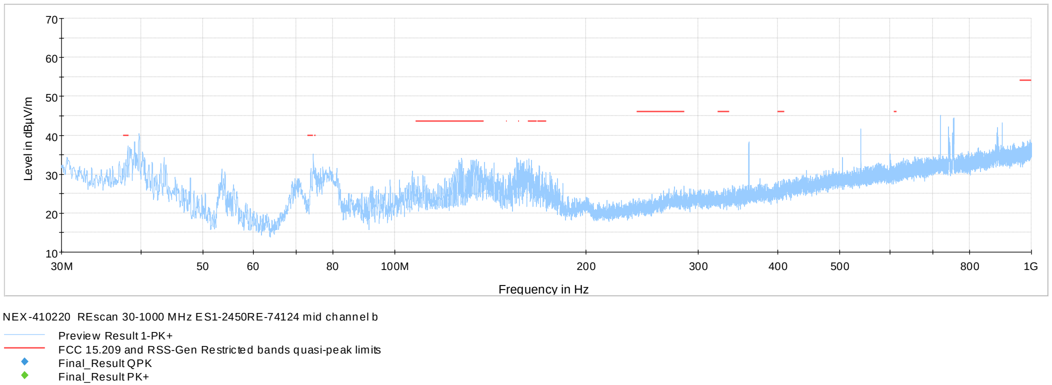


Figure 8.7-20: *Radiated spurious emissions at 30-1000 MHz, 802.11b mid channel*

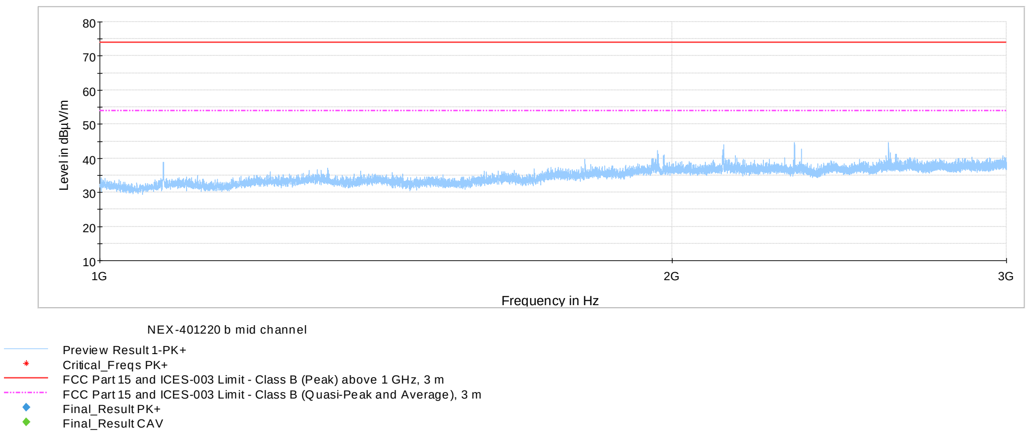


Figure 8.7-21: *Radiated spurious emissions at 1-3 GHz, 802.11b mid channel*

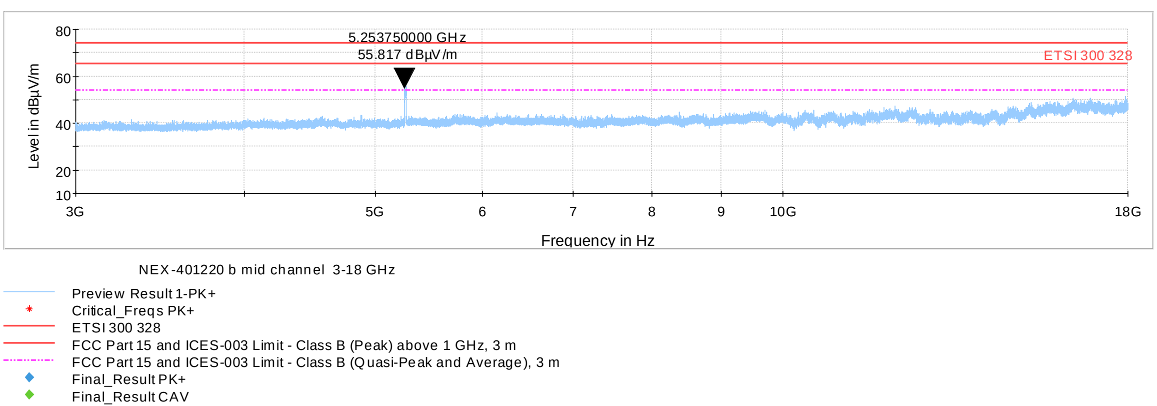
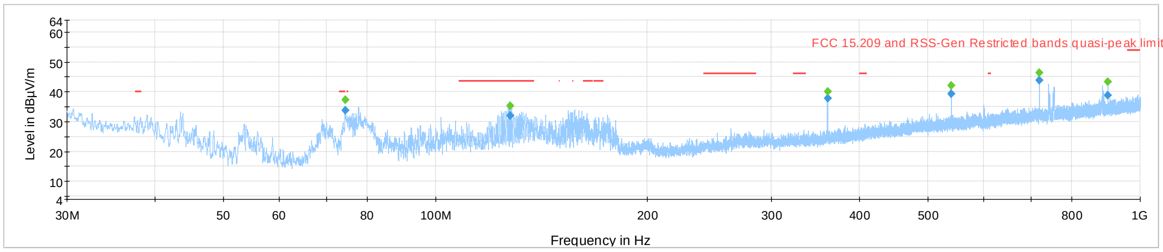


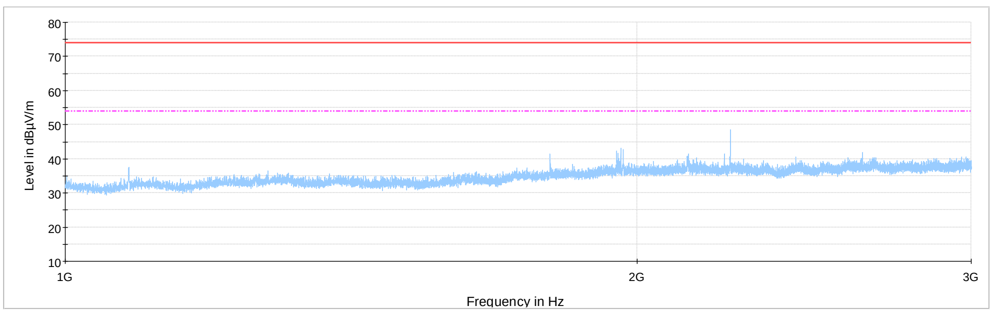
Figure 8.7-22: *Radiated spurious emissions at 3-18 GHz, 802.11b mid channel*



NEX-410220 REscan 30-1000 MHz ES1-2450RE-74124 high channel b

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

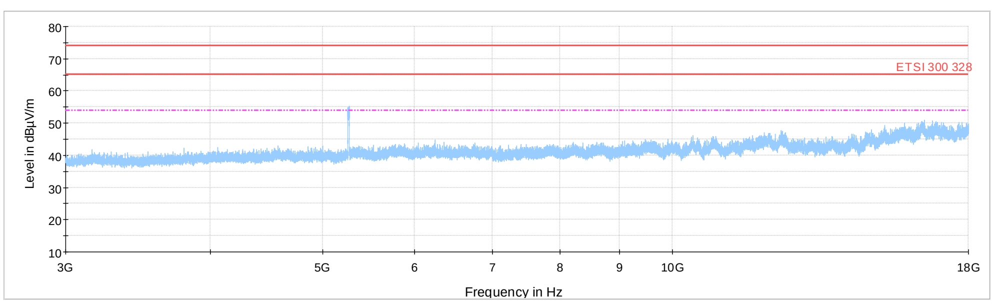
Figure 8.7-23: *Radiated spurious emissions at 30-1000 MHz, 802.11b high channel*



NEX-401220 b high channel

Preview Result 1-PK+
Critical_Freqs PK+
FCC Part 15 and ICES-003 Limit - Class B (Peak) above 1 GHz, 3 m
FCC Part 15 and ICES-003 Limit - Class B (Quasi-Peak and Average), 3 m
Final_Result PK+
Final_Result CAV

Figure 8.7-24: *Radiated spurious emissions at 1-3 GHz, 802.11b high channel*



NEX-401220 b high channel 3-18 GHz

Preview Result 1-PK+
Critical_Freqs PK+
ETSI 300 328
FCC Part 15 and ICES-003 Limit - Class B (Peak) above 1 GHz, 3 m
FCC Part 15 and ICES-003 Limit - Class B (Quasi-Peak and Average), 3 m
Final_Result PK+
Final_Result CAV

Figure 8.7-25: *Radiated spurious emissions at 3-18 GHz, 802.11b high channel*

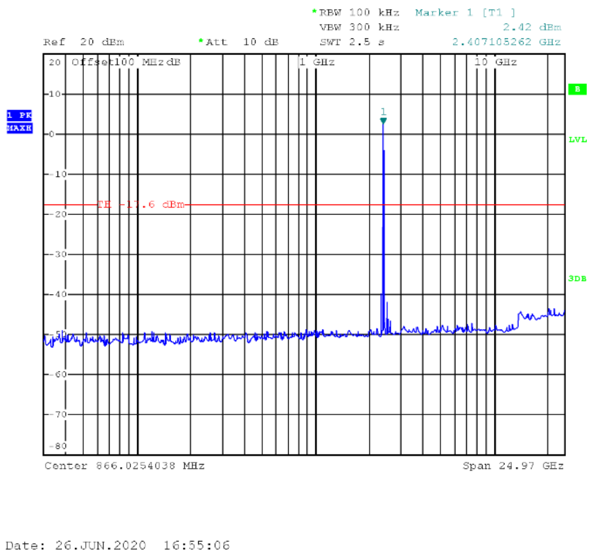


Figure 8.7-26: *Conducted spurious emissions on b ch0 low channel*

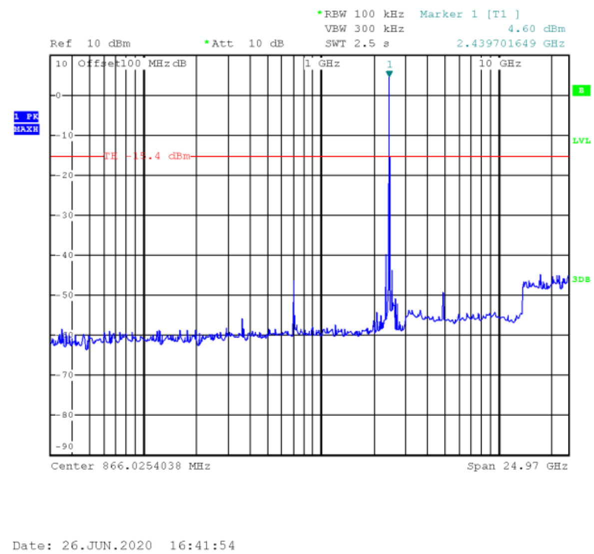


Figure 8.7-27: *Conducted spurious emissions on b ch0 mid channel*

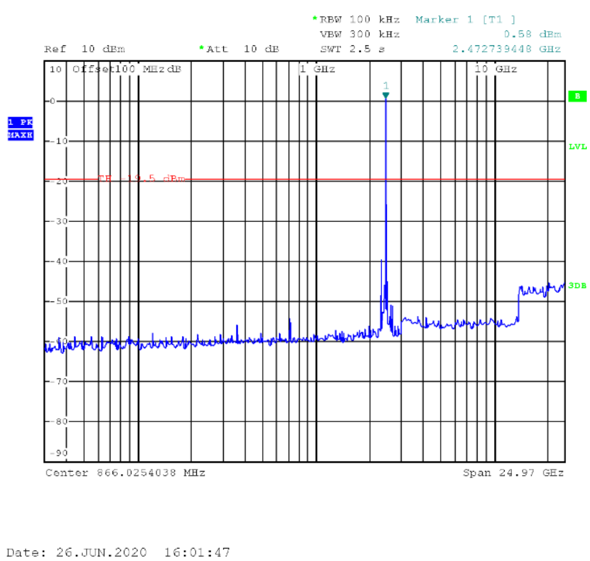


Figure 8.7-28: *Conducted spurious emissions on b ch0 high channel*

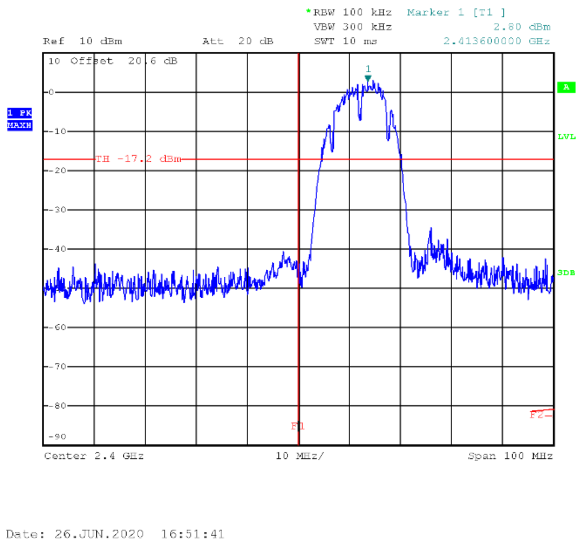


Figure 8.7-29: *Band edge spurious emissions at 2400 MHz on b ch1 low channel*

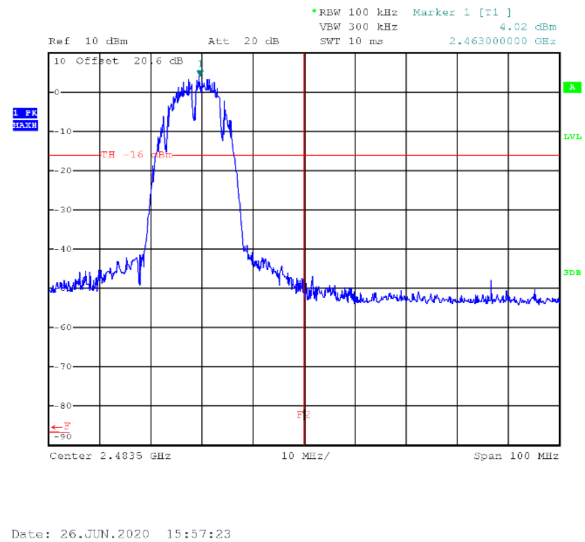


Figure 8.7-30: *Band edge spurious emissions at 2483.5 MHz on b ch1 high channel*

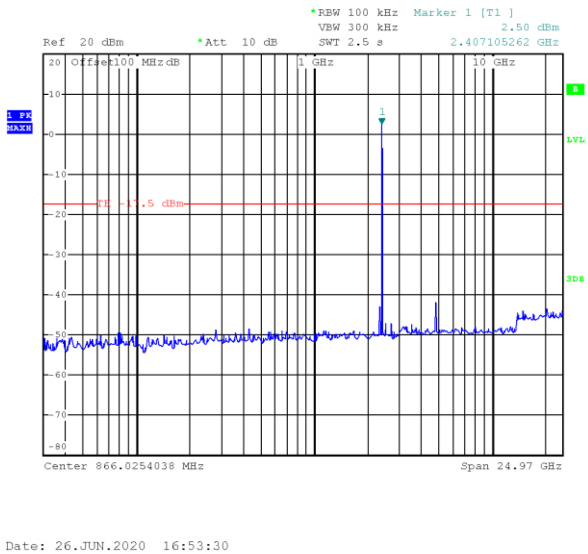


Figure 8.7-31: *Conducted spurious emissions on b ch1 low channel*

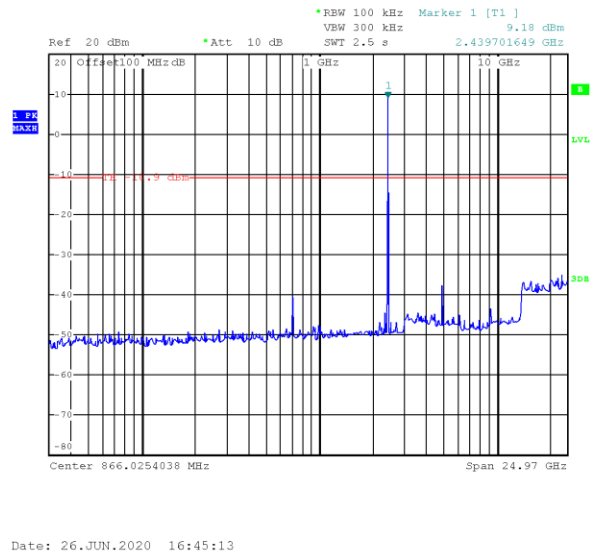


Figure 8.7-32: *Conducted spurious emissions on b ch1 mid channel*

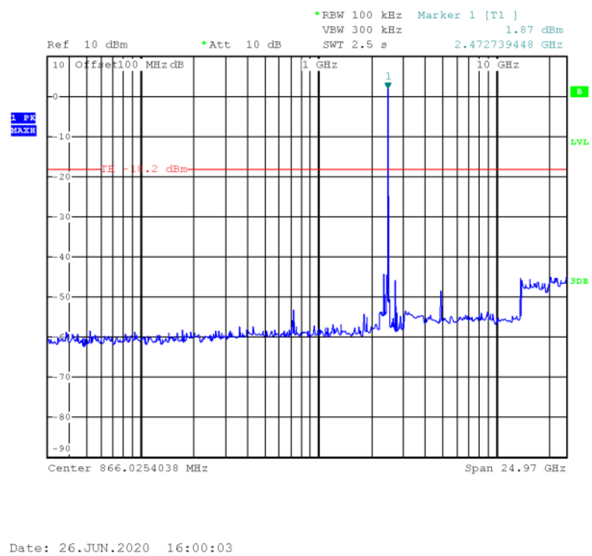


Figure 8.7-33: *Conducted spurious emissions on b ch1 high channel*

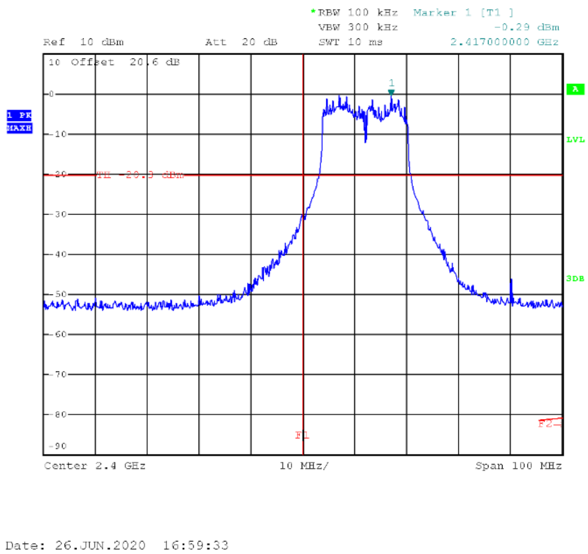


Figure 8.7-34: *Band edge spurious emissions at 2400 MHz on g ch0 low channel*

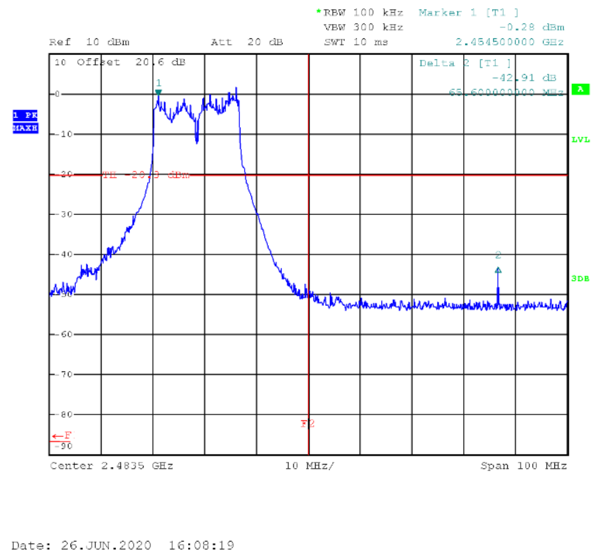


Figure 8.7-35: *Band edge spurious emissions at 2483.5 MHz on g ch0 high channel*

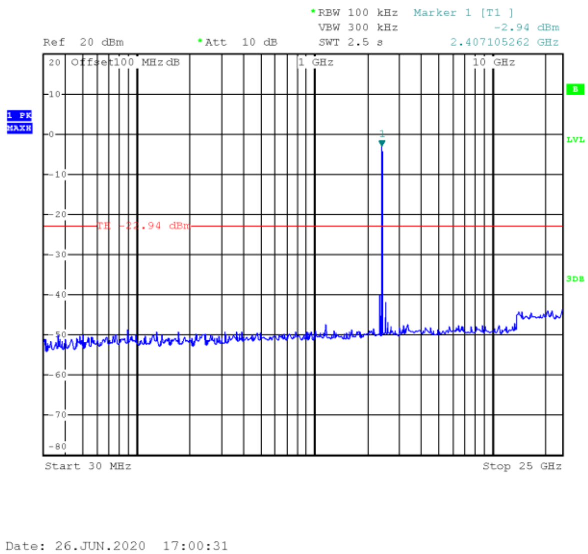


Figure 8.7-36: *Conducted spurious emissions on g ch0 low channel*

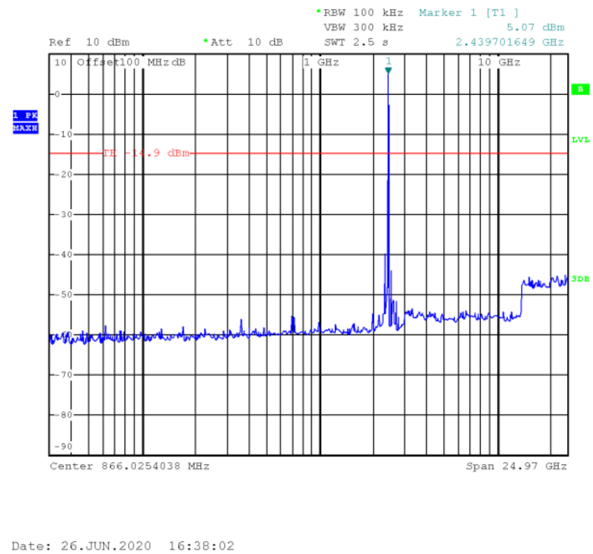


Figure 8.7-37: *Conducted spurious emissions on g ch0 mid channel*

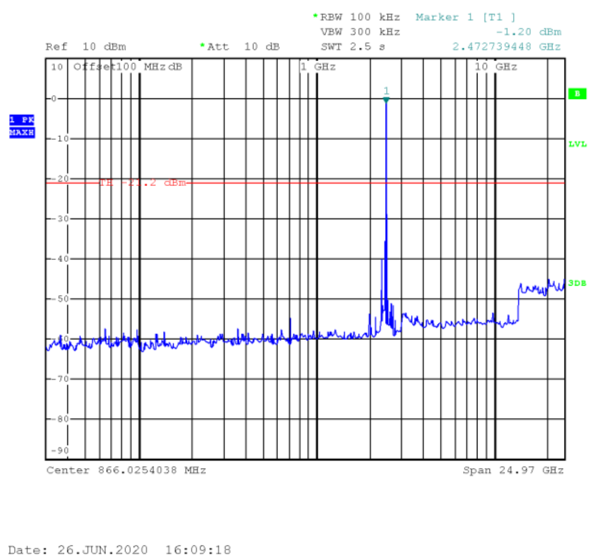


Figure 8.7-38: *Conducted spurious emissions on g ch0 high channel*

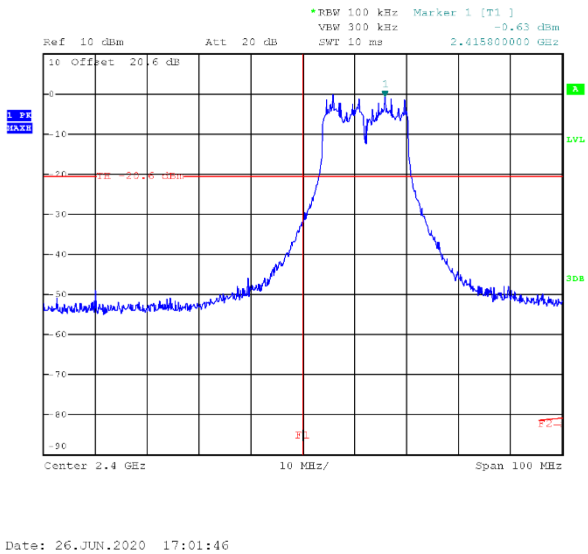


Figure 8.7-39: *Band edge spurious emissions at 2400 MHz on g ch1 low channel*

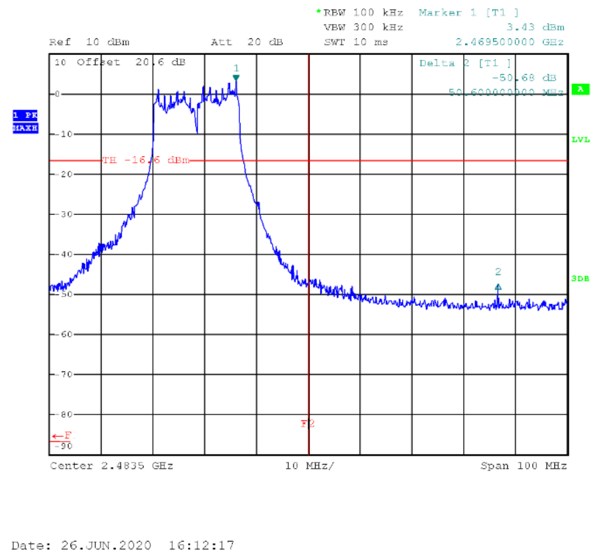


Figure 8.7-40: *Band edge spurious emissions at 2483.5 MHz on g ch1 high channel*

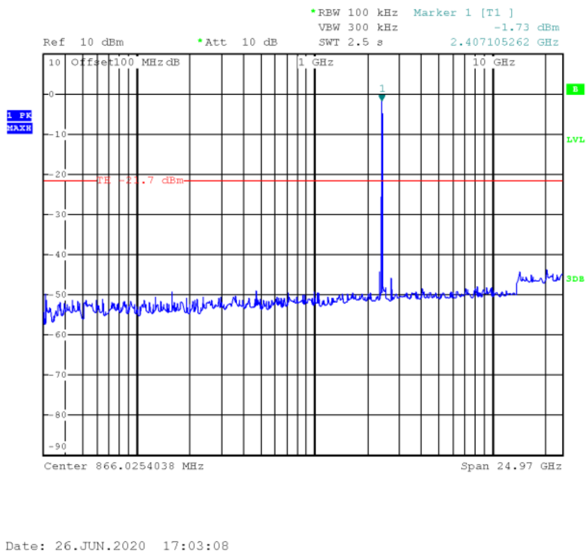


Figure 8.7-41: *Conducted spurious emissions on g ch1 low channel*

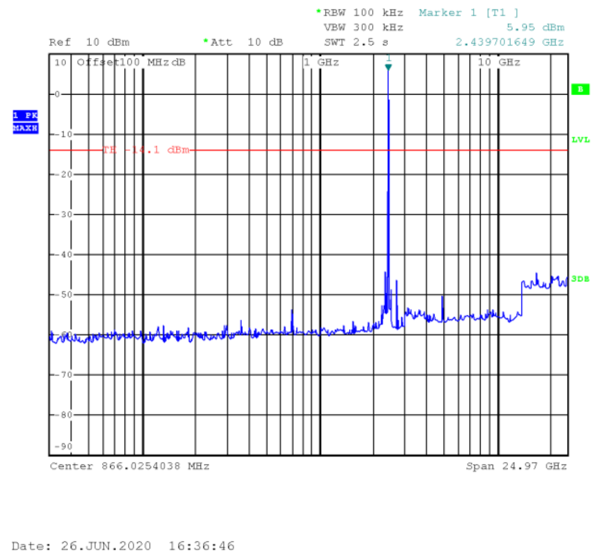


Figure 8.7-42: *Conducted spurious emissions on g ch1 mid channel*

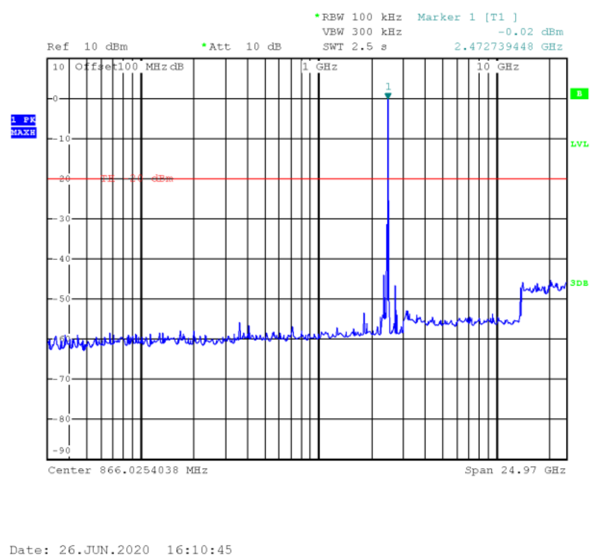


Figure 8.7-43: *Conducted spurious emissions on g ch1 high channel*

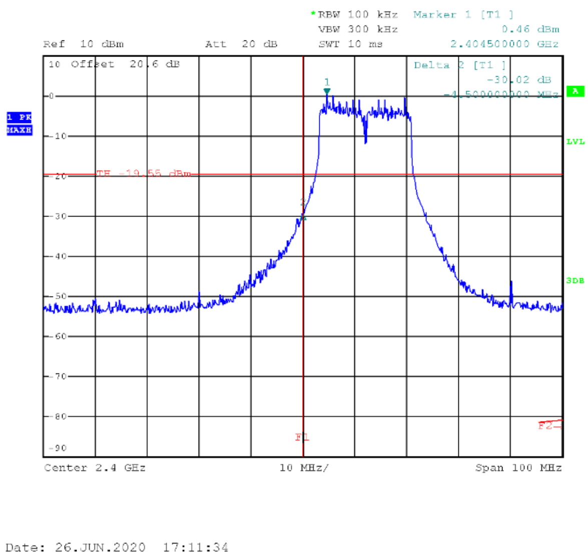


Figure 8.7-44: *Band edge spurious emissions at 2400 MHz on nt20 ch0 low channel*

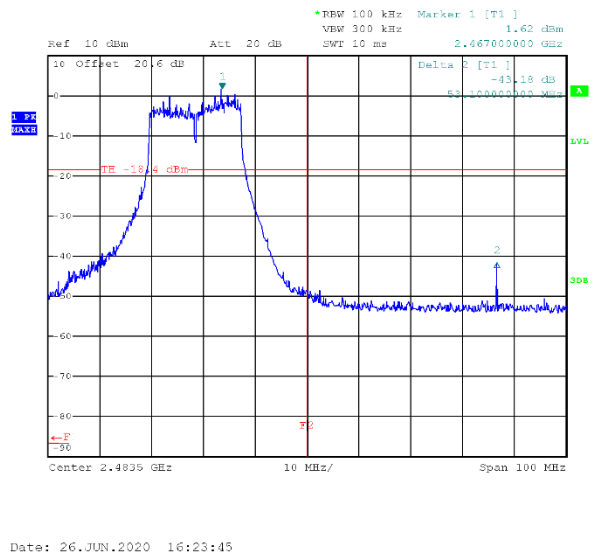


Figure 8.7-45: *Band edge spurious emissions at 2483.5 MHz on nt20 ch0 high channel*

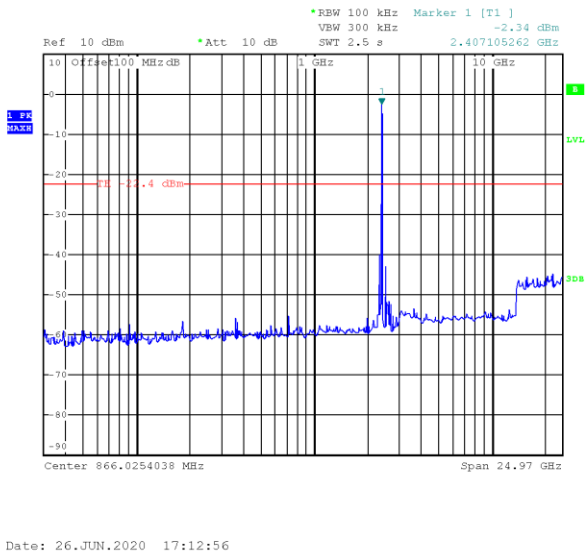


Figure 8.7-46: *Conducted spurious emissions on nt20 ch0 low channel*

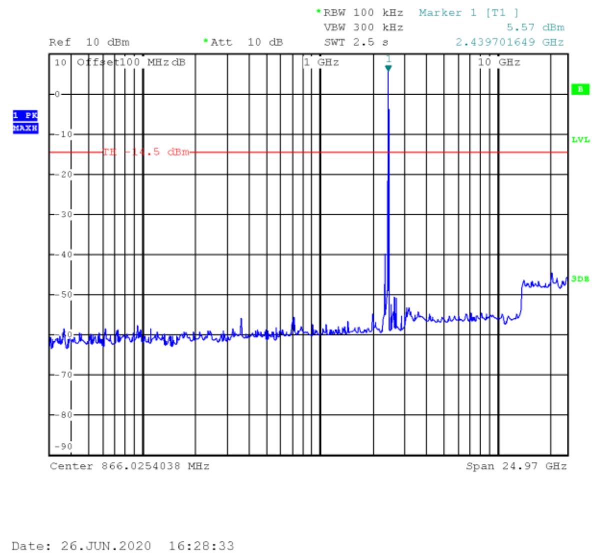


Figure 8.7-47: *Conducted spurious emissions on nt20 ch0 mid channel*

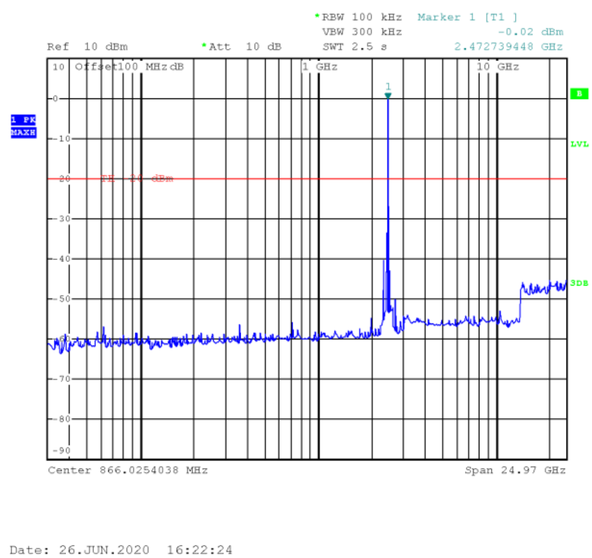


Figure 8.7-48: *Conducted spurious emissions on nt20 ch0 high channel*

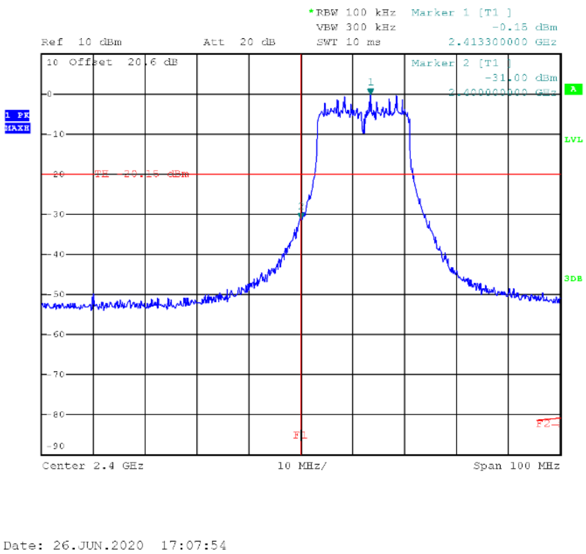


Figure 8.7-49: *Band edge spurious emissions at 2400 MHz on nt20 ch1 low channel*

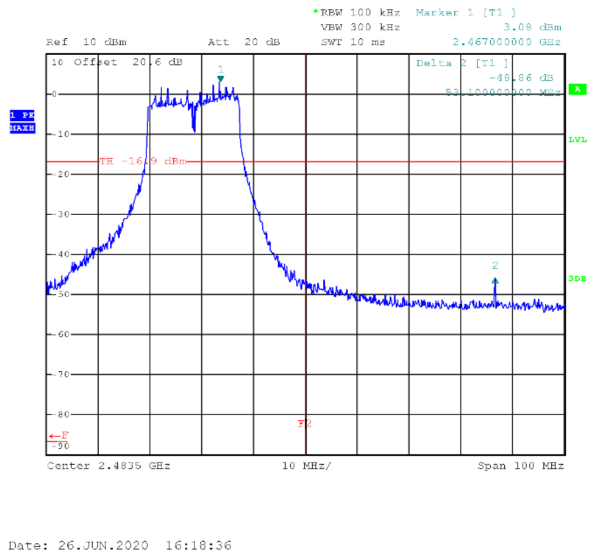


Figure 8.7-50: *Band edge spurious emissions at 2483.5 MHz on nt20 ch1 high channel*

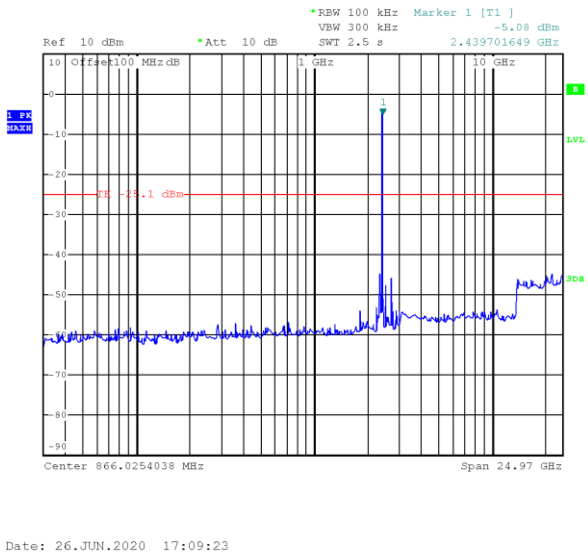


Figure 8.7-51: *Conducted spurious emissions on nt20 ch1 low channel*

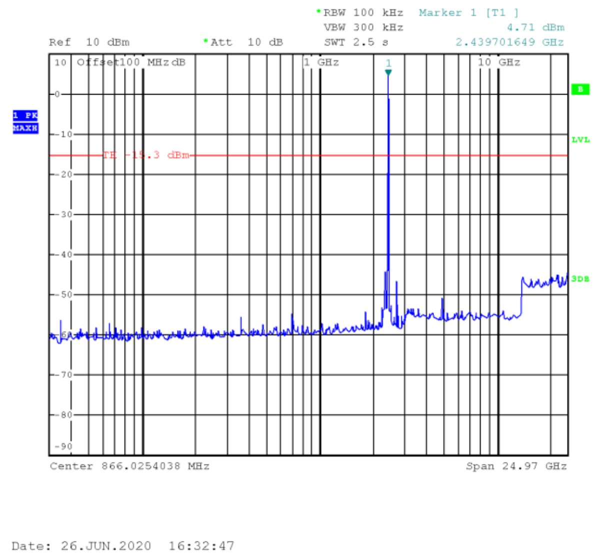


Figure 8.7-52: *Conducted spurious emissions on nt20 ch1 mid channel*

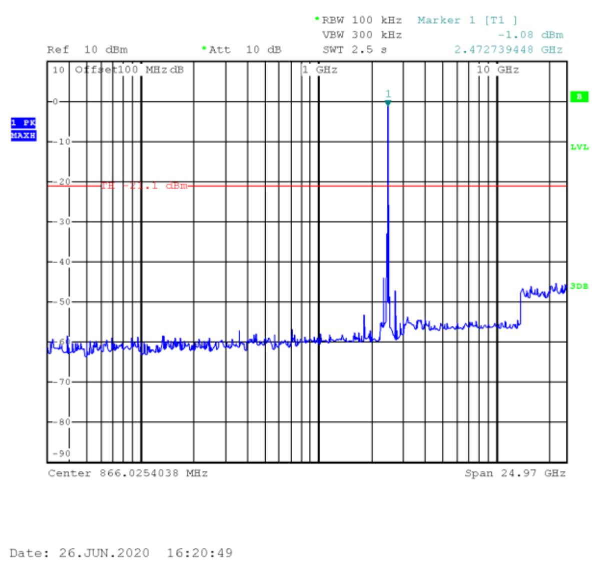


Figure 8.7-53: *Conducted spurious emissions on nt20 ch1 high channel*

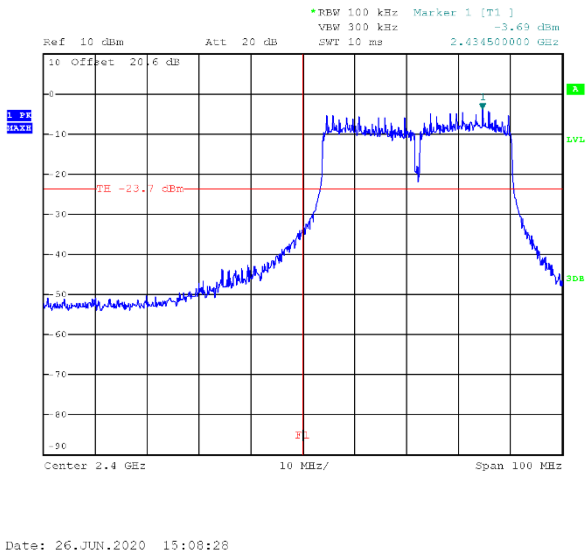


Figure 8.7-54: *Band edge spurious emissions at 2400 MHz on nt40 ch0 low channel*

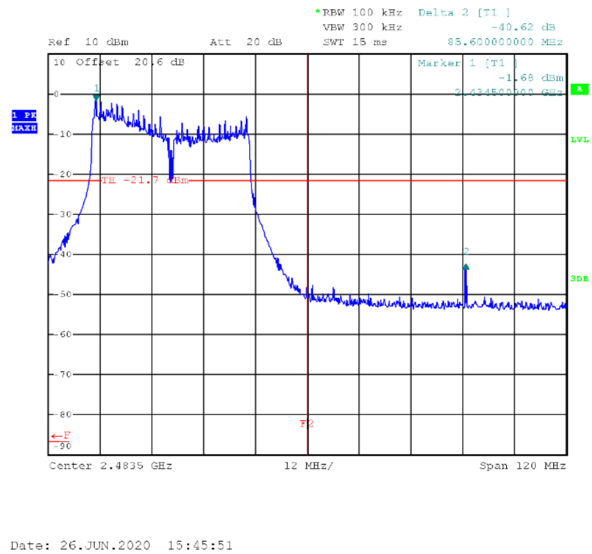


Figure 8.7-55: *Band edge spurious emissions at 2483.5 MHz on nt20 ch0 high channel*

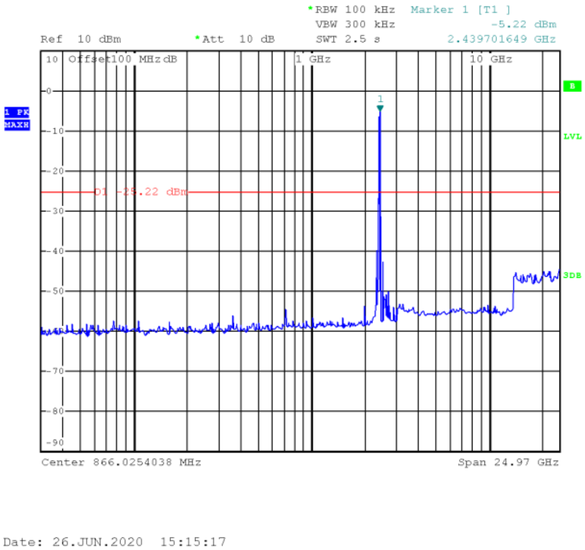


Figure 8.7-56: *Conducted spurious emissions on nt40 ch0 low channel*

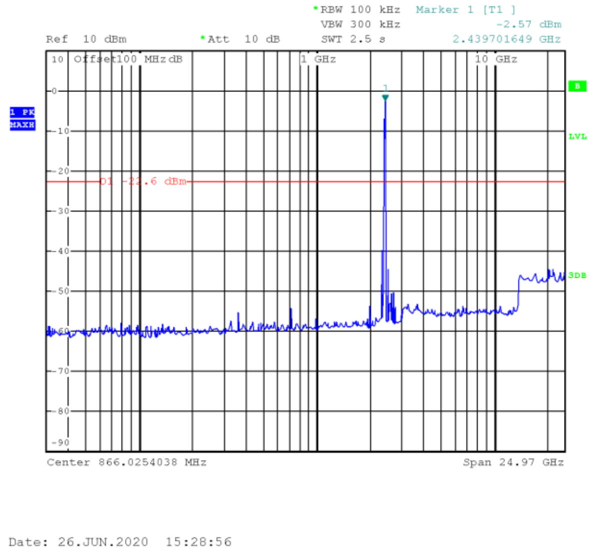


Figure 8.7-57: *Conducted spurious emissions on nt20 ch0 mid channel*

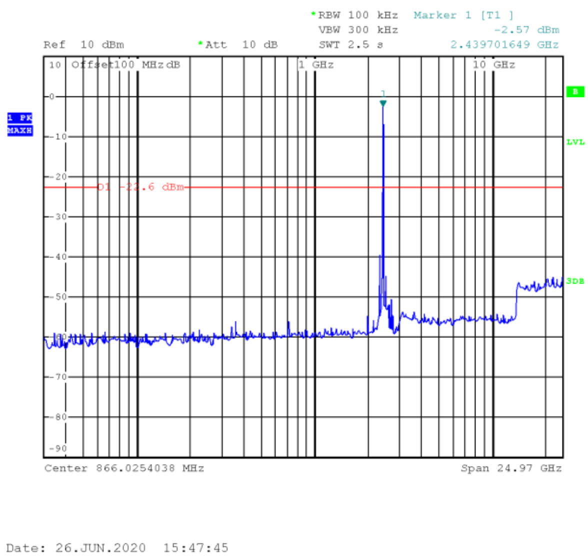


Figure 8.7-58: *Conducted spurious emissions on nt40 ch0 high channel*

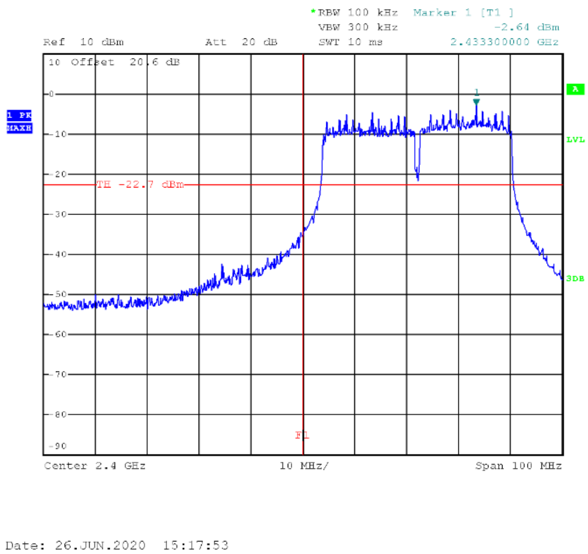


Figure 8.7-59: *Band edge spurious emissions at 2400 MHz on nt40 ch1 low channel*

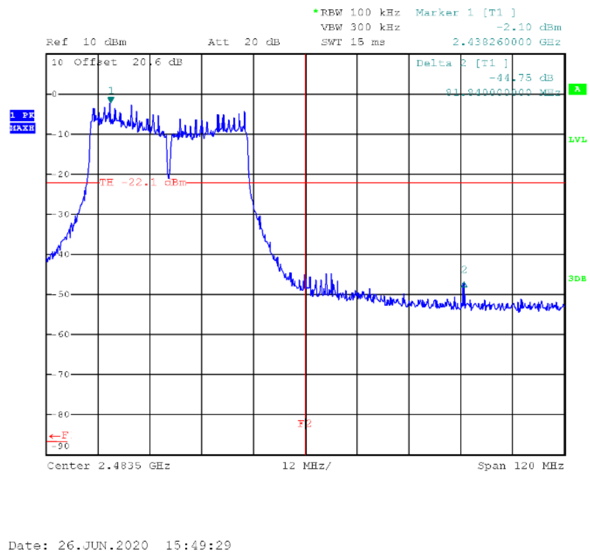


Figure 8.7-60: *Band edge spurious emissions at 2483.5 MHz on nt40 ch1 high channel*

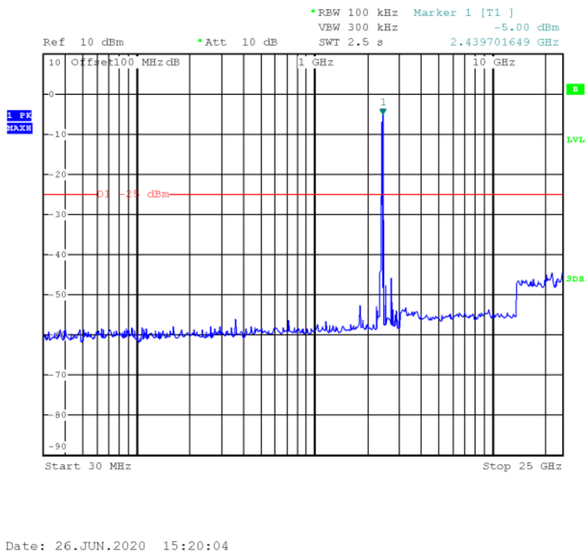


Figure 8.7-61: Conducted spurious emissions on nt40 ch1 low channel

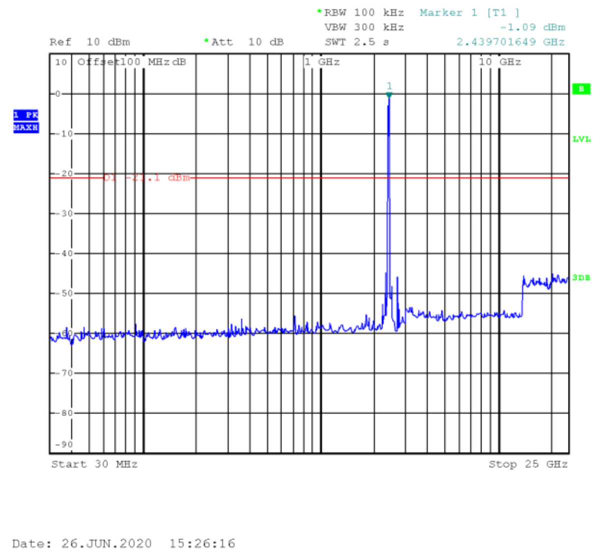


Figure 8.7-62: Conducted spurious emissions on nt40 ch01 mid channel

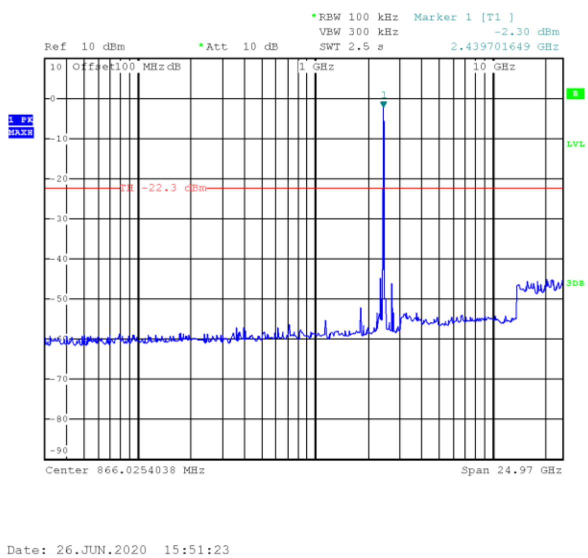


Figure 8.7-63: Conducted spurious emissions on nt40 ch1 high channel

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

8.8.1 References, definitions and limits

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

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

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

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

8.8.2 Test summary

Verdict	Pass		
Tested by	Kevin Rose	Test date	July 28, 2020

8.8.3 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 AVGPSD-1 (trace averaging with EUT transmitting at full power throughout each sweep).
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

Combined PSD for MIMO 2 × 2 application was calculated as follows: $PSD_{combined} = 10 \times log_{10}\left(\left(10^{PSD_{ch0}/10}\right) + \left(10^{PSD_{ch1}/10}\right)\right)$

8.8.4 Test data

Table 8.8-1: *PSD results (antenna port measurement)*

Modulation	Frequency, MHz	PSD, dBm/3 kHz CH0	PSD, dBm/3 kHz CH1	Combined PSD, dBm/3 kHz CH1	PSD limit, dBm/3 kHz	Margin, dB
b	2412	-16.4	-18.9	-14.5	8	22.5
b	2442	-9.6	-10.0	-6.8	8	8.2
b	2462	-16.7	-18.4	-14.5	8	22.5
g	2412	-21.5	-21.0	-18.2	8	26.2
g	2442	-12.8	-14.0	-10.4	8	18.4
g	2462	-18.6	-19.6	-16.1	8	24.1
nt20	2412	-21.5	-22.6	-19.0	8	27.0
nt20	2442	-15.0	-15.7	-12.3	8	20.3
nt20	2462	-19.1	-20.0	-16.5	8	24.5
nt40	2422	-26.8	-27.0	-23.9	8	31.9
nt40	2442	-9.4	-11.8	-7.4	8	15.4
nt40	2452	-23.3	-26.7	-21.7	8	29.7

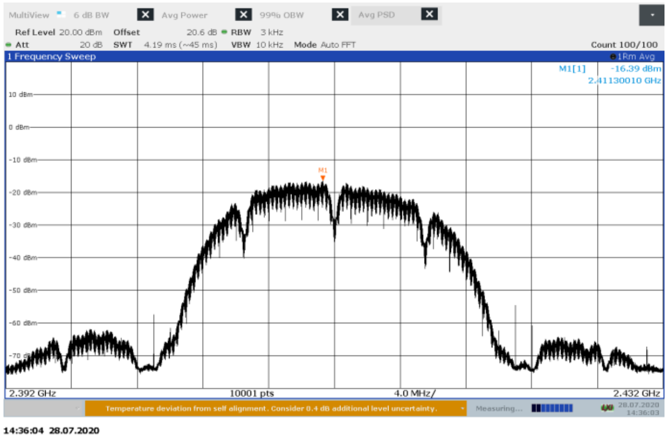


Figure 8.8-1: *802.11b sample plot*

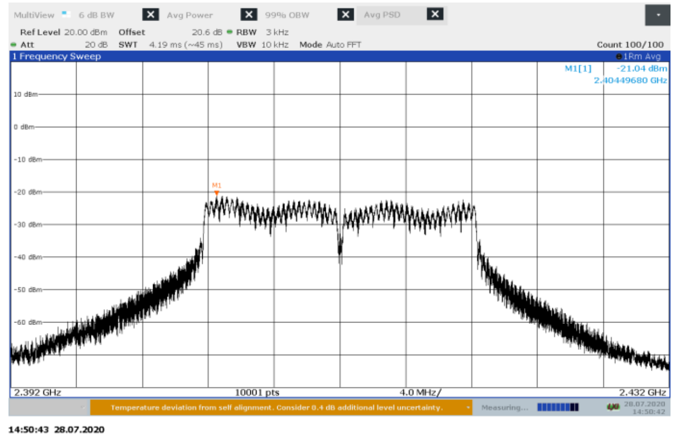


Figure 8.8-2: *802.11g sample plot*

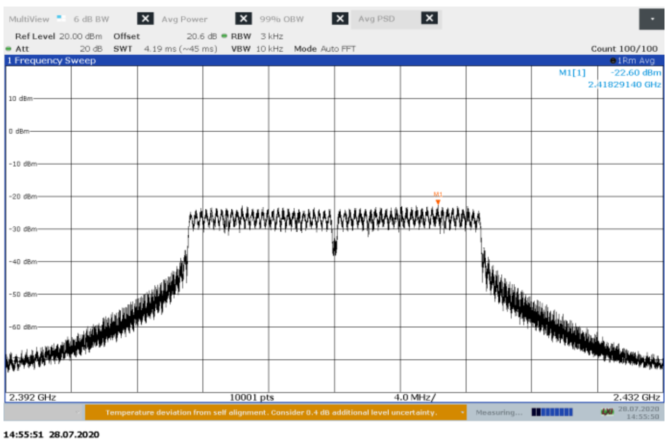


Figure 8.8-3: *802.11nt20 sample plot*

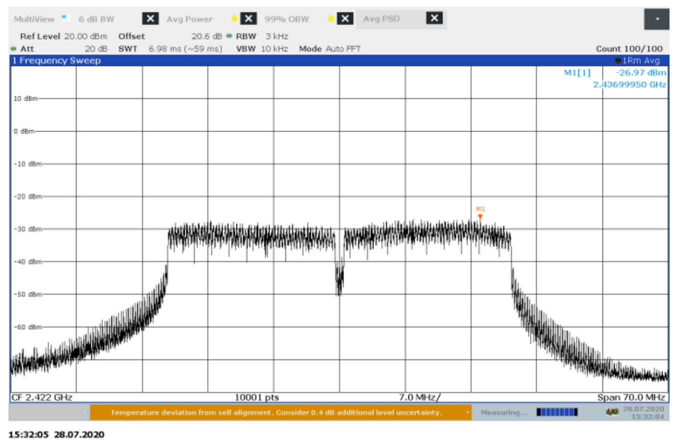


Figure 8.8-4: *802.11nt40 sample plot*

End of the test report