

RADIO TEST REPORT – 449306-6TRFWL

Type of assessment:

Partial assessment

Type of radio equipment:

Wi-Fi device

Equipment class:

DTS

Applicant:

Keyence Corporation

Product marketing name:

Handheld Terminal

Model (HVIN):

DX-W600

FCC ID:

RF41539A

IC Registration number:

5798A-1539A

Specifications:

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

Date of issue: May 3, 2022

Tarek Elkholy, EMC/RF Specialist

Tested by



Signature



David Duchesne, EMC/RF Lab Manager

Reviewed by

Signature

Nemko Canada Inc., a testing laboratory, is accredited by the Standards Council of Canada.
The tests included in this report are within the scope of this accreditation.
The SCC Accreditation Symbol is an official symbol of the Standards Council of Canada, used under licence.

FCC File Number: 15064 (Ottawa/Almonte); 151100 (Montreal); 151097 (Cambridge)

FCC 15.247 and RSS-247; Date: February 2021

www.nemko.com



Lab locations

Company name	Nemko Canada Inc.			
Facilities	<i>Ottawa site:</i> 303 River Road Ottawa, Ontario Canada K1V 1H2	<i>Montréal site:</i> 292 Labrosse Avenue Pointe-Claire, Québec Canada H9R 5L8	<i>Cambridge site:</i> 1-130 Saltsman Drive Cambridge, Ontario Canada N3E 0B2	<i>Almonte site:</i> 1500 Peter Robinson Road West Carleton, Ontario Canada K0A 1L0
	Tel: +1 613 737 9680 Fax: +1 613 737 9691	Tel: +1 514 694 2684 Fax: +1 514 694 3528	Tel: +1 519 650 4811	Tel: +1 613 256-9117
Test site identifier	Organization	Ottawa/Almonte	Montreal	Cambridge
	FCC: ISED:	CA2040 2040A-4	CA2041 2040G-5	CA0101 24676
Website	www.nemko.com			

Limits of responsibility

Note that the results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contained in this report are within Nemko Canada's ISO/IEC 17025 accreditation.

Copyright notification

Nemko Canada Inc. authorizes the applicant to reproduce this report provided it is reproduced in its entirety and for use by the company's employees only. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties.

Nemko Canada Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

© Nemko Canada Inc.

Table of Contents

Table of Contents	3
Section 1 Report summary	4
1.1 Test specifications	4
1.2 Test methods	4
1.3 Exclusions	4
1.4 Statement of compliance	4
1.5 Test report revision history	4
Section 2 Engineering considerations	5
2.1 Modifications incorporated in the EUT for compliance	5
2.2 Technical judgment	5
2.3 Model variant declaration	5
2.4 Deviations from laboratory tests procedures	5
Section 3 Test conditions	6
3.1 Atmospheric conditions	6
3.2 Power supply range	6
Section 4 Measurement uncertainty	7
4.1 Uncertainty of measurement	7
Section 5 Information provided by the applicant	8
5.1 Disclaimer	8
5.2 Applicant/Manufacture	8
5.3 EUT information	8
5.4 Radio technical information	9
5.5 EUT setup details	9
Section 6 Summary of test results	11
6.1 Testing location	11
6.2 Testing period	11
6.3 Sample information	11
6.4 FCC test results	11
6.5 ISED test results	12
Section 7 Test equipment	13
7.1 Test equipment list	13
Section 8 Testing data	14
8.1 Number of frequencies	14
8.2 Antenna requirement	16
8.3 Transmitter output power and e.i.r.p. requirements for DTS in 2.4 GHz	17
8.4 Occupied bandwidth for DTS systems	21
8.5 Spurious (out-of-band) unwanted emissions	23
8.6 Power spectral density for digitally modulated devices	31

Section 1 Report summary

1.1 Test specifications

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

1.2 Test methods

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)
558074 D01 15.247 Meas Guidance v05r02	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

1.3 Exclusions

Partial testing was performed on the product to proof compliance of the EUT originally certified based on the test report RF140808E04S, only power, power spectral density and spurious emissions in restricted bands are tested in this assessment.

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

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

Determining compliance is based on the results of the compliance measurement, not taking into account measurement uncertainty, in accordance with section 1.3 of ANSI C63.10 v2013.

See "Summary of test results" for full details.

1.5 Test report revision history

Table 1.5-1: Test report revision history

Revision #	Date of issue	Details of changes made to test report
TRF	May 3, 2022	Original report issued

Section 2 Engineering considerations

2.1 Modifications incorporated in the EUT for compliance

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

2.2 Technical judgment

None

2.3 Model variant declaration

There were no model variants declared by the applicant.

2.4 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 3 Test conditions

3.1 Atmospheric conditions

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

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

3.2 Power supply range

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

Section 4 Measurement uncertainty

4.1 Uncertainty of measurement

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

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

Table 4.1-1: Measurement uncertainty calculations

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

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/Manufacture

Applicant name	Keyence Corporation
Applicant address	1-3-14, Higashinakajima Higashiyodogawa-ku, Osaka 533-8555, Japan.
Manufacture name	Keyence Corporation
Manufacture address	1-3-14, Higashinakajima Higashiyodogawa-ku, Osaka 533-8555, Japan.

5.3 EUT information

Product	Handheld Terminal
Model	DX-W600
Serial number	74AM000344 (radiated sample), 74AM000496 (conducted sample)
Power supply requirements	Battery: 3.8 V(DC)
Product description and theory of operation	Model: DX-W600 is Handheld Terminal. This product is battery powered. It is equipped with an optical scanner and can read labels such as QR codes.

5.4 Radio technical information

Category of Wideband Data	<input type="checkbox"/> Frequency Hopping Spread Spectrum (FHSS) equipment
Transmission equipment	<input checked="" type="checkbox"/> Other types of Wideband Data Transmission equipment (e.g. DSSS, OFDM, etc.).
Frequency band	2400–2483.5 MHz
Frequency Min (MHz)	2412 MHz (20 MHz bandwidth), 2422 MHz (40 MHz bandwidth)
Frequency Max (MHz)	2462 MHz (20 MHz bandwidth), 2452 MHz (40 MHz bandwidth)
Channel numbers	1–11
RF power Max (W), Conducted	0.0302 W and (14.8 dBm)
Measured BW (MHz), 99% OBW	17.4 MHz (20 MHz bandwidth), 35.8 MHz (40 MHz bandwidth)
Type of modulation	802.11b: DSSS (CCK, DQPSK, DBPSK) 802.11g/n(HT20): OFDM (QPSK, BPSK, 16-QAM, 64-QAM)
Emission classification	W7D
Transmitter spurious, dB μ V/m @ 3 m	53.7 dB μ V/m (peak), 50.1 dB μ V/m (Average) at 4924.1 MHz
Antenna information	Model: FPA2514-5A Peak gain: -4.0 dBi

5.5 EUT setup details

5.5.1 Radio exercise details

Operating conditions	<p>This WiFi / BT module is a module with 802.11ac / a / b / g / n WiFi and Bluetooth communication function. It is programmed to recognize the country code issued by the AP and communicate with the output according to the wireless specifications allowed in each country.</p> <p>Output power level was set according to the table below</p> <ul style="list-style-type: none"> Software: Qualcomm Atheros Radio Control Toolkit Version: V3.0-00191
Transmitter state	Transmitter set into maximum typical duty cycle mode.

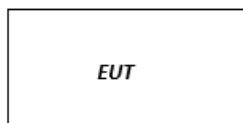
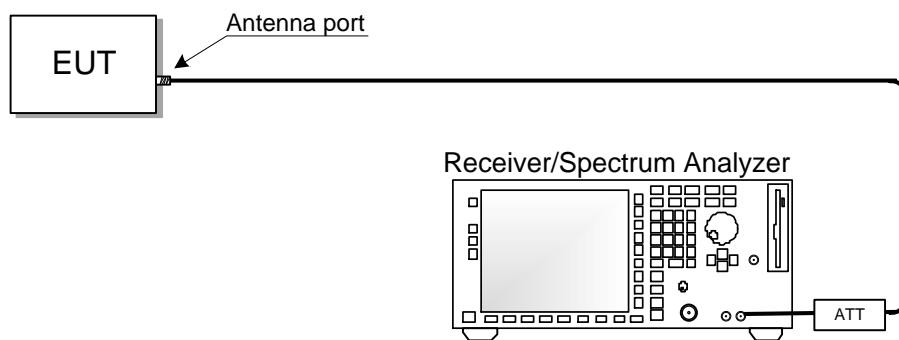
Modulation	Channel number	Frequency (MHz)	Power level (dBm)	Measured Duty Cycle (%)	Calculated DCCF (dB)
802.11b	1	2412	12	98	-
	6	2437	12		
	11	2462	12		
802.11g	1	2412	13	89.7	0.5
	6	2437	16		
	11	2462	13		
802.11n VHT20	1	2412	13	92.5	0.3
	6	2437	16		
	11	2462	12		
802.11n VHT40	3	2422	11	85.2	0.7
	6	2437	14		
	9	2452	8		

Note: DCCF = $10 \log_{10} (1/\text{duty cycle})$, ex. For DC 89.7 %, DCCF = $10 \log_{10} (1/0.897) = 0.5 \text{ dB}$

5.5.2 EUT setup configuration

Table 5.5-1: EUT interface ports

Description	Qty.
Charging DC power input / micro-USB	1

*Figure 5.5-1: Radiated testing block diagram**Figure 5.5-2: Antenna port testing block diagram*

Section 6 Summary of test results

6.1 Testing location

Test location (s)	Cambridge
-------------------	-----------

6.2 Testing period

Test start date	January 25, 2022	Test end date	April 5, 2022
-----------------	------------------	---------------	---------------

6.3 Sample information

Receipt date	September 9, 2021	Nemko sample ID number(s)	2 and 3
--------------	-------------------	---------------------------	---------

6.4 FCC test results

Table 6.4-1: FCC requirements results

Part	Test description	Verdict
Generic requirements		
§15.31(m)	Number of tested frequencies	Pass
§15.203	Antenna requirement	Pass
§15.247(d)	Spurious emissions	Pass
DTS specific requirements		
§15.247(b)(3)	Maximum peak output power	Pass
§15.247(e)	Power spectral density	Pass

Notes: EUT is a battery operated device, the testing was performed using fully charged batteries.
Partial testing was performed on the product to proof compliance of the EUT originally certified based on the test report RF140808E04S, only performed tests are listed in this table.

6.5 ISED test results

Table 6.5-1: ISED requirements results

Part	Test description	Verdict
Generic requirements		
RSS-Gen, 6.9	Operating bands and selection of test frequencies	Pass
RSS-247, 5.5	Unwanted emissions	Pass
DTS specific requirements		
RSS-247, 5.2 (b)	Maximum power spectral density	Pass
RSS-247, 5.4	Transmitter output power and e.i.r.p. requirements	Pass
RSS-247, 5.4 (d)	Systems employing digital modulation techniques	Pass

Notes: ¹According 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.

Partial testing was performed on the product to proof compliance of the EUT originally certified based on the test report RF140808E04S, only performed tests are listed in this table.

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	Feb 7, 2023
Flush mount turntable	SUNAR	FM2022	FA003006	—	NCR
Controller	SUNAR	SC110V	FA002976	—	NCR
Antenna mast	SUNAR	TLT2	FA003007	—	NCR
Vector signal generator	Rohde & Schwarz	SMW200A	FA002970	1 Year	Dec 31, 2022
Spectrum analyzer	Rohde & Schwarz	FSW43	FA002971	1 year	Dec 31, 2022
Receiver/spectrum analyzer	Rohde & Schwarz	ESR26	FA002969	1 year	Nov 30, 2022
Horn antenna (1–18 GHz)	ETS Lindgren	3117	FA002911	1 year	April 21, 2022
Preamp (1–18 GHz)	ETS Lindgren	124334	FA002956	1 year	Mar 30, 2023
Bilog antenna (30–2000 MHz)	SUNAR	JB1	FA003009	1 year	Jan 31, 2023
50 Ω coax cable	Huber + Suhner	None	FA003047	1 year	July 13, 2022
50 Ω coax cable	Huber + Suhner	None	FA003043	1 year	July 13, 2022

Notes: NCR - no calibration required

Section 8 Testing data

8.1 Number of frequencies

8.1.1 References, definitions and limits

FCC §15.31:

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

RSS-Gen, Clause 6.9:

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

Table 8.1-1: Frequency Range of Operation

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

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

8.1.2 Test summary

Verdict	Pass		
Tested by	Tarek Elkholly	Test date	January 25, 2022

8.1.3 Observations, settings and special notes

ANSI C63.10, Clause 5.6.2.1:

The number of channels tested can be reduced by measuring the center channel bandwidth first and then applying the following relaxations as appropriate:

- 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.
- 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.
- If the measured channel bandwidth on the middle channel is less than 50% of the maximum permitted bandwidth, then it is not necessary to measure the bandwidth on the high and low channels.

ANSI C63.10, Clause 5.6.2.2:

For devices with multiple operating modes, measurements on the middle channel can be used to determine the worst-case mode(s). The worst-case modes are as follows:

- 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).
- 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).
- 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.

8.1.4 Test data

Table 8.1-2: Test channels selection – 20 MHz bandwidth

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	2437	2462

Table 8.1-3: Test channels selection – 40 MHz bandwidth

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	2437	2452

8.2 Antenna requirement

8.2.1 References, definitions and limits

FCC §15.203:

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

FCC §15.247:

- (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:
- (4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

RSS-Gen, Clause 6.8:

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

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

8.2.2 Test summary

Verdict	Pass
Tested by	Tarek Elkholy

Test date

January 25, 2022

8.2.3 Observations, settings and special notes

None

8.2.4 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 8.2-1: Antenna information

Model number	Maximum gain	Connector type
FPA2514-5A	-4.0 dBi	WFL

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

8.3.1 References, definitions and limits

FCC §15.247:

- (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:
- (3) For systems using digital modulation in the 2400–2483.5 MHz band: 1 W (30 dBm). As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.
- (4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.
- (c) Operation with directional antenna gains greater than 6 dBi.
 - (1) Fixed point-to-point operation:
 - (i) Systems operating in the 2400–2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.
 - (ii) Fixed, point-to-point operation, as used in paragraphs (c)(1)(i) and (c)(1)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum or digitally modulated intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.
 - (2) In addition to the provisions in paragraphs (b)(1), (b)(3), (b)(4) and (c)(1)(i) of this section, transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams, simultaneously or sequentially, for the purpose of directing signals to individual receivers or to groups of receivers provided the emissions comply with the following:
 - (i) Different information must be transmitted to each receiver.
 - (ii) If the transmitter employs an antenna system that emits multiple directional beams but does not do emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device, i.e., the sum of the power supplied to all antennas, antenna elements, staves, etc. and summed across all carriers or frequency channels, shall not exceed the limit specified in paragraph (b)(1) or (b)(3) of this section, as applicable. However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as follows:
 - (A) The directional gain shall be calculated as the sum of $10 \log$ (number of array elements or staves) plus the directional gain of the element or stave having the highest gain.
 - (B) A lower value for the directional gain than that calculated in paragraph (c)(2)(ii)(A) of this section will be accepted if sufficient evidence is presented, e.g., due to shading of the array or coherence loss in the beamforming.
 - (iii) If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the power limit specified in paragraph (c)(2)(ii) of this section. If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the limit specified in paragraph (c)(2)(ii) of this section. In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the limit specified in paragraph (c)(2)(ii) of this section by more than 8 dB.
 - (iv) Transmitters that emit a single directional beam shall operate under the provisions of paragraph (c)(1) of this section.

References, definitions and limits, continued

RSS-247, Clause 5.4:

Devices shall comply with the following requirements, where applicable:

d. For DTSs employing digital modulation techniques operating in the 2400–2483.5 MHz band, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

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

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

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

- i. Different information must be transmitted to each receiver.
- ii. If the transmitter employs an antenna system that emits multiple directional beams, but does not emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device (i.e. the sum of the power supplied to all antennas, antenna elements, staves, etc., and summed across all carriers or frequency channels) shall not exceed the applicable output power limit specified in sections 5.4(b) and 5.4(d). However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as the sum of $10 \log$ (number of array elements or staves) plus the directional gain of the element or stave having the highest gain.
- iii. If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the applicable power limit specified in sections 5.4(b) and 5.4(d). If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the applicable limit specified in sections 5.4(b) and 5.4(d). In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the applicable limit specified in sections 5.4(b) and 5.4(d) by more than 8 dB.
- iv. Transmitters that transmit a single directional beam shall operate under the provisions of sections 5.4(b), 5.4(d) and 5.4(e).

8.3.2 Test summary

Verdict	Pass		
Tested by	Tarek Elkholly	Test date	March 17, 2022

8.3.3 Observations, settings and special notes

The test was performed as per KDB 558074, section 8.3 with reference to ANSI C63.10 subclause 11.9.2 (average power) using method AVGSA-2 (trace averaging across on- and off-times of the EUT transmissions, followed by duty cycle correction).

Spectrum analyser settings:

Resolution bandwidth	300 kHz for 20 MHz channel; 500 kHz for 40 MHz channel
Video bandwidth	$\geq 3 \times \text{RBW}$
Frequency span	40 MHz for 20 MHz channel; 80 MHz for 40 MHz channel
Detector mode	RMS
Trace mode	Power averaging

8.3.4 Test data

Table 8.3-1: Output power and EIRP results (antenna port measurement) – 802.11b

Conducted		Output power, dBm	Output power limit, dBm	Output power margin, dB	Antenna gain,		EIRP limit, dBm	EIRP margin, dB
Frequency, MHz	output power, dBm				dBi	EIRP, dBm		
2412	12.1	30.0	17.9	-4.0	13.9	36.0	22.1	
2437	11.5	30.0	18.5	-4.0	14.5	36.0	21.5	
2462	10.8	30.0	19.2	-4.0	15.2	36.0	20.8	

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

Table 8.3-2: Output power and EIRP results (antenna port measurement) – 802.11g

Conducted		Output power, dBm	Output power limit, dBm	Output power margin, dB	Antenna gain,		EIRP limit, dBm	EIRP margin, dB
Frequency, MHz	output power, dBm				dBi	EIRP, dBm		
2412	12.7	30.0	17.3	-4.0	13.3	36.0	22.7	
2437	14.8	30.0	15.2	-4.0	11.2	36.0	24.8	
2462	11.5	30.0	18.5	-4.0	14.5	36.0	21.5	

Note: The conducted output power is corrected to the relevant DCCF.

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

Table 8.3-3: Output power and EIRP results (antenna port measurement) – 802.11n VHT20

Conducted		Output power, dBm	Output power limit, dBm	Output power margin, dB	Antenna gain,		EIRP limit, dBm	EIRP margin, dB
Frequency, MHz	output power, dBm				dBi	EIRP, dBm		
2412	12.4	30.0	17.6	-4.0	13.6	36.0	22.4	
2437	14.5	30.0	15.5	-4.0	11.5	36.0	24.5	
2462	10.2	30.0	19.8	-4.0	15.8	36.0	20.2	

Note: The conducted output power is corrected to the relevant DCCF.

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

Table 8.3-4: Output power and EIRP results (antenna port measurement) – 802.11n VHT40

Conducted		Output power, dBm	Output power limit, dBm	Output power margin, dB	Antenna gain,		EIRP limit, dBm	EIRP margin, dB
Frequency, MHz	output power, dBm				dBi	EIRP, dBm		
2422	10.1	30.0	19.9	-4.0	15.9	36.0	20.1	
2437	12.5	30.0	17.5	-4.0	13.5	36.0	22.5	
2452	6.6	30.0	23.4	-4.0	19.4	36.0	16.6	

Note: The conducted output power is corrected to the relevant DCCF.

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

Test data, continued

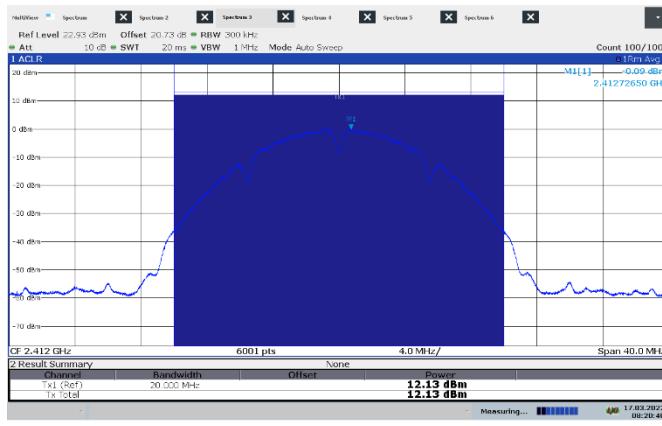


Figure 8.3-1: Sample plot, output power on low channel 802.11b

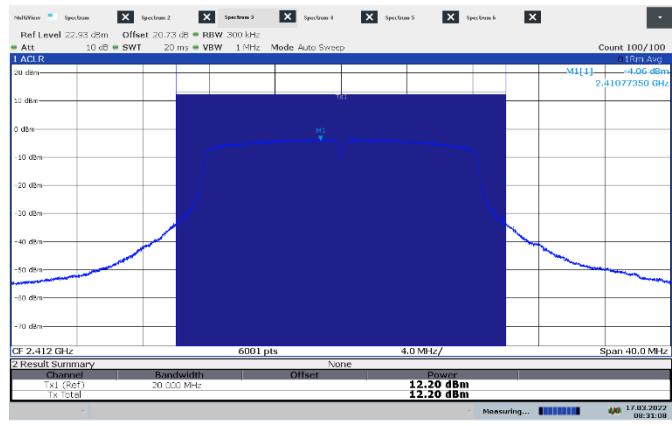


Figure 8.3-2: Sample plot, output power on mid channel 802.11g

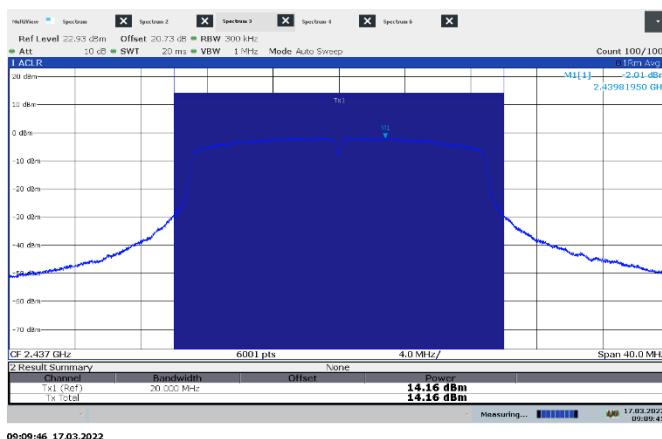


Figure 8.3-3: Sample plot, output power on low channel 802.11n VHT20

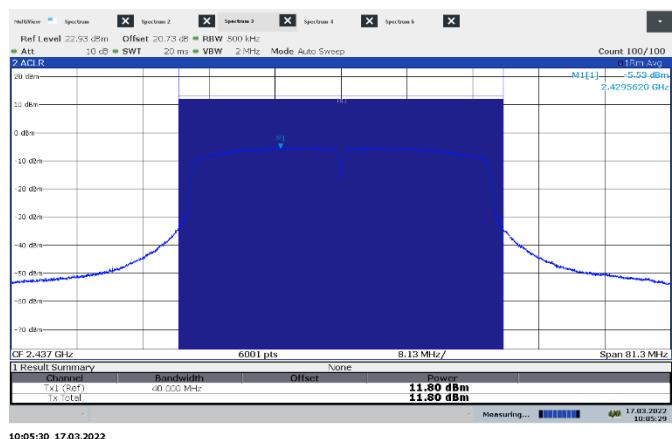


Figure 8.3-4: Sample plot, output power on mid channel 802.11n VHT40

8.4 Occupied bandwidth for DTS systems

8.4.1 References, definitions and limits

FCC §15.247:

- (a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:
- (2) Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

RSS-247, Clause 5.2:

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

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

RSS-Gen, Clause 6.7:

For the 99% emission bandwidth, the trace data points are recovered and directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached, and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded. The difference between the two recorded frequencies is the occupied bandwidth (or the 99% emission bandwidth).

8.4.2 Test summary

Verdict	Pass
Tested by	Tarek Elkholly

Test date

March 17, 2022

8.4.3 Observations, settings and special notes

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

Spectrum analyser settings:

Resolution bandwidth	99% OBW: 1–5% of OBW
Video bandwidth	$\geq 3 \times$ RBW
Frequency span	50 MHz for 20 MHz channel; 70 MHz for 40 MHz channel
Detector mode	Peak
Trace mode	Max Hold

8.4.4 Test data

Table 8.4-1: 99% occupied bandwidth results

Modulation	Frequency, MHz	99% occupied bandwidth, MHz
802.11b	2437	13.0
802.11g	2437	16.3
802.11n VHT20	2437	17.4
802.11n VHT40	2437	35.8

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

Test data, continued

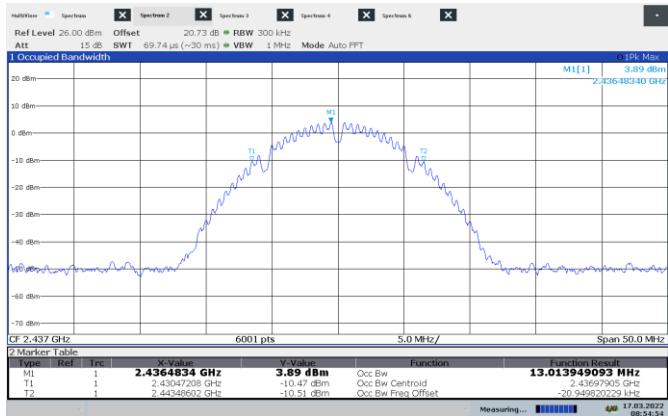


Figure 8.4-1: 99% occupied bandwidth on 802.11b, sample plot



Figure 8.4-2: 99% occupied bandwidth on 802.11g, sample plot

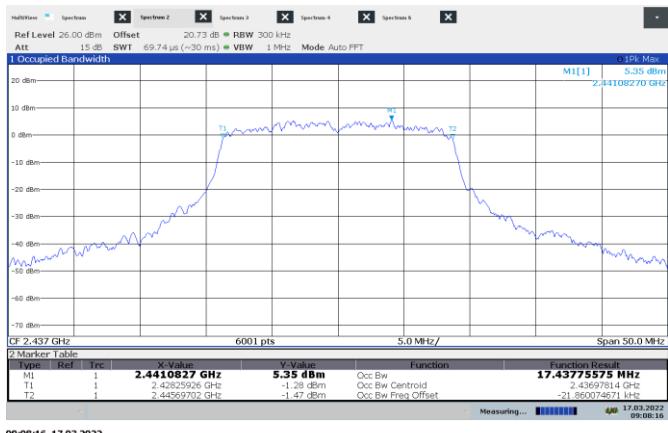


Figure 8.4-3: 99% occupied bandwidth on 802.11n VHT20, sample plot

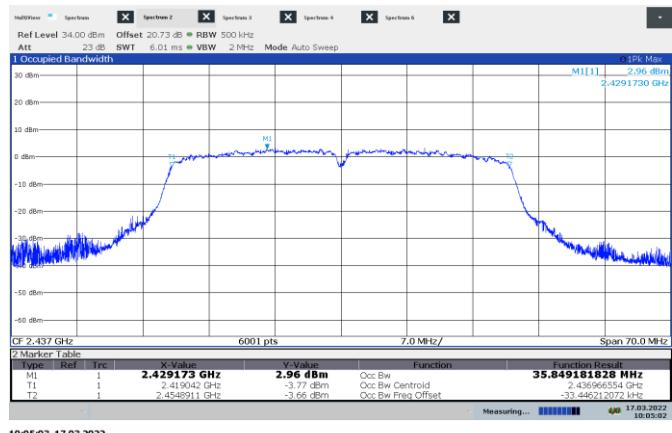


Figure 8.4-4: 99% occupied bandwidth on 802.11n VHT40, sample plot

8.5 Spurious (out-of-band) unwanted emissions

8.5.1 References, definitions and limits

FCC §15.247:

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

RSS-247, Clause 5.5:

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

Table 8.5-1: 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.

References, definitions and limits, continued

Table 8.5-2: ISED restricted frequency bands

MHz	MHz	MHz	GHz
0.090–0.110	12.57675–12.57725	399.9–410	7.25–7.75
0.495–0.505	13.36–13.41	608–614	8.025–8.5
2.1735–2.1905	16.42–16.423	960–1427	9.0–9.2
3.020–3.026	16.69475–16.69525	1435–1626.5	9.3–9.5
4.125–4.128	16.80425–16.80475	1645.5–1646.5	10.6–12.7
4.17725–4.17775	25.5–25.67	1660–1710	13.25–13.4
4.20725–4.20775	37.5–38.25	1718.8–1722.2	14.47–14.5
5.677–5.683	73–74.6	2200–2300	15.35–16.2
6.215–6.218	74.8–75.2	2310–2390	17.7–21.4
6.26775–6.26825	108–138	2483.5–2500	22.01–23.12
6.31175–6.31225	149.9–150.05	2655–2900	23.6–24.0
8.291–8.294	156.52475–156.52525	3260–3267	31.2–31.8
8.362–8.366	156.7–156.9	3332–3339	36.43–36.5
8.37625–8.38675	162.0125–167.17	3345.8–3358	
8.41425–8.41475	167.72–173.2	3500–4400	
12.29–12.293	240–285	4500–5150	Above 38.6
12.51975–12.52025	322–335.4	5350–5460	

Note: Certain frequency bands listed in Table 8.5-2 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 8.5-3: 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			

8.5.2 Test summary

Verdict	Pass		
Tested by	Tarek Elkholly	Test date	April 4, 2022

8.5.3 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.
- Radiated measurements were performed at a distance of 3 m, except for 18-26 GHz scan, it was performed at distance of 1 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 peak radiated measurements within restricted bands above 1 GHz:

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

Spectrum analyser settings for conducted spurious emissions measurements:

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

8.5.4 Test data

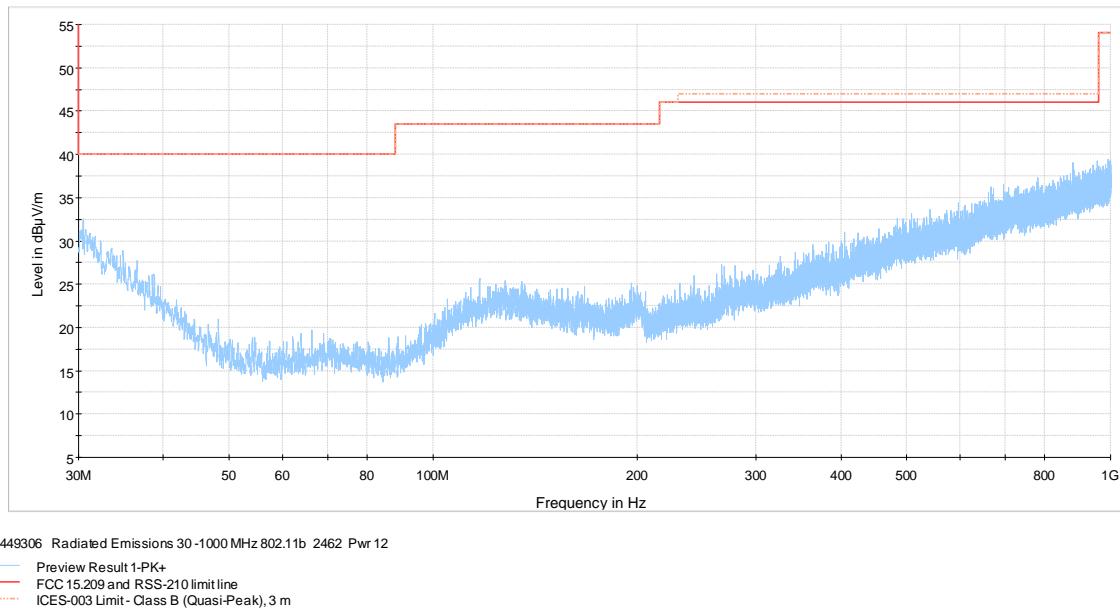


Figure 8.5-1: Sample plot, radiated spurious emissions 30-1000 MHz on 802.11b ch. 11

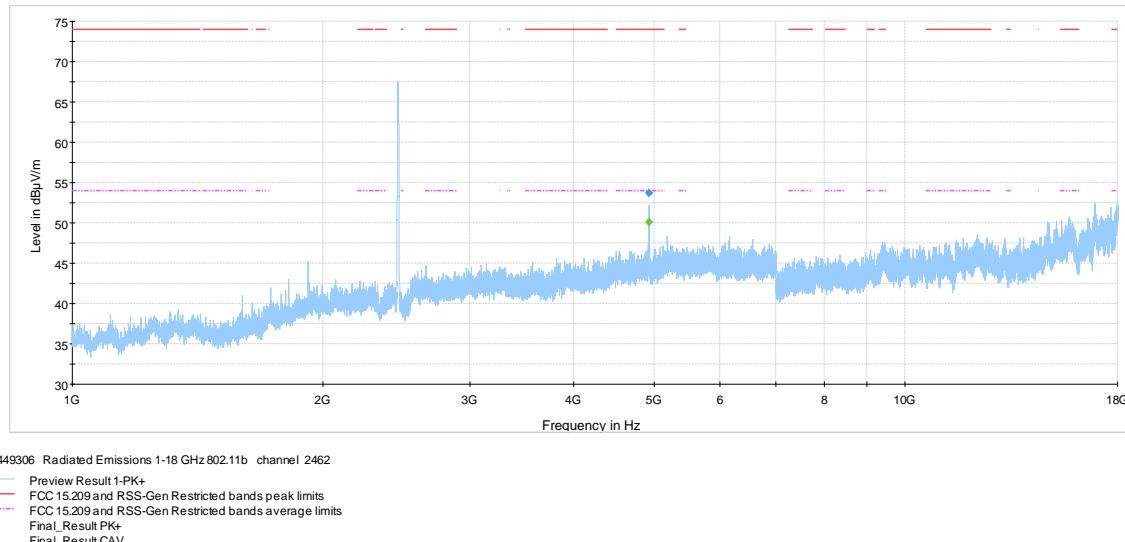
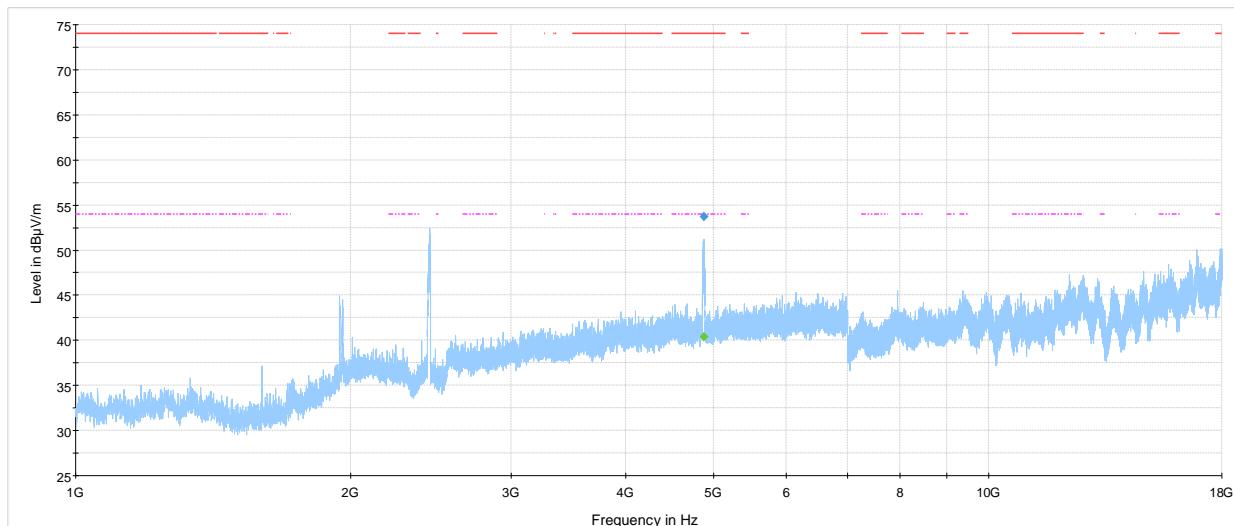


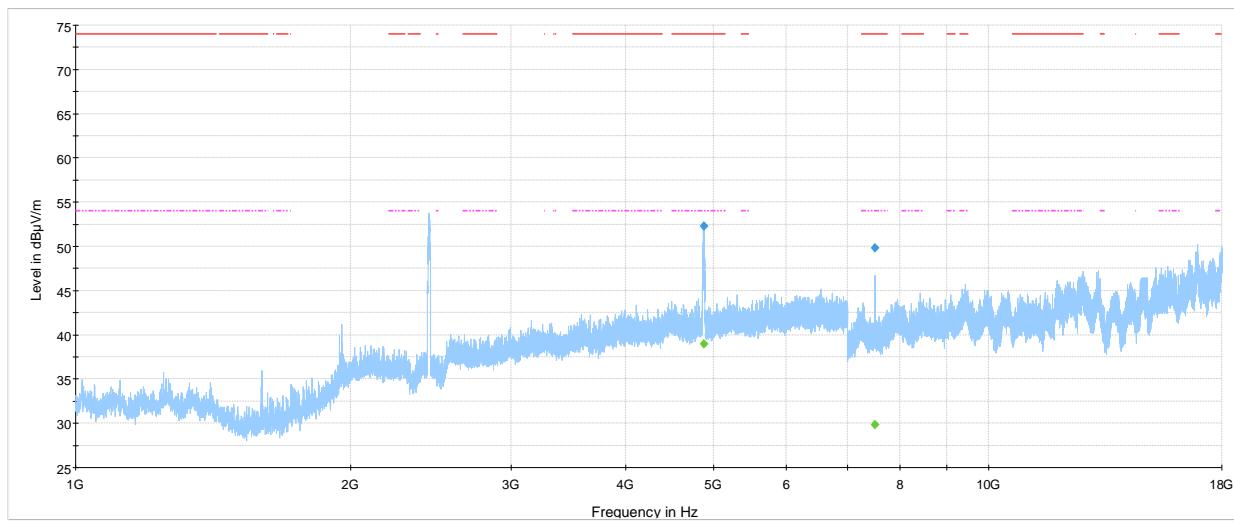
Figure 8.5-2: Sample plot, radiated spurious emissions 1-18 GHz on 802.11b ch 11

Test data, continued



NEX-449306 Radiated Emission 1-18 GHz, 802.11g channel 6
 Preview Result 1-PK+
 FCC 15.209 and RSS-Gen Restricted bands peak limits
 FCC 15.209 and RSS-Gen Restricted bands average limits
 Final_Result PK+
 Final_Result CAV

Figure 8.5-3: Sample plot, radiated spurious emissions 1-18 GHz on 802.11g ch 6



NEX-449306 Radiated Emission 1-18 GHz, 802.11n VHT20 channel 6
 Preview Result 1-PK+
 FCC 15.209 and RSS-Gen Restricted bands peak limits
 FCC 15.209 and RSS-Gen Restricted bands average limits
 Final_Result PK+
 Final_Result CAV

Figure 8.5-4: Sample plot, radiated spurious emissions 1-18 GHz on 802.11n VHT20 ch 6

Test data, continued

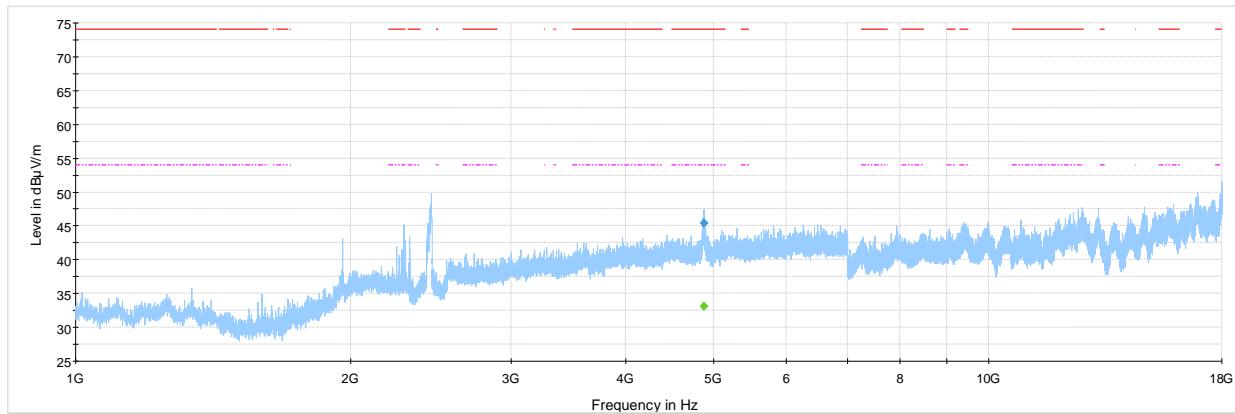


Figure 8.5-5: Sample plot, radiated spurious emissions 1-18 GHz on 802.11n VHT40 ch 6

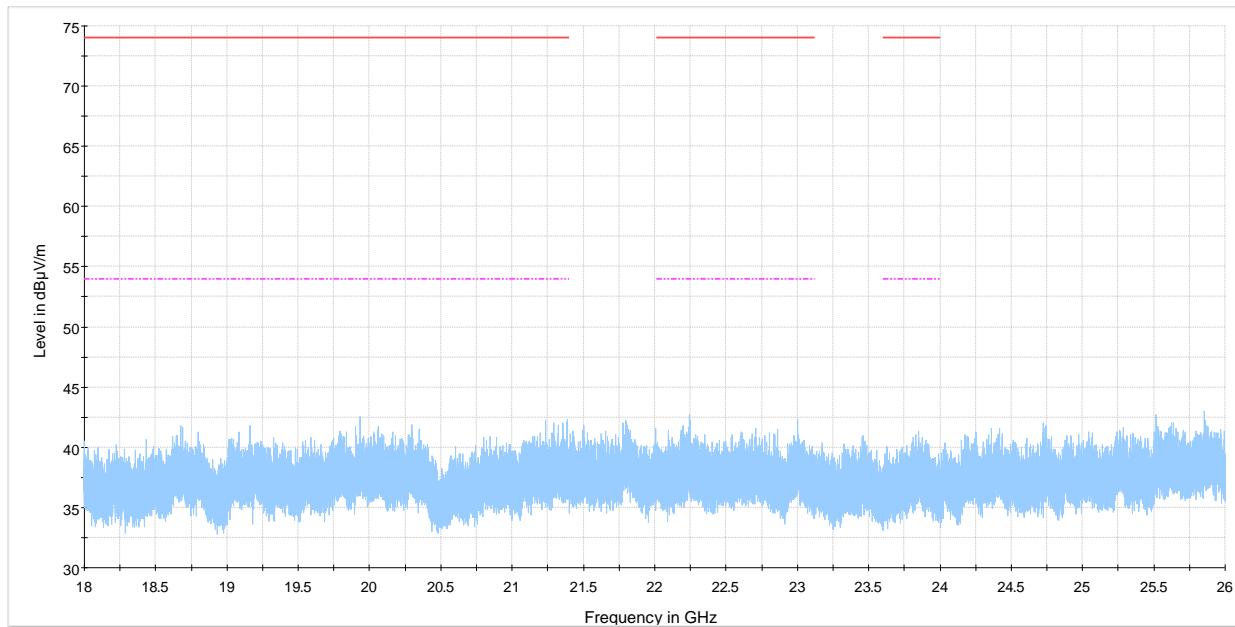
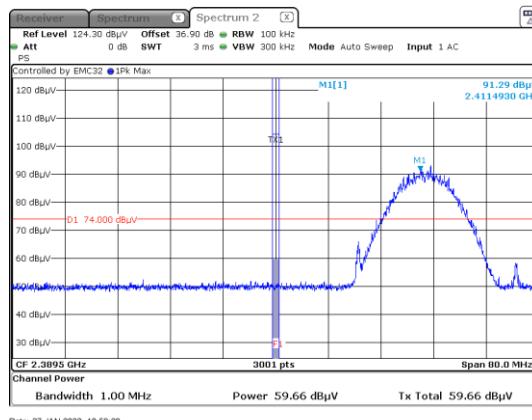


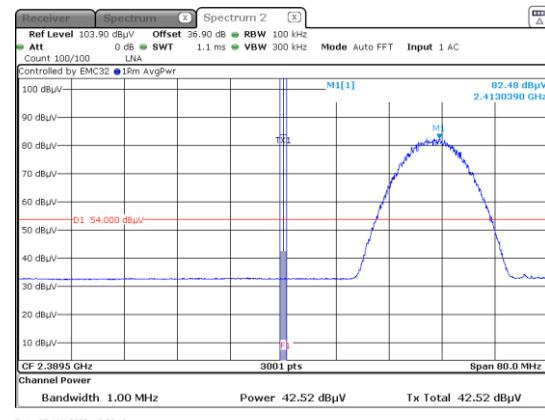
Figure 8.5-6: Sample plot, radiated spurious emissions 18-26 GHz on 802.11g ch 6

Test data, continued



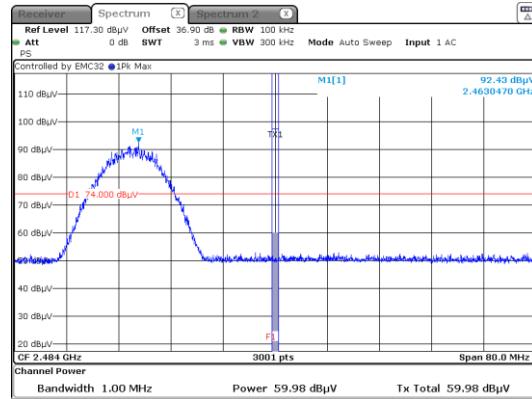
Date: 27.JAN.2022 10:59:29

Figure 8.5-7: Sample plot, radiated band edge 802.11b low ch. Peak



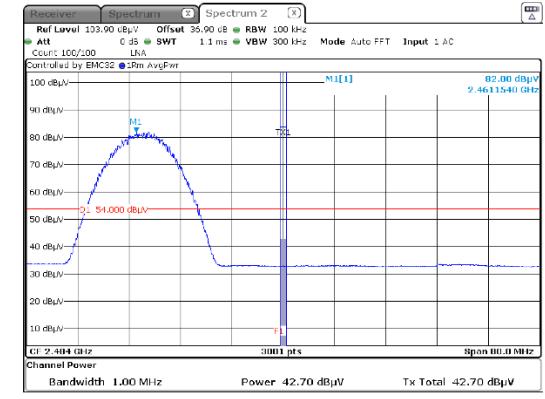
Date: 27.JAN.2022 10:58:13

Figure 8.5-8: Sample plot, radiated band edge 802.11b low ch. Average



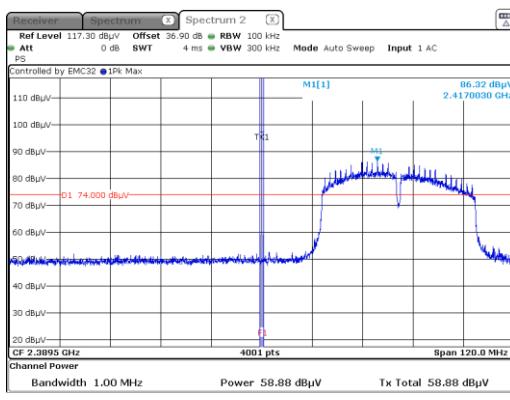
Date: 27.JAN.2022 11:52:14

Figure 8.5-9: Sample plot, radiated band edge 802.11b high ch. Peak



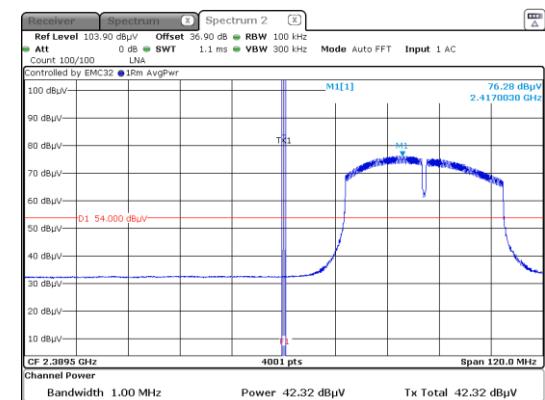
Date: 27.JAN.2022 11:00:25

Figure 8.5-10: Sample plot, radiated band edge 802.11b high ch. Average



Date: 4 APR 2022 07:51:21

Figure 8.5-11: Sample plot, radiated band edge 802.11n VHT40 low ch. Peak



Date: 4 APR 2022 07:50:49

Figure 8.5-12: Sample plot, radiated band edge 802.11n VHT40 low ch. Average

Test data, continued

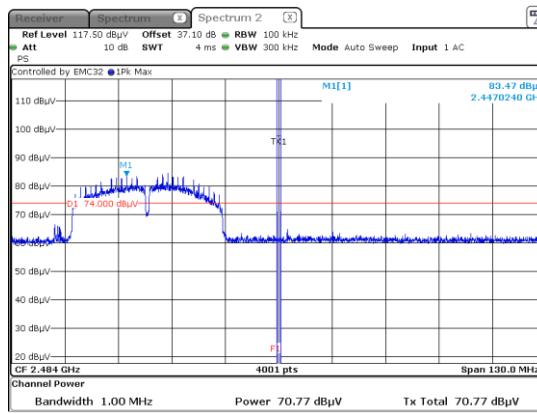


Figure 8.5-13: Sample plot, radiated band edge 802.11n VHT40 high ch. Peak

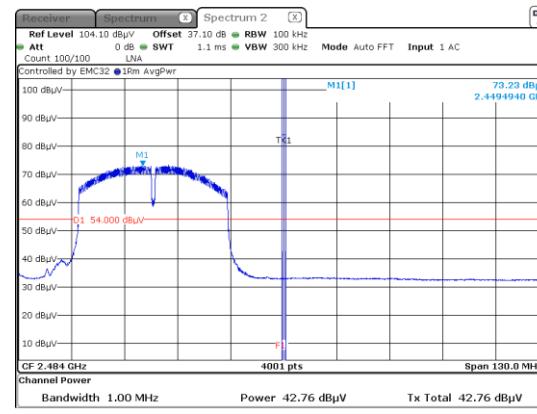


Figure 8.5-14: Sample plot, radiated band edge 802.11n VHT40 high ch. Average

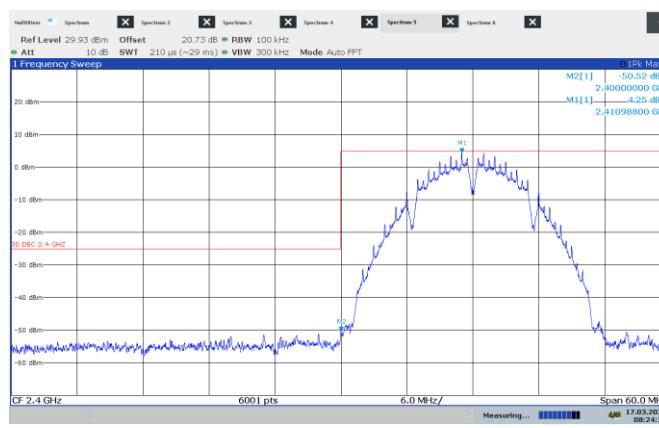


Figure 8.5-15: Sample plot, conducted band edge at non-res. bands 802.11b low ch.

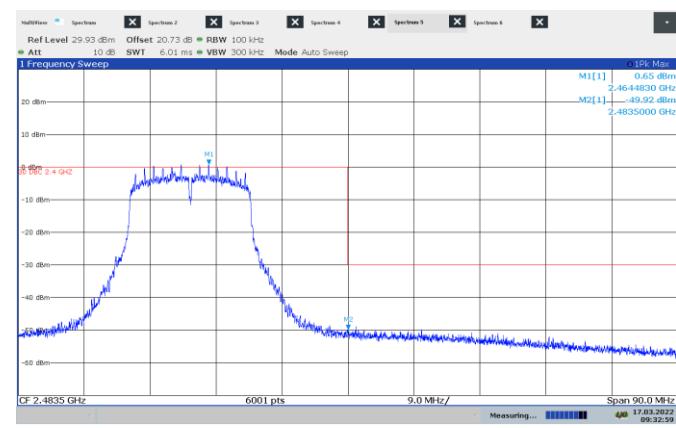


Figure 8.5-16: Sample plot, conducted band edge at non-res. bands 802.11b high ch.

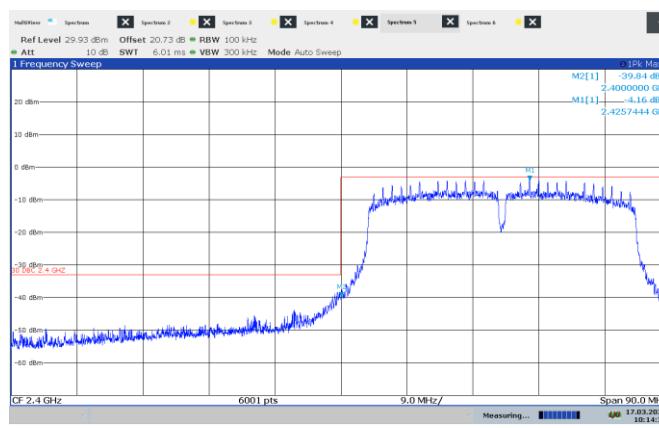


Figure 8.5-17: Sample plot, conducted band edge at non-res. bands 802.11n VHT40 low ch.

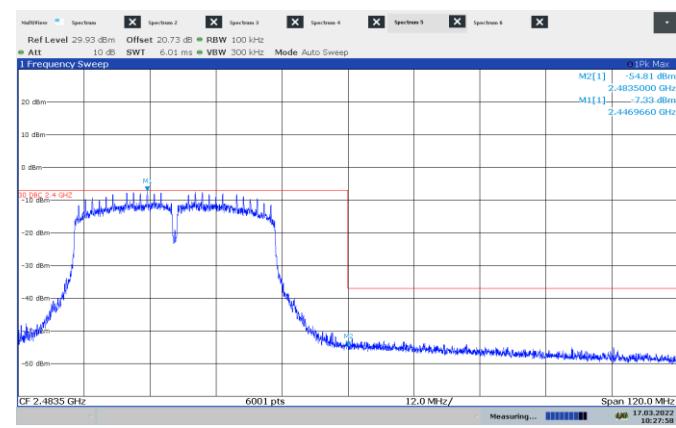


Figure 8.5-18: Sample plot, conducted band edge at non-res. bands 802.11n VHT40 high ch.

8.6 Power spectral density for digitally modulated devices

8.6.1 References, definitions and limits

FCC §15.247:

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

RSS-247, Clause 5.2:

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

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

RSS-247, Clause 5.3:

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

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

8.6.2 Test summary

Verdict	Pass		
Tested by	Tarek Elkholly	Test date	March 17, 2022

8.6.3 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-2 (trace averaging across on- and off-times of the EUT transmissions, followed by duty cycle correction). Spectrum analyser settings:

Resolution bandwidth:	3 kHz
Video bandwidth:	$\geq 3 \times \text{RBW}$
Frequency span:	1.5 times the OBW (Average)
Detector mode:	RMS
Trace mode:	Power averaging
Averaging sweeps number:	100

8.6.4 Test data

Table 8.6-1: PSD results (antenna port measurement) – 802.11b

Frequency, MHz	PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
2412	-19.2	8.0	27.2
2437	-19.9	8.0	27.9
2462	-20.0	8.0	28.0

Notes: None

Table 8.6-2: PSD results (antenna port measurement) – 802.11g

Frequency, MHz	PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
2412	-21.9	8.0	29.9
2437	-19.8	8.0	27.8
2462	-23.3	8.0	31.3

Notes: The PSD values are corrected to the relevant DCCF.

Table 8.6-3: PSD results (antenna port measurement) – 802.11n VHT20

Frequency, MHz	PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
2412	-21.3	8.0	29.3
2437	-19.3	8.0	27.3
2462	-24.1	8.0	32.1

Notes: The PSD values are corrected to the relevant DCCF.

Table 8.6-4: PSD results (antenna port measurement) – 802.11n VHT40

Frequency, MHz	PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
2422	-28.7	8.0	36.7
2437	-25.8	8.0	33.8
2452	-32.0	8.0	40.0

Notes: The PSD values are corrected to the relevant DCCF.

Test data, continued

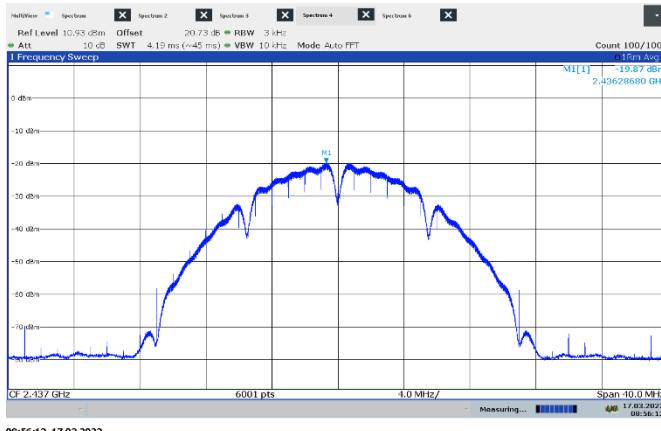


Figure 8.6-1: Sample plot, PSD on mid channel 802.11b

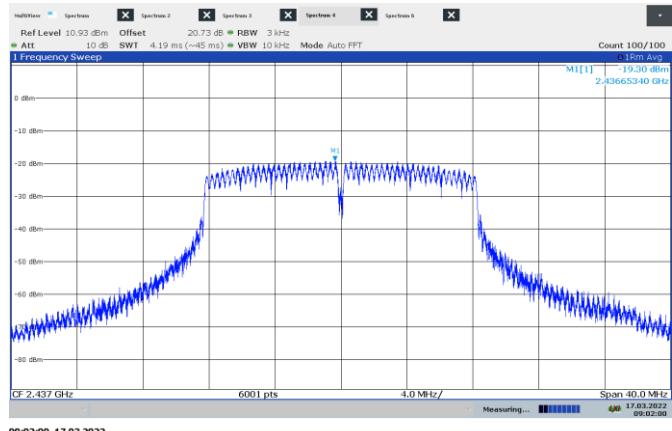


Figure 8.6-2: Sample plot, PSD on mid channel 802.11g

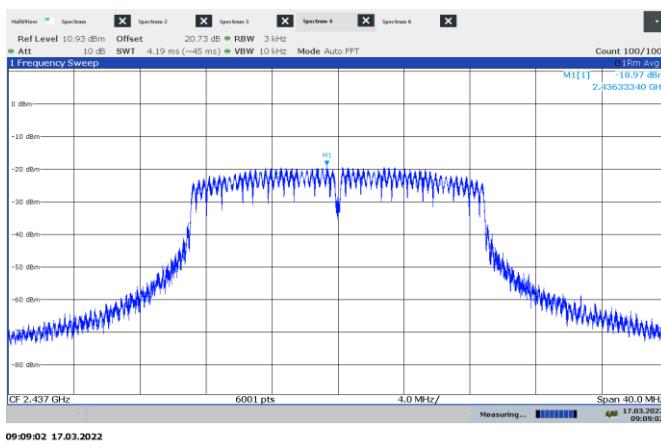


Figure 8.6-3: Sample plot, PSD on mid channel 802.11n VHT20

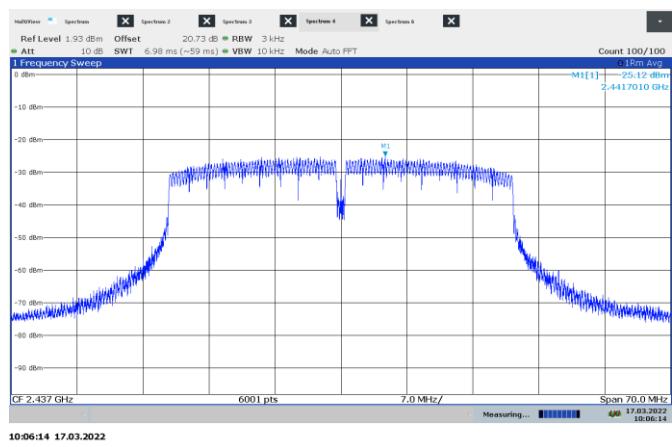


Figure 8.6-4: Sample plot, PSD on mid channel 802.11n VHT40

End of the test report