Nemko

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Wireless test report – 378820-3TRFWL

Type of assessment:

Original Certification

Applicant:

RADWIN Ltd.

Product type:

2.4 GHz Wi-Fi Module Incorporated in Television Band Device (TVBD)

Model (of TVBD):

TVWS SU INT

Model variant (of TVBD):

RW-5HA0-0PWS

FCC ID (of TVBD):

Q3K-500TVWSSU

Test standard specification:

FCC 47 CFR Part 15 Subpart C, §15.247

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

Date of issue: December 10, 2019

Andrey Adelberg, Senior EMC/Wireless Specialist

Tested by

Signature

Kevin Rose, Wireless/EMC Specialist

Reviewed by

Signature

Test location(s)

Company name	Nemko Canada Inc.
Site name	Ottawa
Address	303 River Road
City	Ottawa
Province	Ontario
Postal code	K1V 1H2
Country	Canada
Telephone	+1 613 737 9680
Facsimile	+1 613 737 9691
Toll free	+1 800 563 6336
Website	www.nemko.com
Site number (3 m SAC)	FCC: CA2040; IC: 2040A-4

Limits of responsibility

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

Copyright notification

Table of contents

Section 1. Report summary

1.1 Applicant and manufacturer

Company name	RADWIN Ltd.
Address	27 Habarzel Street
City	Tel Aviv
Province/State	–
Postal/Zip code	6971039
Country	Israel

1.2 Test specification

Code of Federal Regulations (CFR)

Title	47	Telecommunication
Chapter	I	Federal Communications Commission (FCC)
Subchapter	A	General
Part	15	Radio Frequency Devices
Subpart	C	Intentional Radiators
Paragraph	247	Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

1.3 Test methods

558074 D01 15.247 Meas Guidance v05r02 (April 2, 2019)	Guidance for compliance measurements on digital transmission system, frequency hopping spread spectrum system, and hybrid system devices operating under section 15.247 of the FCC rules.
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was performed against all relevant requirements of the test standard except as noted in section 1.5 below. Results obtained indicate that the product under test complies in full with the requirements tested. The test results relate only to the items tested.

See "Summary of test results" for full details.

1.5 Exclusions

None

1.6 Test report revision history

Revision #	Date of issue	Details of changes made to test report
TRF	December 10, 2019	Original report issued

Section 2. Summary of test results

2.1 FCC Part 15 Subpart C, general requirements test results

Table 2.1-1: *FCC general requirements results*

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

Notes: EUT is incorporated inside an AC powered device.

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

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

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

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	October 14, 2019
Nemko sample ID number	2

3.2 EUT information

Product type	2.4 GHz Wi-Fi Module Incorporated in Television Band Device (TVBD)
Model	TVWS SU INT (of TVBD)
Model variant	RW-5HA0-0PWS (of TVBD)
Serial number	Prototype

3.3 Technical information

Frequency band	2400–2483.5 MHz
Frequency Min (MHz)	2412 (for 802.11n HT20); 2422 (for 802.11n HT40)
Frequency Max (MHz)	2462 (for 802.11n HT20); 2452 (for 802.11n HT40)
RF power Max (W), Conducted	0.365 (for 802.11n HT20); 0.468 (for 802.11n HT40)
Measured BW (kHz), 6 dB BW	17615 (for 802.11n HT20); 35513 (for 802.11n HT40)
Type of modulation	802.11n HT20 and 802.11n HT40
Emission classification (F1D, G1D, D1D)	D1D
Transmitter spurious, dBµV/m @ 3 m	51.58 (average) at 2483.5 MHz
Power requirements	55 V_{DC} from PoE: 120 V_{AC} 60 Hz
Antenna information	Integrated printed antenna with 3 dBi gain

3.4 Product description and theory of operation

The 2.4 GHz Wi-Fi module incorporated in the Television Band Device (TVBD) model TVWS SU INT is a short-range transmitting device intended for configuration and commission of the TVBD prior to the establishment of an operational link. The configuration is processed via WINTouch smartphone application.

3.5 EUT exercise details

The EUT power input is provided from the TVBD which is powered from the 55 VDC PoE Power Supply. During the tests a laptop was used to connect to the EUT and configure the device to transmit continuously with the desired modulation and power. All conducted measurements were performed on the SISO TX chain. The EUT was tested with the appropriate antennas for spurious and conducted emissions to ensure the enclosure variation did not have impact.

3.6 EUT setup diagram

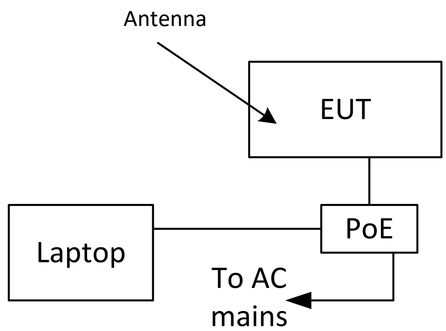


Figure 3.6-1: *Setup diagram*

Section 4. Engineering considerations

4.1 Modifications incorporated in the EUT

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

4.2 Technical judgment

None

4.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 5. Test conditions

5.1 Atmospheric conditions

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

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

5.2 Power supply range

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

Section 6. Measurement uncertainty

6.1 Uncertainty of measurement

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

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

Table 6.1-1: *Measurement uncertainty*

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

Section 7. Test equipment

7.1 Test equipment list

Table 7.1-1: *Equipment list*

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
3 m EMI test chamber	TDK	SAC-3	FA002047	1 year	January 24, 2020
Flush mount turntable	Sunol	FM2022	FA002082	—	NCR
Controller	Sunol	SC104V	FA002060	—	NCR
Antenna mast	Sunol	TLT2	FA002061	—	NCR
61505 AC source	Chroma	61509	FA003036	—	VOU
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 26	FA002043	1 year	May 8, 2020
Spectrum analyzer	Rohde & Schwarz	FSU	FA001877	1 year	October 31, 2020
Horn (1–18 GHz)	ETS Lindgren	3117	FA002840	1 year	January 16, 2020
Preamp (1–18 GHz)	ETS Lindgren	124334	FA002873	1 year	November 4, 2020
Bilog antenna (20–3000 MHz)	Sunol	JB3	FA002108	1 year	January 3, 2020
Horn antenna (1–18 GHz)	EMCO	3115	FA000825	1 year	October 31, 2020
LISN	Rohde & Schwarz	ENV216	FA002515	1 year	July 18, 2020
Horn antenna (18–40 GHz)	EMCO	3116	FA001847	1 year	November 7, 2020
Pre-amplifier (18–26 GHz)	Narda	BBS-1826N612	FA001550	—	VOU

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 Definitions and limits

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

8.1.2 Test date

Start date	November 18, 2019

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.

EUT input is provided from the TVBD which is powered from the 55 Vdc PoE 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) Number of frequencies

8.2.1 Definitions and limits

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.

Table 8.2-1: *Frequency Range of Operation*

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

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

8.2.2 Test date

Start date	November 18, 2019

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 for 802.11n HT20*

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 8.2-3: *Test channels selection for 802.11n HT40*

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

8.3 FCC 15.203 Antenna requirement

8.3.1 Definitions and limits

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.

8.3.2 Test date

Start date	November 18, 2019

8.3.3 Observations, settings and special notes

None

8.3.4 Test data

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

8.4 FCC 15.207(a) AC power line conducted emissions limits

8.4.1 Definitions and limits

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.

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 date

Start date	November 19, 2019

8.4.3 Observations, settings and special notes

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.

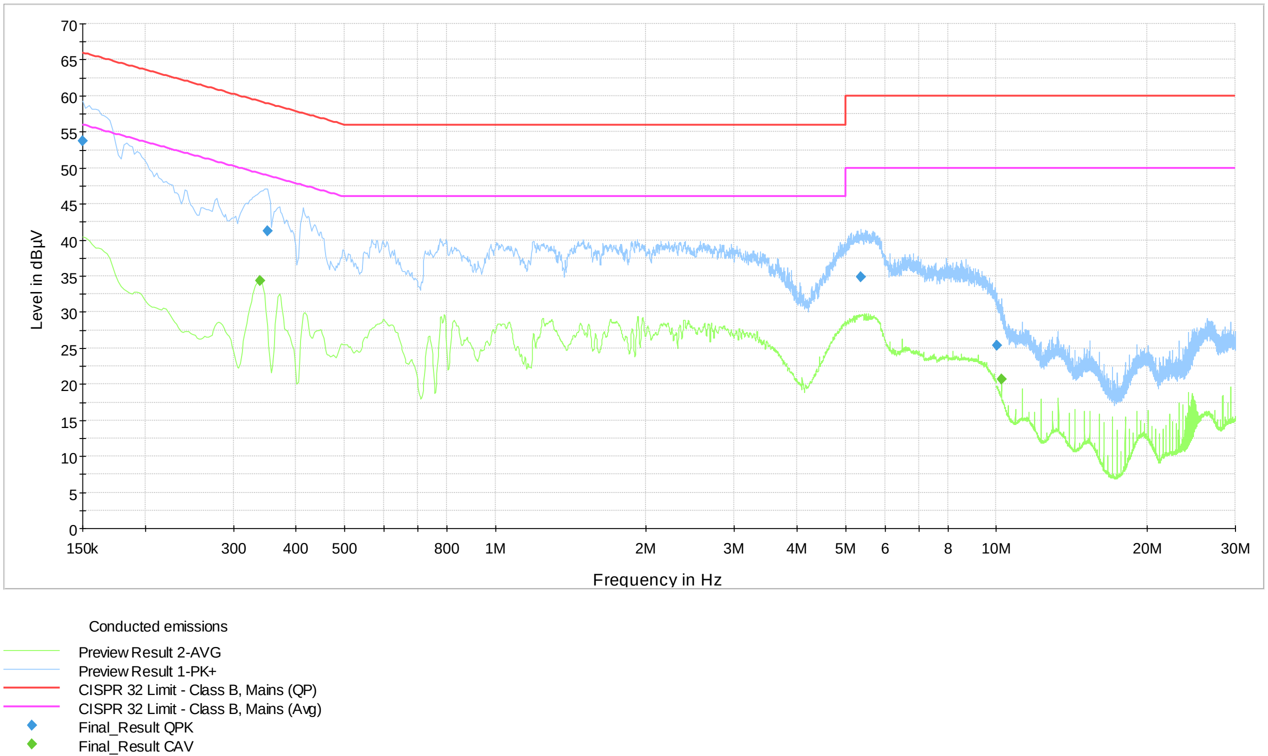
Receiver settings for preview measurements:

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



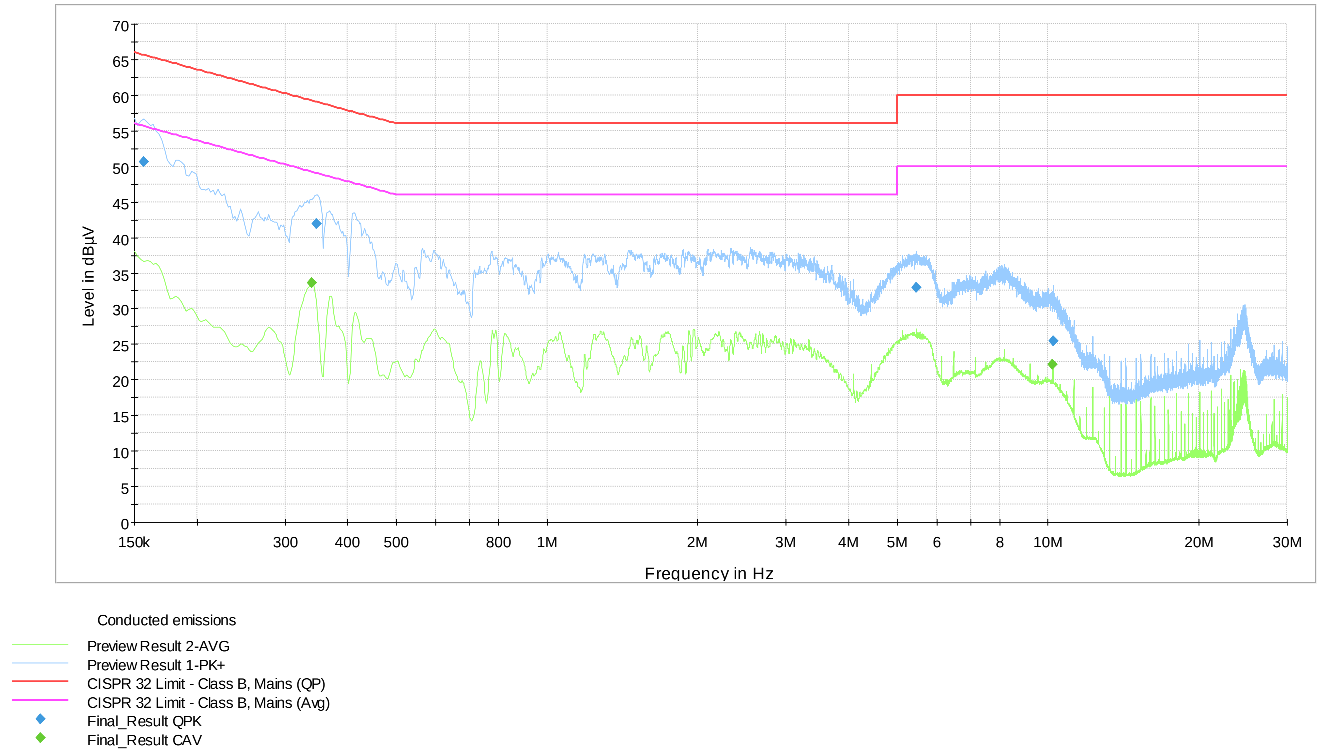
Plot 8.4-1: *Conducted emissions on phase line*

Table 8.4-2: *Quasi-peak measurement results for phase line*

Frequency, MHz	Quasi-Peak, dBµV/m	Quasi-Peak limit, dBµV/m	Margin, dB	Correction factor, dB
0.156750	50.59	65.63	15.04	9.90
0.345750	41.95	59.06	17.11	9.90
5.451000	32.97	60.00	27.03	10.10
10.227250	25.40	60.00	34.60	10.50

Table 8.4-3: *Average measurement results for phase line*

Frequency, MHz	Average, dBµV/m	Average limit, dBµV/m	Margin, dB	Correction factor, dB
0.339000	34.38	49.23	14.85	9.90
10.229500	20.69	50.00	29.31	10.50



Plot 8.4-2: *Conducted emissions on neutral line*

Table 8.4-4: *Quasi-peak measurement results for neutral line*

Frequency, MHz	Quasi-Peak, dBµV/m	Quasi-Peak limit, dBµV/m	Margin, dB	Correction factor, dB
0.156750	50.59	65.63	15.04	9.90
0.345750	41.95	59.06	17.11	9.90
5.451000	32.97	60.00	27.03	10.10
10.227250	25.40	60.00	34.60	10.50

Table 8.4-5: *Average measurement results for neutral line*

Frequency, MHz	Average, dBµV/m	Average limit, dBµV/m	Margin, dB	Correction factor, dB
0.339000	33.62	49.23	15.61	9.90
10.222750	22.13	50.00	27.87	10.50

8.5 FCC 15.247(a)(2) Minimum 6 dB bandwidth for DTS systems

8.5.1 Definitions and limits

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.

8.5.1 Test date

Start date	November 18, 2019

8.5.2 Observations, settings and special notes

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

Resolution bandwidth	100 kHz
Video bandwidth	≥3 × RBW
Frequency span	40 MHz for 20 MHz channel; 80 MHz for 40 MHz channel
Detector mode	Peak
Trace mode	Max Hold

8.5.3 Test data

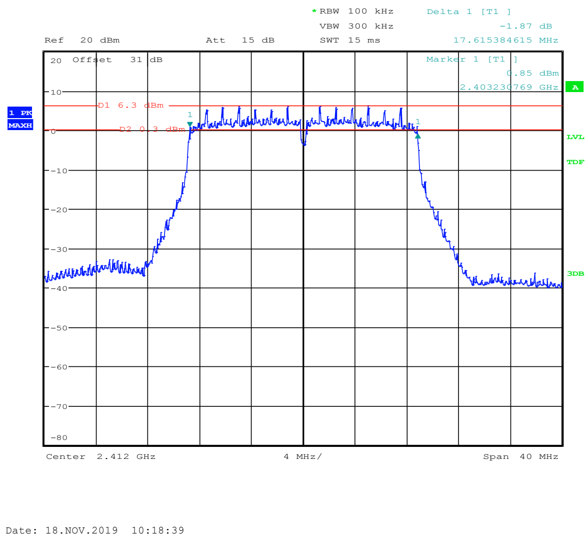
Table 8.5-1: *6 dB bandwidth results*

Modulation	Frequency, MHz	6 dB bandwidth, MHz	Minimum limit, MHz	Margin, MHz
802.11n HT20	2412	17.615	0.500	17.115
	2437	17.564	0.500	17.064
	2462	17.590	0.500	17.090
802.11n HT40	2422	35.128	0.500	34.628
	2437	35.513	0.500	35.013
	2452	35.513	0.500	35.013

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

Modulation	Frequency, MHz	99% occupied bandwidth, kHz
802.11n HT20	2412	17.564
	2437	17.564
	2462	17.564
802.11n HT40	2422	35.897
	2437	35.897
	2452	35.897

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



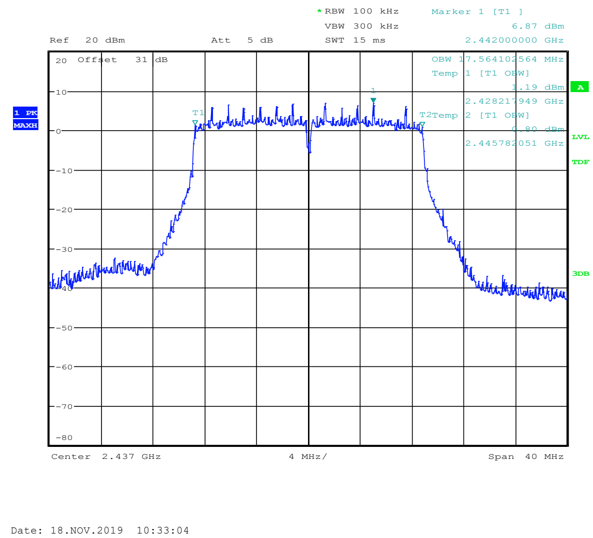
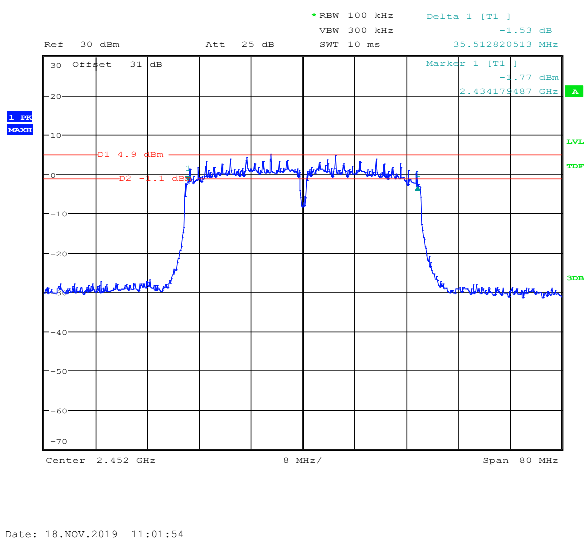


Figure 8.5-1: *6 dB bandwidth on 802.11n HT20, sample plot*

Figure 8.5-2: *6 dB bandwidth on 802.11n HT40, sample plot*



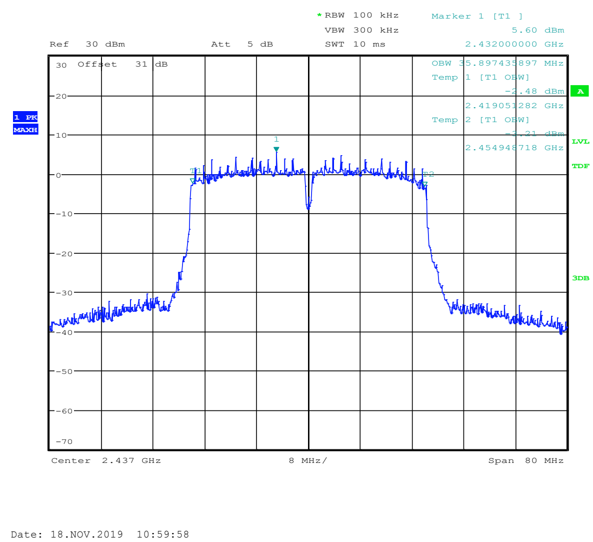


Figure 8.5-3: *99% occupied bandwidth on 802.11n HT20, sample plot*

Figure 8.5-4: *99% occupied bandwidth on 802.11n HT40, sample plot*

8.6 FCC 15.247(b) Transmitter output power and e.i.r.p. requirements for DTS in 2 GHz

8.6.1 Definitions and limits

(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.

8.6.1 Test date

Start date	November 18, 2019

8.6.2 Observations, settings and special notes

The test was performed as per KDB 558074, section 8.3 with reference to ANSI C63.10 subclause 11.9.1 (peak power)
The test was performed using method RBW≥DTS bandwidth (Maximum peak conducted output power)
Spectrum analyser settings:

Resolution bandwidth	1 MHz (integration over 20 MHz and 40 MHz Tx channel)
Video bandwidth	≥3 × RBW
Frequency span	40 MHz for 20 MHz channel; 80 MHz for 40 MHz channel
Detector mode	Peak
Trace mode	Max-hold

8.6.3 Test data

Table 8.6-1: *Output power measurements results for 802.11n TH20*

Frequency, MHz	Conducted output power, dBm		Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
	Measured	Limit					
2412	25.43	30.00	4.57	3.00	28.43	36.00	7.57
2437	25.62	30.00	4.38	3.00	28.62	36.00	7.38
2462	25.03	30.00	4.97	3.00	28.03	36.00	7.97

Table 8.6-2: *Output power measurements results for 802.11n TH40*

Frequency, MHz	Conducted output power, dBm		Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
	Measured	Limit					
2422	26.70	30.00	3.30	3.00	29.70	36.00	6.30
2437	26.67	30.00	3.33	3.00	29.67	36.00	6.33
2452	26.54	30.00	3.46	3.00	29.54	36.00	6.46

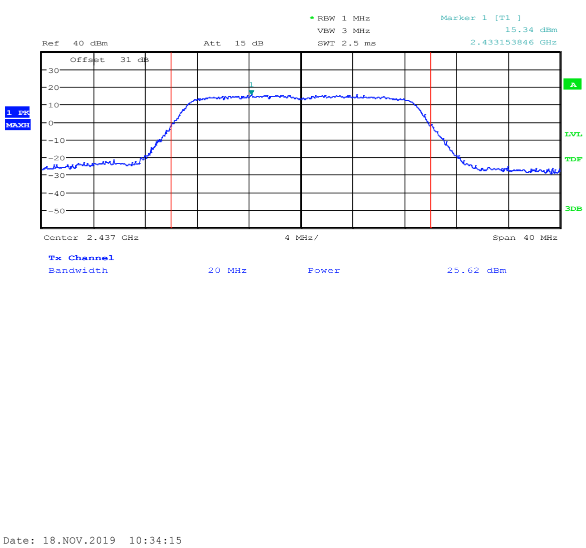


Figure 8.6-1: *Output power on 802.11n HT20, sample plot*

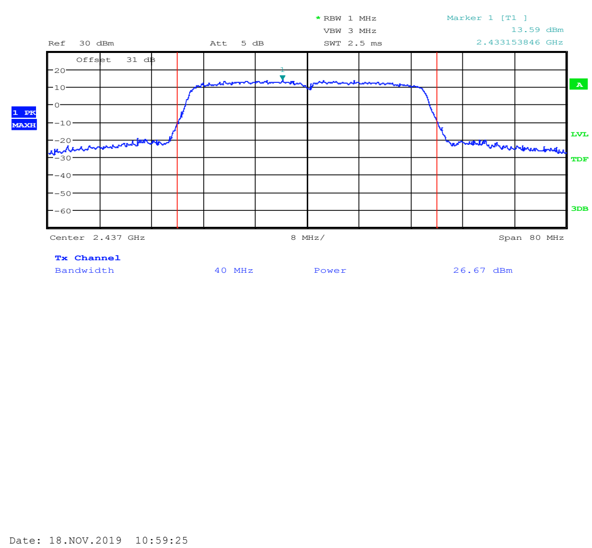


Figure 8.6-2: *Output power on 802.11n HT40, sample plot*

8.7 FCC 15.247(d) Spurious (out-of-band) unwanted emissions

8.7.1 Definitions and limits

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)).

Table 8.7-1: *FCC §15.209 – 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: *FCC §15.205 - restricted frequency bands*

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
0.495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2690–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	Above 38.6
13.36–13.41			

8.7.1 Test date

Start date	November 18, 2019

8.7.2 Observations, settings and special notes

The spectrum was searched from 30 MHz to the 10th harmonic.
EUT was set to transmit with 100 % duty cycle.
Radiated measurements were performed at a distance of 3 m.
DTS emissions in non-restricted frequency bands test was performed as per KDB 558074, section 8.5 with reference to ANSI C63.10 subclause 11.11.
Since fundamental power was tested using the maximum peak conducted output power procedure to demonstrate compliance, the spurious emissions limit is −20 dBc/100 kHz.
DTS emissions in restricted frequency bands test was performed as per KDB 558074, section 8.6 with reference to ANSI C63.10 subclause 11.12.
DTS band-edge emission measurements test was performed as per KDB 558074, section 8.7 with reference to ANSI C63.10 subclause 11.13.

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

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

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

Resolution bandwidth:	1 MHz (Peak); 1 MHz (Average)
Video bandwidth:	3 MHz (Peak); 10 Hz (Average)
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 8.7-3: *Radiated field strength measurement results for 802.11n HT20*

Channel	Frequency, MHz	Peak Field strength, dBμV/m		Margin, dB	Average Field strength, dBμV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2390.0	55.43	74.00	18.57	48.43	54.00	5.57
Low	4824.0	49.38	74.00	24.62	49.38	54.00	4.62
Mid	4874.0	49.62	74.00	24.38	49.62	54.00	4.38
High	2483.5	50.94	74.00	23.06	39.85	54.00	14.15
High	4924.0	49.74	74.00	24.26	49.74	54.00	4.26

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

Table 8.7-4: *Radiated field strength measurement results for 802.11n HT40*

Channel	Frequency, MHz	Peak Field strength, dBμV/m		Margin, dB	Average Field strength, dBμV/m		Margin, dB
		Measured	Limit		Measured	Limit	
Low	2390.0	61.10	74.00	12.90	51.58	54.00	2.42
Low	4824.0	46.77	74.00	27.23	46.77	54.00	7.23
Mid	2390.0	59.14	74.00	14.86	50.03	54.00	3.97
Mid	4874.0	47.29	74.00	26.71	47.29	54.00	6.71
High	2483.5	57.95	74.00	16.05	46.14	54.00	7.86
High	4904.0	47.55	74.00	26.45	47.55	54.00	6.45

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

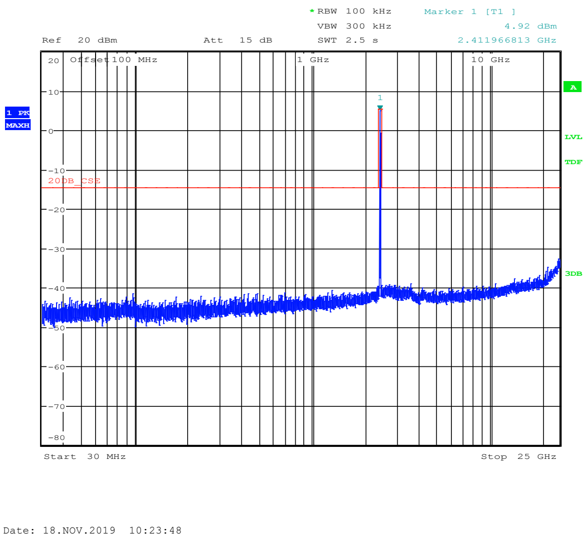


Figure 8.7-1: *Conducted spurious emissions for 802.11n HT20, low channel*

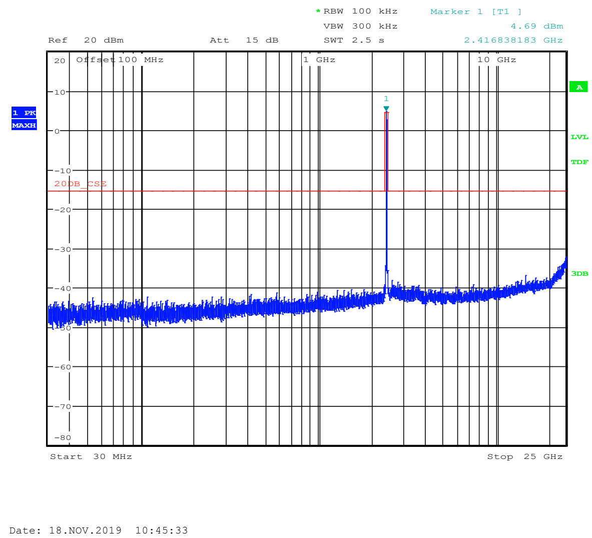


Figure 8.7-2: *Conducted spurious emissions for 802.11n HT40, low channel*

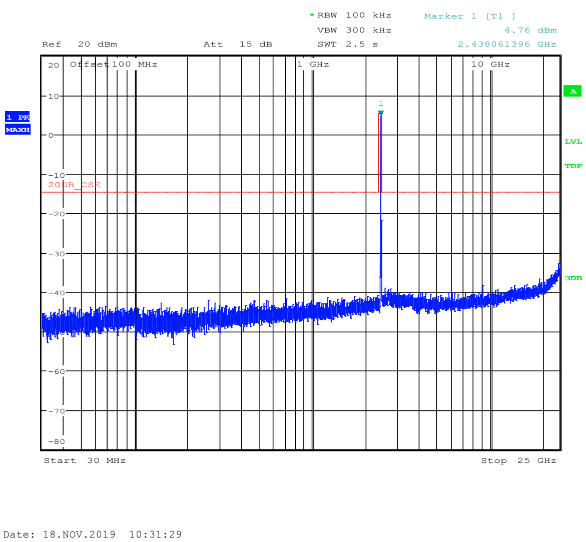


Figure 8.7-3: *Conducted spurious emissions for 802.11n HT20, mid channel*

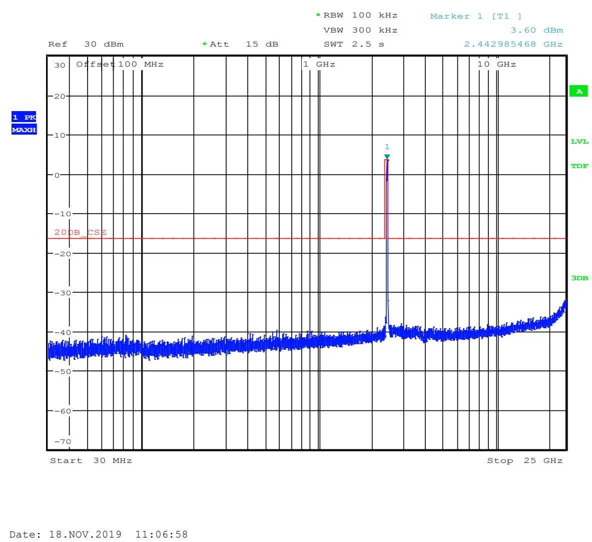


Figure 8.7-4: *Conducted spurious emissions for 802.11n HT40, mid channel*

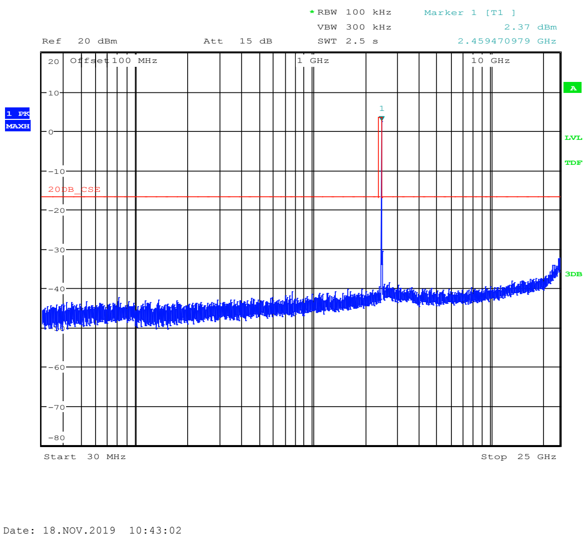


Figure 8.7-5: *Conducted spurious emissions for 802.11n HT20, high channel*

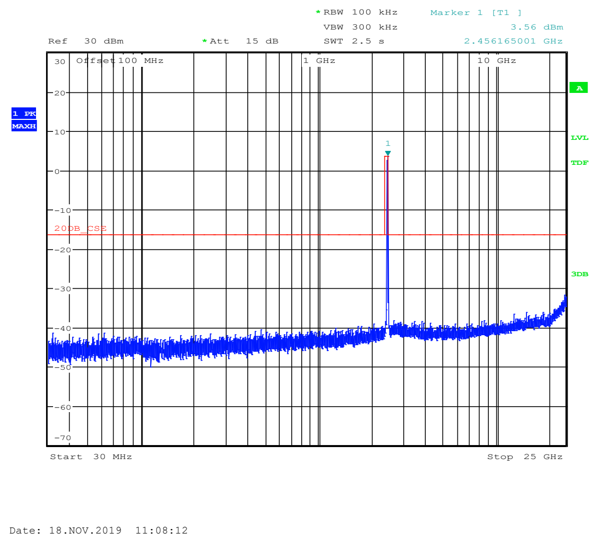


Figure 8.7-6: *Conducted spurious emissions for 802.11n HT40, high channel*

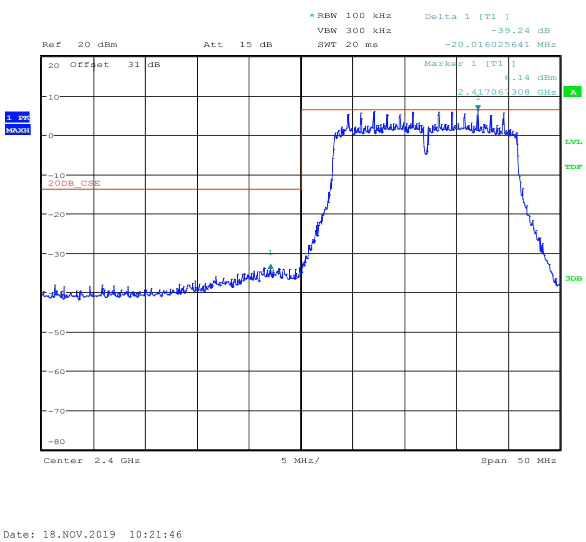


Figure 8.7-7: *Conducted spurious emissions for 802.11n HT20, lower band edge*

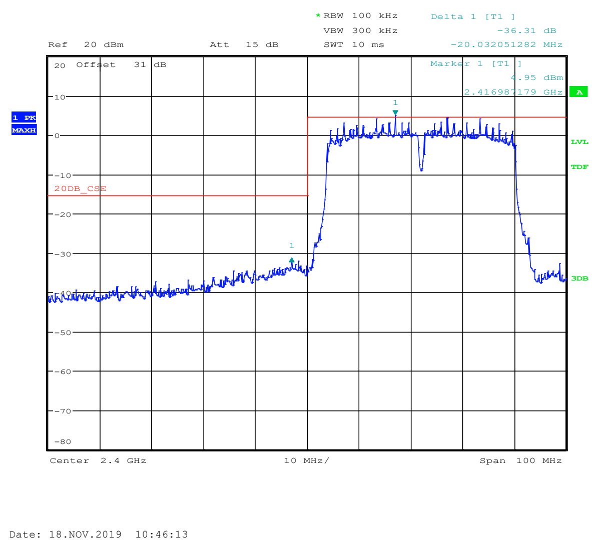


Figure 8.7-8: *Conducted spurious emissions for 802.11n HT40, lower band edge*

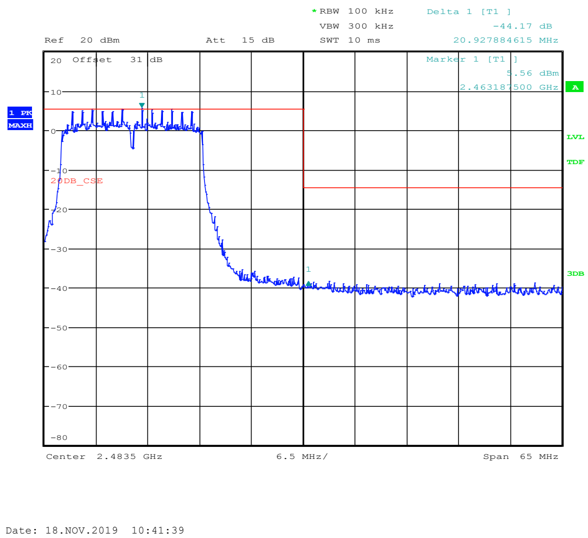


Figure 8.7-9: *Conducted spurious emissions for 802.11n HT20, upper band edge*

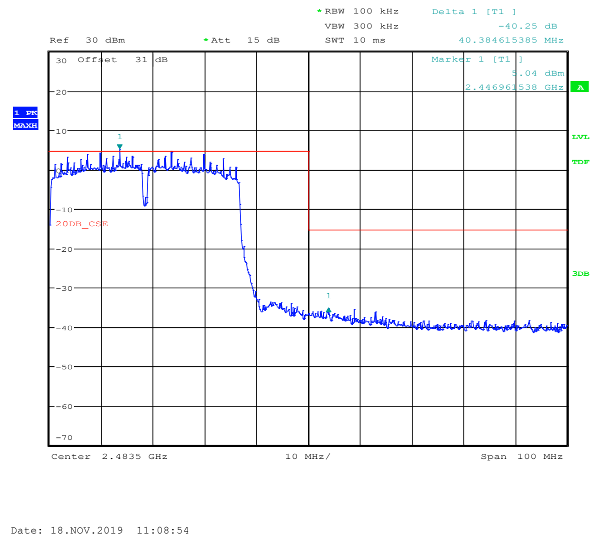


Figure 8.7-10: *Conducted spurious emissions for 802.11n HT40, upper band edge*

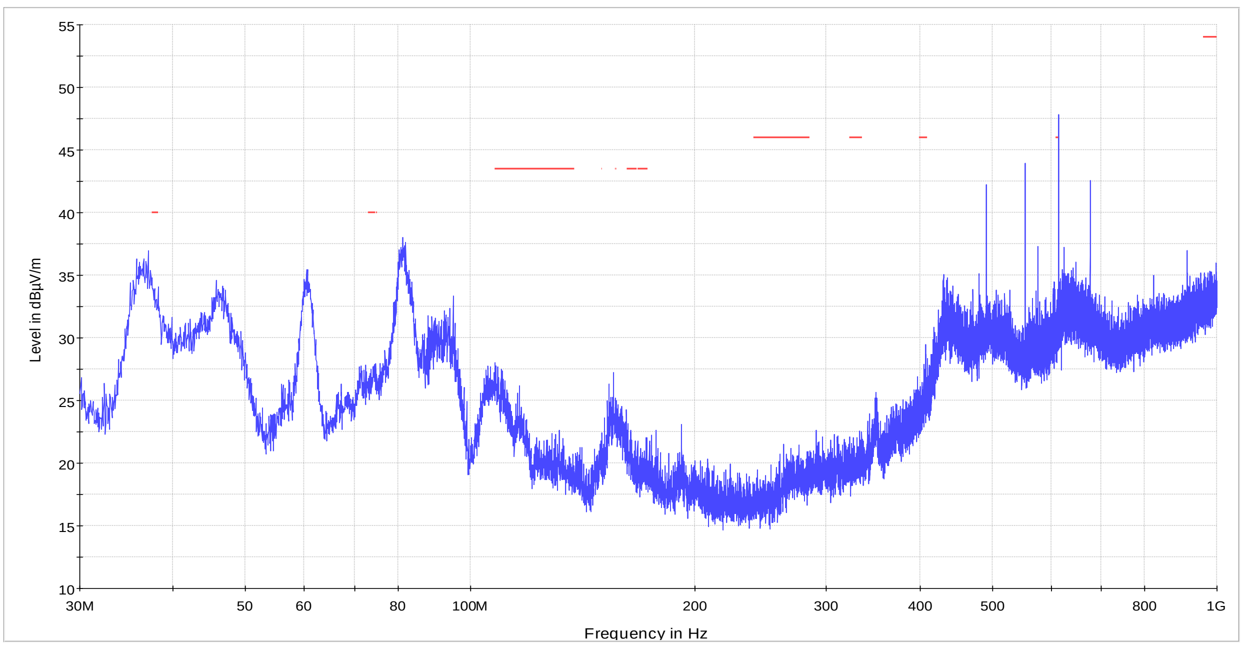


Figure 8.7-11: *Radiated spurious emissions below 1 GHz for low channel*

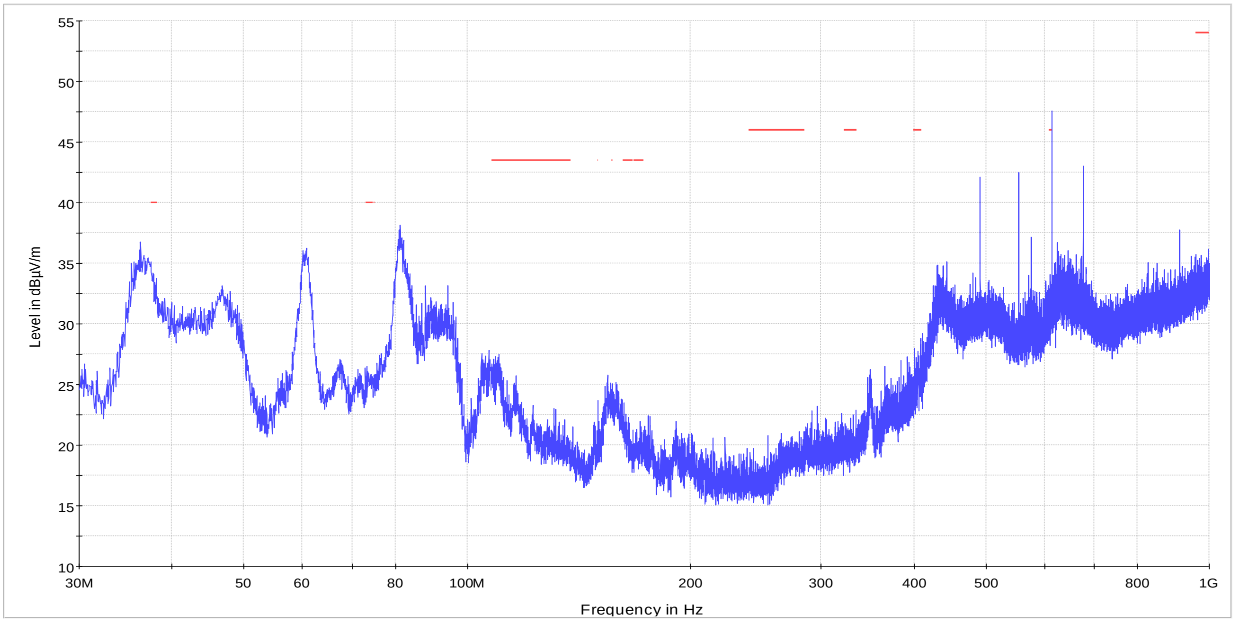


Figure 8.7-12: *Radiated spurious emissions below 1 GHz for mid channel*

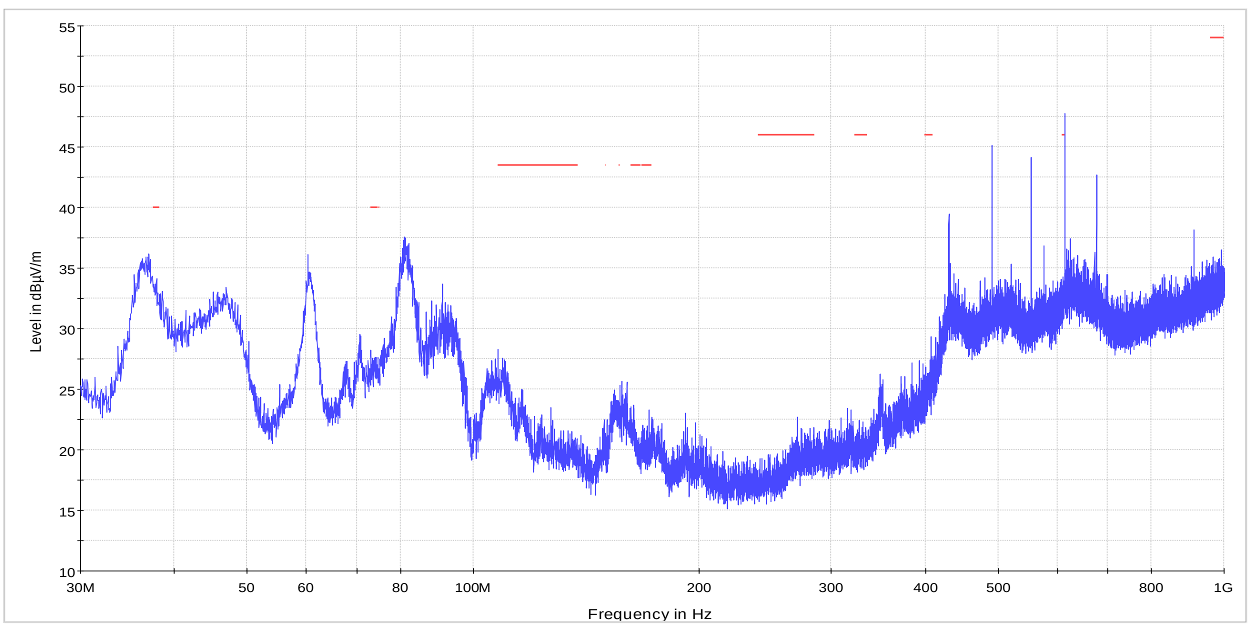


Figure 8.7-13: *Radiated spurious emissions below 1 GHz for mid channel*

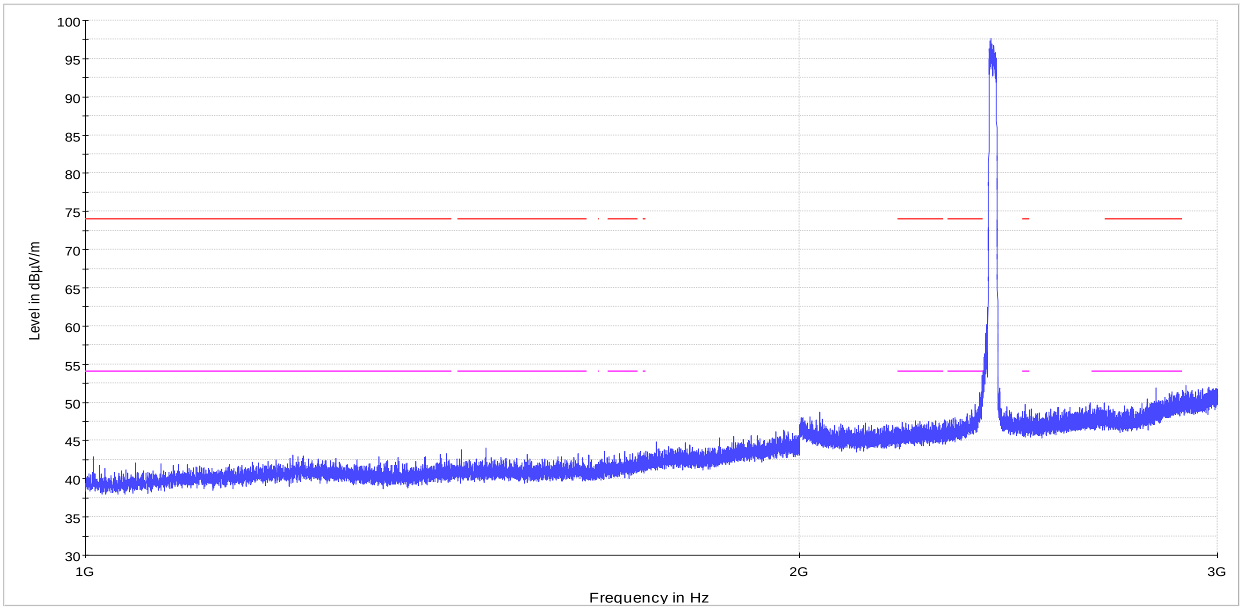


Figure 8.7-14: *Radiated spurious emissions within 1–3 GHz for low 20 MHz channel*

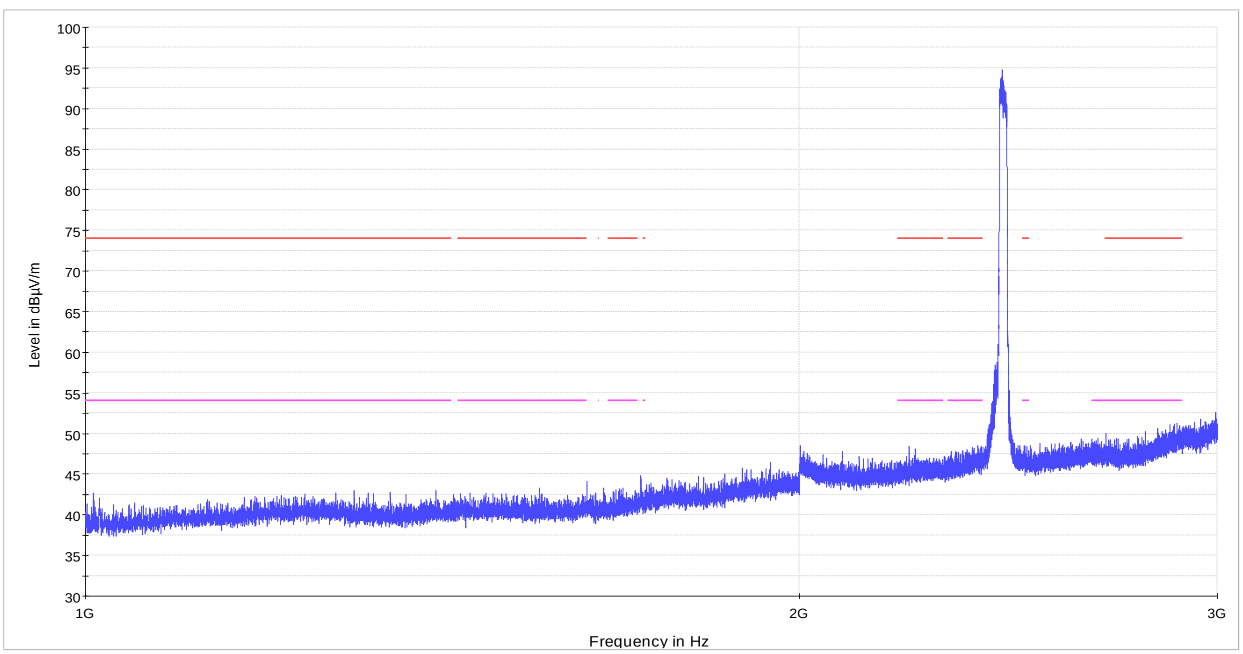


Figure 8.7-15: *Radiated spurious emissions within 1–3 GHz for mid 20 MHz channel*

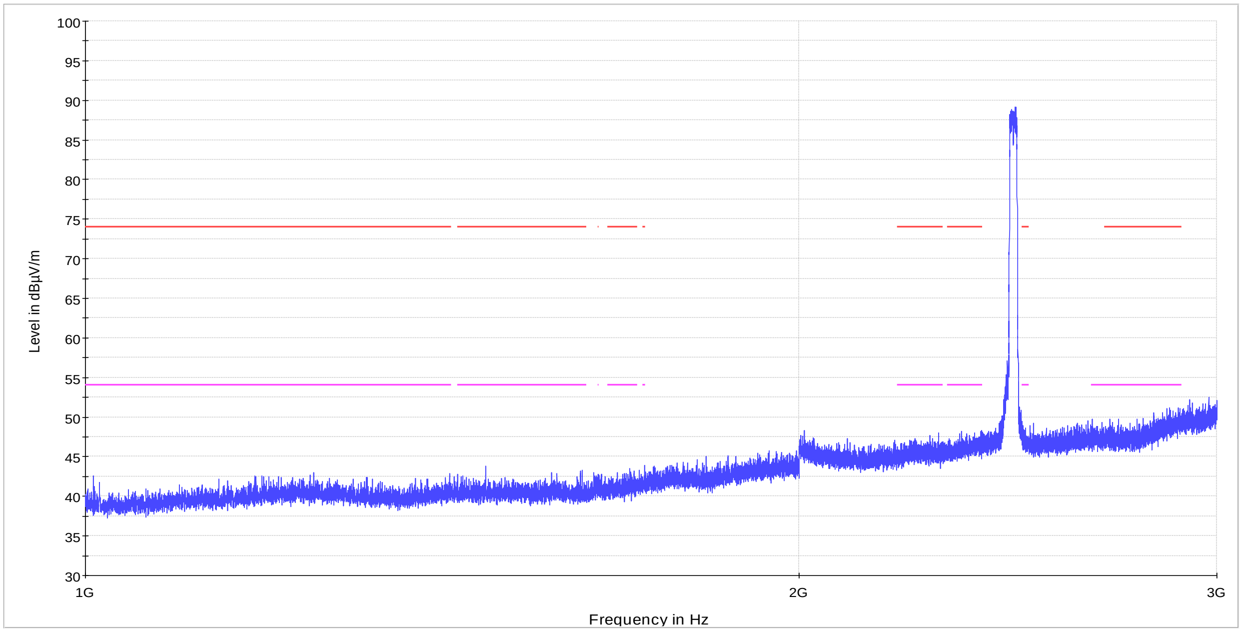


Figure 8.7-16: *Radiated spurious emissions within 1–3 GHz for high 20 MHz channel*

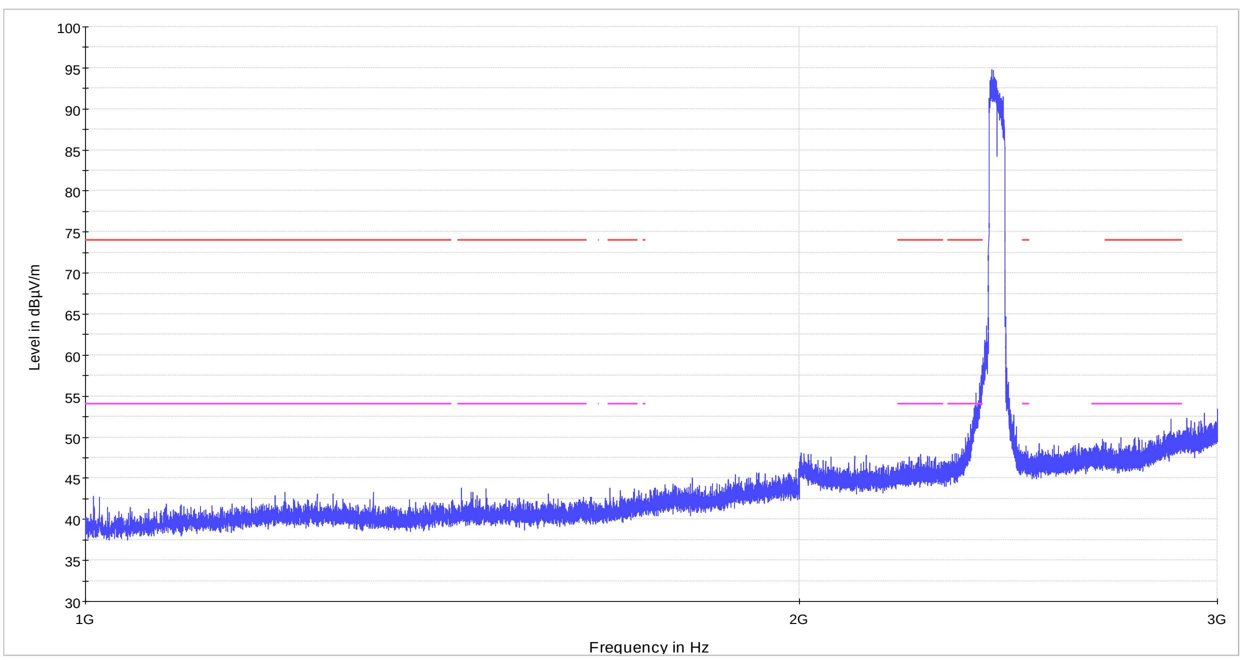


Figure 8.7-17: *Radiated spurious emissions within 1–3 GHz for low 40 MHz channel*

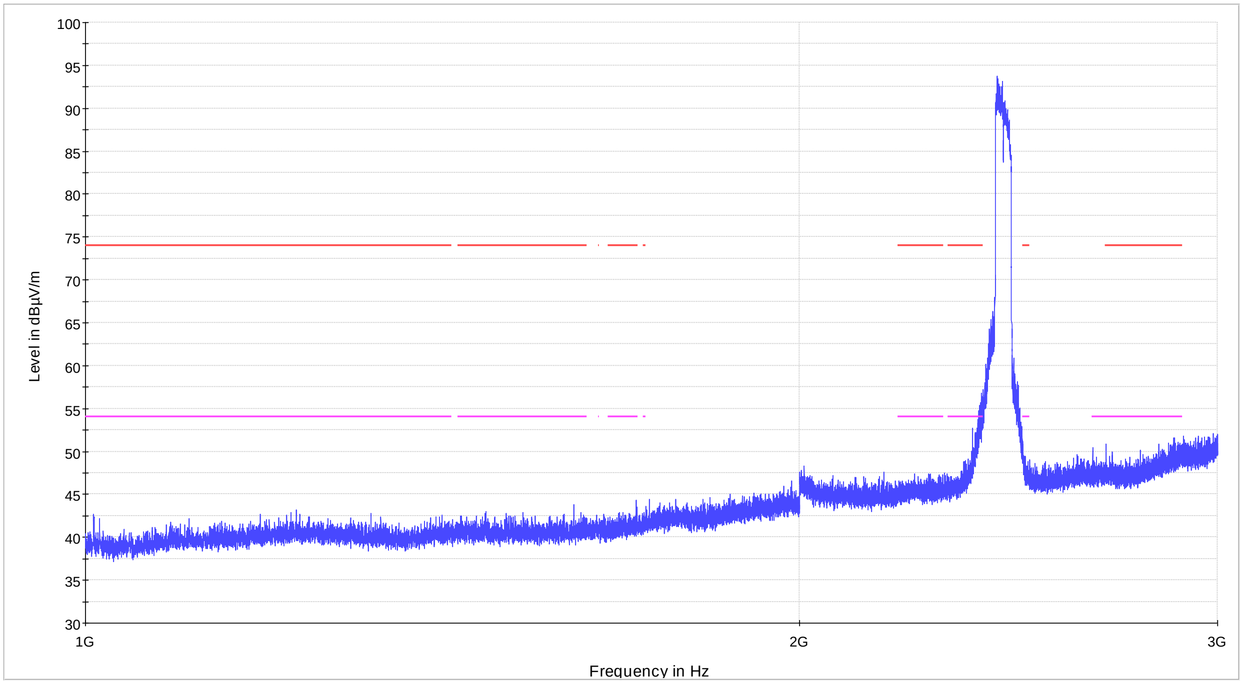


Figure 8.7-18: *Radiated spurious emissions within 1–3 GHz for mid 40 MHz channel*

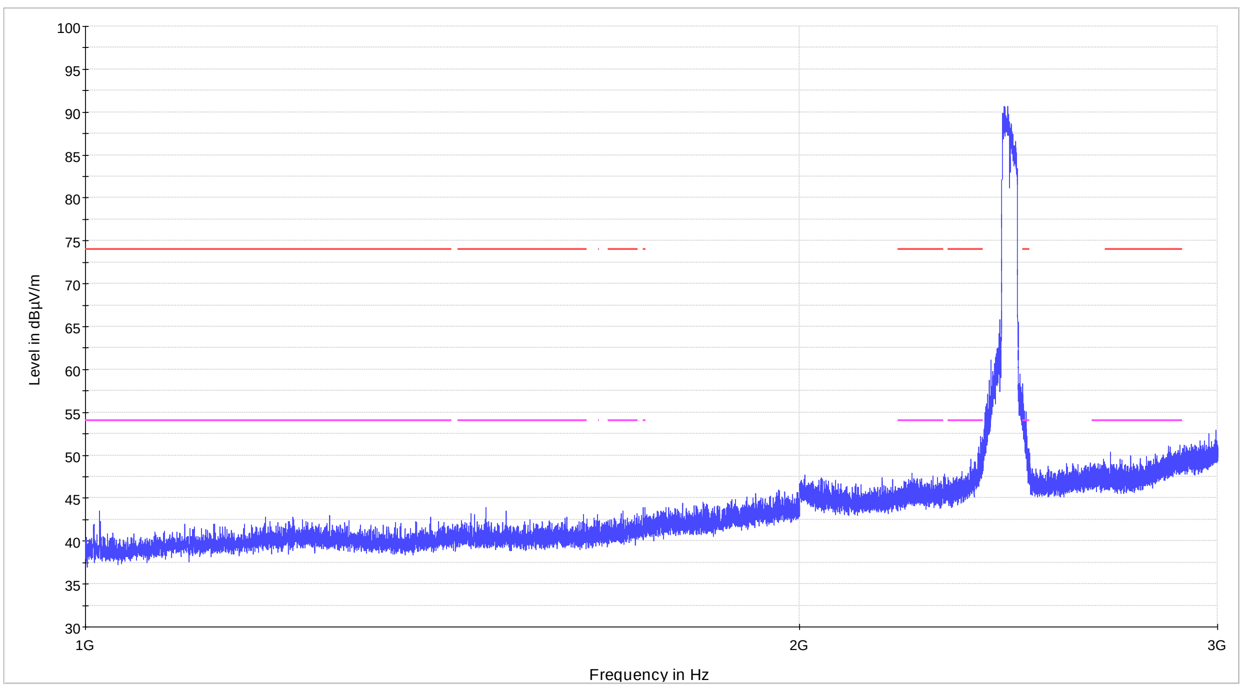


Figure 8.7-19: *Radiated spurious emissions within 1–3 GHz for high 40 MHz channel*

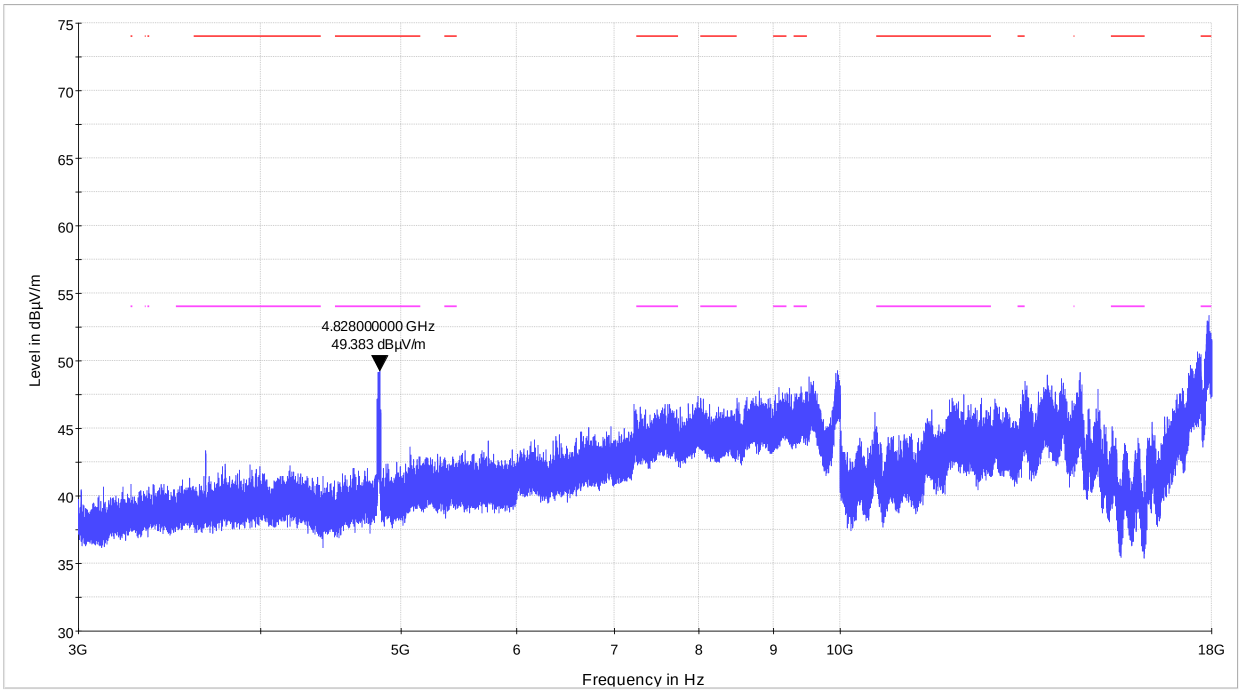


Figure 8.7-20: *Radiated spurious emissions within 3–18 GHz for low 20 MHz channel*

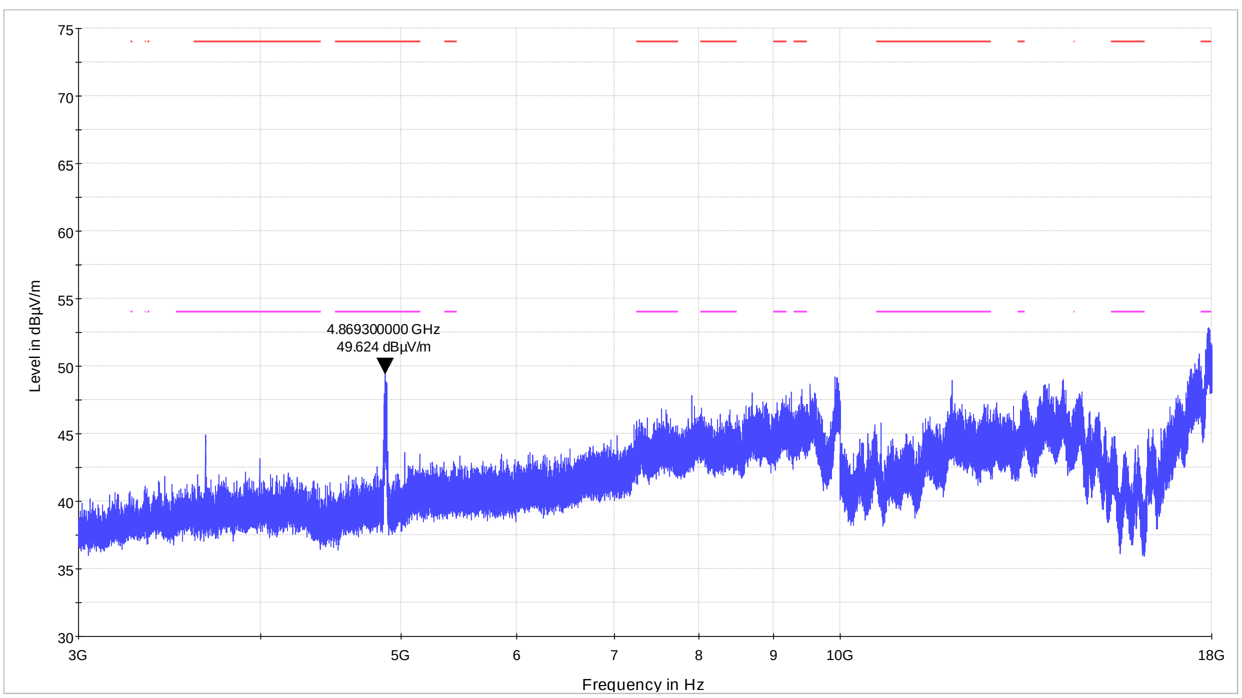


Figure 8.7-21: *Radiated spurious emissions within 3–18 GHz for mid 20 MHz channel*

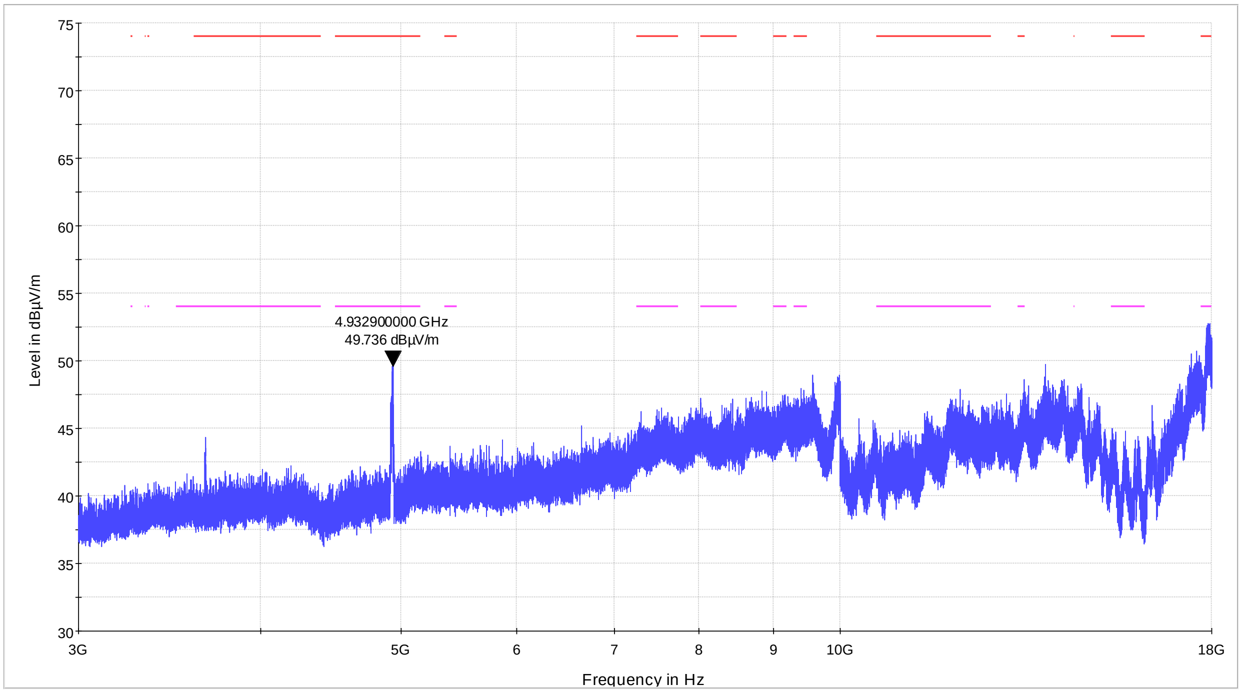


Figure 8.7-22: *Radiated spurious emissions within 3–18 GHz for high 20 MHz channel*

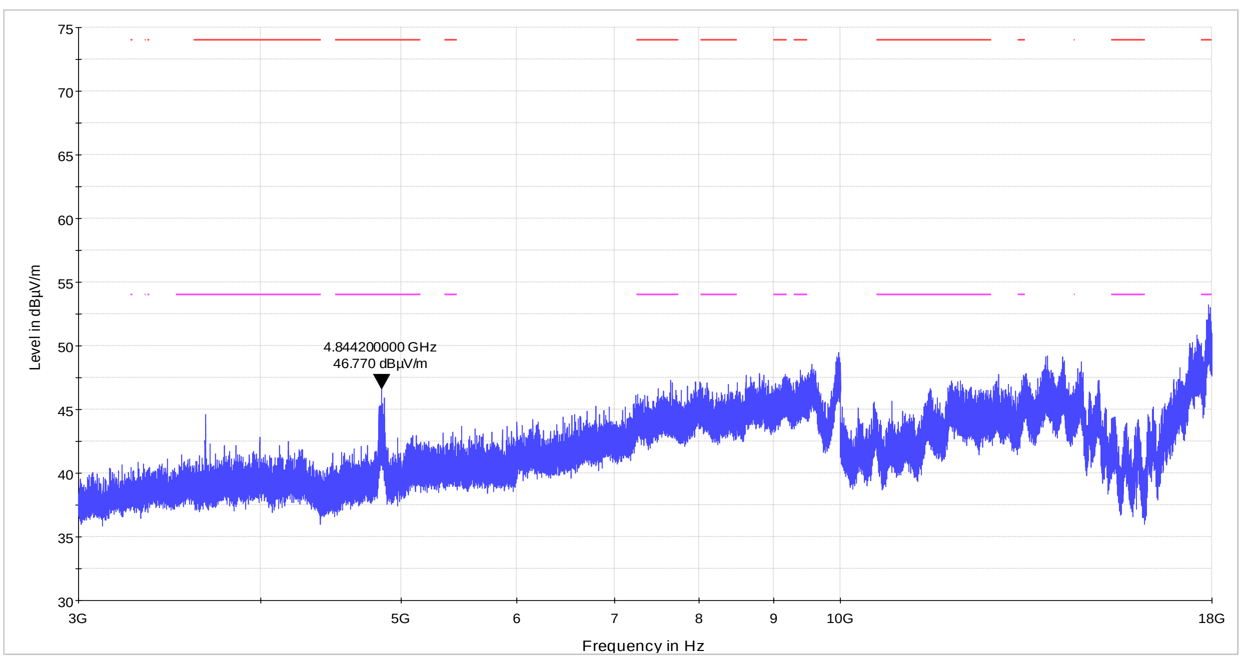


Figure 8.7-23: *Radiated spurious emissions within 3–18 GHz for low 40 MHz channel*

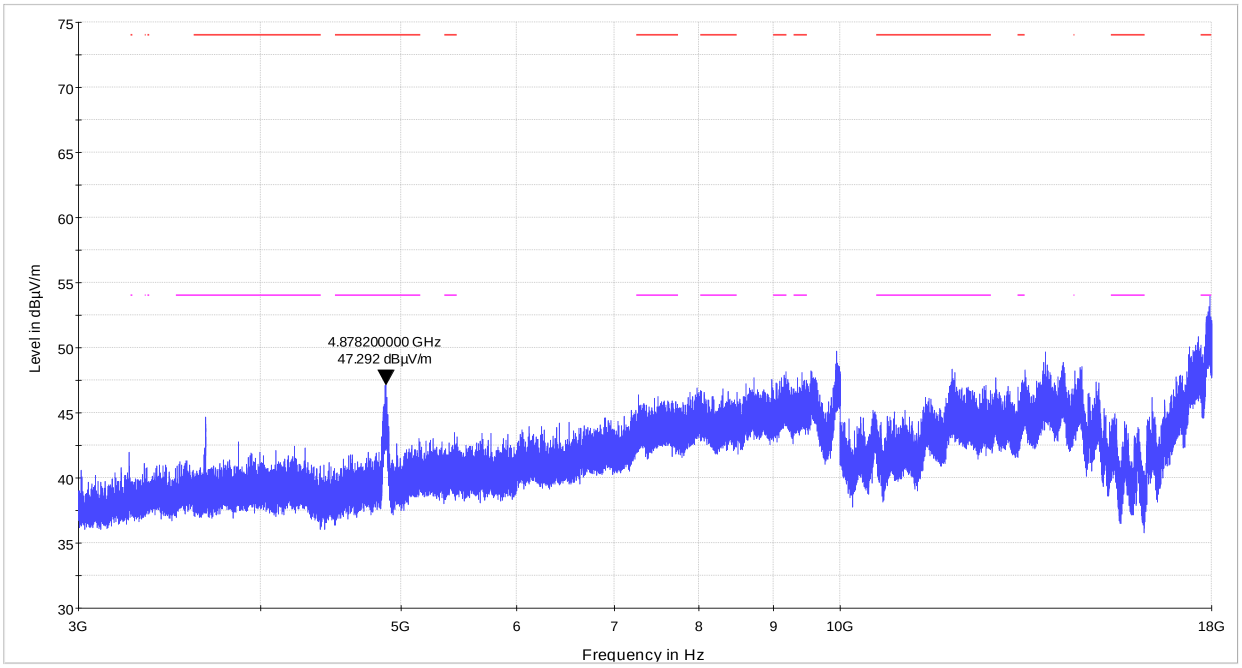


Figure 8.7-24: *Radiated spurious emissions within 3–18 GHz for mid 40 MHz channel*

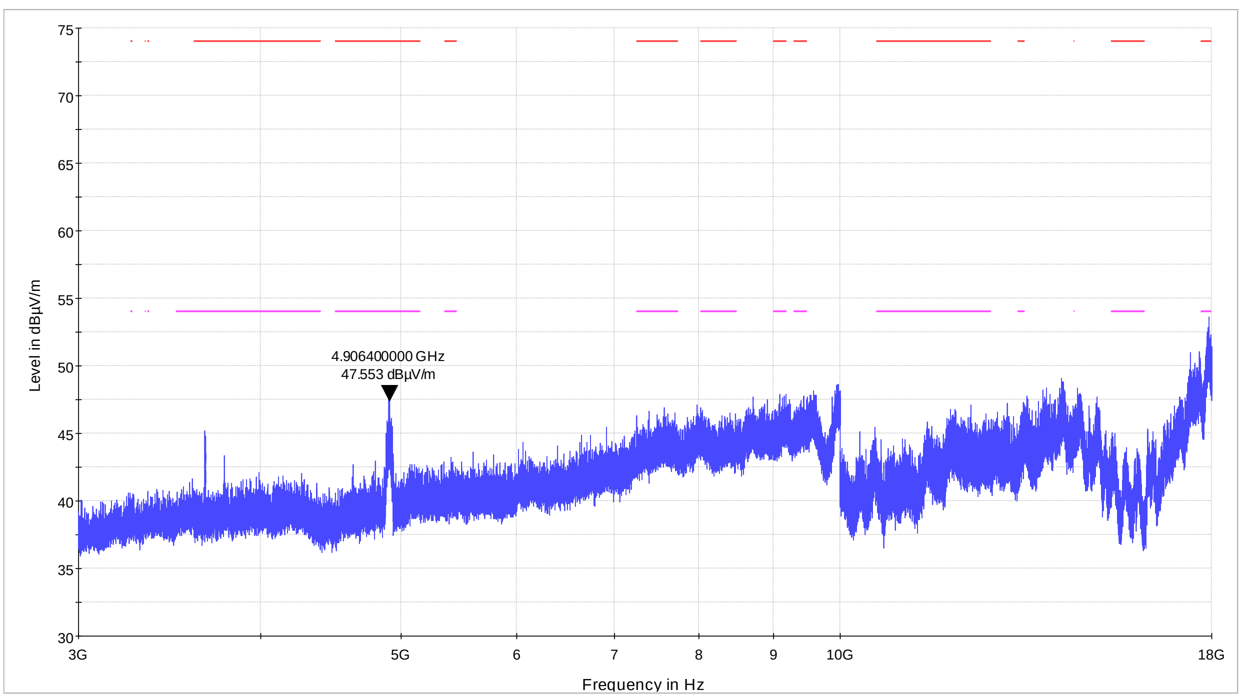


Figure 8.7-25: *Radiated spurious emissions within 3–18 GHz for high 40 MHz channel*

Figure 8.7-26: *Radiated spurious emissions above 18 GHz for low 20 MHz channel*

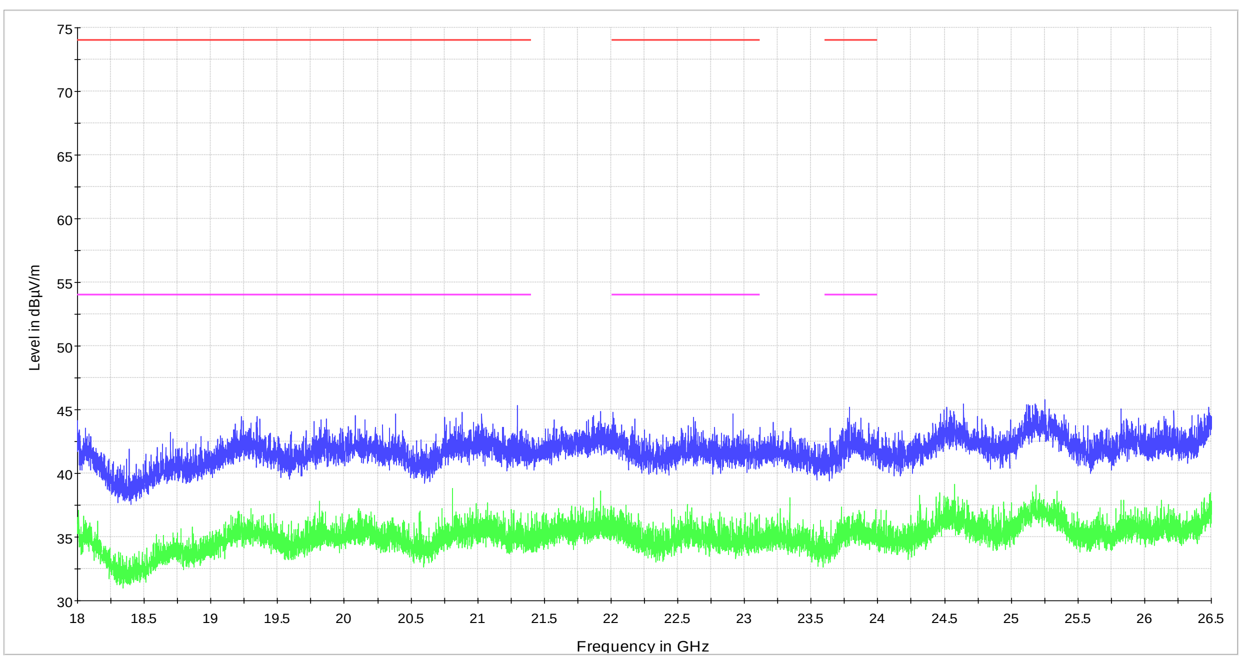


Figure 8.7-27: *Radiated spurious emissions above 18 GHz for mid 20 MHz channel*

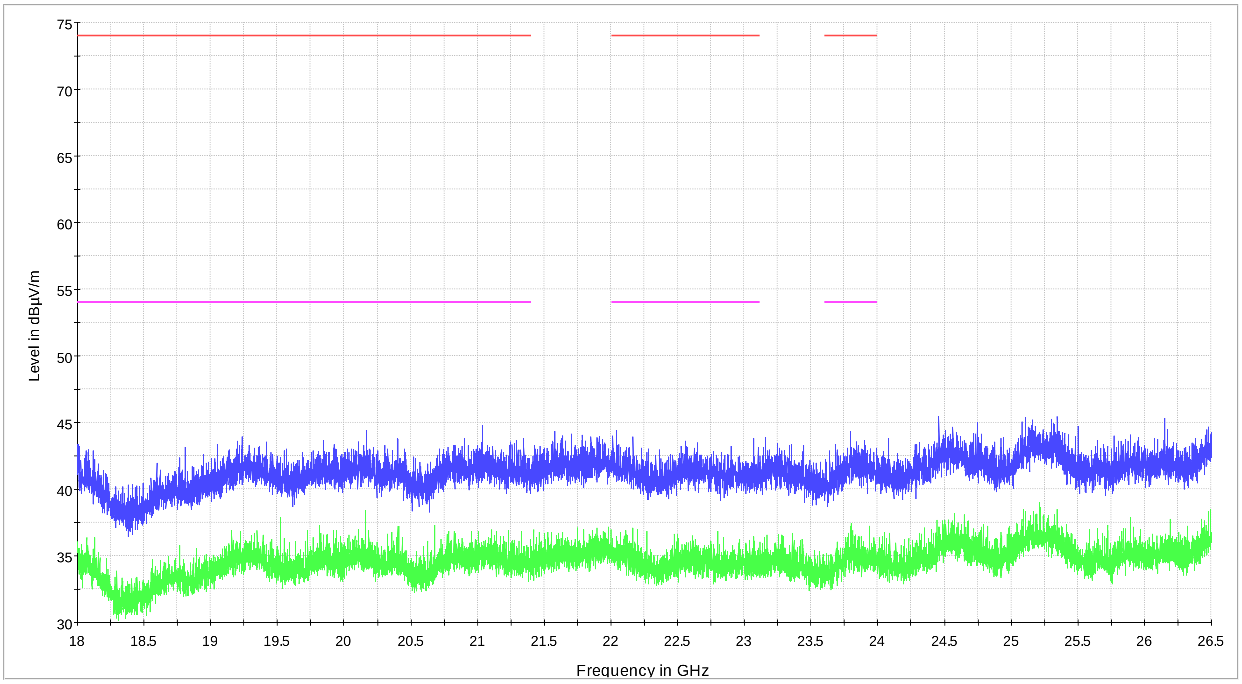


Figure 8.7-28: *Radiated spurious emissions above 18 GHz for high 20 MHz channel*

Figure 8.7-29: *Radiated spurious emissions above 18 GHz for low 40 MHz channel*

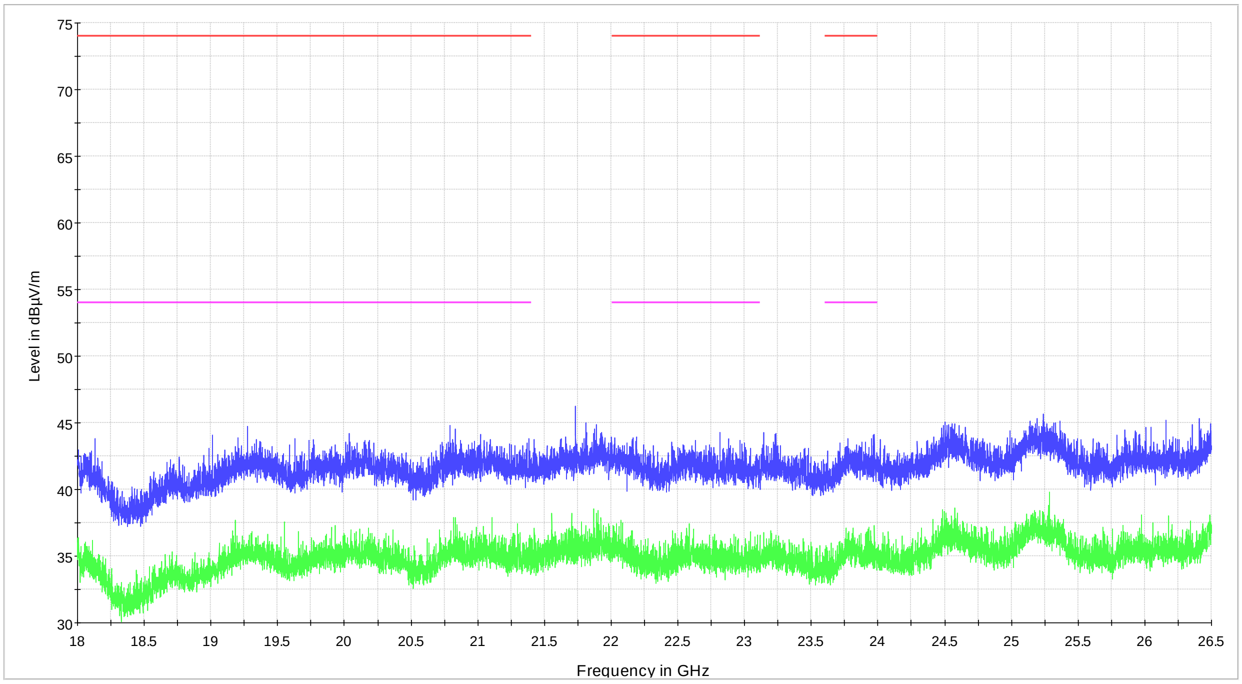


Figure 8.7-30: *Radiated spurious emissions above 18 GHz for mid 40 MHz channel*

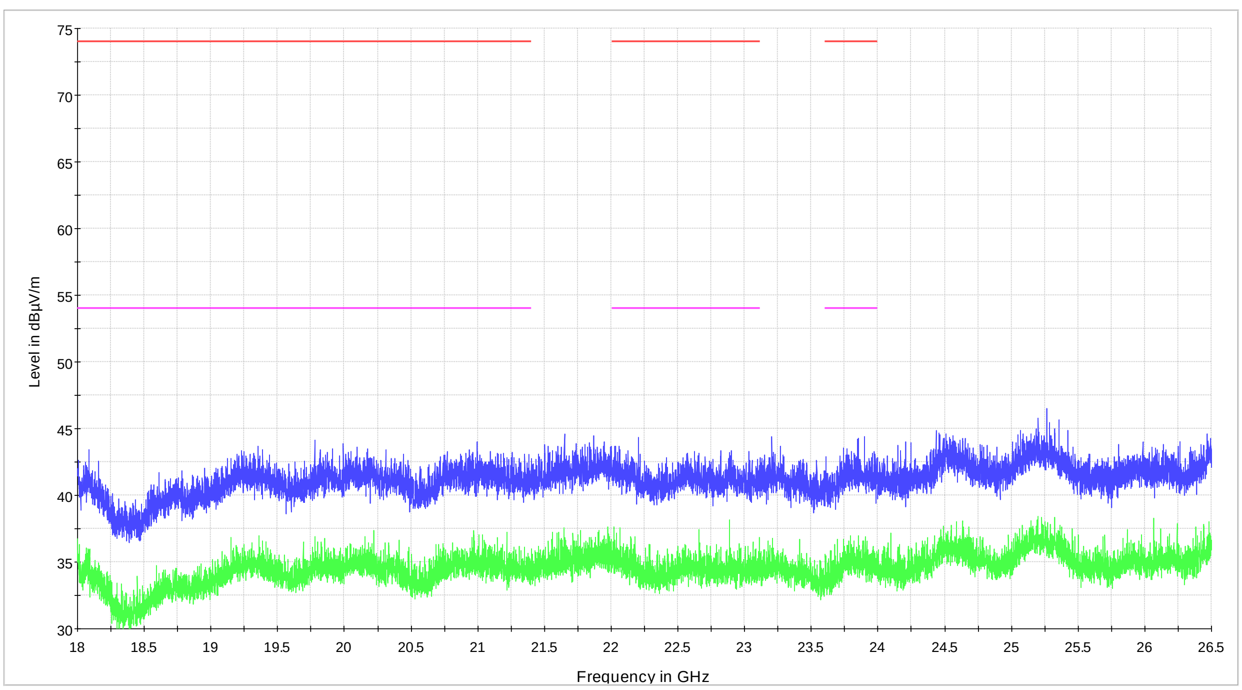


Figure 8.7-31: *Radiated spurious emissions above 18 GHz for high 40 MHz channel*

8.8 FCC 15.247(e) Power spectral density for digitally modulated devices

8.8.1 Definitions and limits

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.

8.8.1 Test date

Start date	November 18, 2019

8.8.2 Observations, settings and special notes

Power spectral density test was performed as per KDB 558074, section 8.4 with reference to ANSI C63.10 subclause 11.10.
The test was performed using method PKPSD (peak PSD).
Spectrum analyser settings:

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

8.8.3 Test data

Table 8.8-1: *PSD measurements results*

Modulation	Frequency, MHz	PSD, dBm/3 kHz	PSD limit, dBm/3 kHz	Margin, dB
802.11n HT20	2412	-8.55	8.00	16.55
	2437	-7.90	8.00	15.90
	2462	-9.67	8.00	17.67
802.11n HT40	2422	-11.00	8.00	19.00
	2437	-10.12	8.00	18.12
	2452	-10.00	8.00	18.00

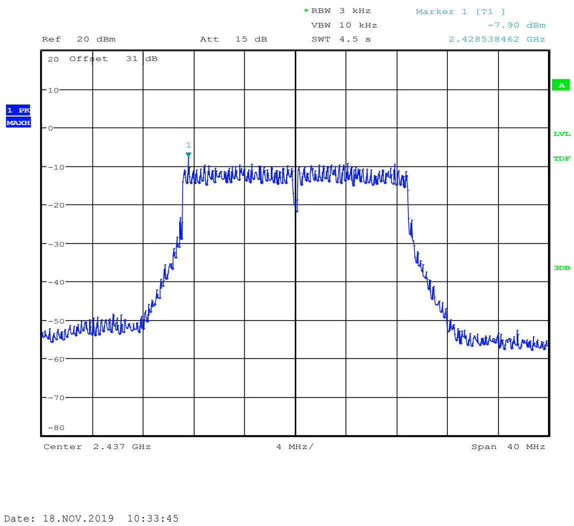


Figure 8.8-1: *PSD sample plot on 802.11n HT20*

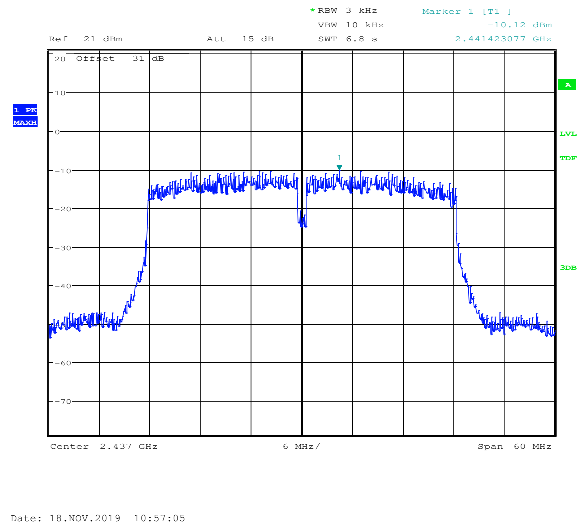
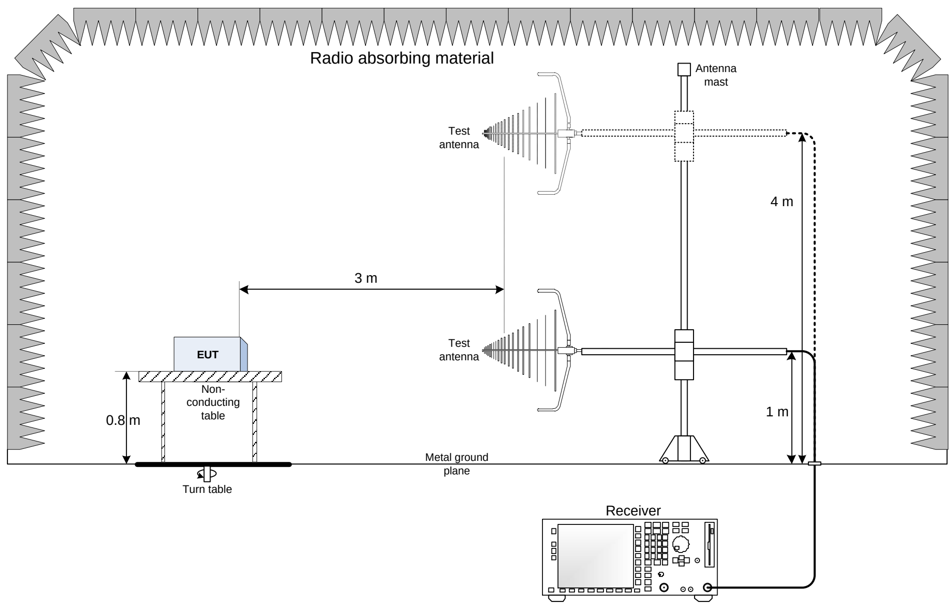


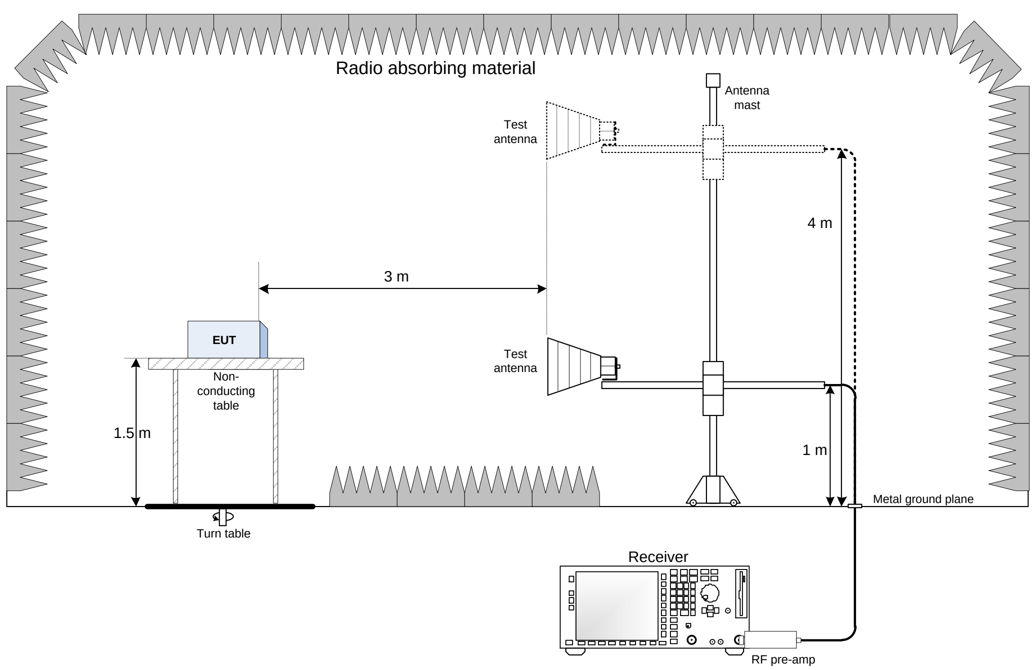
Figure 8.8-2: *PSD sample plot on 802.11n HT40*

Section 9. Block diagrams of test set-ups

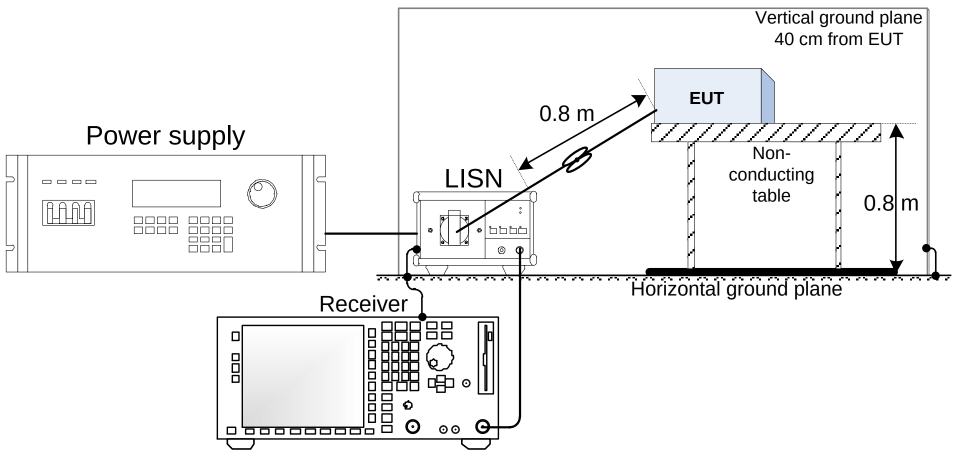
9.1 Radiated emissions set-up for frequencies below 1 GHz



9.2 Radiated emissions set-up for frequencies above 1 GHz



9.3 Conducted emissions set-up



9.4 Antenna port set-up