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Wireless test report – 368276-3TRFWL

Applicant:

Mikrotikls SIA

Product name:

WLAN 802.11a/n/ac and 802.11b/g/n router

Model:

RBLHGG-5HPacD2HPnD-XL-US

Model variant:

FCC ID:

TV7LHG5HPACD2HPD

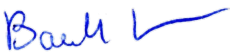
IC Registration number:

7442A-LHG5ACD2HPD

Specifications:

- FCC 47 CFR Part 15 Subpart E, §15.407
  Unlicensed National Information Infrastructure Devises
- RSS-247, Issue 2, Section 6, Feb 2017
  Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

Date of issue: November, 19 2019

Test engineer(s):	Daniele Guarnone, Wireless/EMC Specialist	Signature:	
Reviewed by:	Paolo Barbieri, Wireless/EMC Specialist	Signature:	

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Site number	FCC Test Firm Registration Number: 682159 ISED#: 9109A

Tested by	Daniele Guarnone
Reviewed by	Paolo Barbieri
Review date	April 5, 2019
Reviewer signature	

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	Mikrotikls SIA
Address	Brivibas gatve 214i LV-1039 Riga Latvia

1.2 Test specifications

FCC 47 CFR Part 15, Subpart E, Clause 15.407 RSS-247, Issue 2, February 2017	Unlicensed National Information Infrastructure Devises Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

1.3 Test methods

789033 D02 General UNII Test Procedures New Rules v02r01 (Dec 14, 2017)	Guidelines for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices Part 15, Subpart E
FCC 16-24 (March 2, 2016)	Memorandum opinion and order for U-NII-3 (5.725–5.85 GHz) band
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
RSS-Gen, Issue 5, April 2018	General Requirements for Compliance of Radio Apparatus

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was completed against all relevant requirements of the test standard. 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 #	Details of changes made to test report
TRF	Original report issued

Section 2. Summary of test results

2.1 FCC Part 15 Subpart C, general requirements test results

Part	Test description	Verdict
§15.31(e)	Variation of power source	Pass[1]
§15.203	Antenna requirement	Pass[2]

Notes: [1] Measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, was performed with the supply voltage varied between 85 % and 115 % of the nominal rated supply voltage. No noticeable output power variation was observed
[2]The Antennas uses a unique coupling to the intentional radiator.

2.2 FCC Part 15 Subpart E, test results

Part	Test description	Verdict
§15.403(i)	Emission bandwidth	Pass
§15.407(a)(1)	Power and density limits within 5.15–5.25 GHz band	Not applicable
§15.407(a)(2)	Power and density limits within 5.25–5.35 GHz and 5.47–5.725 GHz bands	Not applicable
§15.407(a)(3)	Power and density limits within 5.725–5.85 GHz band	Pass
§15.407(b)(1)	Undesirable emission limits for 5.15–5.25 GHz band	Not applicable
§15.407(b)(2)	Undesirable emission limits for 5.25–5.35 GHz band	Not applicable
§15.407(b)(3)	Undesirable emission limits for 5.47–5.725 GHz bands	Not applicable
§15.407(b)(4)	Undesirable emission limits for 5.725–5.85 GHz band	Pass
§15.407(b)(6)	Conducted limits for U-NII devices using an AC power line	Pass
§15.407(e)	Minimum 6 dB bandwidth of U-NII devices within the 5.725–5.85 GHz band	Pass
§15.407(g)	Frequency stability	Pass
§15.407(h)(1)[1]	Transmit power control (TPC)	Not applicable
§15.407(h)(2)[1]	Dynamic Frequency Selection (DFS)	Not applicable

Notes: [1] DFS and TPC requirements are only applicable to 5.25–5.35 GHz and 5.47–5.725 GHz bands

2.3 RSS-Gen, Issue 4, test results

Part	Test description	Verdict
6.6	Occupied Bandwidth	Pass
7.1.2[1]	Receiver radiated emission limits	Not applicable
7.1.3[1]	Receiver conducted emission limits	Not applicable
8.8	Power Line Conducted Emissions Limits for Licence-Exempt Radio Apparatus	Pass
8.11[2]	Frequency stability	--

Notes: [1] According to sections 5.2 and 5.3 of RSS-Gen, Issue 4: if EUT does not have a stand-alone receiver neither scanner receiver, then it exempt from receiver requirements.
[2] According to section 8.11 of RSS-Gen, Issue 4: if the frequency stability of the licence-exempt radio apparatus is not specified in the applicable standard (RSS), measurement of the frequency stability is not required

2.4 ISED RSS-247, Issue 2, test results

Section	Test description	Verdict
6.1 (1)[1]	Types of Modulation	Pass
6.2.1 (1)	Power limits for 5150–5250 MHz band	Not applicable
6.2.2 (1)	Power limits for 5250–5350 MHz band	Not applicable
6.2.3 (1)	Power limits for 5470–5600 MHz and 5650–5725 MHz bands	Not applicable
6.2.4 (1)	Power limits for 5725–5850 MHz band	Pass
6.2.4 (1)	Minimum 6 dB bandwidth	Pass
6.2.1 (2)	Unwanted emission limits for 5150–5250 MHz band	Not applicable
6.2.2 (2)	Unwanted emission limits for 5250–5350 MHz band	Not applicable
6.2.2 (2)	TPC requirements for devices with a maximum e.i.r.p. greater than 500 mW	Not applicable
6.2.2 (3)	E.i.r.p. at different elevations restrictions for 5250–5350 MHz band	Not applicable
6.2.3 (2)	Unwanted emission limits for 5470–5600 MHz and 5650–5725 MHz bands	Not applicable
6.2.4 (2)	Unwanted emission limits for 5725–5850 MHz band	Pass
6.3	Dynamic Frequency Selection (DFS) for devices operating in the bands 5250–5350 MHz, 5470–5600 MHz and 5650–5725 MHz	Not applicable

Notes: [1] The EUT employs digital modulations: 802.11a/n

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	February 21, 2019
Nemko sample ID number	Item #2

3.2 EUT information

Product name	WLAN 802.11a/n/ac and 802.11b/g/n router
Model	RBLHGG-5HPacD2HPnD-XL-US
Model variant	--
Serial number	--

3.3 Technical information

Applicant IC company number	7442A
IC UPN number	LHG5ACD2HPD
All used IC test site(s) Reg. number	9109A
RSS number and Issue number	RSS-247 Issue 2, Section 6, February 2017
Frequency band	5725–5850 MHz
Frequency Min (MHz)	5745 (20 MHz channel), 5755 (40 MHz channel), 5787 (80 MHz channel)
Frequency Max (MHz)	5825 (20 MHz channel), 5795 (40 MHz channel), 5787 (80 MHz channel)
Measured BW (kHz) (26 dB)	19500 (20 MHz channel), 38240 (40 MHz channel), 84560 (80 MHz channel),
Measured BW (kHz) (6 dB)	16000 (20 MHz channel), 35120 (40 MHz channel), 76500 (80 MHz channel),
Type of modulation	802.11a/n
Emission classification (F1D, G1D, D1D)	W7D
Transmitter spurious, Units @ distance	31.2 dBµV/m at 96.96MHz, @ 3 m
Power requirements	24 $V_{DC,}$ via 120 V_{AC} adapter or battery
Antenna information	The EUT uses a unique antenna coupling. EUT has 2 antenna configurations. The max antenna peak gain is 18 dBi at 2.4 GHz band and 27 dBi at 5 GHz WIFI bands.

3.4 Product description and theory of operation

The LHG is an outdoor wireless router with with an integrated dual polarization grid antenna

3.5 EUT exercise details

EUT was set to continuously transmit mode during tests, by test software provided by client.
These tools/scripts configure the radio modules to enable continuous transmission with the ability to adjust modulation, frequency and output power as required.

3.6 EUT setup diagram

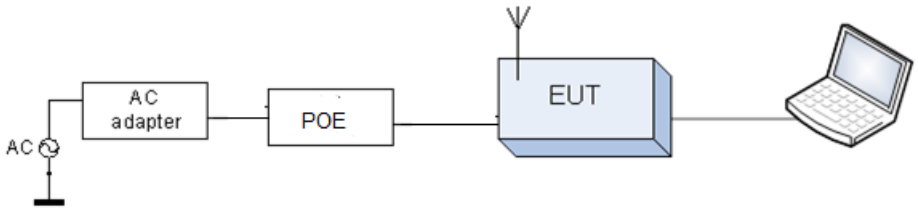


Figure 3.6-1: *Setup diagram*

3.7 EUT sub assemblies

Table 3.7-1: *EUT sub assemblies*

Description	Brand name	Model/Part number	Serial number
Power supply	Fullpower	SAW 30-240-1200G R2A	
Gigabit POE	Mikrotik	--	--

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

Differences between the variants are as below. REGATE-10-12 was chosen as representative worst-case.

4.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 5. Test conditions

5.1 Atmospheric conditions

18÷33 °C	18÷33 °C
30÷60 %	30÷60 %
980÷1060 hPa	980÷1060 hPa

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

EUT	Type	Test	Range and Setup features	Measurement Uncertainty	Notes
Transmitter	Conducted	Frequency error	0.001 MHz ÷ 40 GHz	0.08 ppm	(1)
		Carrier power RF Output Power	10 kHz ÷ 30 MHz	1.0 dB	(1)
			30 MHz ÷ 18 GHz	1.5 dB	(1)
			18 MHz ÷ 40 GHz	3.0 dB	(1)
		Adjacent channel power	1 MHz ÷ 18 GHz	1.6 dB	(1)
		Conducted spurious emissions	10 kHz ÷ 26 GHz	3.0 dB	(1)
			26 GHz ÷ 40 GHz	4.5 dB	(1)
		Intermodulation attenuation	1 MHz ÷ 18 GHz	2.2 dB	(1)
		Attack time – frequency behaviour	1 MHz ÷ 18 GHz	2.0 ms	(1)
		Attack time – power behaviour	1 MHz ÷ 18 GHz	2.5 ms	(1)
		Release time – frequency behaviour	1 MHz ÷ 18 GHz	2.0 ms	(1)
		Release time – power behaviour	1 MHz ÷ 18 GHz	2.5 ms	(1)
		Transient behaviour of the transmitter– Transient frequency behaviour	1 MHz ÷ 18 GHz	0.2 kHz	(1)
		Transient behaviour of the transmitter – Power level slope	1 MHz ÷ 18 GHz	9%	(1)
		Frequency deviation - Maximum permissible frequency deviation	0.001 MHz ÷ 18 GHz	1.3%	(1)
		Frequency deviation - Response of the transmitter to modulation frequencies above 3 kHz	0.001 MHz ÷ 18 GHz	0.5 dB	(1)
		Dwell time	-	3%	(1)
		Hopping Frequency Separation	0.01 MHz ÷ 18 GHz	1%	(1)
		Occupied Channel Bandwidth	0.01 MHz ÷ 18 GHz	2%	(1)
		Modulation Bandwidth	0.01 MHz ÷ 18 GHz	2%	(1)
	Radiated	Radiated spurious emissions	10 kHz ÷ 26.5 GHz	6.0 dB	(1)
			26.5 GHz ÷ 40 GHz	8.0 dB	(1)
		Effective radiated power transmitter	10 kHz ÷ 26.5 GHz	6.0 dB	(1)
			26,5 GHz ÷ 40 GHz	8.0 dB	(1)
Receiver	Radiated	Radiated spurious emissions	10 kHz ÷ 26.5 GHz	6.0 dB	(1)
			26.5 GHz ÷ 40 GHz	8.0 dB	(1)
		Sensitivity measurement	1 MHz ÷ 18 GHz	6.0 dB	(1)
	Conducted	Conducted spurious emissions	10 kHz ÷ 26 GHz	3.0 dB	(1)
			26 GHz ÷ 40 GHz	4.5 dB	(1)
(1) The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k = 2 which has been derived from the assumed normal probability distribution with infinite degrees of freedom and for a coverage probability of 95 %					

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.
EMI receiver 2 Hz ÷ 44 GHz	R&S	ESW44	101620	2018/05	2020/08
Broadband preamplifier	Schwarzbeck	BBV 9718	9718-137	2018/08	2019/08
Trilog Broadband Antenna	Schwarzbeck	VULB 9162	9162-025	2018/07	2021/07
Semi-anechoic chamber	Nemko	10m semi-anechoic chamber	530	2018/09	2021/09
Antenna mast	R&S	HCM	836 529/05	NCR	NCR
Controller	R&S	HCC	836 620/7	NCR	NCR
EMI receiver 9 kHz ÷ 3 GHz	R&S	ESCI	100888	2018/09	2020/10
LISN 9 kHz ÷ 30 MHz	R&S	ESH2-Z5	872 460/041	2018/09	2020/09
Climatic Chamber	ESPEC	ARS 1100	4100000067	2018/11	2019/11
EMI receiver 20 Hz ÷ 8 GHz	R&S	ESU8	100202	2019/01	2020/01
Bilog antenna 1 ÷18 GHz	Schwarzbeck	STLP 9148-123	123	2018/09	2021/09
Double Ridged Waveguide Horn	RF SPIN	DRH40	061106a40	2017/02	2020/02
Wide band Amplifier 18 GHz ÷ 40 GHz	MITEQ	AMF-5F-18004000-37-8P	128061	2018/09	2020/09
High pass filter	Wainwright Instruments	WHNX6-2555-3500-26500-60CC	01	2018/10	2020/10

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

Section 8. Testing data

8.1 FCC 15.403(i) Emission bandwidth, 15.407(e) 6 dB bandwidth

8.1.1 Definitions and limits

FCC:
15.403(i) For purposes of this subpart the emission bandwidth shall be determined by measuring the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, that are 26 dB down relative to the maximum level of the modulated carrier. Determination of the emissions bandwidth is based on the use of measurement instrumentation employing a peak detector function with an instrument resolution bandwidth approximately equal to 1.0 percent of the emission bandwidth of the device under measurement.
15.407(e) **Within the 5.725–5.85 GHz band, the minimum 6 dB bandwidth of U-NII devices shall be at least 500 kHz.**

8.1.2 Test summary

Test start date	July 31, 2019
Test engineer	Daniele Guarnone

8.1.3 Observations, settings and special notes

Spectrum analyzer settings:

Resolution bandwidth	approximately 1% of EBW (for 26 dB BW), 100 kHz (for 6 dB BW)
Video bandwidth	> RBW
Detector mode	Peak
Trace mode	Max Hold

8.1.4 Test data

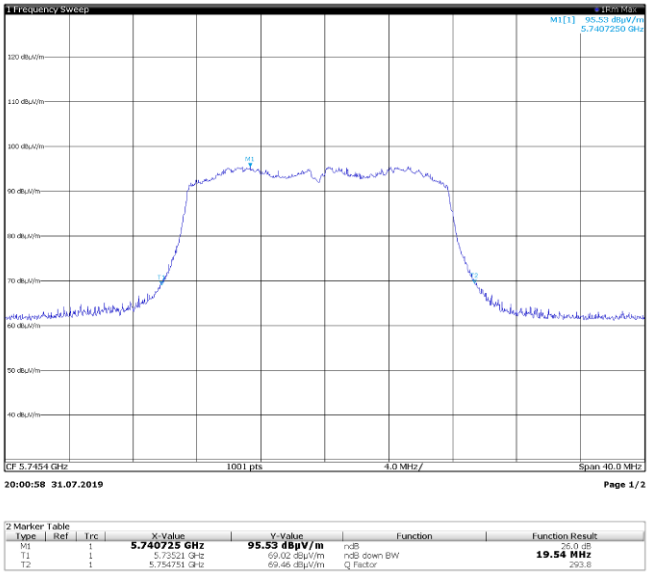
Table 8.1-1: *26 dB bandwidth results*

Modulation	Frequency, MHz	26 dB bandwidth, MHz
802.11a	5745	19.34
	5785	19.34
	5825	19.50
802.11n HT20	5745	19.38
	5785	19.50
	5825	18.65
802.11n HT40	5755	38.23
	5795	38.24
802.11ac	5787	85.56

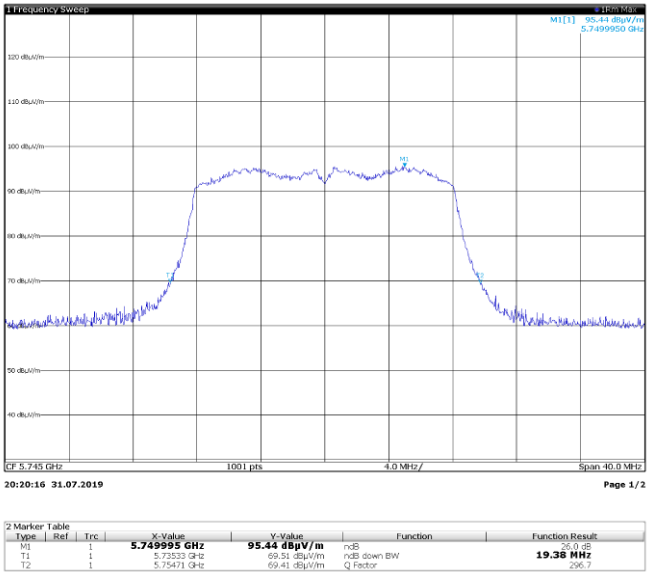
Table 8.1-2: *6 dB bandwidth results*

Modulation	Frequency, MHz	6 dB bandwidth, MHz	Minimum limit, MHz	Minimum margin, MHz
802.11a	5745	15.48	0.5	16.34
	5785	15.14	0.5	16.30
	5825	15.14	0.5	16.34
802.11n HT20	5745	16.00	0.5	16.34
	5785	15.12	0.5	16.38
	5825	15.12	0.5	16.5
802.11n HT40	5755	35.00	0.5	36.5
	5795	35.12	0.5	36.5
802.11ac	5787	76.5	0.5	77

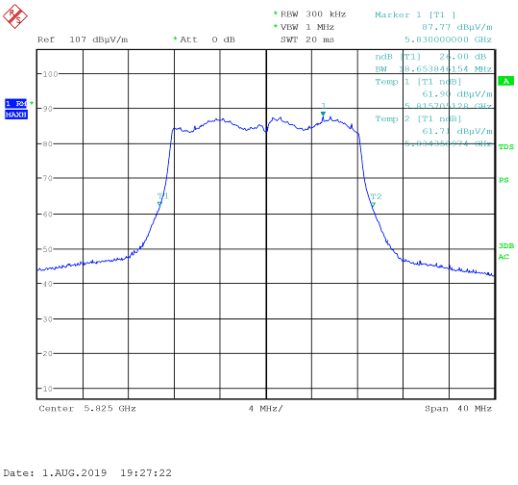
Low channel



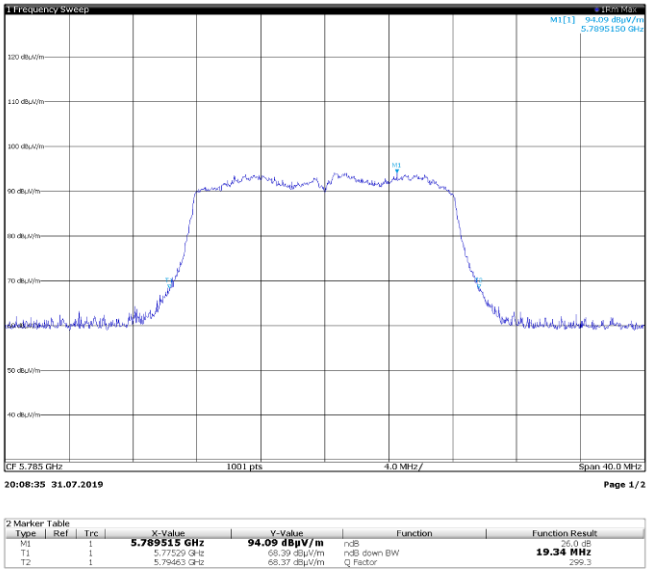
26 dB bandwidth on 802.11a, sample plot



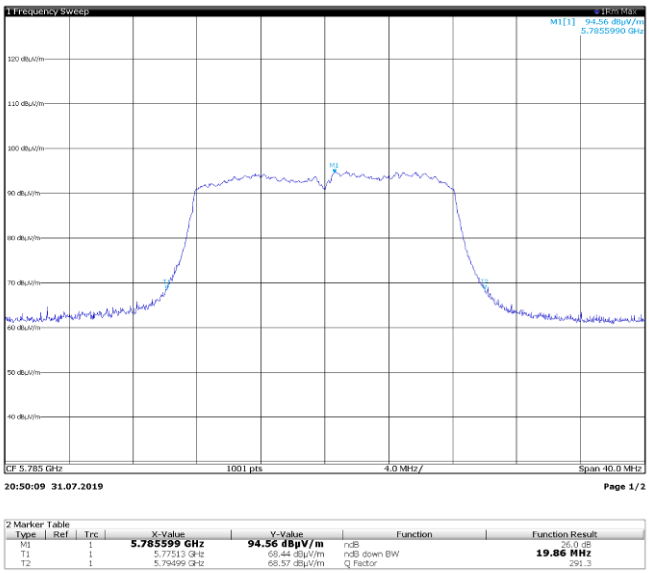
26 dB bandwidth on 802.11n HT20, sample plot



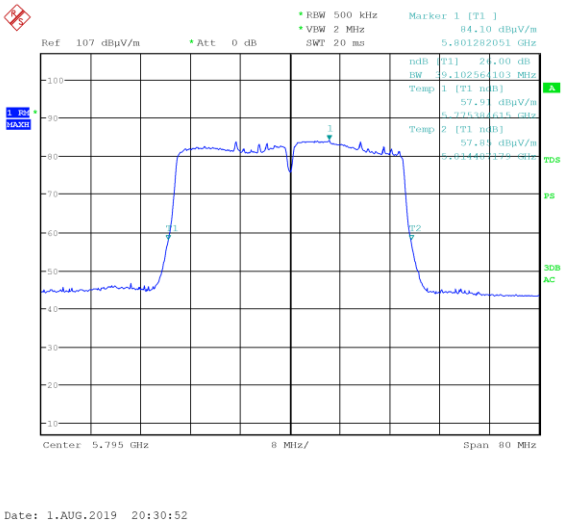
26 dB bandwidth on 802.11n HT40, sample plot



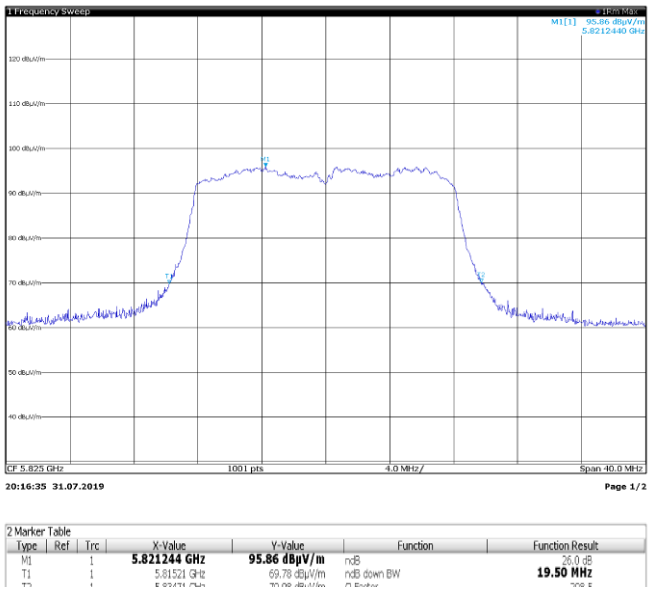
26 dB bandwidth on 802.11a, sample plot



26 dB bandwidth on 802.11n HT20, sample plot



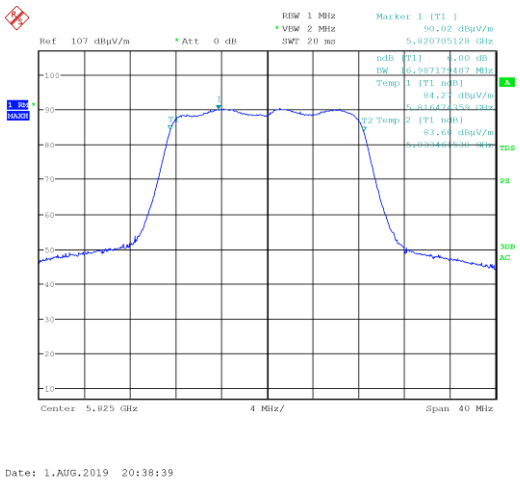
26 dB bandwidth on 802.11n HT40, sample plot



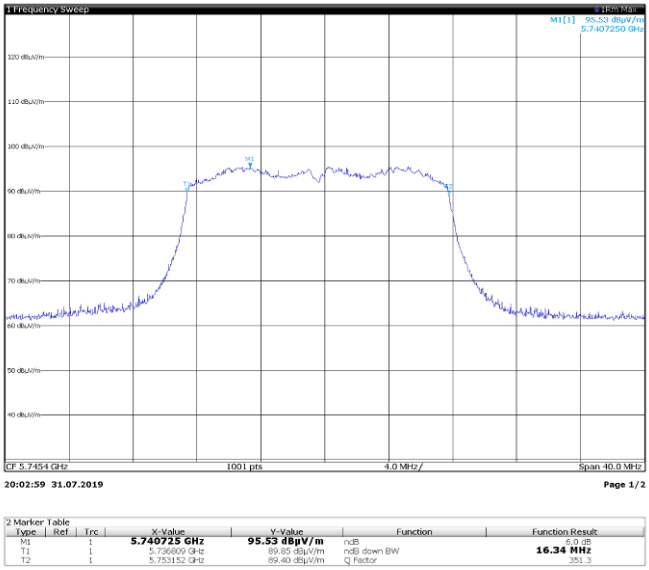
2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**5.821244 GHz**	**95.86 dBµV/m**	ndB	26.0 dB
T1		1	5.81521 GHz	69.78 dBµV/m	ndB down BW	**19.50 MHz**

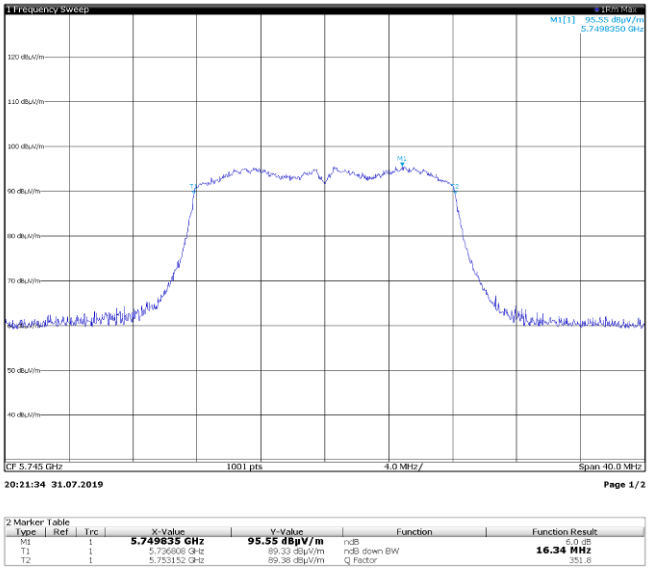
26 dB bandwidth on 802.11a, sample plot



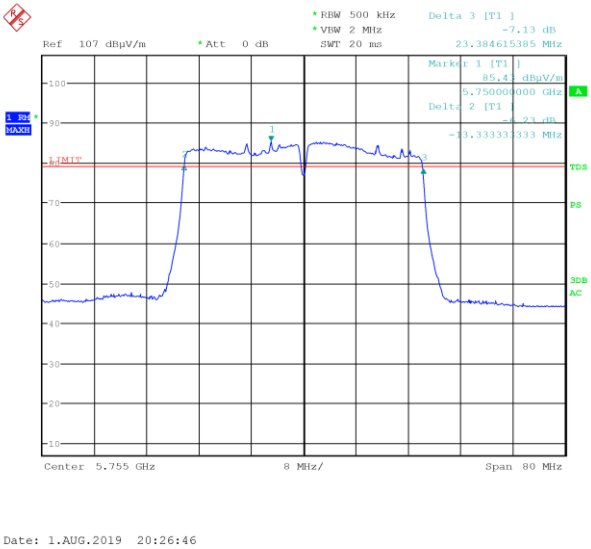
26 dB bandwidth on 802.11n HT20, sample plot



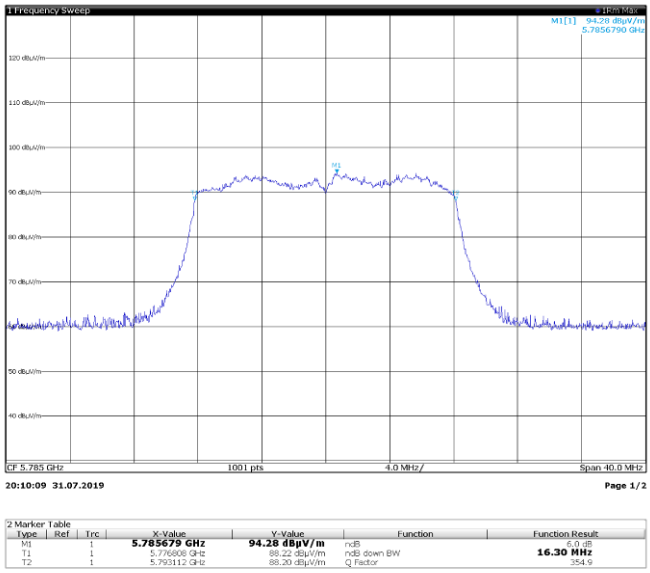
6 dB bandwidth on 802.11a, sample plot



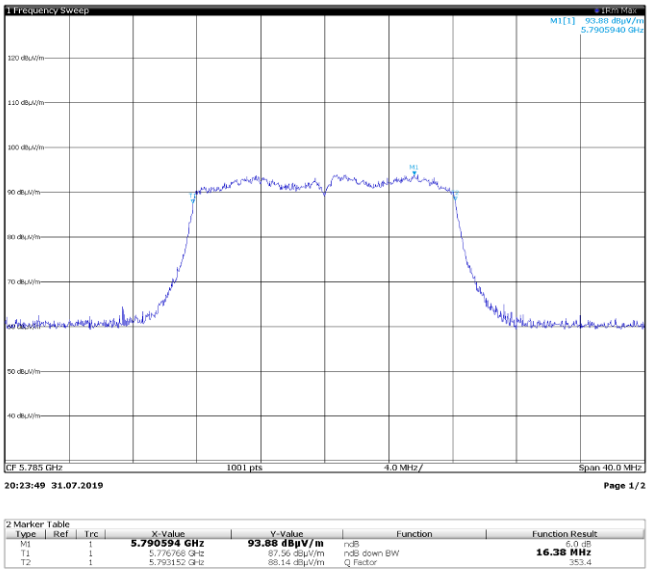
6 dB bandwidth on 802.11n HT20, sample plot



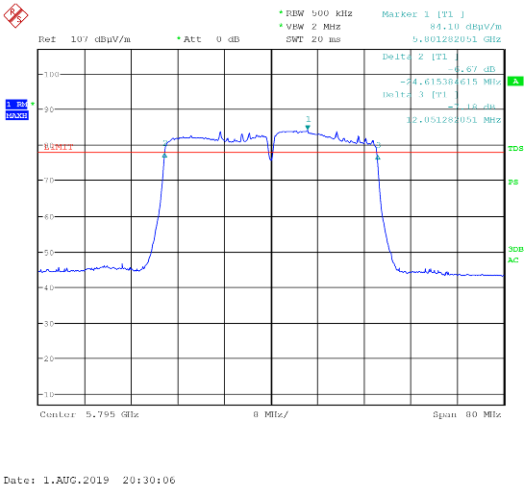
6 dB bandwidth on 802.11n HT40, sample plot



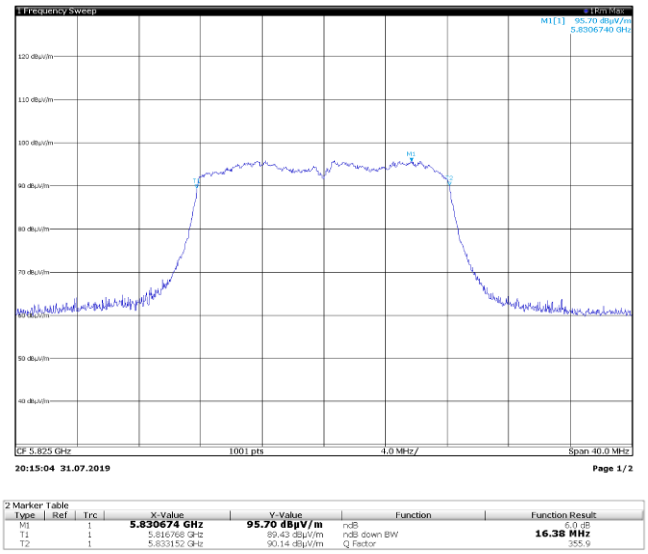
6 dB bandwidth on 802.11a, sample plot



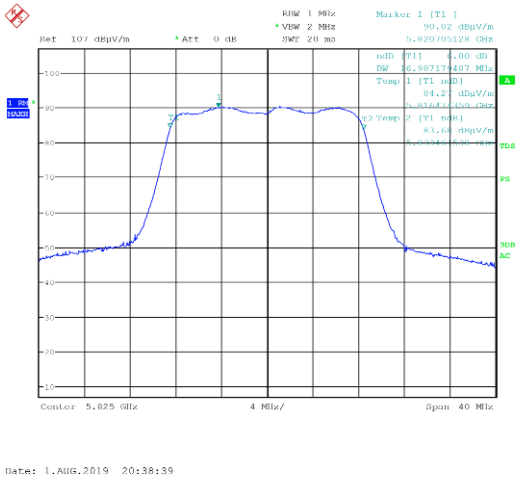
6 dB bandwidth on 802.11n HT20, sample plot



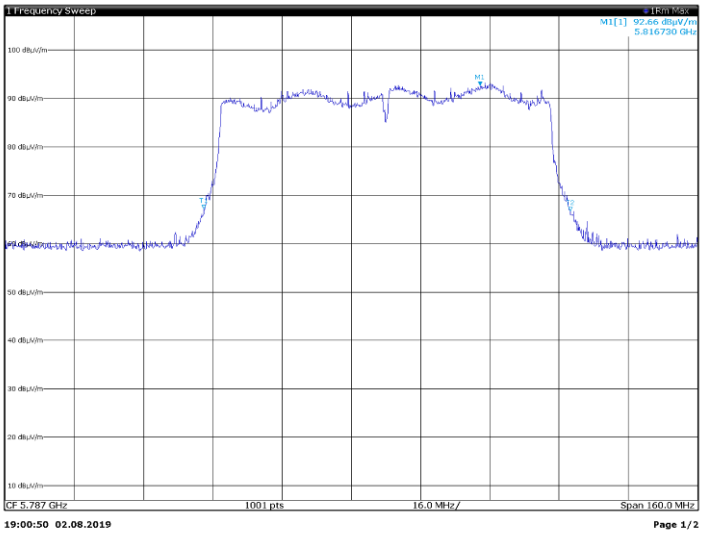
6 dB bandwidth on 802.11n HT40, sample plot



6 dB bandwidth on 802.11a, sample plot



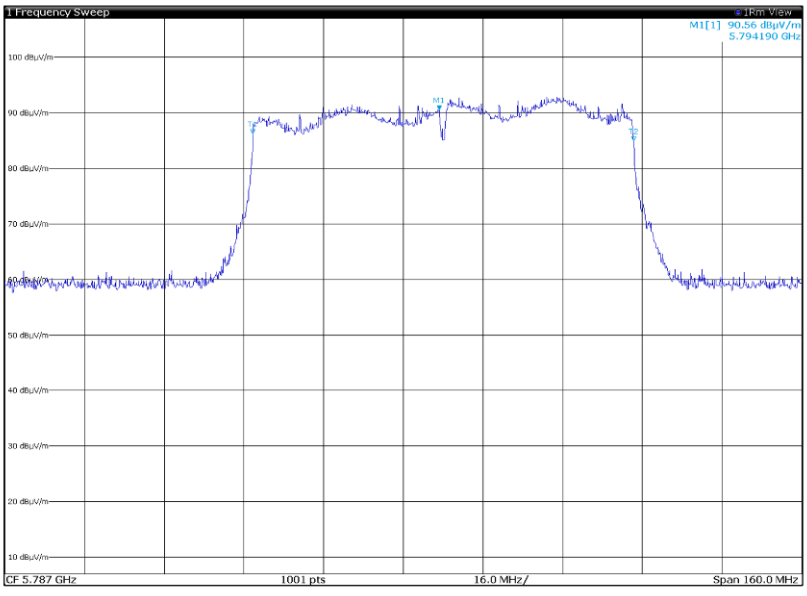
6 dB bandwidth on 802.11n HT20, sample plot



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**5.81673 GHz**	**92.66 dBµV/m**	ndB	26.0 dB
T1		1	5.75295 GHz	67.17 dBµV/m	ndB down BW	**84.56 MHz**
T2		1	5.83751 GHz	66.70 dBµV/m	Q Factor	68.8

26 dB bandwidth on 802.11a, 80 MHz



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**5.79419 GHz**	**90.56 dBµV/m**	ndB	6.0 dB
T1		1	5.75679 GHz	86.18 dBµV/m	ndB down BW	**76.40 MHz**
T2		1	5.83319 GHz	84.97 dBµV/m	Q Factor	75.8

6 dB bandwidth on 802.11a, 80 MHz

8.2 RSS-Gen 6.6 Occupied bandwidth

8.2.1 Definitions and limits

The emission bandwidth (×dB) is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated × dB below the maximum in-band spectral density of the modulated signal. Spectral density (power per unit bandwidth) is to be measured with a detector of resolution bandwidth in the range of 1% to 5% of the anticipated emission bandwidth, and a video bandwidth at least 3× the resolution bandwidth.

When the occupied bandwidth limit is not stated in the applicable RSS or reference measurement method, the transmitted signal bandwidth shall be reported as the 99% emission bandwidth, as calculated or measured.

8.2.2 Test summary

Test start date	April 5, 2019
Test engineer	Daniele Guarnone

8.2.3 Observations, settings and special notes

Spectrum analyzer settings:

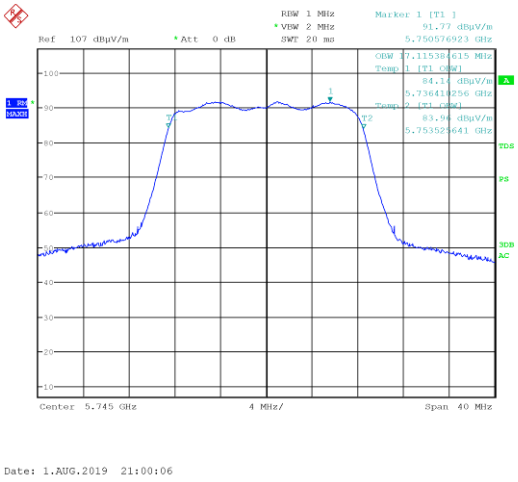
Resolution bandwidth:	1 % to 5 % of OBW
Video bandwidth:	≥3 × RBW
Detector mode:	Peak
Trace mode:	Max Hold

8.2.4 Test data

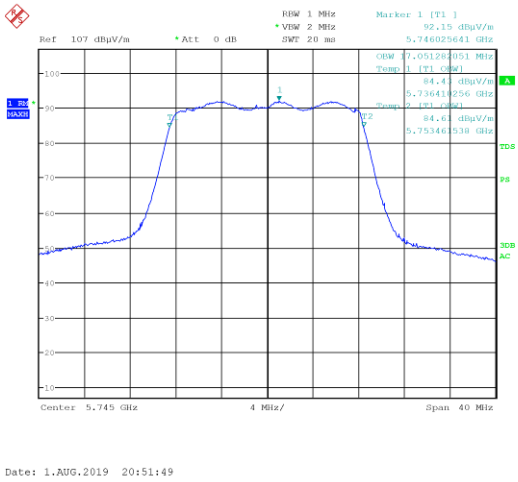
Table 8.2-1: *99 % bandwidth results*

Modulation	Frequency, MHz	99 % bandwidth, MHz
802.11a	5745	16.6
	5785	16.6
	5825	16.5
802.11n HT20	5745	17.6
	5785	16.6
	5825	16.5
802.11n HT40	5755	36.4
	5795	36.1
802.11n HT80	5787	75.8

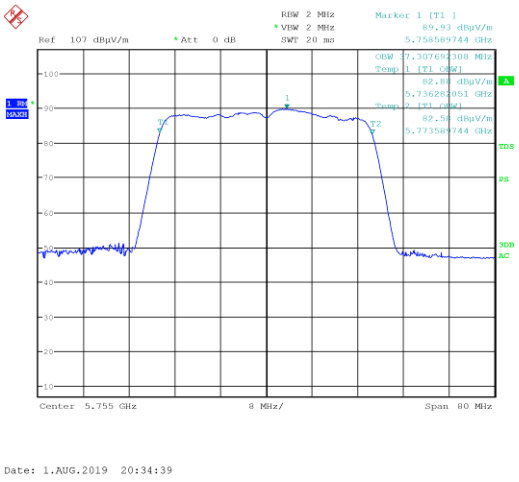
8.2.4 Test data, continued



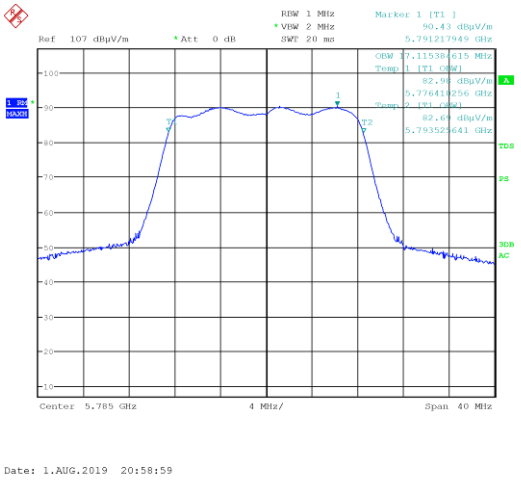
99 % bandwidth on 802.11a, sample plot



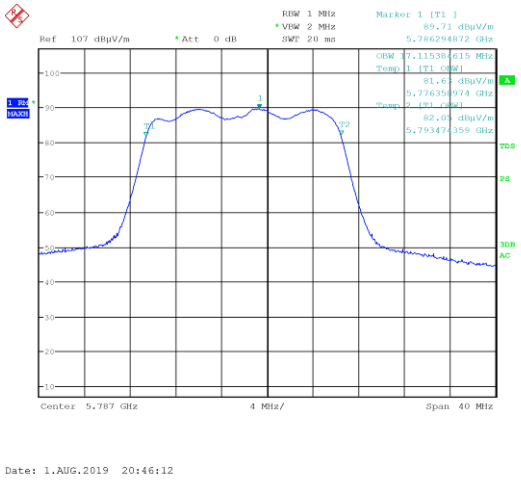
99 % bandwidth on 802.11n HT20, sample plot



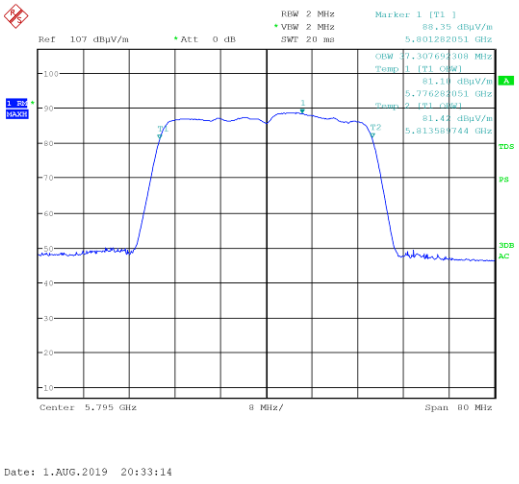
99 % bandwidth 802.11n HT40, sample plot



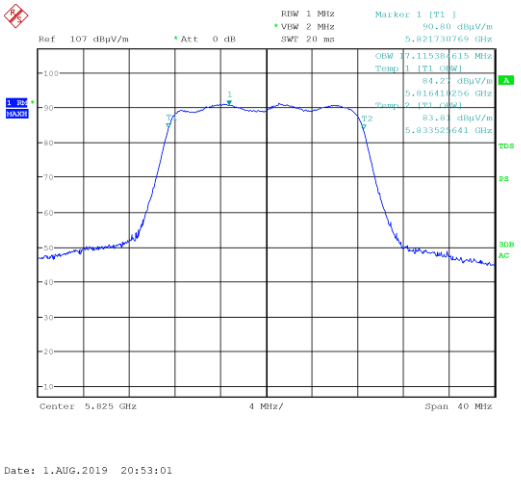
99 % bandwidth on 802.11a, sample plot



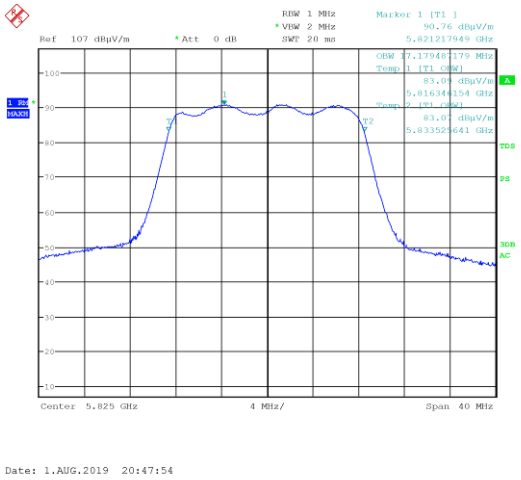
99 % bandwidth on 802.11n HT20, sample plot



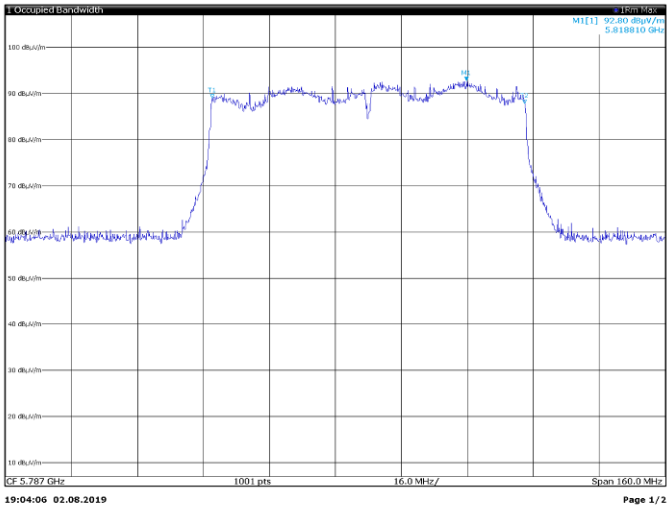
99 % bandwidth 802.11n HT40, sample plot



99 % bandwidth on 802.11a, sample plot



99 % bandwidth on 802.11n HT20, sample plot



99 % bandwidth on 802.11aC, sample plot

8.3 FCC 15.407(a)(3) and RSS-247 6.2.4.1 5.725–5.85 GHz band output power and spectral density limits

8.3.1 Definitions and limits

FCC:
For the band 5.725–5.85 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W. In addition, the maximum power spectral density shall not exceed 30 dBm in any 500-kHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. However, fixed point-to-point U-NII devices operating in this band may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted power. Fixed, point-to-point operations exclude the use of point-to-multipoint systems, omnidirectional applications, and multiple collocated transmitters transmitting the same information. The operator of the U-NII device, or if the equipment is professionally installed, the installer, is responsible for ensuring that systems employing high gain directional antennas are used exclusively for fixed, point-to-point operations.

ISED:
The maximum conducted output power shall not exceed 1 W. The power spectral density shall not exceed 30 dBm in any 500 kHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. However, fixed point-to-point devices operating in this band may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted power. Fixed point-to-point operations exclude the use of point-to-multipoint systems, omnidirectional applications and multiple collocated transmitters transmitting the same information.

8.3.2 Test summary

Test start date:	April 5, 2019
Test engineer:	Daniele Guarnone

8.3.3 Observations, settings and special notes

As per manufacturer declaration, EUT is for indoor use only. EUT was configured to continuous transmit mode during tests.
Output power was tested using RMS power meter.
The highest and lowest data rate setting have been investigated, only the worst-cases were presented.

Spectrum analyzer settings for PSD measurement:

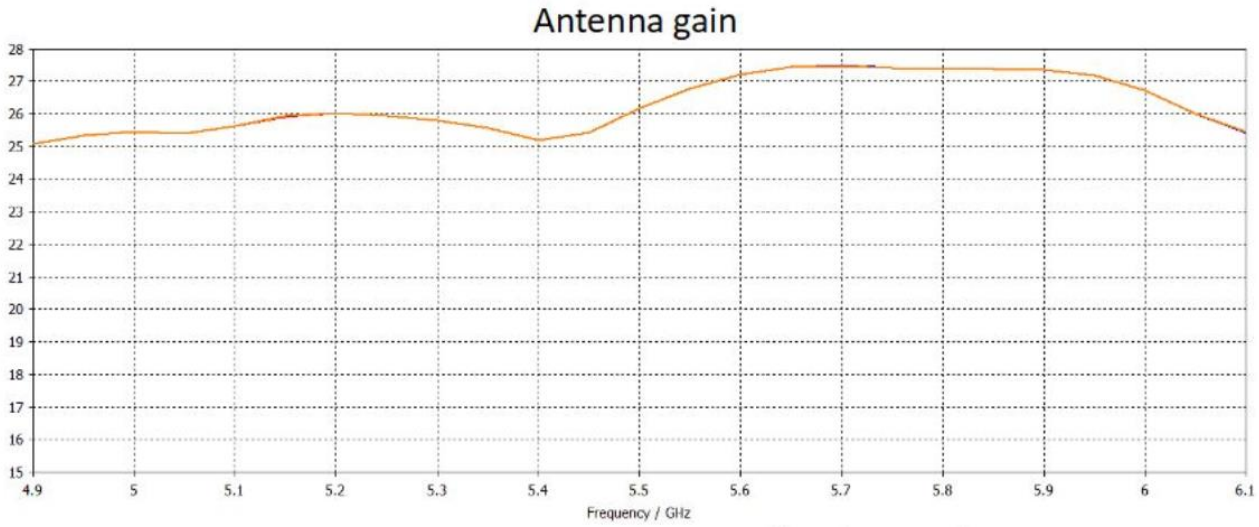
Resolution bandwidth	500 kHz
Video bandwidth	2 MHz
Frequency span	> EBW
Detector mode	RMS
Trace mode	Power Averaging over 100 sweeps

the MIMO mode is turn on during the tests

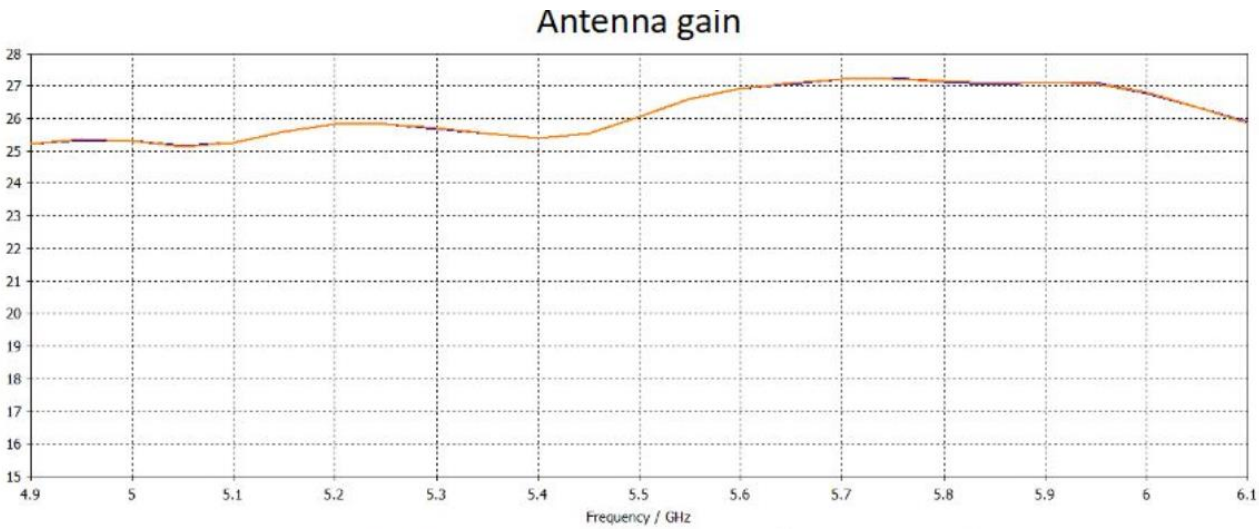
EIRP CALCULATION

$EIRP = P_{combined} + antenna\ directional\ gain$

Max antenna gain: 27.5 (see below the gain measurement provided by manufacturer)



LHG_XL_52_5 GHz_gain-graphic_horz-pol



LHG_XL_52_5 GHz_gain-graphic_horz-pol

DIRECTIONAL GAIN

According to KDB 662911 (F)(2)(e)(i):

Directional antenna gain $G_{DIR} = G_{MAX} + 10*Log (N_{ANT}/N_{SS})$, where N_{SS} is the number of independent spatial streams of data and G_{MAX} is the gain of the antenna having the highest gain (in dBi).

Device supports spatial multiplexing/cyclic delay diversity in MIMO configurations and single stream legacy modes. Antenna gain for both chains is the same. Signals between chains are correlated. Then $N_{ANT} = 2$ and $N_{SS} = 1$:

G_{DIR} = 27.5 dBi + 10∗Log (2/1) = 30.5 dBi.

Total antenna gain was calculated as follows: $Directional\ gain = 10\log[(10^{\frac{G1}{20}} + 10^{\frac{G2}{20}})^2 / N_{ANT}]$

OUTPUT POWER/EIRP/PSD LIMIT ADJUSTMENT

Output power/EIRP/PSD limit – (Total antenna gain – 6 dBi).
FCC Output power limit is 30 dBm – (30.5 - 6) = 30 dBm – 24.5 = 5.5 dBm
FCC PSD limit is 17 dBm/MHz – (30.5 - 6) = 17 dBm/MHz – 24.5 = -7.5 dBm/MHz

ISED e.i.r.p limit is 200 mW (23 dBm) or 10 + 10∗Log (B), dBm, whichever power is less.

ISED PSD limit is 10 dBm/MHz e.i.r.p

E-FIELD CALCULATION
According to KDB 558074 and ANSI C63.10:

$EIRP_{dBm} = S_{dB\mu V/m} + 20*Log(d_m) - 104.7$

Example of calculation:
$EIRP_{dBm=}$104.4 dBuV/m+20*log10(3)-104.7=9.2

Output power/EIRP/PSD limit adjustment (in case antenna gain is more than 6 dBi): Output power/EIRP/PSD limit – (Total antenna gain – 6 dBi).
EIRP = E + 20xlog (d) -104.7
E= E field (dBuV/m)
D= distance (m)

According clause 14.5 of ANSI C63.10 where radiated measurements are used for determining compliance with conducted limits, the following steps are required to ensure that the total emission power or PSD is determined for equipment driving cross-polarized antennas:
a) Measure radiated emissions with vertical and horizontal polarizations of the measurement antenna.
b) Convert each radiated measurement to transmit power or PSD based on the antenna gain.
c) Sum the powers or PSDs across the two polarizations.

8.3.4 Test data

Fcc Total power (Sum of E Field in vertical and horizontal polarization) to dBm EIRP (Total E Field – antenna gain -20*log10(3)-104.7 dB

Modulation	Frequency,	Conducted output power, dBm				EIRP,	EIRP limit,	
	MHz	Measured	Limit	Margin, dB	Antenna gain, dBi	dBm	dBm	EIRP margin, dB
802.11a	5745	-19.8	5.5	-25.3	30.5	10.7	36.0	-25.3
	5785	-21.1	5.5	-26.6	30.5	9.4	36.0	-26.6
	5825	-19.9	5.5	-25.4	30.5	10.6	36.0	-25.4
802.11n HT20	5745	-20.3	5.5	-25.8	30.5	10.2	36.0	-25.8
	5785	-21.8	5.5	-27.3	30.5	8.7	36.0	-27.3
	5825	-19.9	5.5	-25.4	30.5	10.6	36.0	-25.4
802.11n HT40	5755	-20.4	5.5	-25.9	30.5	10.1	36.0	-25.9
	5795	-21.5	5.5	-27.0	30.5	9.0	36.0	-27.0
802.11ac 80	5787	-14.3	5.5	-19.8	30.5	16.2	36.0	-19.8

Vertical polarization

Modulation	Frequency, MHz	dBm Measured	dBm Limit	Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB	dBuV/m
802.11a	5745	-25.3	5.5	-30.8	30.5	5.2	36.0	-30.8	100.3
	5785	-26.9	5.5	-32.4	30.5	3.6	36.0	-32.4	98.7
	5825	-25.6	5.5	-31.1	30.5	4.9	36.0	-31.1	100.1
802.11n HT20	5745	-26.9	5.5	-32.4	30.5	3.6	36.0	-32.4	98.7
	5785	-30.9	5.5	-36.4	30.5	-0.4	36.0	-36.4	94.8
	5825	-25.6	5.5	-31.1	30.5	4.9	36.0	-31.1	100.1
802.11n HT40	5755	-25.7	5.5	-31.2	30.5	4.8	36.0	-31.2	99.9
	5795	-27.1	5.5	-32.6	30.5	3.4	36.0	-32.6	98.6
802.11ac 80	5787	-20.2	5.5	-25.7	30.5	10.3	36.0	-25.7	105.5

Horizontal polarization

Modulation	Frequency, MHz	dBm Measured	dBm Limit	Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB	dBuV/m
802.11a	5745	-21.3	5.5	-26.8	30.5	9.2	36.0	-26.8	104.4
	5785	-22.4	5.5	-27.9	30.5	8.1	36.0	-27.9	103.2
	5825	-21.2	5.5	-26.7	30.5	9.3	36.0	-26.7	104.4
802.11n HT20	5745	-21.4	5.5	-26.9	30.5	9.1	36.0	-26.9	104.3
	5785	-22.4	5.5	-27.9	30.5	8.1	36.0	-27.9	103.3
	5825	-21.2	5.5	-26.7	30.5	9.3	36.0	-26.7	104.4
802.11n HT40	5755	-21.9	5.5	-27.4	30.5	8.6	36.0	-27.4	103.7
	5795	-22.9	5.5	-28.4	30.5	7.6	36.0	-28.4	102.8
802.11ac 80	5787	-15.6	5.5	-21.1	30.5	14.9	36.0	-21.1	110.1

Test method KDB 558074 and ANSI C63.10

FCC Psd *measurements (Sum of E Field in vertical and horizontal polarization) to dBm EIRP (Total E Field – antenna gain -20*log10(3)-104.7 dB*

Total power (Sum of E Field in vertical and horizontal polarization) to dBm EIRP (Total E Field – antenna gain -20*log10(3)-104.7 dB

Modulation	Frequency,	Conducted output power, dBm/MHz				EIRP,
	MHz	Measured	Limit	Margin, dB	Antenna gain, dBi	dBm/MHz
802.11a	5745	-30.20	-7.5	-22.70	30.5	0.30
	5785	-31.10	-7.5	-23.60	30.5	-0.60
	5825	-30.20	-7.5	-22.70	30.5	0.30
802.11n HT20	5745	-30.35	-7.5	-22.85	30.5	0.15
	5785	-31.10	-7.5	-23.60	30.5	-0.60
	5825	-30.24	-7.5	-22.74	30.5	0.26
802.11n HT40	5755	-33.66	-7.5	-26.16	30.5	-3.16
	5795	-32.51	-7.5	-25.01	30.5	-2.01
			-7.5		30.5	
802.11ac 80	5787	-34.21	-7.5	-26.71	30.5	-3.71

Horizontal polarization

Modulation	Frequency,	dBm		Margin, dB	Antenna gain, dBi	EIRP,	EIRP limit,	EIRP margin, dB	E Field dBuV/m
	MHz	Measured	Limit			dBm	dBm		
802.11a	5745	-32.29	-7.5	-24.79	30.5	-1.79	--	--	93.37
	5785	-32.66	-7.5	-25.16	30.5	-2.16	--	--	93
	5825	-31.72	-7.5	-24.22	30.5	-1.22	--	--	93.94
802.11n HT20	5745	-32.24	-7.5	-24.74	30.5	-1.74	--	--	93.42
	5785	-32.66	-7.5	-25.16	30.5	-2.16	--	--	93
	5825	-31.74	-7.5	-24.24	30.5	-1.24	--	--	93.92
802.11n HT40	5755	-35.20	-7.5	-27.70	30.5	-4.70	--	--	90.46
	5795	-35.46	-7.5	-27.96	30.5	-4.96	--	--	90.2
			-7.5				--	--	
802.11ac 80	5787	-35.57	-7.5	-28.07	30.5	-5.07	--	--	90.09

Vertical polarization

Modulation	Frequency,	dBm		Margin, dB	Antenna gain, dBi	EIRP,	EIRP limit,	EIRP margin, dB	E Field dBuV/m
	MHz	Measured	Limit			dBm	dBm		
802.11a	5745	-34.38	-7.5	-26.88	30.5	-3.88	--	--	91.28
	5785	-36.30	-7.5	-28.80	30.5	-5.80	--	--	89.36
	5825	-35.51	-7.5	-28.01	30.5	-5.01	--	--	90.15
802.11n HT20	5745	-34.88	-7.5	-27.38	30.5	-4.38	--	--	90.78
	5785	-36.30	-7.5	-28.80	30.5	-5.80	--	--	89.36
	5825	-35.58	-7.5	-28.08	30.5	-5.08	--	--	90.08
802.11n HT40	5755	-38.93	-7.5	-31.43	30.5	-8.43	--	--	86.73
	5795	-35.58	-7.5	-28.08	30.5	-5.08	--	--	90.08
			-7.5		30.5		--	--	
802.11ac 80	5787	-39.91	-7.5	-32.41	30.5	-9.41	--	--	85.75

ISED e.i.r.p limit is 200 mW (23 dBm) or 10 + 10∗Log (B), dBm, whichever power is less.

ISED PSD limit is 10 dBm/MHz e.i.r.p

FCC Psd **measurements** (Sum of E Field in vertical and horizontal polarization) to dBm EIRP (Total E Field – antenna gain -20*log10(3)-104.7 dB

Modulation	Frequency,	Conducted output power, dBm			Antenna gain,	EIRP,	EIRP limit,	EIRP margin,
	MHz	Measured	Limit	Margin, dB	dBi	dBm	dBm	dB
802.11a	5745	-19.8	--	--	30.5	10.7	22.1	-11.4
	5785	-21.1	--	--	30.5	9.4	22.1	-12.7
	5825	-19.9	--	--	30.5	10.6	22.1	-11.5
802.11n HT20	5745	-20.3	--	--	30.5	10.2	22.1	-11.9
	5785	-21.8	--	--	30.5	8.7	22.1	-13.4
	5825	-19.9	--	--	30.5	10.6	22.1	-11.5
802.11n HT40	5755	-20.4	--	--	30.5	10.1	23.0	-12.9
	5795	-21.5	--	--	30.5	9.0	23.0	-14.0
			--	--				
802.11ac 80	5787	-14.3	--	--	30.5	16.2	23.0	-6.8

VERTICAL POLARIZATION

Modulation	Frequency,	dBm			Antenna	EIRP,	EIRP limit,	EIRP	
	MHz	Measured	Limit	Margin, dB	gain, dBi	dBm	dBm	margin, dB	dBuV/m
802.11a	5745	-25.3	--	--	30.5	5.2	22.1	-16.9	100.3
	5785	-26.9	--	--	30.5	3.6	22.1	-18.5	98.7
	5825	-25.6	--	--	30.5	4.9	22.1	-17.2	100.1
802.11n HT20	5745	-26.9	--	--	30.5	3.6	22.1	-18.5	98.7
	5785	-30.9	--	--	30.5	-0.4	22.1	-22.5	94.8
	5825	-25.6	--	--	30.5	4.9	22.1	-17.2	100.1
802.11n HT40	5755	-25.7	--	--	30.5	4.8	22.1	-17.3	99.9
	5795	-27.1	--	--	30.5	3.4	23.0	-19.6	98.6
			--	--			23.0		
802.11ac 80	5787	-20.0	--	--	30.5	10.5	23.0	-12.7	105.5

Horizontal polarization

Modulation	Frequency,	dBm			Antenna	EIRP,	EIRP limit,	EIRP	
	MHz	Measured	Limit	Margin, dB	gain, dBi	dBm	dBm	margin, dB	dBuV/m
802.11a	5745	-21.3	--	--	30.5	9.2	22.1	-12.9	104.4
	5785	-22.4	--	--	30.5	8.1	22.1	-14.0	103.2
	5825	-21.2	--	--	30.5	9.3	22.1	-12.8	104.4
802.11n HT20	5745	-21.4	--	--	30.5	9.1	22.1	-13.0	104.3
	5785	-22.4	--	--	30.5	8.1	22.1	-14.0	103.3
	5825	-21.2	--	--	30.5	9.3	22.1	-12.8	104.4
802.11n HT40	5755	-21.9	--	--	30.5	8.6	22.1	-13.5	103.7
	5795	-22.9	--	--	30.5	7.6	23.0	-15.4	102.8
			--	--			23.0		
802.11ac 80	5787	-15.6	--	--	30.5	14.9	23.0	-8.1	110.1

ISED PSD limit is 10 dBm/MHz e.i.r.p

ISED Psd measurements (Sum of E Field in vertical and horizontal polarization) to dBm EIRP (Total E Field – antenna gain -20*log10(3)-104.7 dB

Modulation	Frequency,	Conducted output power, dBm/MHz				EIRP,	EIRP limit,	
	MHz	Measured	Limit	Margin, dB	Antenna gain, dBi	dBm/MHz	dBm/MHz	EIRP margin, dB
802.11a	5745	-30.20	--	--	30.5	0.30	10	-9.70
	5785	-31.10	--	--	30.5	-0.60	10	-10.60
	5825	-30.20	--	--	30.5	0.30	10	-9.70
802.11n HT20	5745	-30.35	--	--	30.5	0.15	10	-9.85
	5785	-31.10	--	--	30.5	-0.60	10	-10.60
	5825	-30.24	--	--	30.5	0.26	10	-9.74
802.11n HT40	5755	-33.66	--	--	30.5	-3.16	10	-13.16
	5795	-32.51	--	--	30.5	-2.01	10	-12.01
			--	--	30.5		10	-10.00
802.11ac 80	5787	-34.21	--	--	30.5	-3.71	10	-13.71
			--	--				

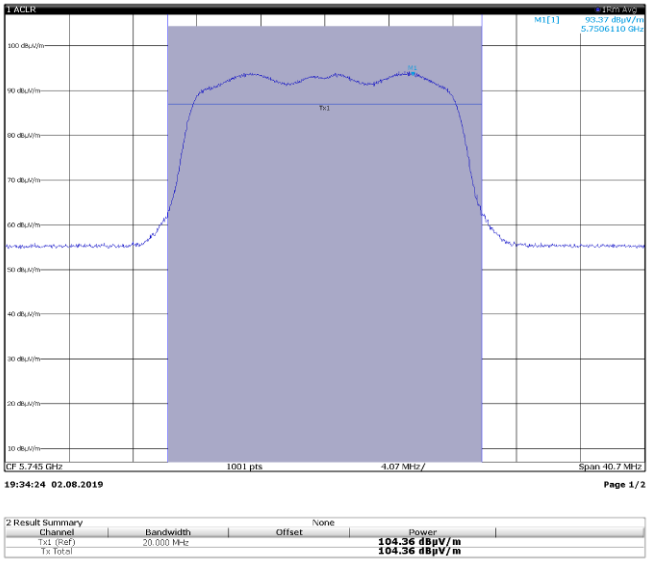
VERTICAL POLARIZATION

Modulation	Frequency,	dBm/MHz		Margin,	Antenna	EIRP,	EIRP limit,	EIRP margin,	
	MHz	Measured	Limit	dB	gain, dBi	dBm/MHz	dBm/MHz	dB	dBuV/m/MHz
802.11a	5745	-34.38	--	--	30.5	-3.88	10	-13.88	91.28
	5785	-36.30	--	--	30.5	-5.80	10	-15.80	89.36
	5825	-35.51	--	--	30.5	-5.01	10	-15.01	90.15
802.11n HT20	5745	-34.88	--	--	30.5	-4.38	10	-14.38	90.78
	5785	-36.30	--	--	30.5	-5.80	10	-15.80	89.36
	5825	-35.58	--	--	30.5	-5.08	10	-15.08	90.08
802.11n HT40	5755	-38.93	--	--	30.5	-8.43	10	-18.43	86.73
	5795	-35.58	--	--	30.5	-5.08	10	-15.08	90.08
			--	--	30.5		10	-10.00	
802.11ac 80	5787	-39.91	--	--	30.5	-9.41	10	-19.41	85.75
			--	--					

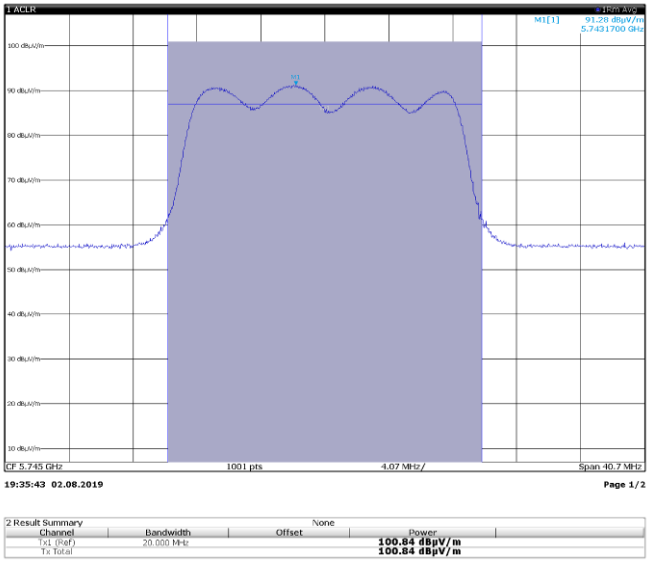
Horizontal polarization

Modulation	Frequency,	dBm/MHz		Margin,	Antenna	EIRP,	EIRP limit,	EIRP margin,	
	MHz	Measured	Limit	dB	gain, dBi	dBm/MHz	dBm/MHz	dB	dBuV/m/MHz
802.11a	5745	-32.29			30.5	-1.79	10	-11.79	93.37
	5785	-32.66			30.5	-2.16	10	-12.16	93
	5825	-31.72			30.5	-1.22	10	-11.22	93.94
802.11n HT20	5745	-32.24			30.5	-1.74	10	-11.74	93.42
	5785	-32.66			30.5	-2.16	10	-12.16	93
	5825	-31.74			30.5	-1.24	10	-11.24	93.92
802.11n HT40	5755	-35.20			30.5	-4.70	10	-14.70	90.46
	5795	-35.46			30.5	-4.96	10	-14.96	90.2
							10	-10.00	
802.11ac 80	5787	-35.57			30.5	-5.07	10	-15.07	90.09

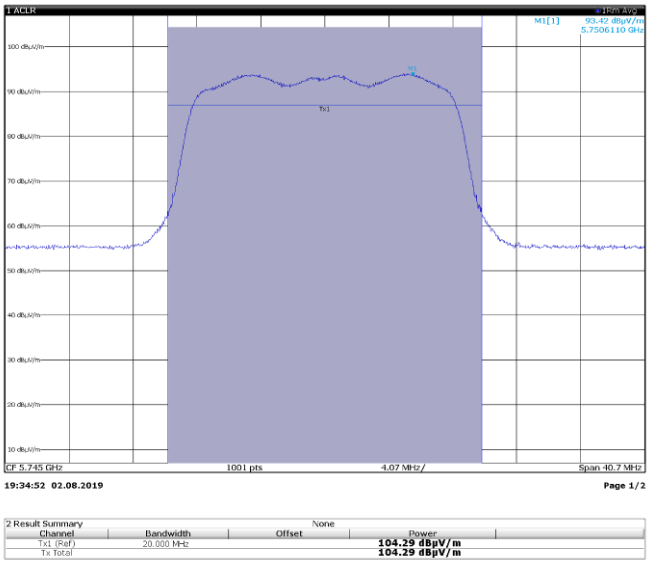
detector = RMS (power averaging).



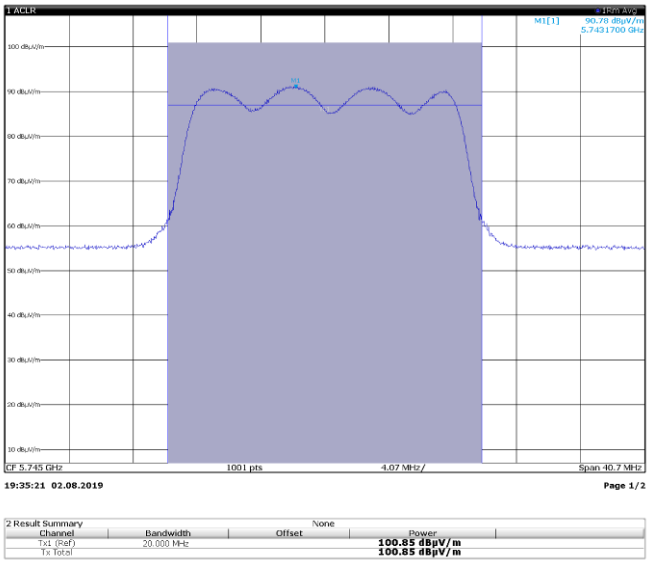
eirp on 802.11a Sample plot horizontal



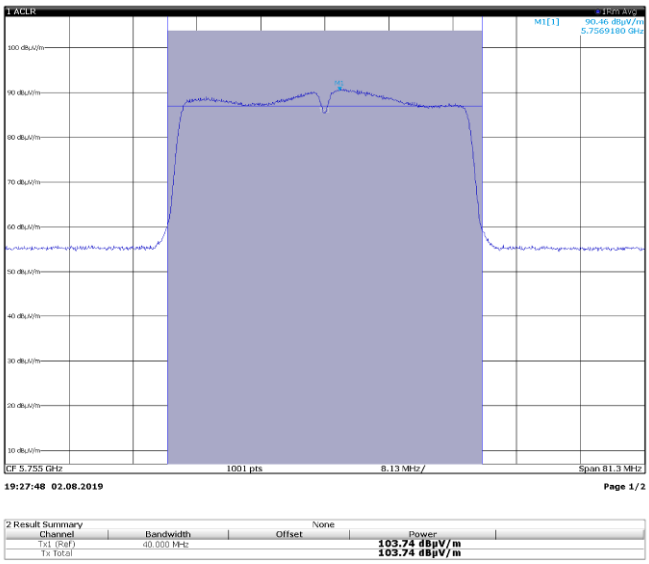
eirp on 802.11a Sample plot vertical



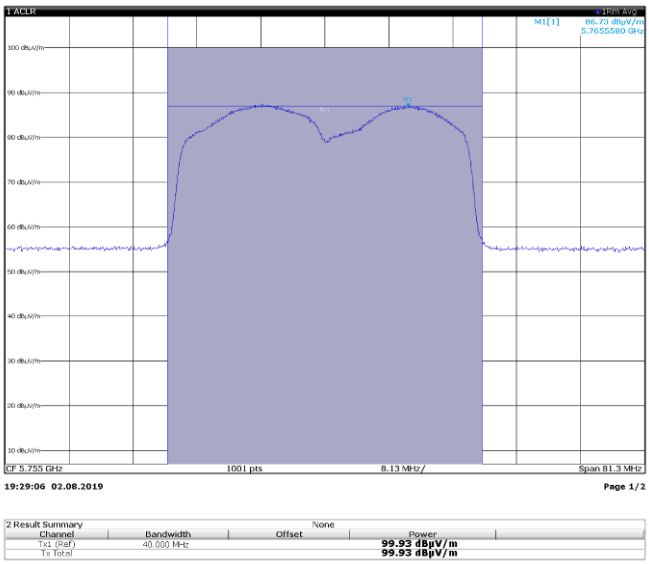
eirp on 802.11Nht20 Sample plot horizontal



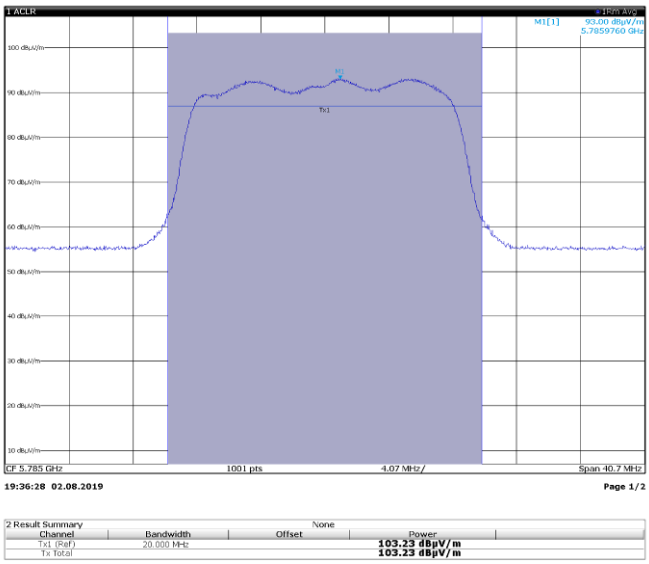
eirp on 802.11Nht20 Sample plot vertical



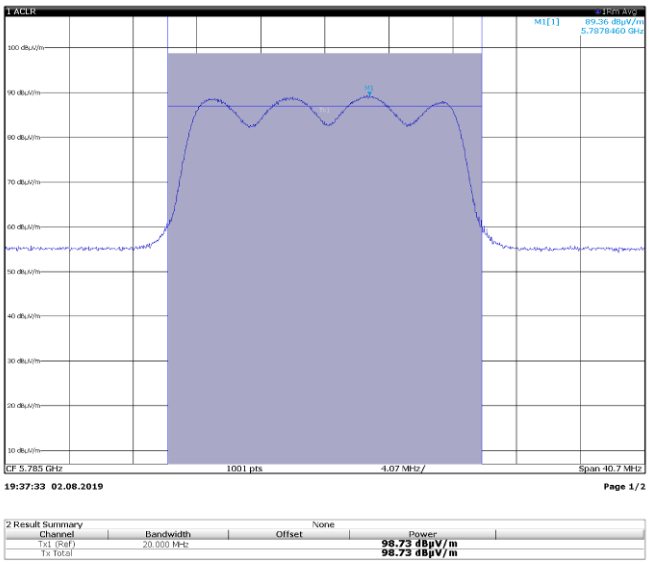
eirp on 802.11Nht40 Sample plot horizontal



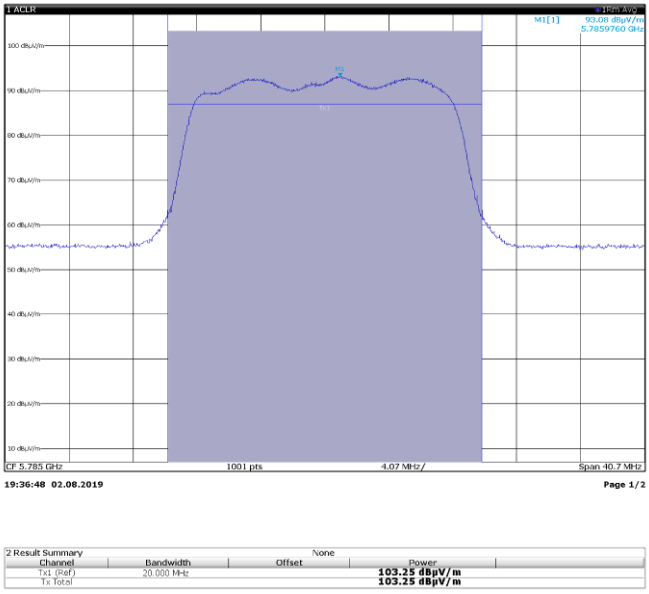
eirp on 802.11Nht40 Sample plot vertical



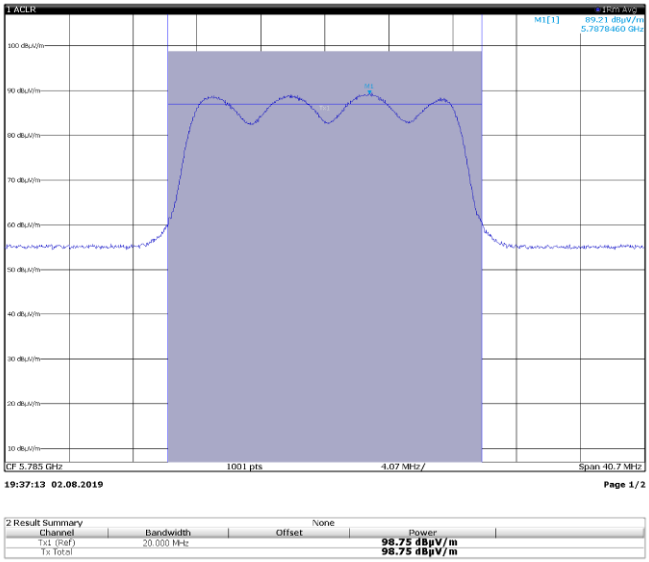
eirp on 802.11a Sample plot horizontal



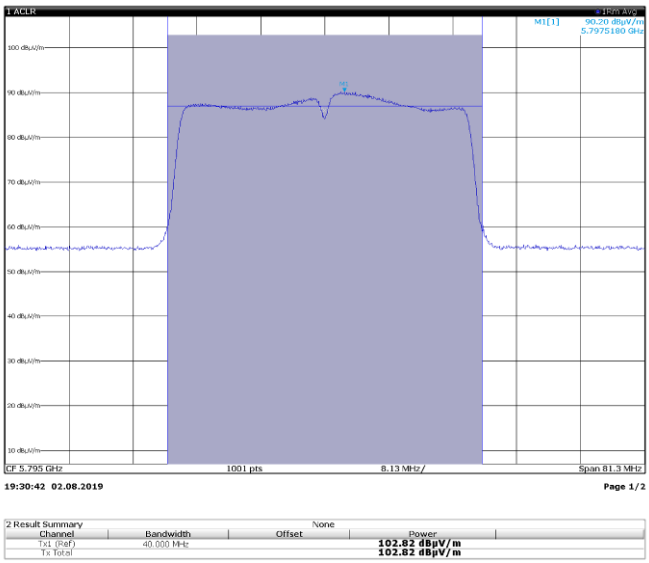
eirp on 802.11a Sample plot vertical



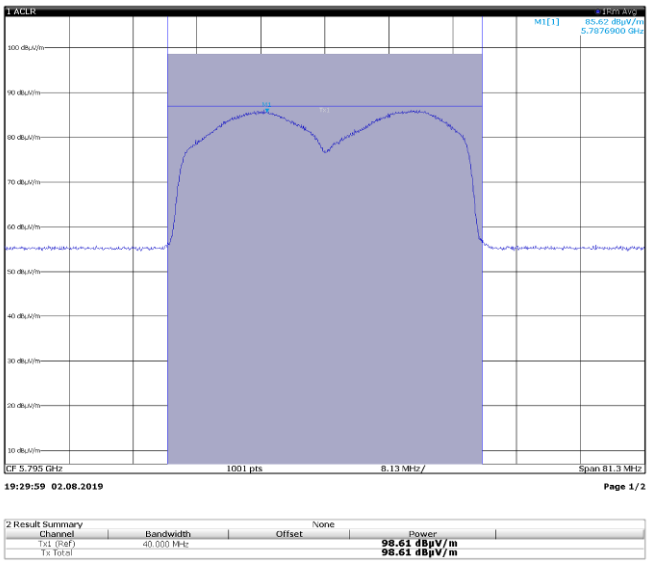
eirp on 802.11Nht20 Sample plot horizontal



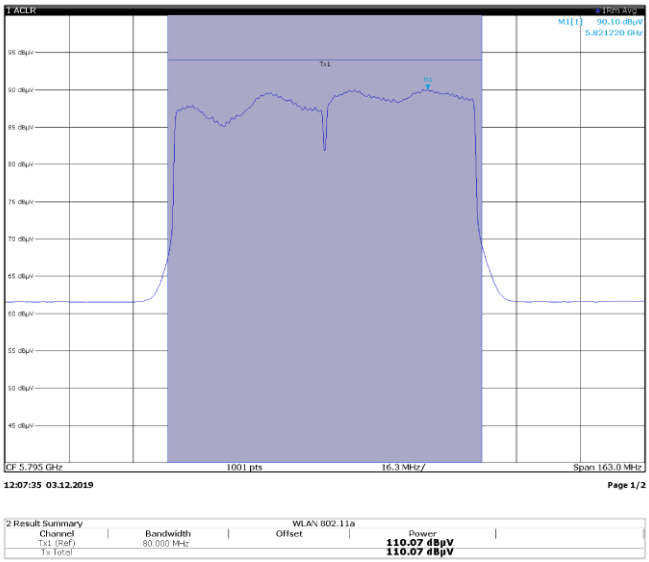
eirp on 802.11Nht20 Sample plot vertical



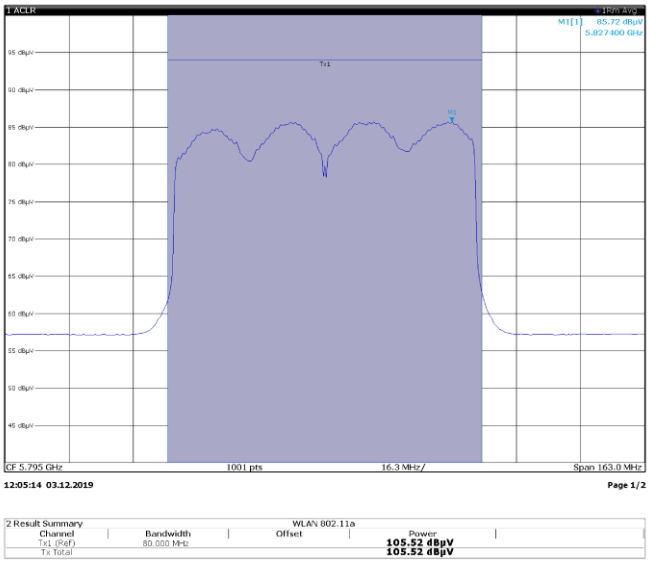
eirp on 802.11Nht40 Sample plot horizontal



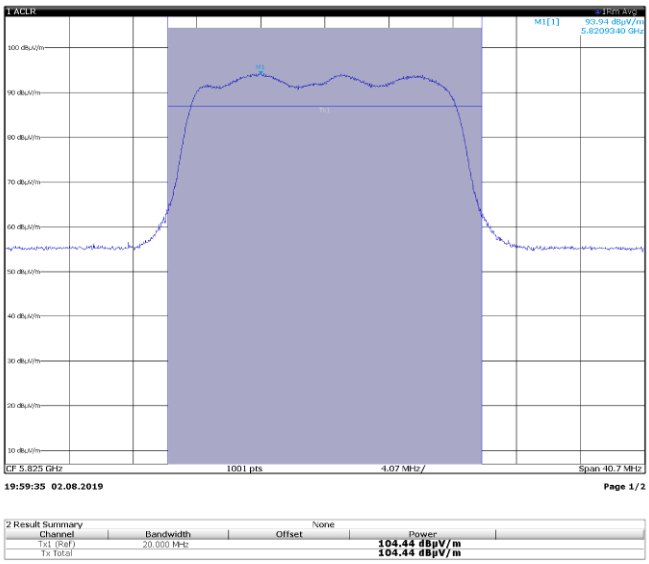
eirp on 802.11Nht40 Sample plot vertical



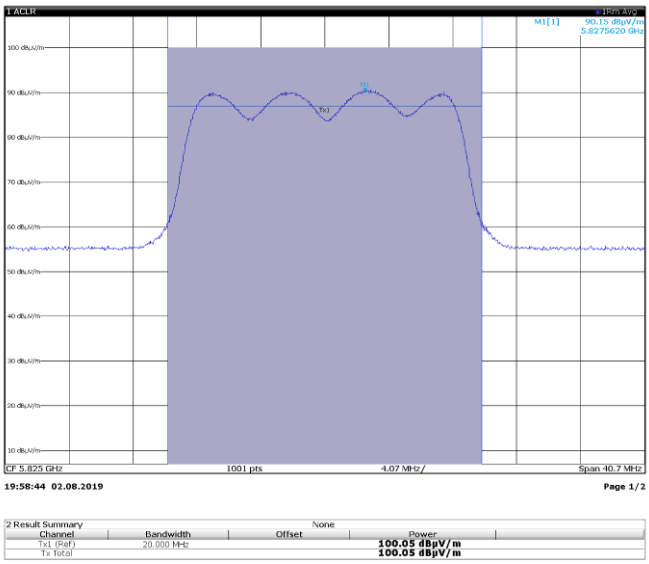
eirp on 802.11ac (80MHz) Sample plot horizontal



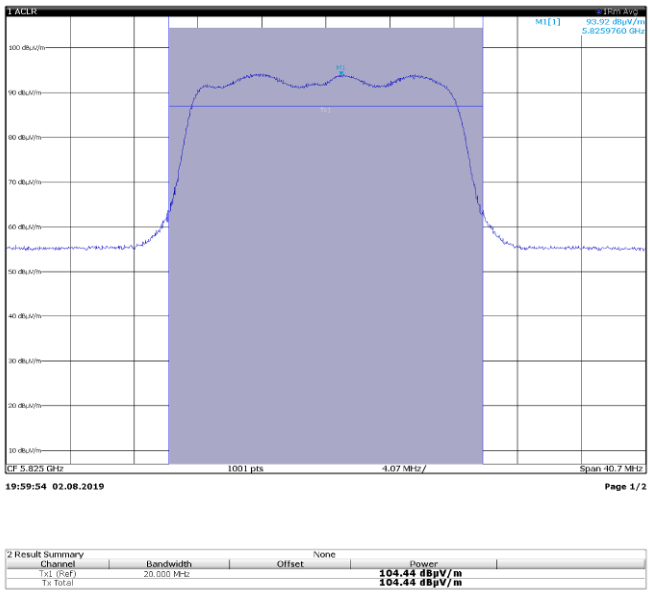
eirp on 802.11ac (80 MHz) Sample plot vertical



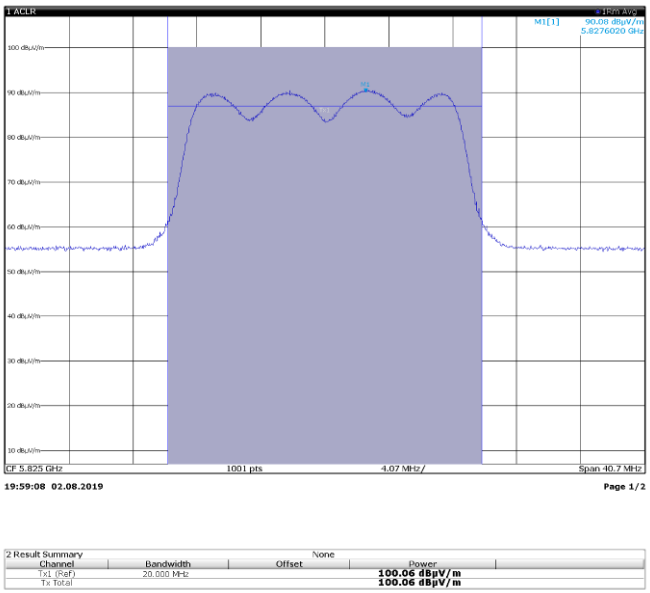
Psd eirp on 802.11a Sample plot horizontal



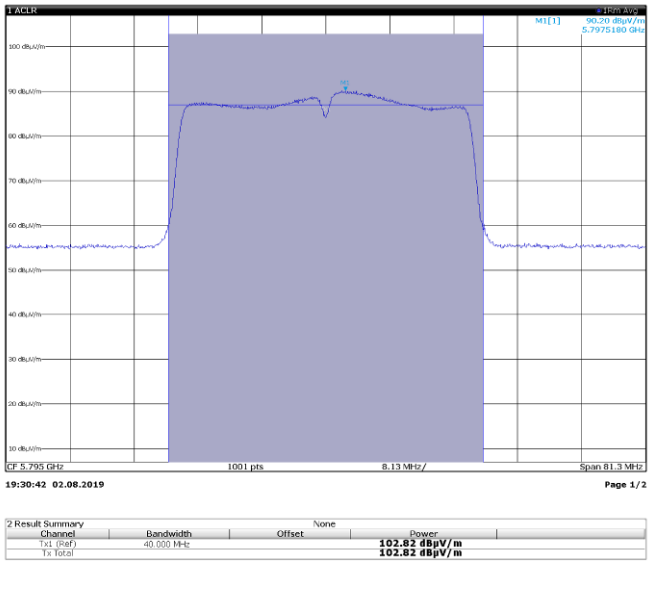
Psd eirp on 802.11a Sample plot vertical

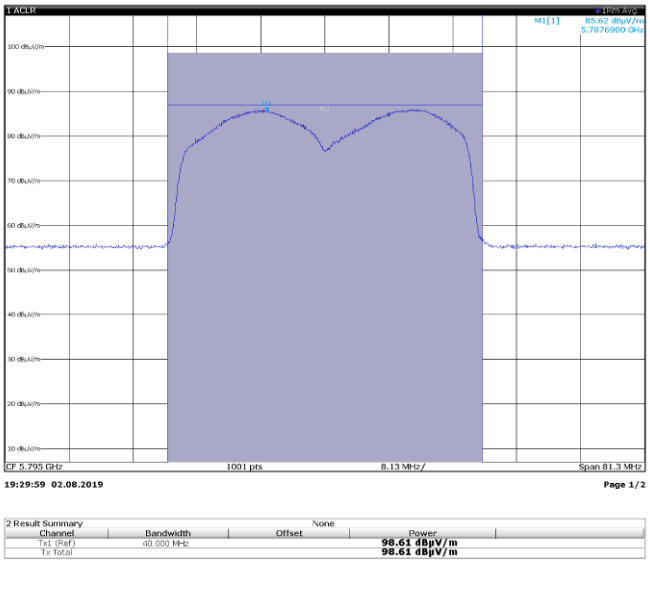


Psd eirp on 802.11Nht20 Sample plot horizontal



Psd eirp on 802.11Nht20 Sample plot vertical





8.4 FCC 15.407(b) and RSS-247 6.2.4.2 Spurious (out-of-band) emissions

8.4.1 Definitions and limits

FCC:

(i) All emissions shall be limited to a level of −27 dBm/MHz at 75 MHz or more above or below the band edge increasing linearly to 10 dBm/MHz at 25 MHz above or below the band edge, and from 25 MHz above or below the band edge increasing linearly to a level of 15.6 dBm/MHz at 5 MHz above or below the band edge, and from 5 MHz above or below the band edge increasing linearly to a level of 27 dBm/MHz at the band edge.
(ii) Devices certified before March 2, 2017 with antenna gain greater than 10 dBi may demonstrate compliance with the emission limits in § 15.247(d), but manufacturing, marketing and importing of devices certified under this alternative must cease by March 2, 2018. Devices certified before March 2, 2018 with antenna gain of 10 dBi or less may demonstrate compliance with the emission limits in § 15.247(d), but manufacturing, marketing and importing of devices certified under this alternative must cease before March 2, 2020.

For radiated emission:

−27 dBm/MHz at 75 MHz are 68.2 dBuV/m at 3m;
10 dBm/MHz are 105.2 dBuV/m at 3m,
15.6 dBm/MHz are 110.8 dBuV/m at 3m
27 dBm/MHz are 122.2 dBuV/m

ISED:
Devices operating in the band 5725-5850 MHz with antenna gain greater than 10 dBi can have unwanted emissions that comply with either the limits in this section or in section 5.5 until six (6) months after the publication date of this standard for certification. Certified devices that do not comply with emission limits in this section shall not be manufactured, imported, distributed, leased, offered for sale or sold after April 1, 2018.

Devices operating in the band 5725-5850 MHz with antenna gain of 10 dBi or less can have unwanted emissions that comply with either the limits in this section or in section 5.5 until April 1, 2018 for certification. Certified devices that do not comply with emission limits in this section shall not be manufactured, imported, distributed, leased, offered for sale or sold after April 1, 2020.

Devices operating in the band 5725-5850 MHz shall have e.i.r.p. of unwanted emissions comply with the following:

a. 27 dBm/MHz at frequencies from the band edges decreasing linearly to 15.6 dBm/MHz at 5 MHz above or below the band edges;
b. 15.6 dBm/MHz at 5 MHz above or below the band edges decreasing linearly to 10 dBm/MHz at 25 MHz above or below the band edges;
c. 10 dBm/MHz at 25 MHz above or below the band edges decreasing linearly to −27 dBm/MHz at 75 MHz above or below the band edges; and
d.−27 dBm/MHz at frequencies more than 75 MHz above or below the band edges.

Table 8.4-1: *FCC §15.209 and RSS-Gen – Radiated emission limits*

Frequency, MHz	Field strength of emissions µV/m	Field strength of emissions dBµV/m	Measurement distance, m
0.009–0.490	2400/F *(F in kHz)*	$67.6 - 20 \times \log_{10}$(F) *(F in kHz)*	300
0.490–1.705	24000/F *(F in kHz)*	$87.6 - 20 \times \log_{10}$(F) *(F in kHz)*	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 8.4-2: *ISED restricted frequency bands*

MHz	MHz	MHz	GHz
0.090–0.110	12.51975–12.52025	399.9–410	5.35–5.46
2.1735–2.1905	12.57675–12.57725	608–614	7.25–7.75
3.020–3.026	13.36–13.41	960–1427	8.025–8.5
4.125–4.128	16.42–16.423	1435–1626.5	9.0–9.2
4.17725–4.17775	16.69475–16.69525	1645.5–1646.5	9.3–9.5
4.20725–4.20775	16.80425–16.80475	1660–1710	10.6–12.7
5.677-5.683	25.5–25.67	1718.8–1722.2	13.25–13.4
6.215–6.218	37.5–38.25	2200–2300	14.47–14.5
6.26775–6.26825	73–74.6	2310–2390	15.35–16.2
6.31175–6.31225	74.8–75.2	2655–2900	17.7–21.4
8.291–8.294	108–138	3260–3267	22.01–23.12
8.362–8.366	156.52475–156.52525	3332–3339	23.6–24.0
8.37625–8.38675	156.7–156.9	3345.8–3358	31.2–31.8
8.41425–8.41475	240–285	3500–4400	36.43–36.5
12.29–12.293	322–335.4	4500–5150	Above 38.6

Note: Certain frequency bands listed in Table 8.4-2 and above 38.6 GHz are designated for low-power license-exempt applications. These frequency bands and the requirements that apply to the devices are set out in this Standard

Table 8.4-3: *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			

8.4.2 Test summary

Test start date:	April 02 2019
Test engineer:	Daniele Guarnone

8.4.3 Observations, settings and special notes

The spectrum was searched from 30 MHz to 40 GHz while the EUT was continuously transmitting.
Radiated measurements below 18 GHz were performed at a distance of 3 m. Radiated measurements above 18 GHz were performed at a distance of 1 m. Cabinet radiation were performed while the antenna connector was terminated with 50 Ω load. Below 1 GHz and above 18 GHz, no emissions related to RF transmitter were detected within 6 dB below the limit.

Spectrum analyser for peak conducted measurements within restricted bands below 1 GHz:

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

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

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

Spectrum analyser for average conducted measurements within restricted bands above 1 GHz for frequencies where peak results were above the average limit:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	RMS
Trace mode:	Power average
Number of averaging traces:	100

Spectrum analyser for peak conducted measurements outside restricted bands:

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

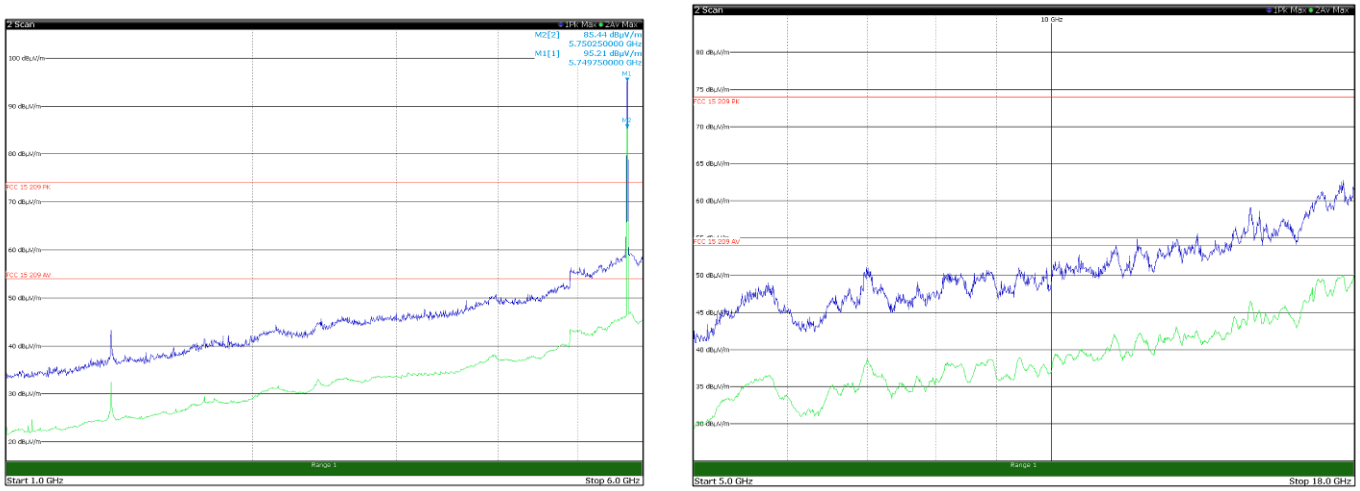
Spectrum analyzer settings for radiated measurements within restricted bands below 1 GHz:

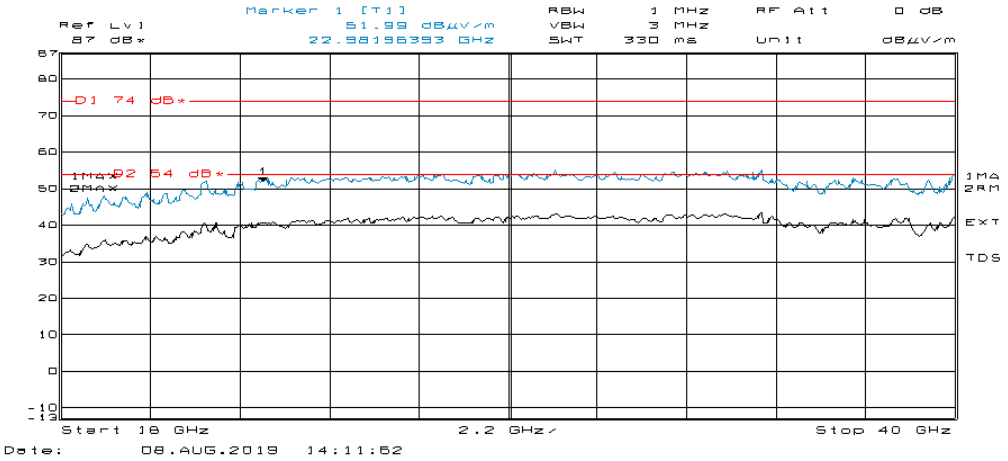
Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyzer 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

8.4.4 Test data





Spurious emissions outside restricted band, Tx on 5745 MHz, 802.11a horizontal

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Remarks
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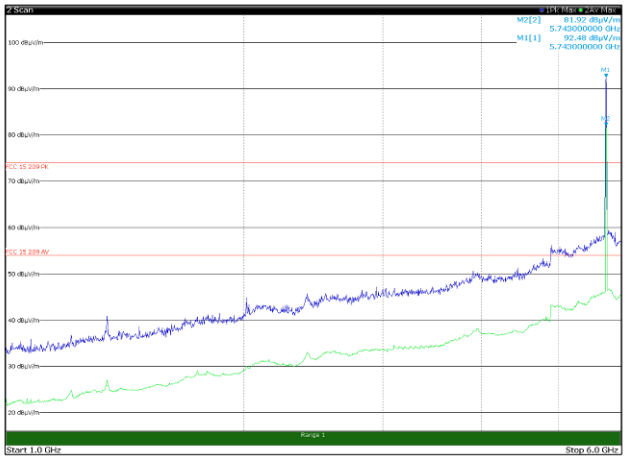
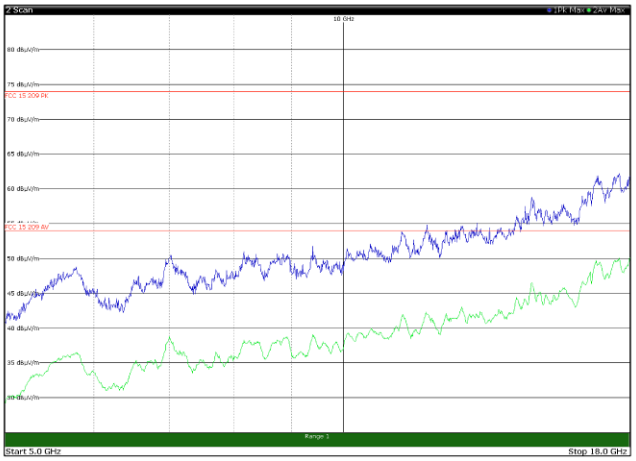
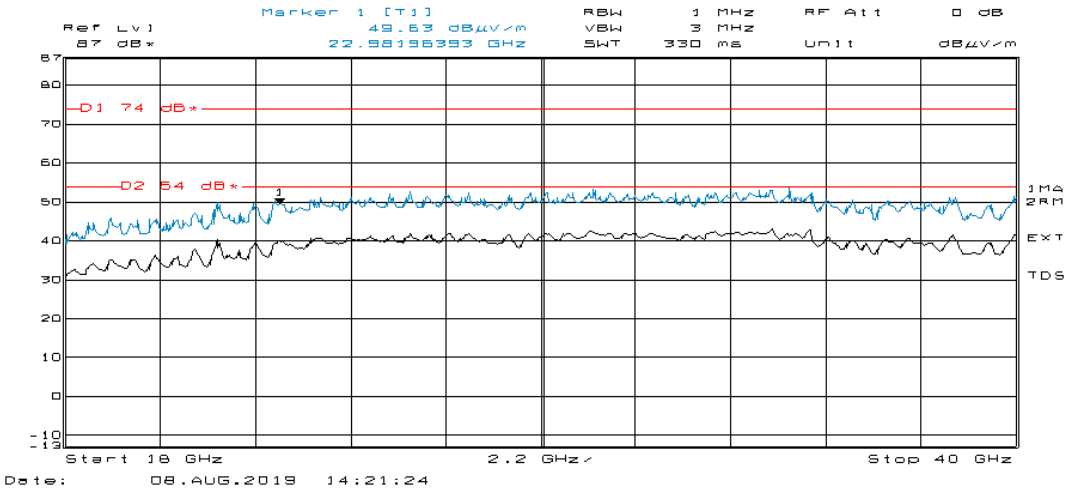
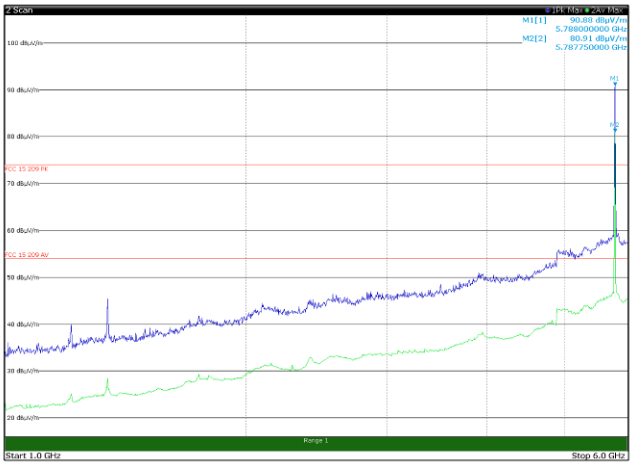


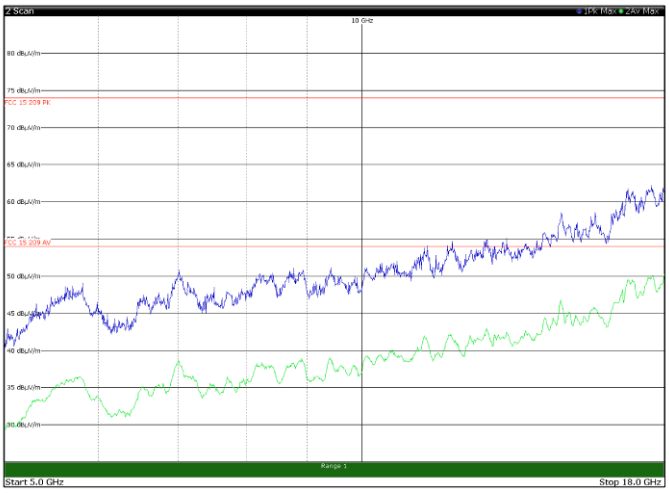


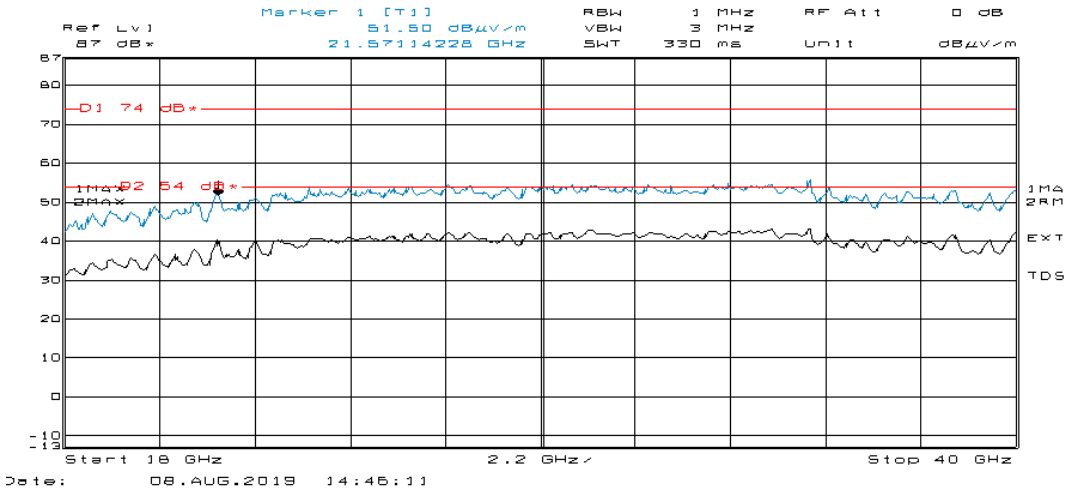


Spurious emissions outside restricted bands, Tx on 5745 MHz, 802.11a vertical

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Remarks
--	--	--	---	--	

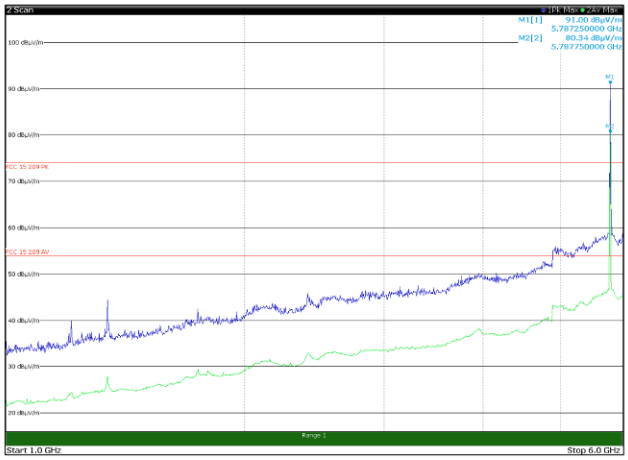


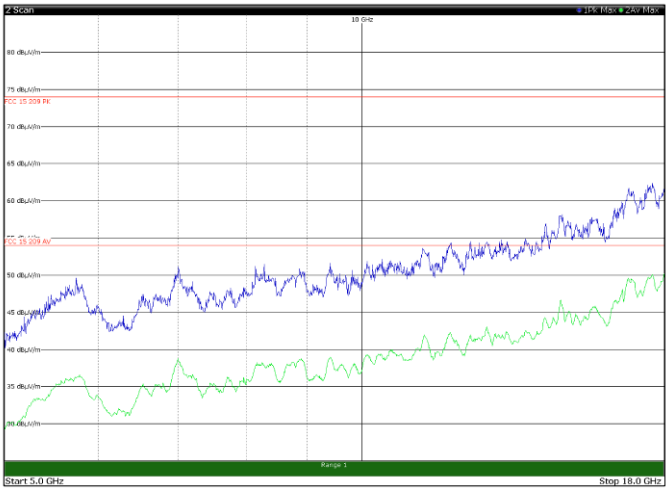


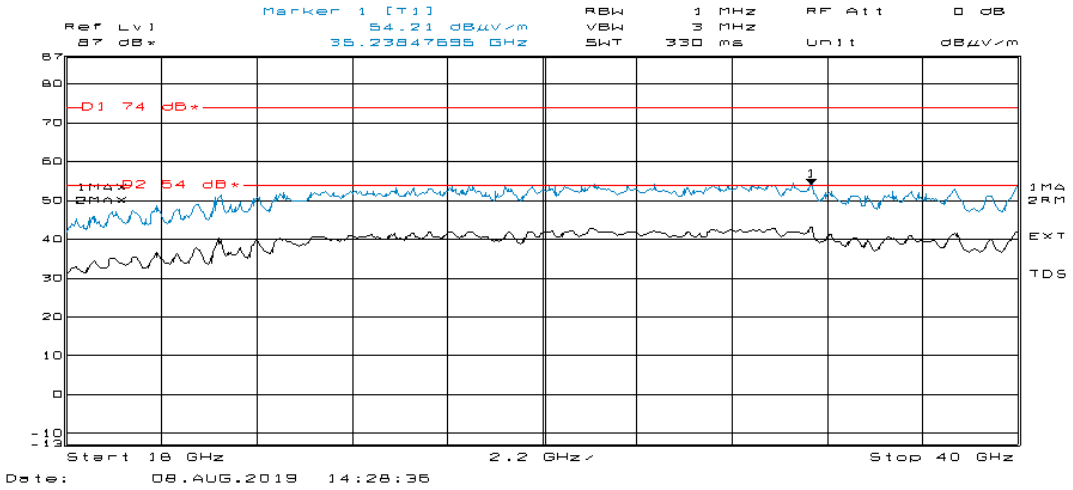


Spurious emissions outside restricted bands, Tx on 5785 MHz, 802.11a horizontal

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Remarks
--	--	--	---	--	

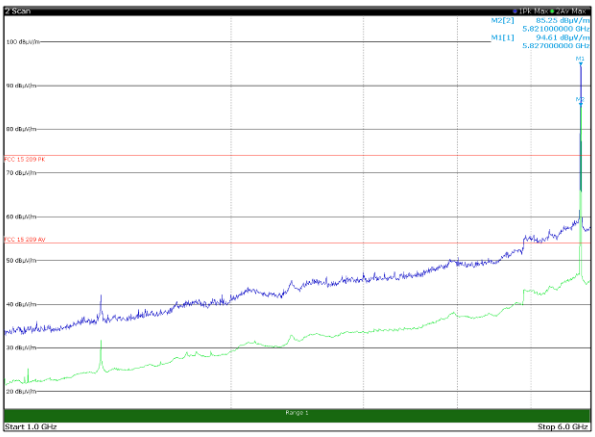


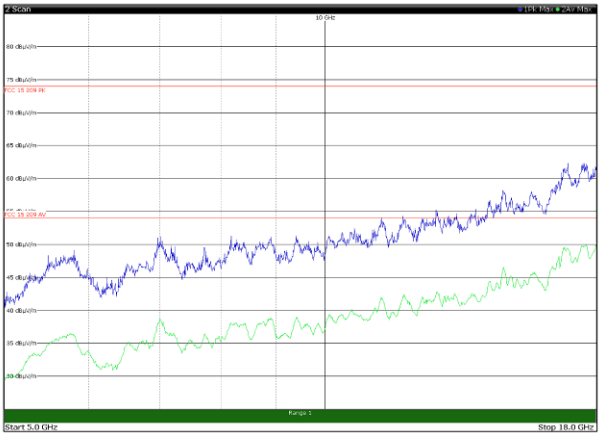


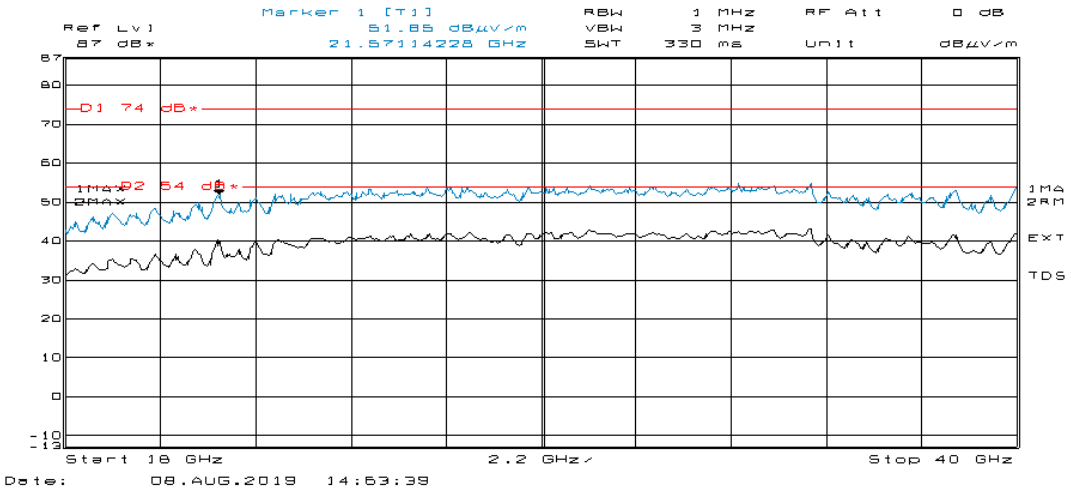


Spurious emissions outside restricted bands, Tx on 5785 MHz, 802.11a vertical

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Remarks
--	--	--	---	--	

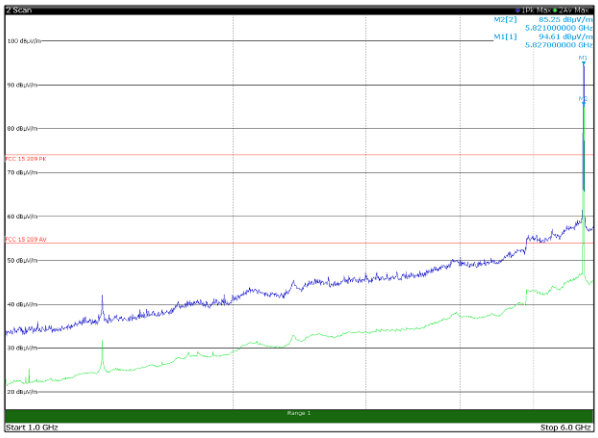


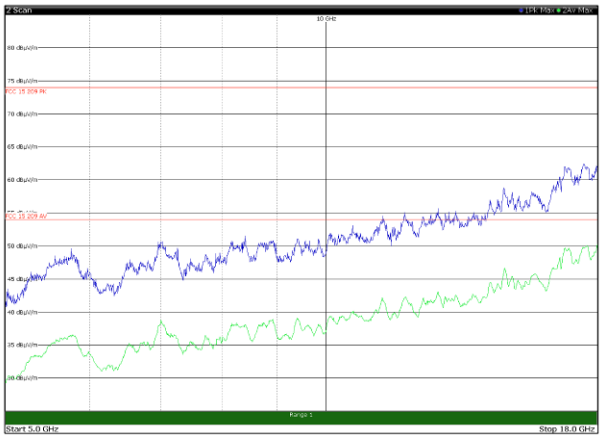


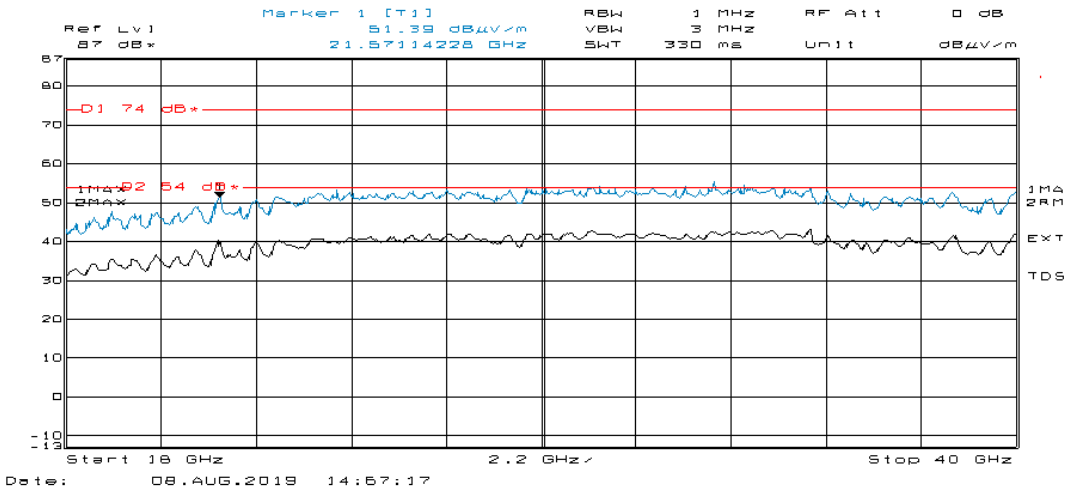


Spurious emissions outside restricted bands, Tx on 5825 MHz, 802.11a horizontal

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Remarks
--	--	--	---	--	







Spurious emissions outside restricted bands, Tx on 5825 MHz, 802.11a vertical

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Remarks
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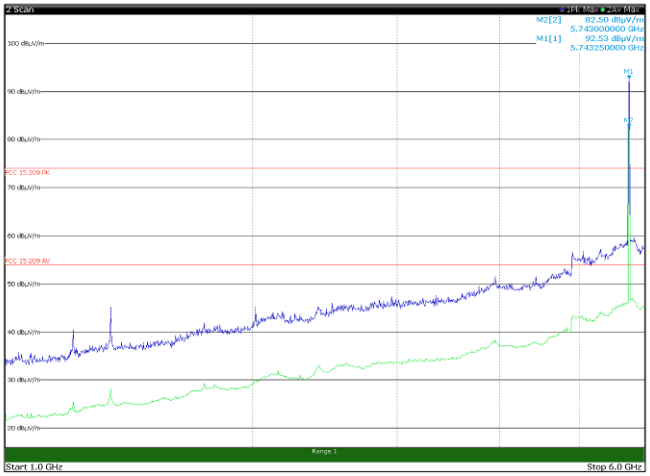
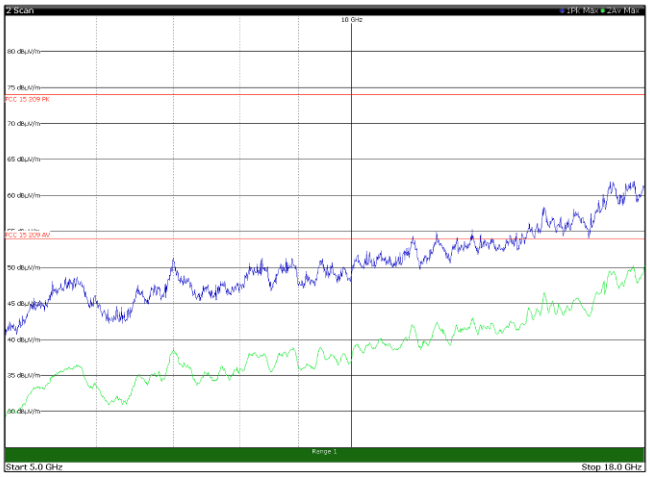
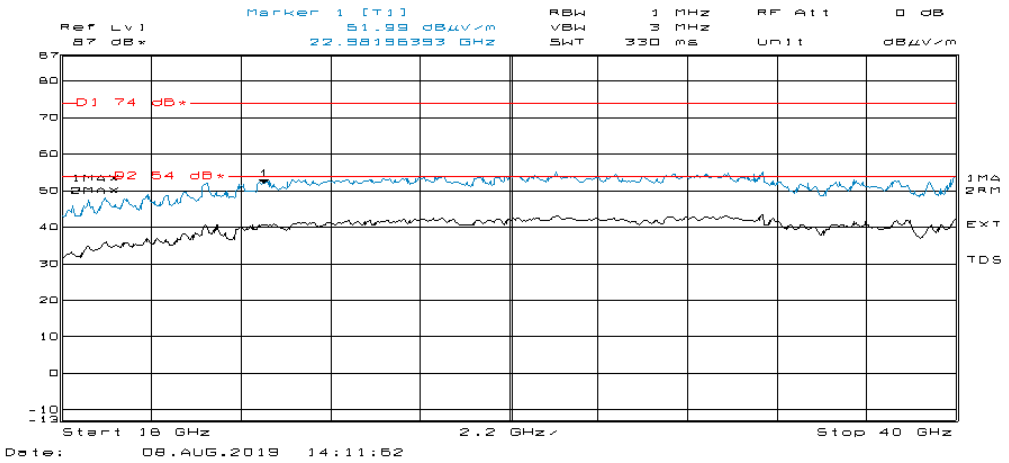
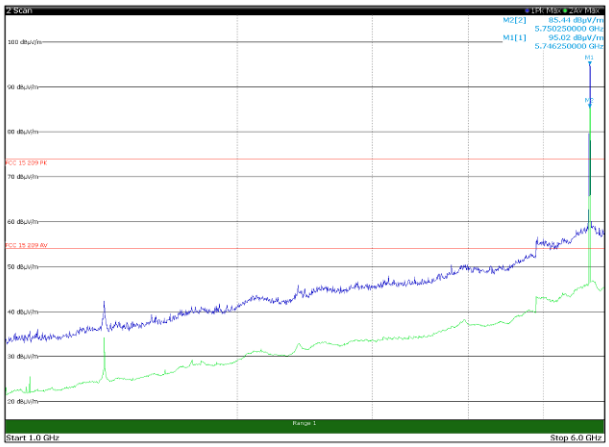


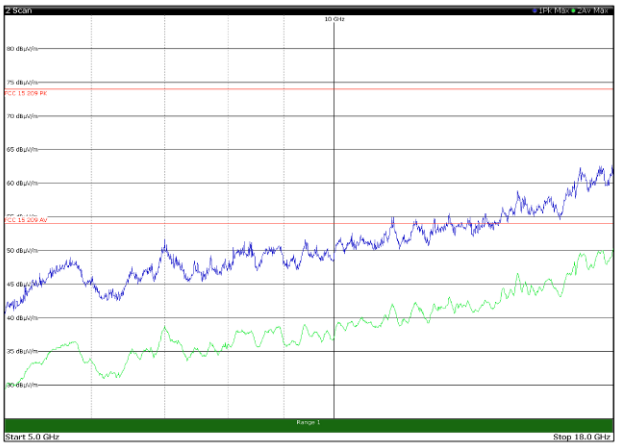


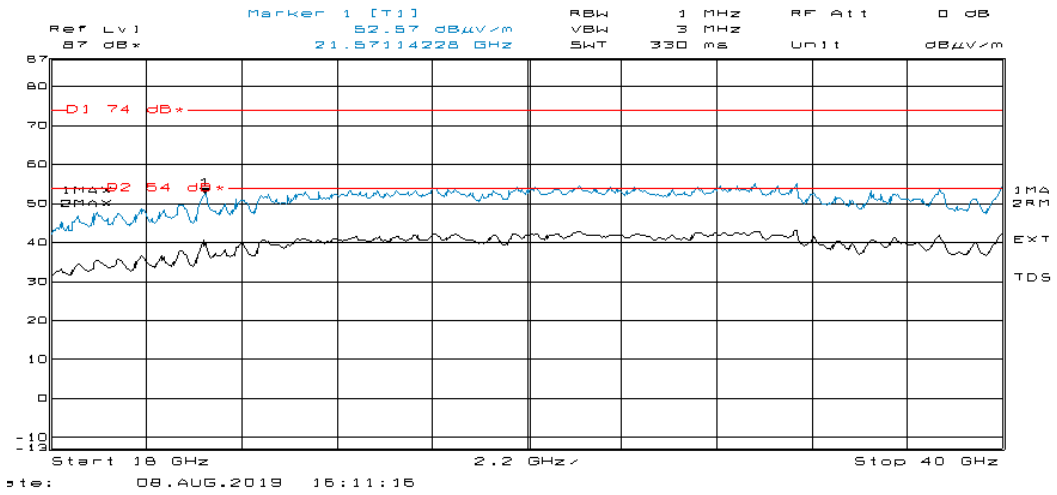


Spurious emissions outside restricted band, Tx on 5745 MHz, 802.11 nHt20 horizontal

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Remarks
--	--	--	---	--	

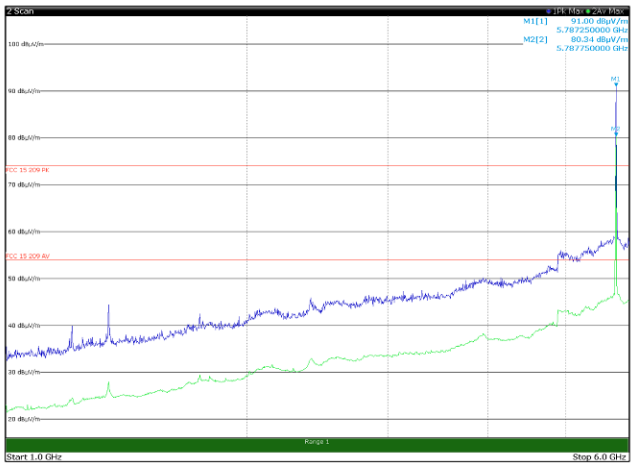


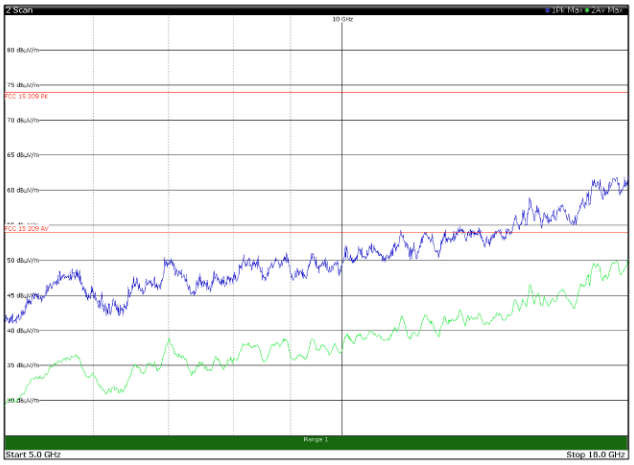


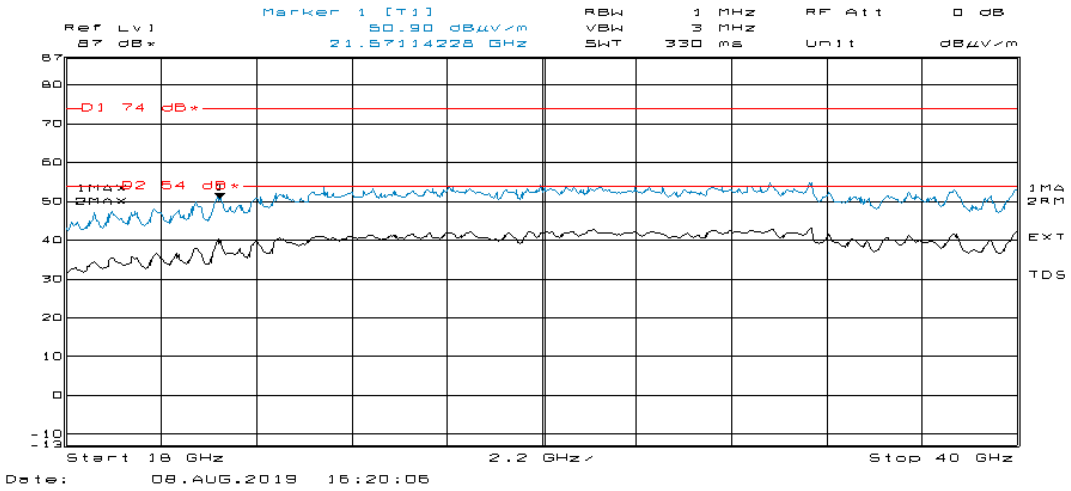


Spurious emissions outside restricted bands, Tx on 5745 MHz, 802.11 nHt20 vertical

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Remarks
--	--	--	---	--	







Spurious emissions outside restricted bands, Tx on 5785 MHz, 802.11 nHt20 horizontal

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Remarks
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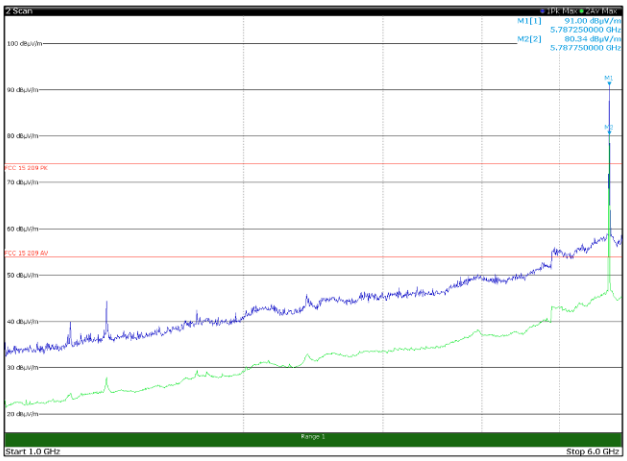
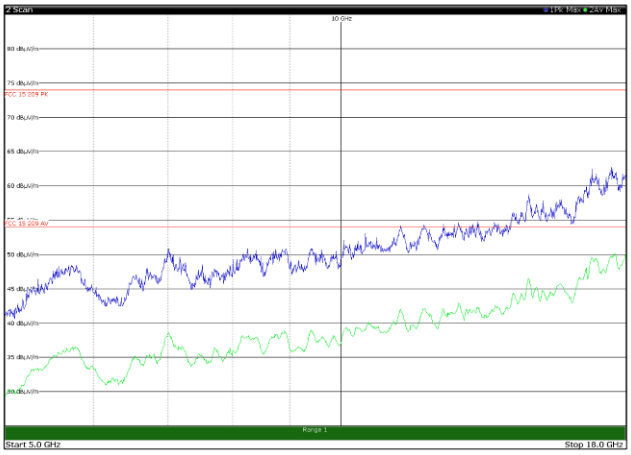
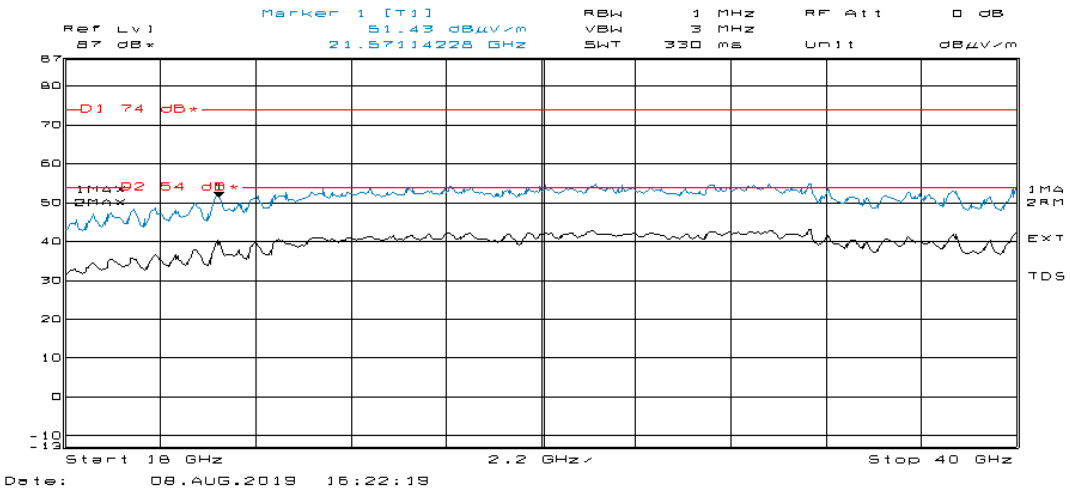
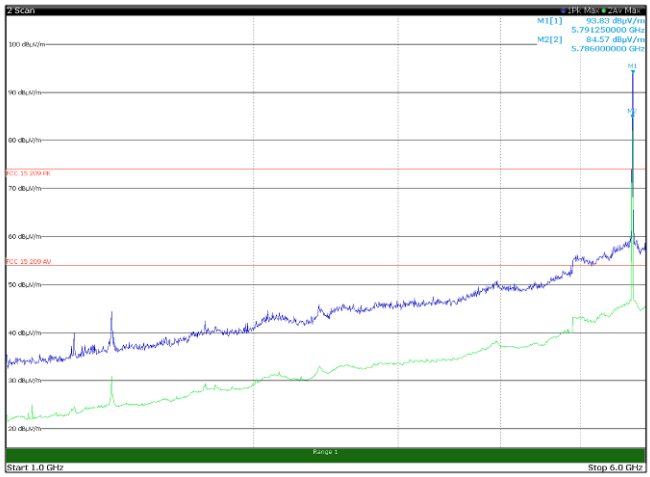


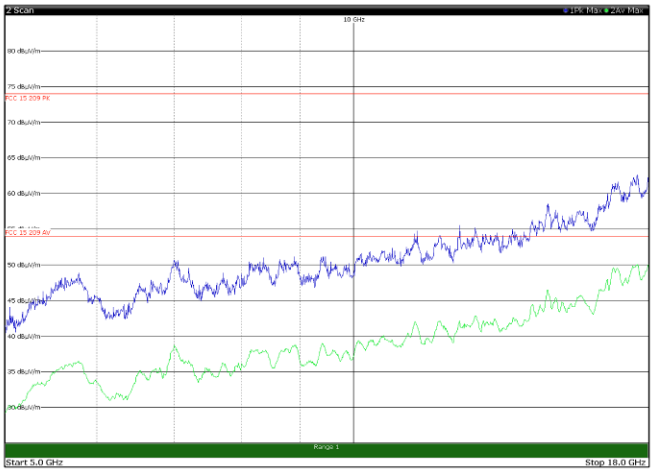


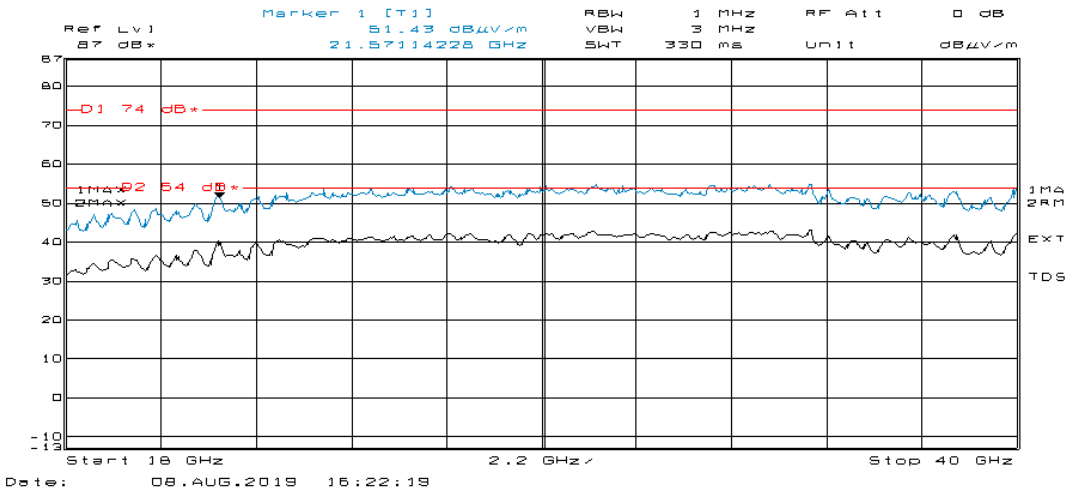


Spurious emissions outside restricted bands, Tx on 5785 MHz, 802.11 nHt20 vertical

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Remarks
--	--	--	---	--	







Spurious emissions outside restricted bands, Tx on 5825 MHz, 802.11nHT20 horizontal

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Remarks
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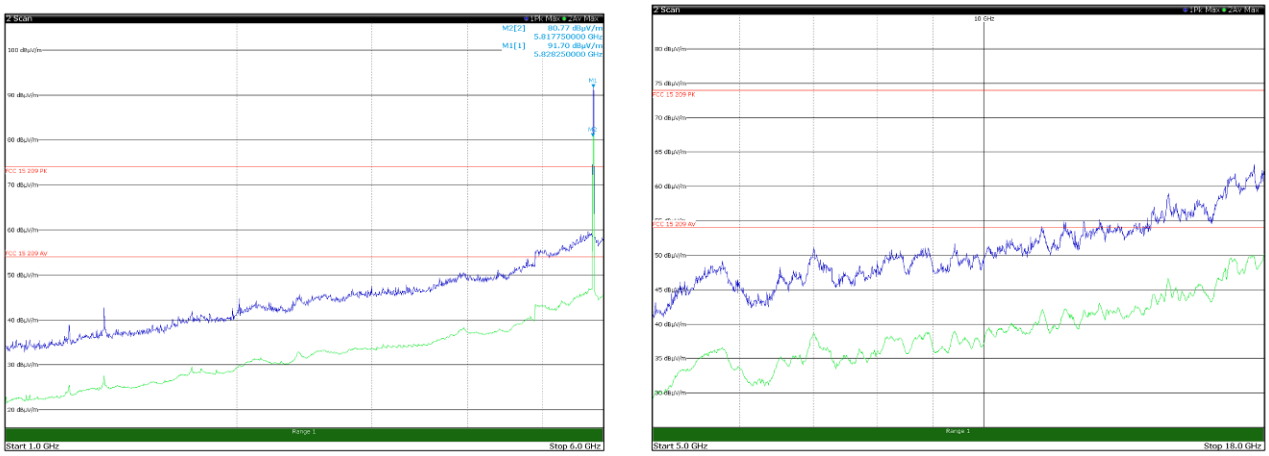
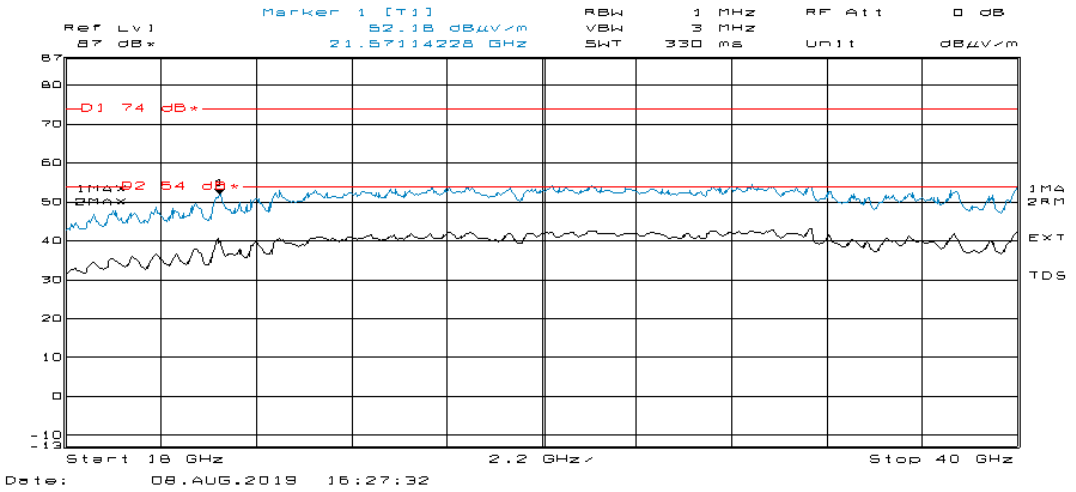
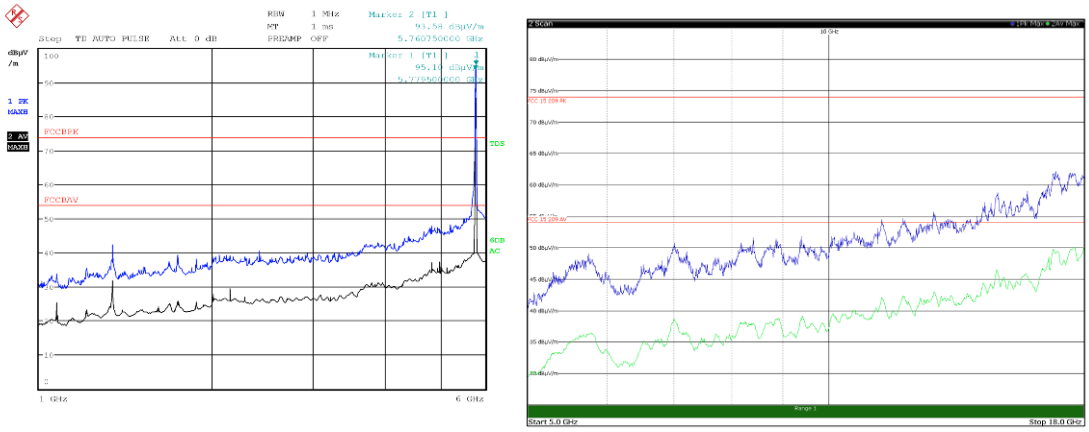
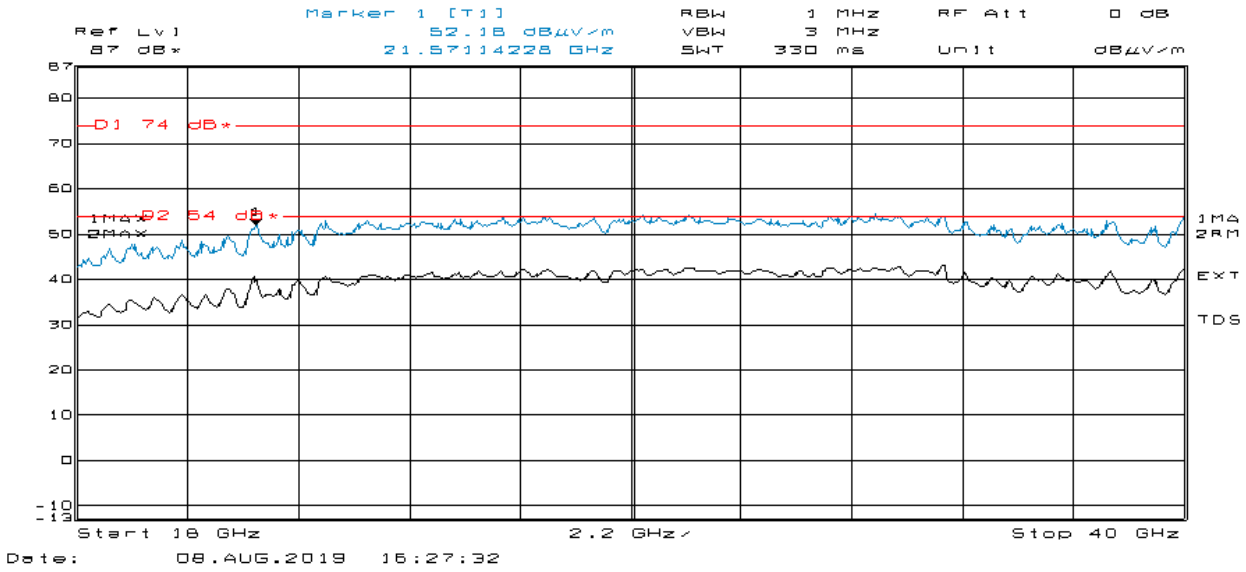




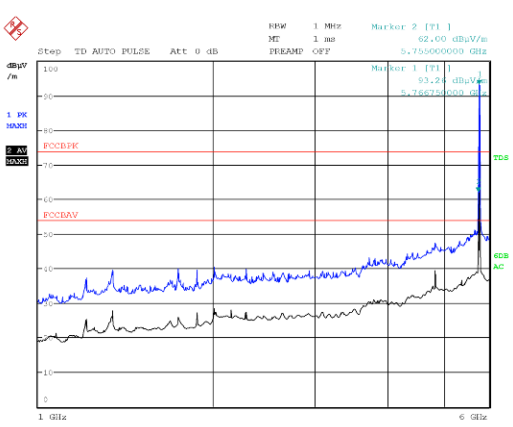
Spurious emissions outside restricted bands, Tx on 5825 MHz, 802.11nHT20 vertical

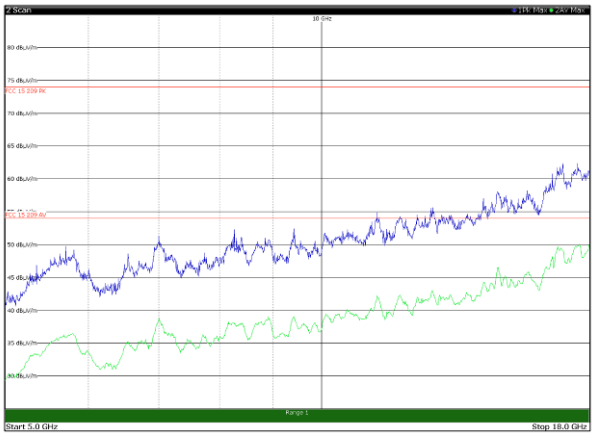
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Remarks
--	--	--	---	--	

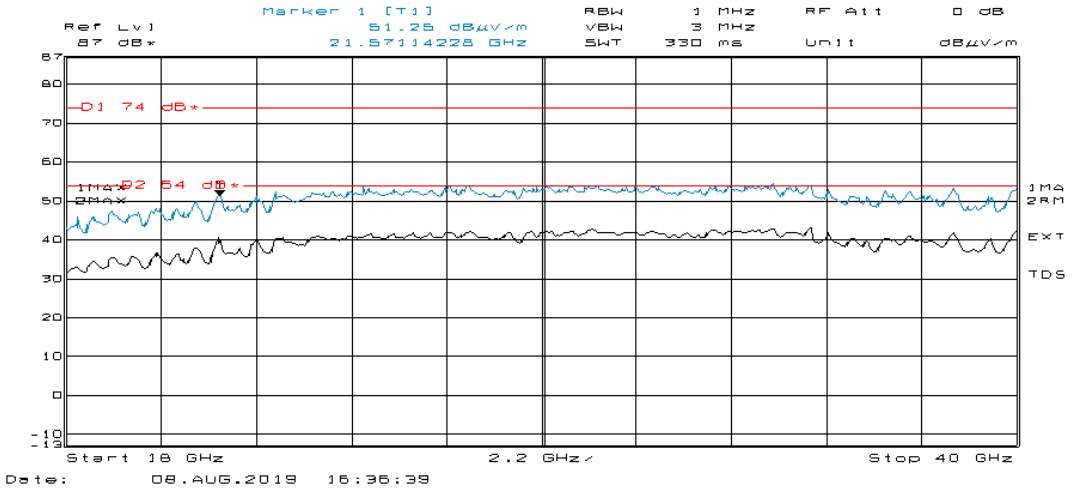




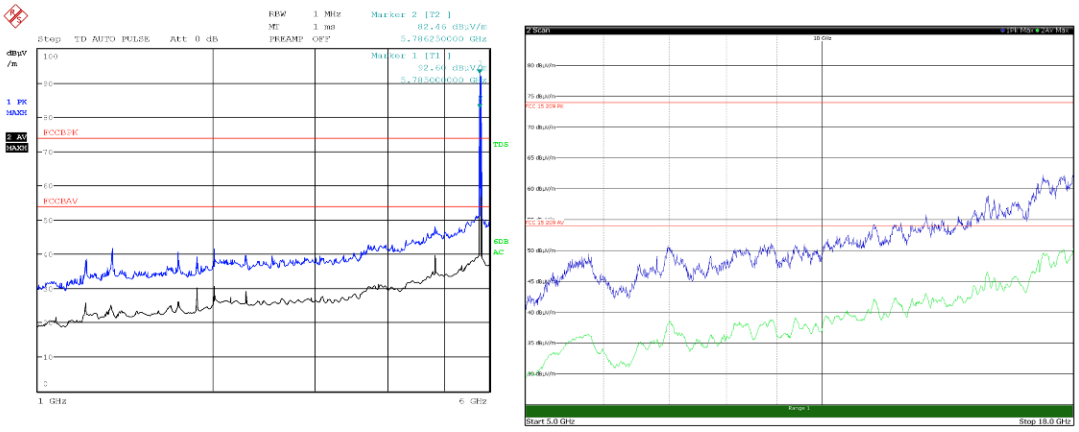
Spurious emissions outside restricted bands, Tx on 5755 MHz, 802.11Nht40 horizontal

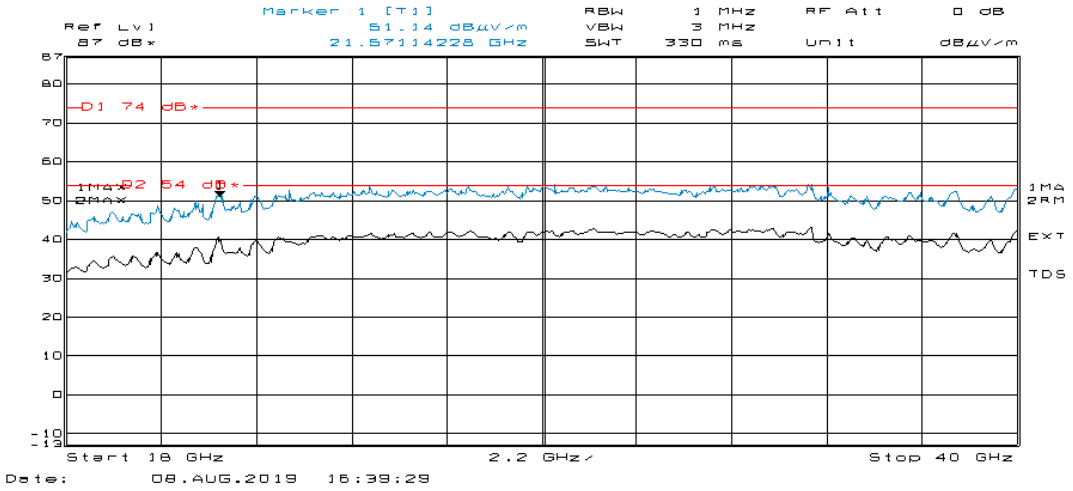




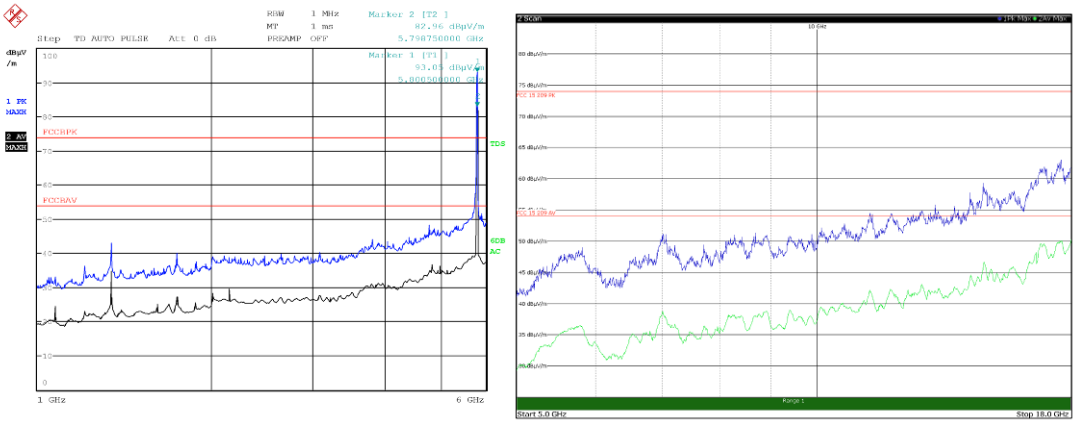


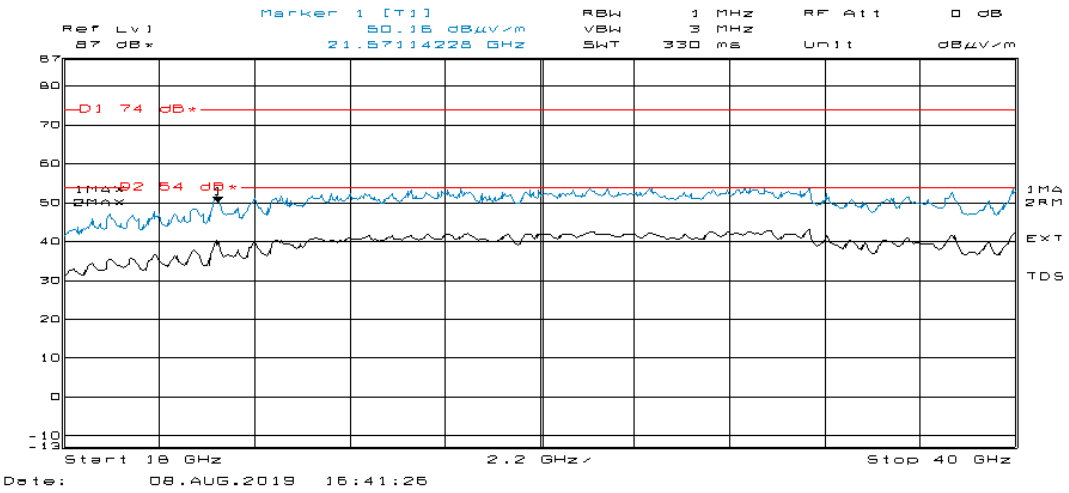
Spurious emissions outside restricted bands, Tx on 5755 MHz, 802.11Nht40 vertical



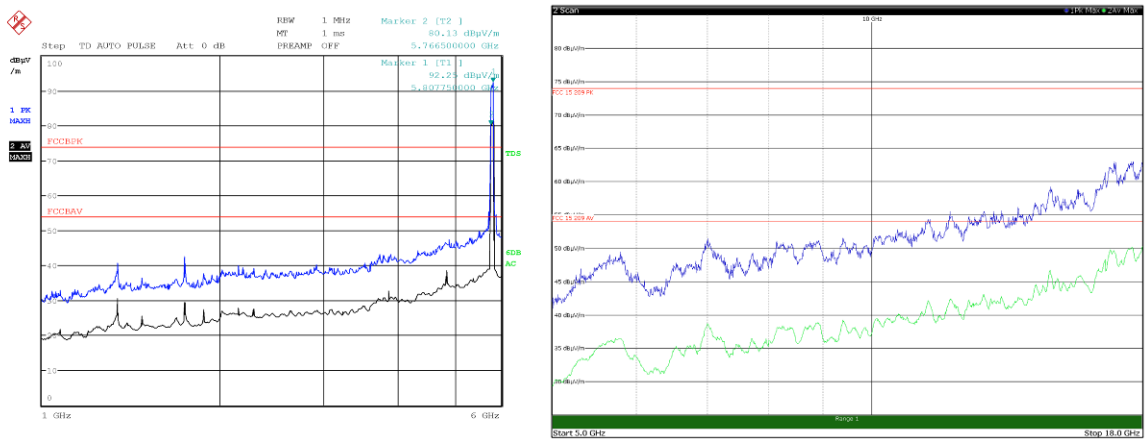


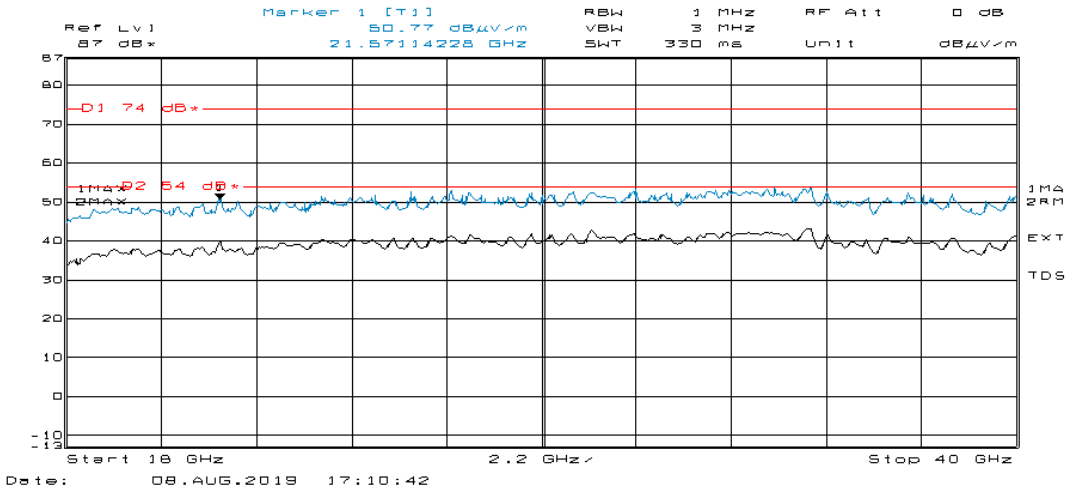
Spurious emissions outside restricted bands, Tx on 5795 MHz, 802.11Nht40 vertical



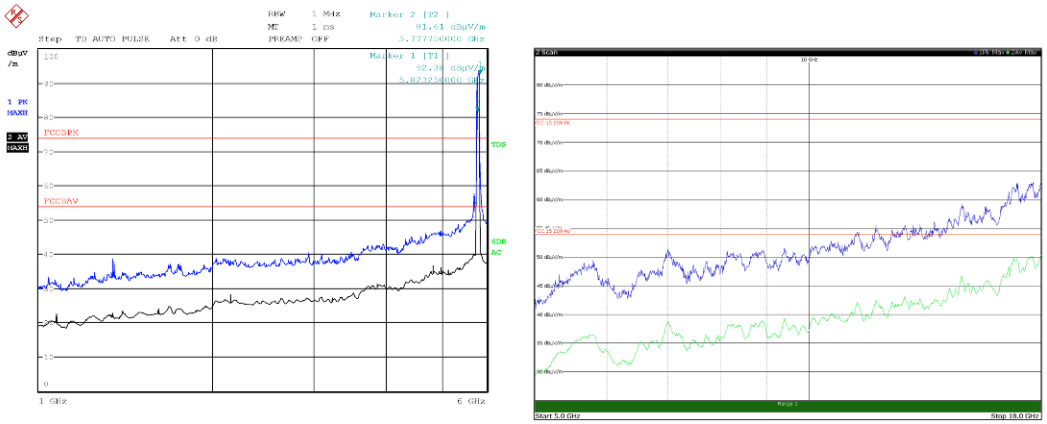


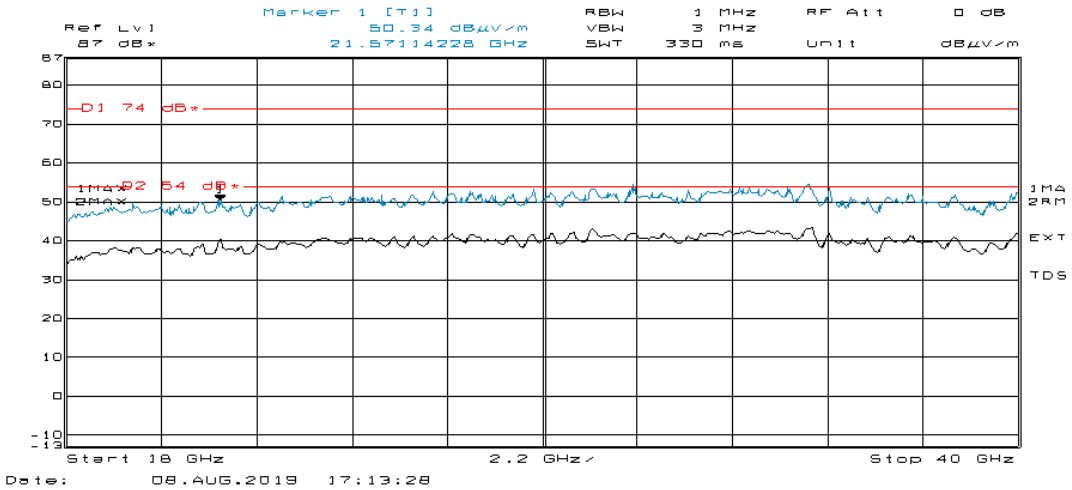
Spurious emissions outside restricted bands, Tx on 5795 MHz, 802.11Nht40 horizontal





Spurious emissions outside restricted bands, Tx on 5787 MHz, 802.11ac vertical



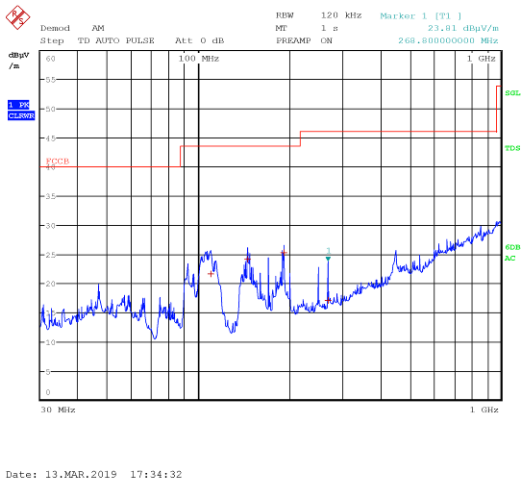


Spurious emissions outside restricted bands, Tx on 5787 MHz, 802.11ac horizontal

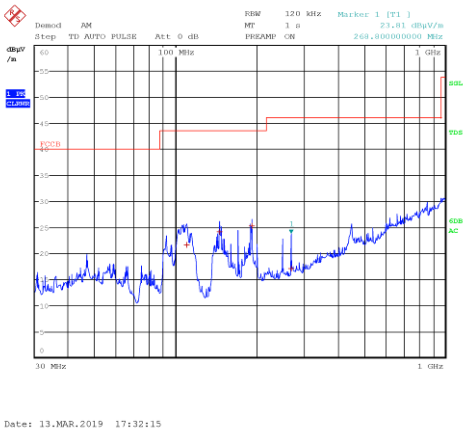
Also other modulations have been investigated: not appreciable variation of the results were obtained

Section 8 Radiated measurement 802.11n HT40 horizontal polarization

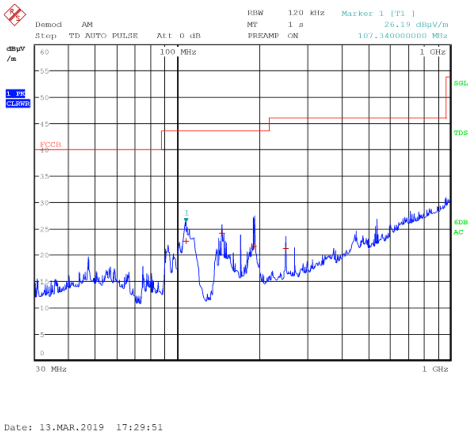
Low channel



Mid channel



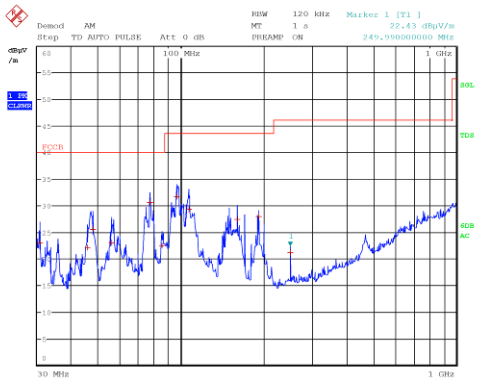
High channel



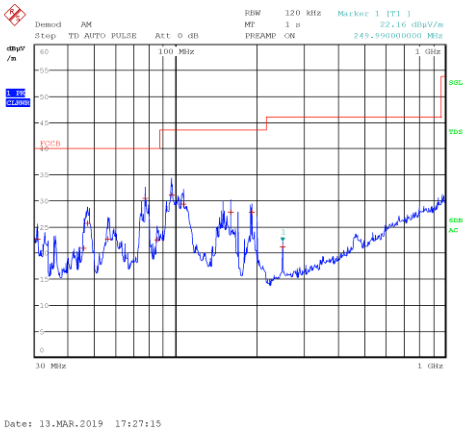
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
109.8000	21.7	43.5	-21.8	QP
145.2600	24.2	43.5	-19.3	QP
192.0000	25.3	43.5	-18.2	QP
268.8000	17.1	46.0	-28.9	QP
109.8000	21.7	43.5	-21.8	QP

Section 8 Radiated measurement 802.11n HT40 vertical polarization

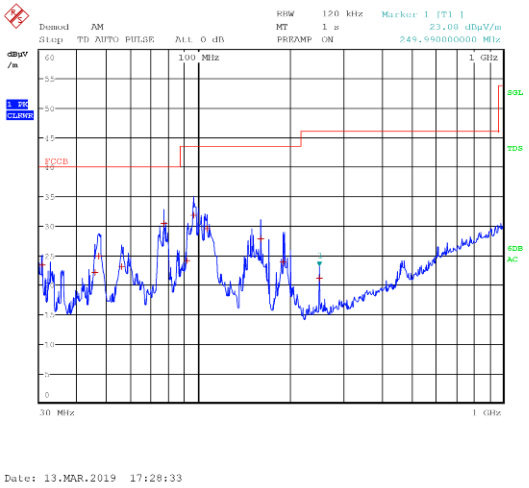
Low channel



Mid channel

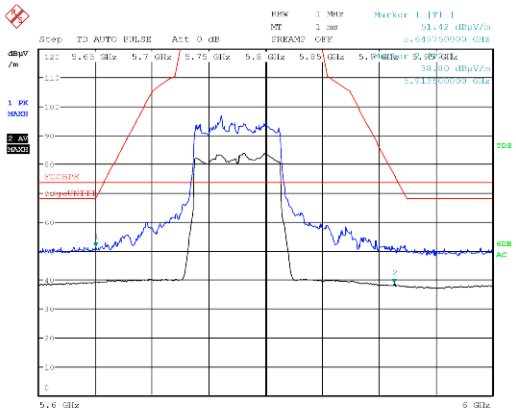


High channel



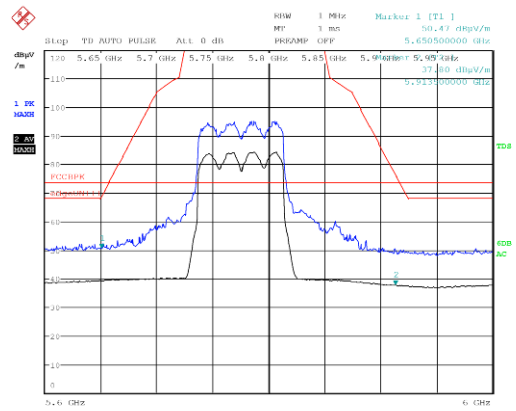
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
30.5700	22.7	40.0	-17.3	QP
45.6000	21.0	40.0	-19.0	QP
47.0100	25.7	40.0	-14.3	QP
56.0700	22.7	40.0	-17.3	QP
77.1900	30.5	40.0	-9.5	QP
85.5000	22.5	40.0	-17.5	QP
96.6900	31.2	43.5	-12.3	QP
106.7100	29.4	43.5	-14.1	QP
159.9900	27.9	43.5	-15.6	QP
192.0000	27.9	43.5	-15.6	QP
249.9900	21.1	46.0	-24.9	QP

802.11AC 80MHZ BAND EDGE horizontal



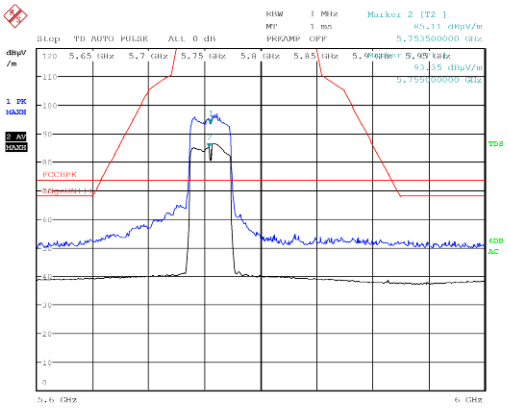
Date: 9.AUG.2019 18:43:44

802.11AC 80MHZ BAND EDGE vertical



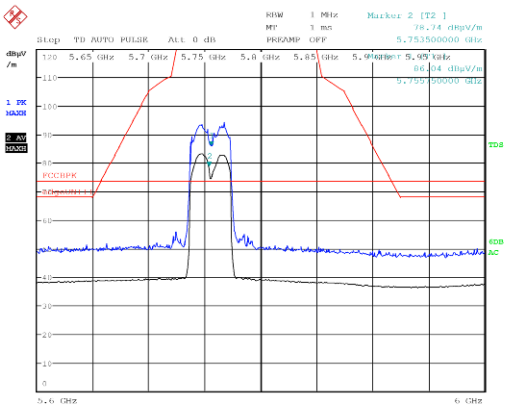
Date: 9.AUG.2019 18:46:05

802.11 Nht40 BAND EDGE horizontal



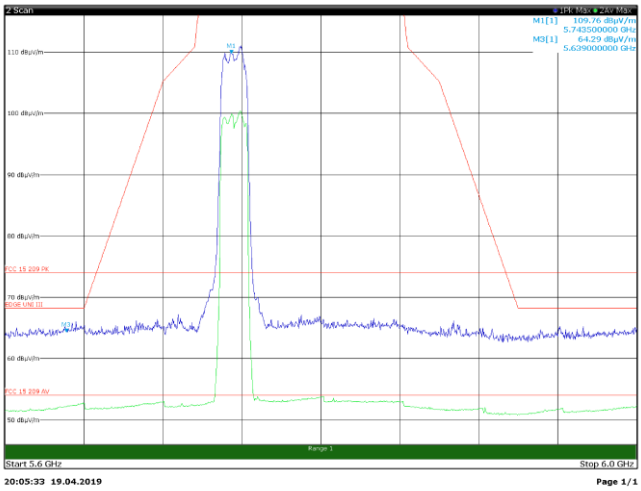
Date: 9.AUG.2019 19:03:14

802.11 Nht40 BAND EDGE vertical

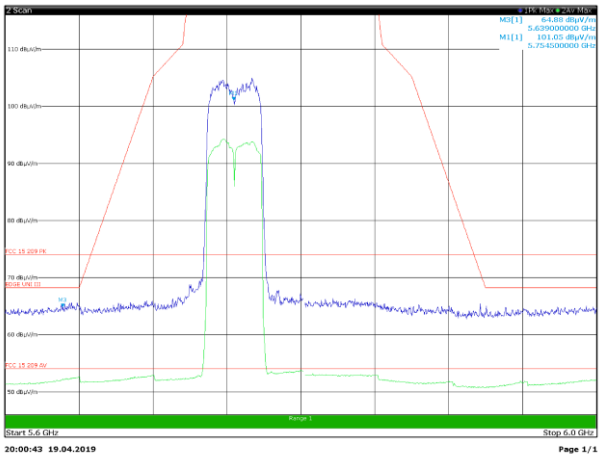


Date: 9.AUG.2019 19:05:37

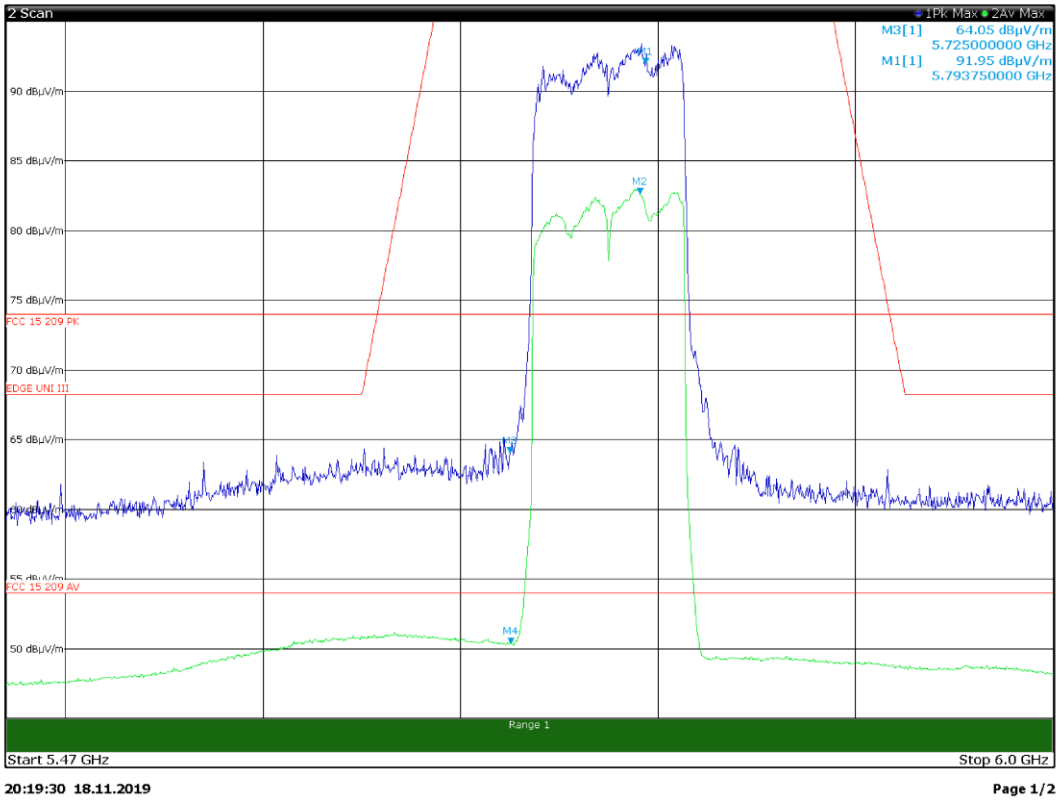
802.11 Nht20BAND EDGE horizontal



802.11 Nht20BAND EDGE vertical



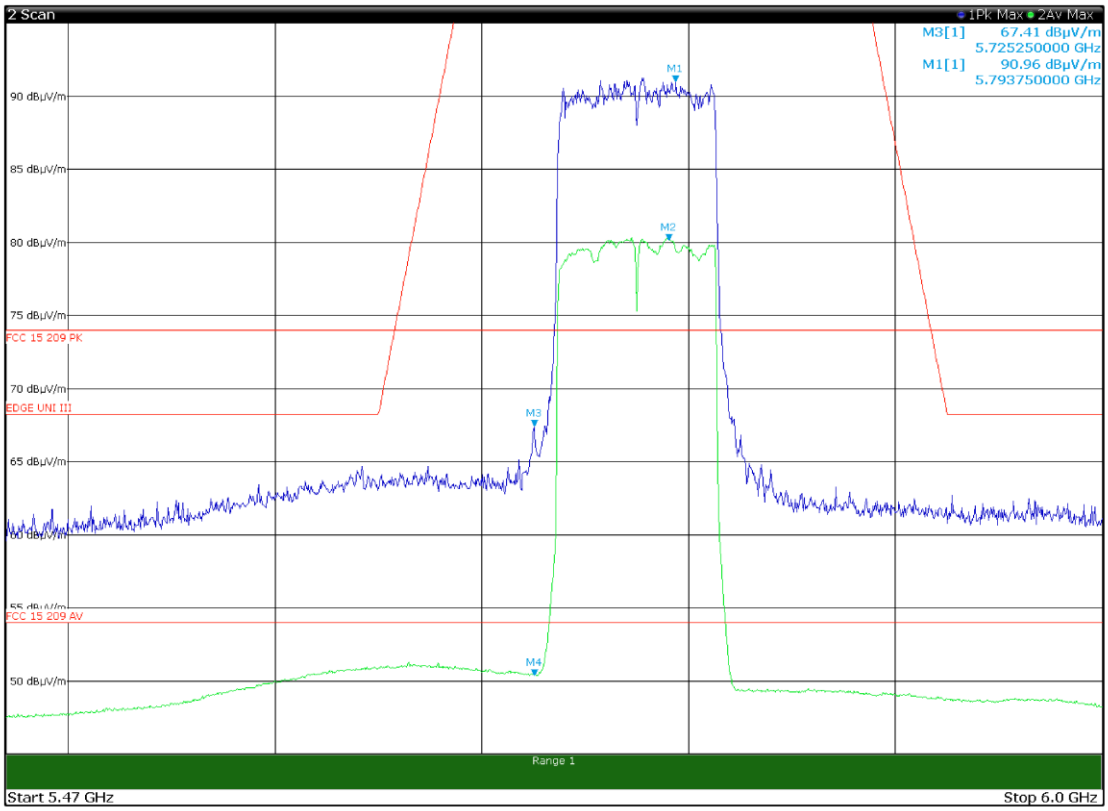
802.11 AC 80 MHz band, horizontal



3 Marker Table

Wnd	Type	Ref	Trc	X-value	Y-value
Scan	M1		1	**5.79375 GHz**	**91.95 dBµV/m**
Scan	M2		2	**5.79075 GHz**	**82.64 dBµV/m**
Scan	M3		1	**5.725 GHz**	**64.05 dBµV/m**
Scan	M4		2	**5.72525 GHz**	**50.39 dBµV/m**

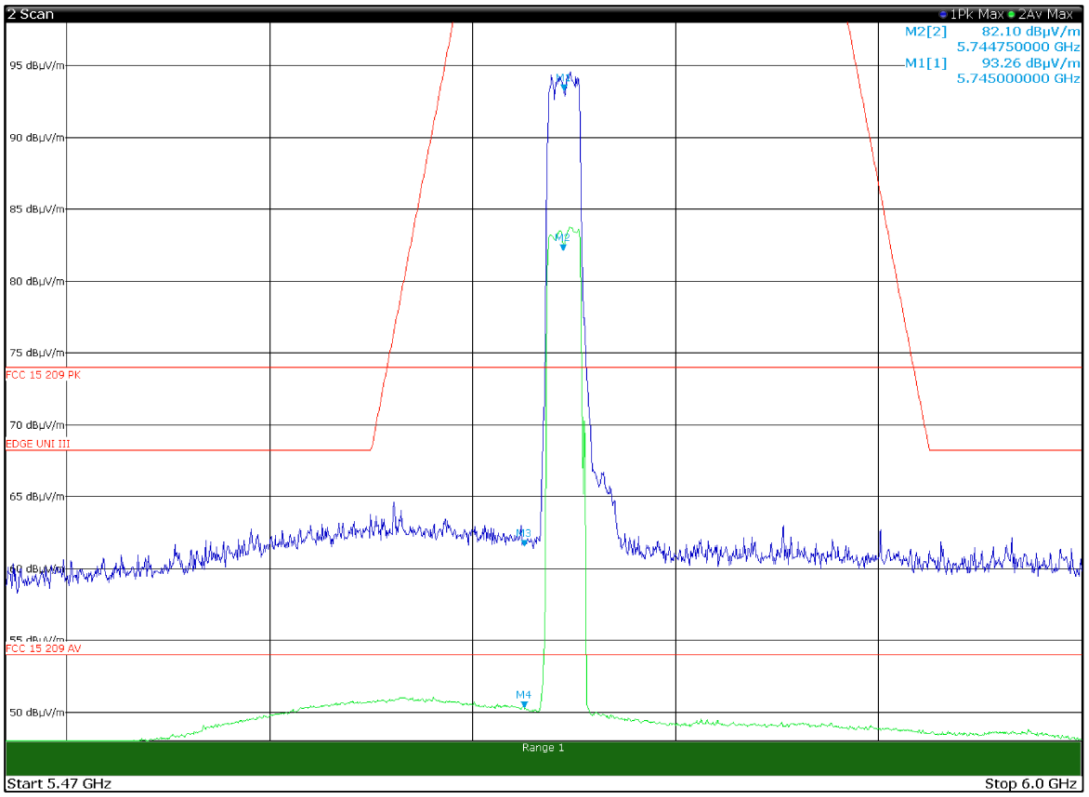
802.11 AC 80 MHz band, vertical



3 Marker Table

Wnd	Type	Ref	Trc	X-value	Y-value
Scan	M1		1	**5.79375 GHz**	**90.96 dBµV/m**
Scan	M2		2	**5.7905 GHz**	**80.14 dBµV/m**
Scan	M3		1	**5.72525 GHz**	**67.41 dBµV/m**
Scan	M4		2	**5.72525 GHz**	**50.35 dBµV/m**

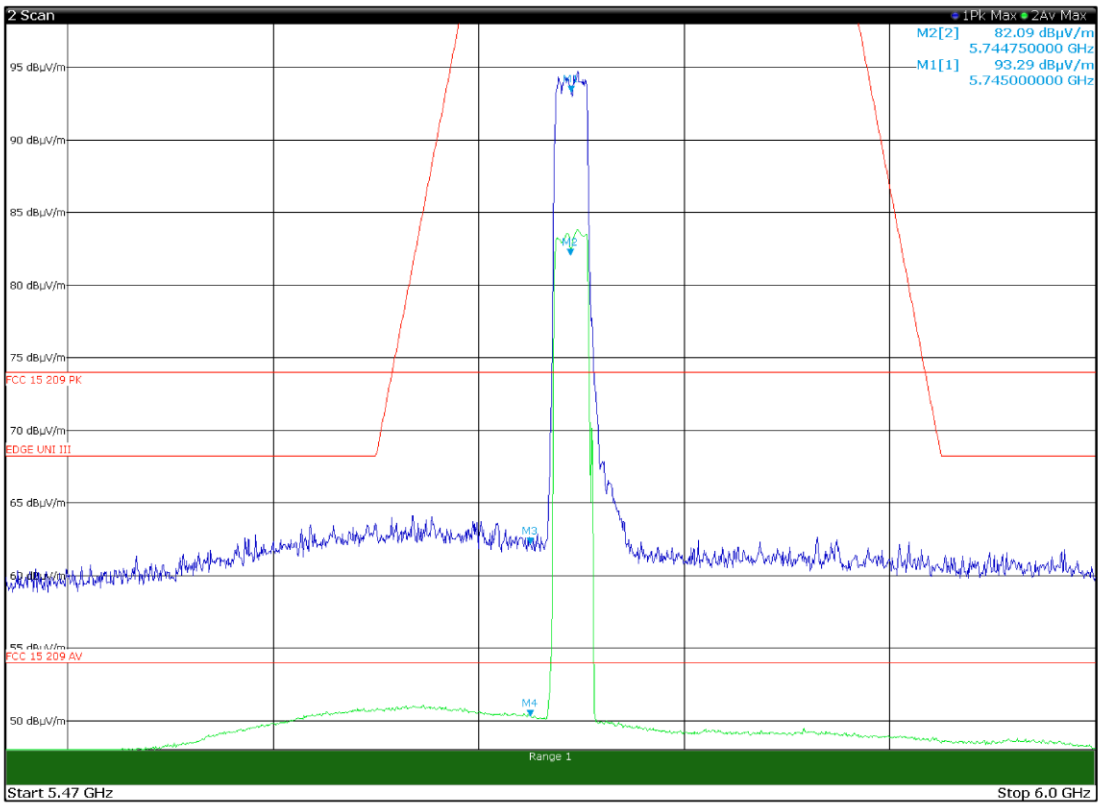
802.11nHT20 vertical



3 Marker Table

Wnd	Type	Ref	Trc	X-value	Y-value
Scan	M1		1	**5.745 GHz**	**93.26 dBµV/m**
Scan	M2		2	**5.74475 GHz**	**82.1 dBµV/m**
Scan	M3		1	**5.72525 GHz**	**61.58 dBµV/m**
Scan	M4		2	**5.72525 GHz**	**50.29 dBµV/m**

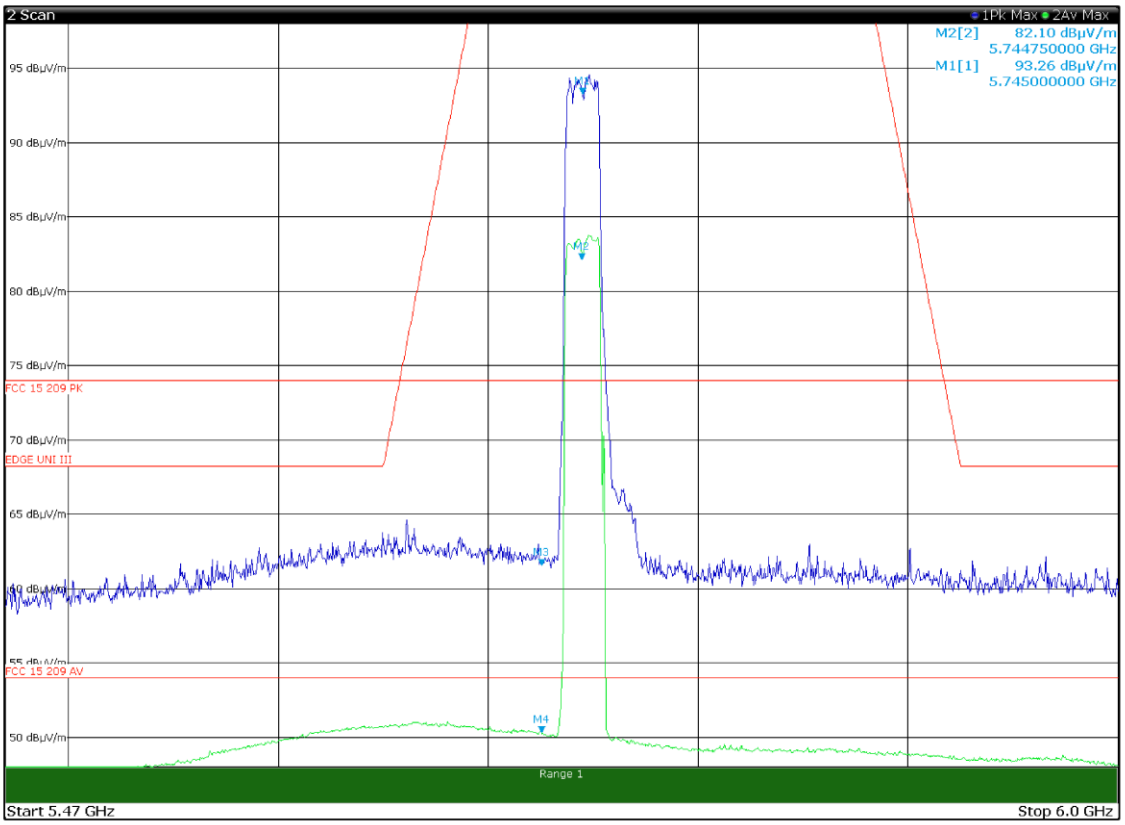
802.11nHT20 horizontal



3 Marker Table

Wnd	Type	Ref	Trc	X-value	Y-value
Scan	M1		1	**5.745 GHz**	**93.29 dBµV/m**
Scan	M2		2	**5.74475 GHz**	**82.09 dBµV/m**
Scan	M3		1	**5.725 GHz**	**62.2 dBµV/m**
Scan	M4		2	**5.725 GHz**	**50.31 dBµV/m**

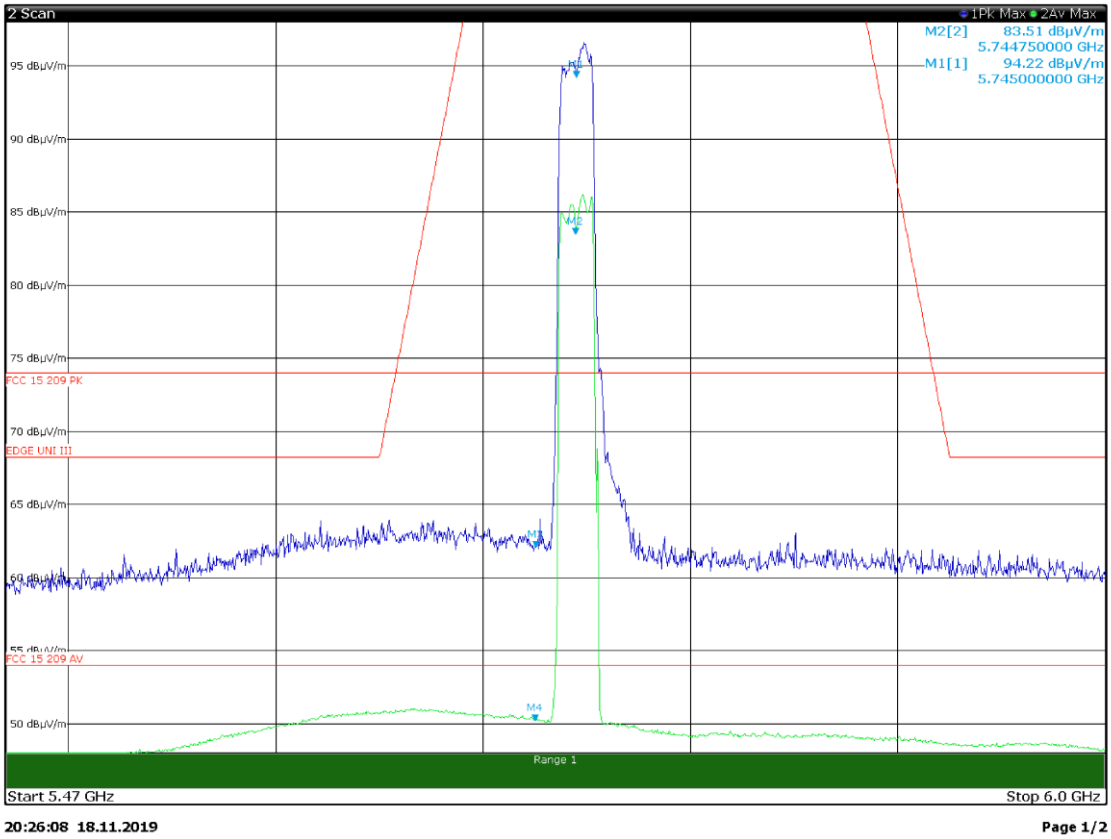
802.11 a vertical



3 Marker Table

Wnd	Type	Ref	Trc	X-value	Y-value
Scan	M1		1	**5.745 GHz**	**93.26 dBµV/m**
Scan	M2		2	**5.74475 GHz**	**82.1 dBµV/m**
Scan	M3		1	**5.72525 GHz**	**61.58 dBµV/m**
Scan	M4		2	**5.72525 GHz**	**50.29 dBµV/m**

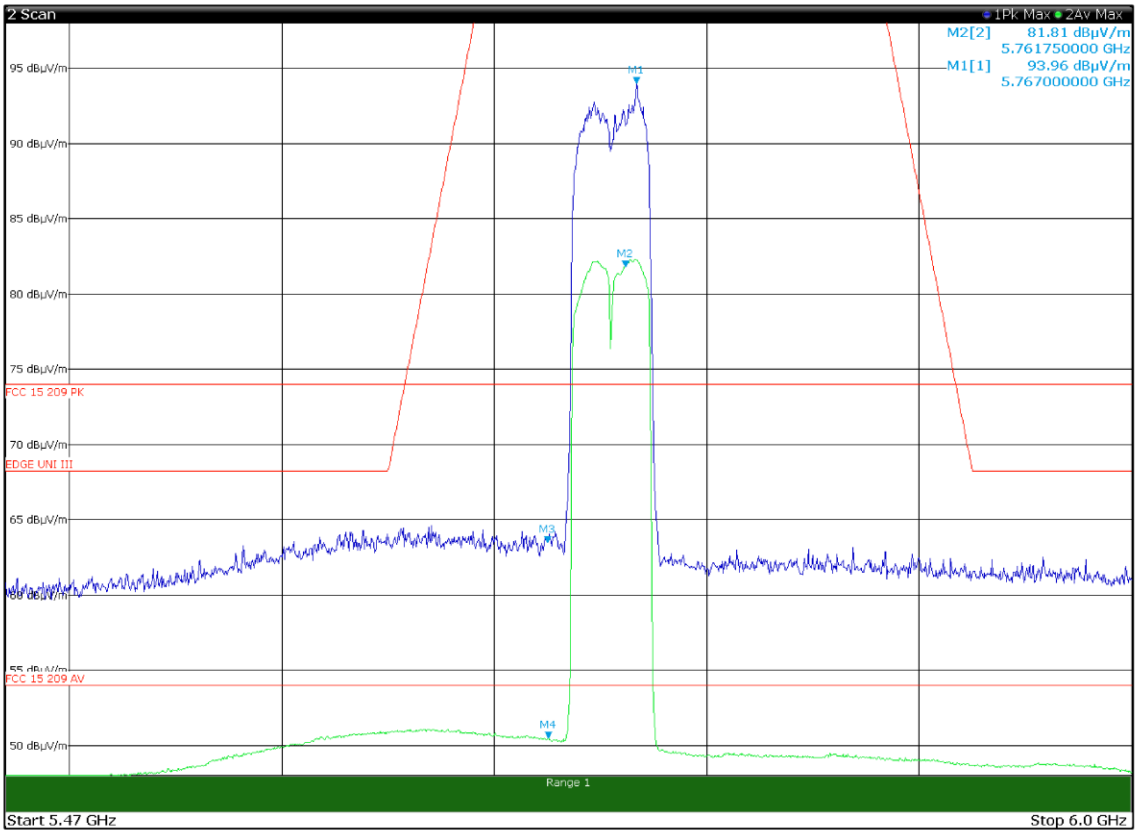
802.11 a horizontal



3 Marker Table

Wnd	Type	Ref	Trc	X-value	Y-value
Scan	M1		1	**5.745 GHz**	**94.22 dBµV/m**
Scan	M2		2	**5.74475 GHz**	**83.51 dBµV/m**
Scan	M3		1	**5.72525 GHz**	**62.07 dBµV/m**
Scan	M4		2	**5.725 GHz**	**50.21 dBµV/m**

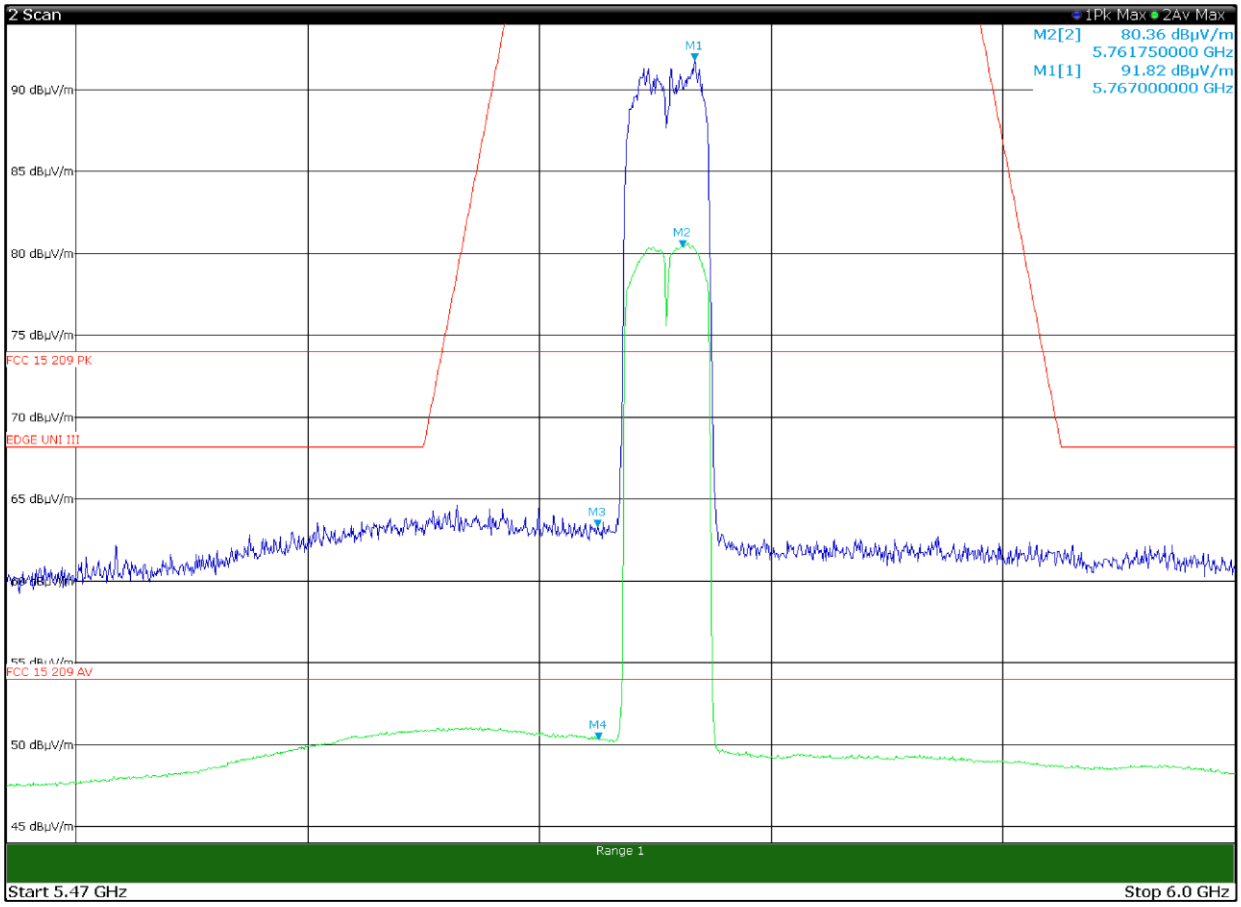
802.11 n Ht40 MHz horizontal



3 Marker Table

Wnd	Type	Ref	Trc	X-value	Y-value
Scan	M1		1	**5.767 GHz**	**93.96 dBµV/m**
Scan	M2		2	**5.76175 GHz**	**81.81 dBµV/m**
Scan	M3		1	**5.725 GHz**	**63.5 dBµV/m**
Scan	M4		2	**5.72525 GHz**	**50.48 dBµV/m**

802.11 nHT40 MHz vertical



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3 Marker Table

Wnd	Type	Ref	Trc	X-value	Y-value
Scan	M1		1	**5.767 GHz**	**91.82 dBµV/m**
Scan	M2		2	**5.76175 GHz**	**80.36 dBµV/m**
Scan	M3		1	**5.725 GHz**	**63.3 dBµV/m**
Scan	M4		2	**5.72525 GHz**	**50.34 dBµV/m**

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

8.5.1 Definitions and limits

FCC §15.407(6)(b):

Any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in §15.207

FCC §15.207(a):
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.

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

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

Table 8.5-1: *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.

8.5.2 Test summary

Test start date:	April 04 2019
Test engineer:	Daniele Guarnone

8.5.3 Observations, settings and special notes

The EUT was set up as tabletop configuration.

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.

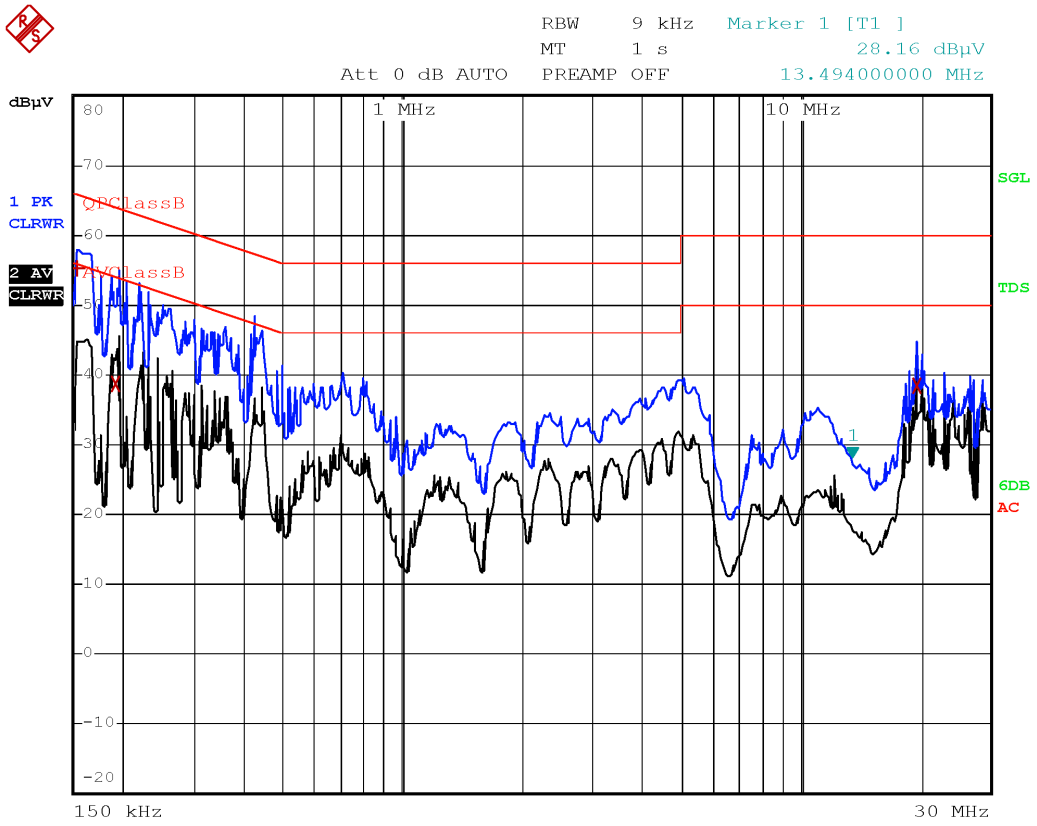
Receiver settings for preview measurements:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Peak and Average
Trace mode	Max Hold
Measurement time	100 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	100 ms

8.5.4 Test data



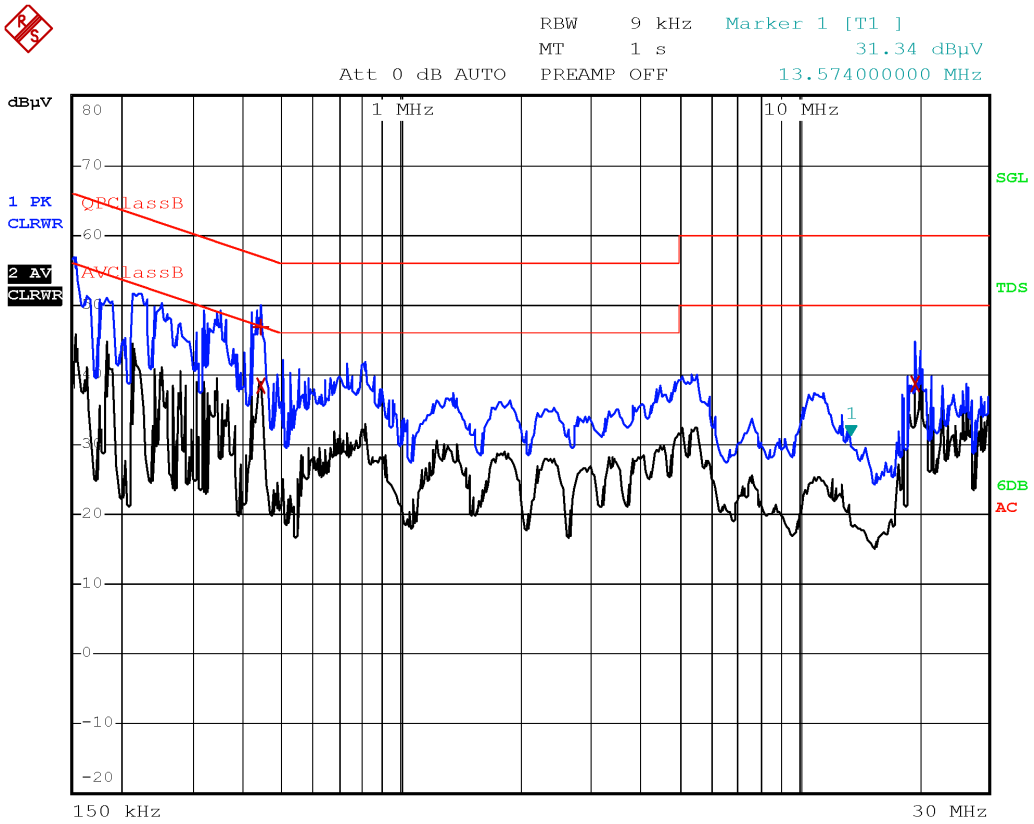
Date: 4.APR.2019 20:15:04

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
0.1540	55.3	65.8	**-10.5**	QP
0.1940	38.7	53.9	**-15.2**	Av
19.7100	38.6	50.0	**-11.4**	Av

Plot 8.5-1: Conducted emissions on phase line

Notes:
[1] Result (dBµV) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + attenuator (dB)
[3] Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions have been recorded.

Sample calculation: 37.1 dBµV (result) = 26.6 dBµV (receiver reading) + 9.5 dB (Correction factor)



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Plot 8.5-2: Conducted emissions on neutral line

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
0.1540	55.3	65.8	-10.5	QP
0.1940	38.7	53.9	-15.2	Av
19.7100	38.6	50.0	-11.4	Av

Table 8.5-2: Quasi-Peak conducted emissions results on neutral line

Notes:

[1] Result (dBµV) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + attenuator (dB)
[3] Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions have been recorded.

Sample calculation: 37.1 dBµV (result) = 26.6 dBµV (receiver reading) + 9.5 dB (Correction factor)

8.6 FCC 15.407(g) and RSS-Gen 8.11 Frequency stability

8.6.1 Definitions and limits

Manufacturers of U-NII (IC: LE-LAN) devices are responsible for ensuring frequency stability such that an emission is maintained within the band of operation under all conditions of normal operation as specified in the user's manual.

8.6.2 Test summary

Test start date:	April,05 2019
Test engineer:	Yong Huang

8.6.1 Observations, settings and special notes

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

8.6.2 Test data

Table 8.6-1: *Frequency drift measurement*

Test conditions Temperature, Voltage	Nominal frequency, GHz	Frequency, GHz	Drift, Hz
+85 °C, Nominal	5.785	--	--
+70 °C, Nominal	5.785	--	--
+23 °C, +15 %	5.785	--	--
+23 °C, Nominal	5.785	--	--
+23 °C, −15 %	5.785	--	--
-40 °C, Nominal	5.785	--	--

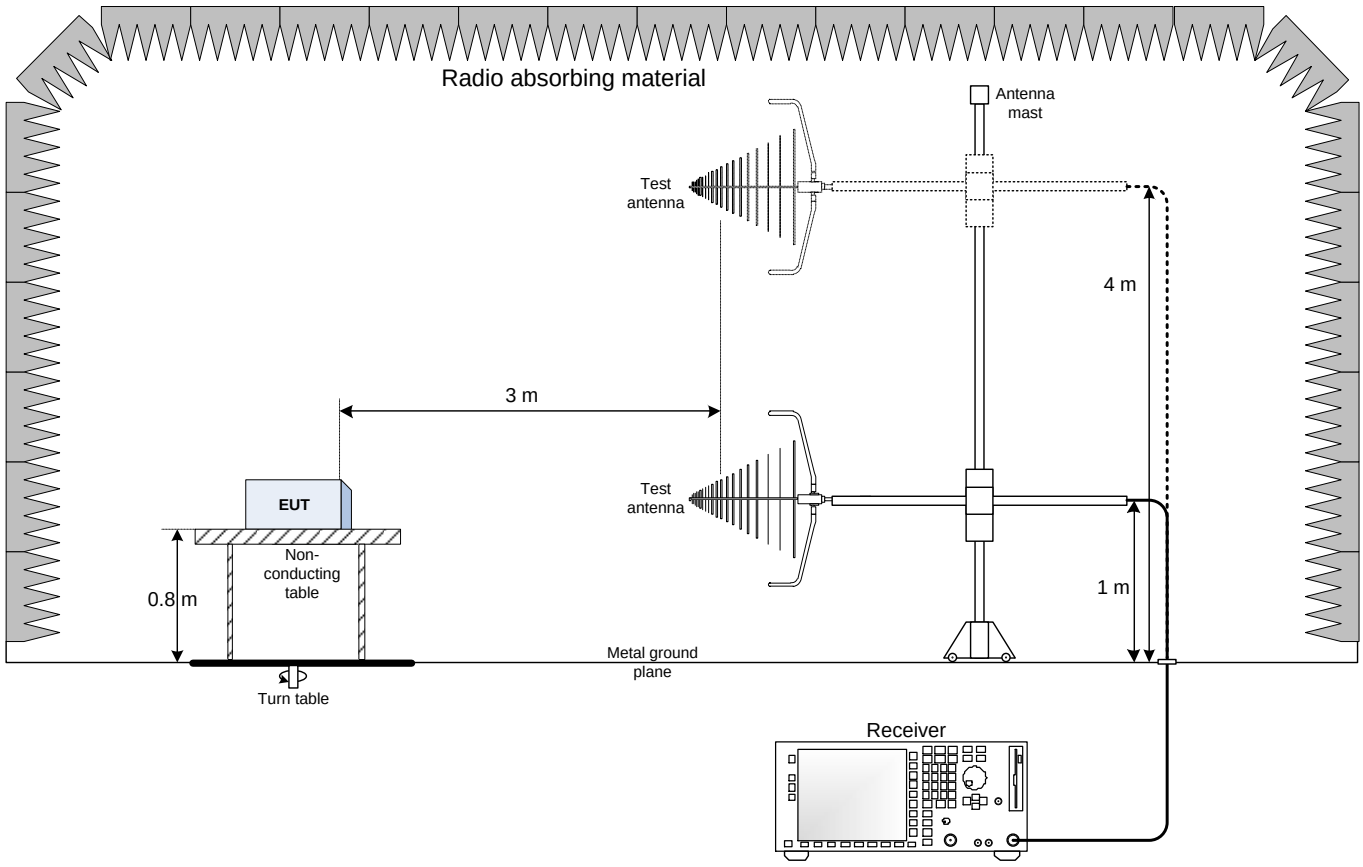
Minimum lower band edge margin is more than 1 kHz

Minimum upper band edge margin is more than 107 kHz

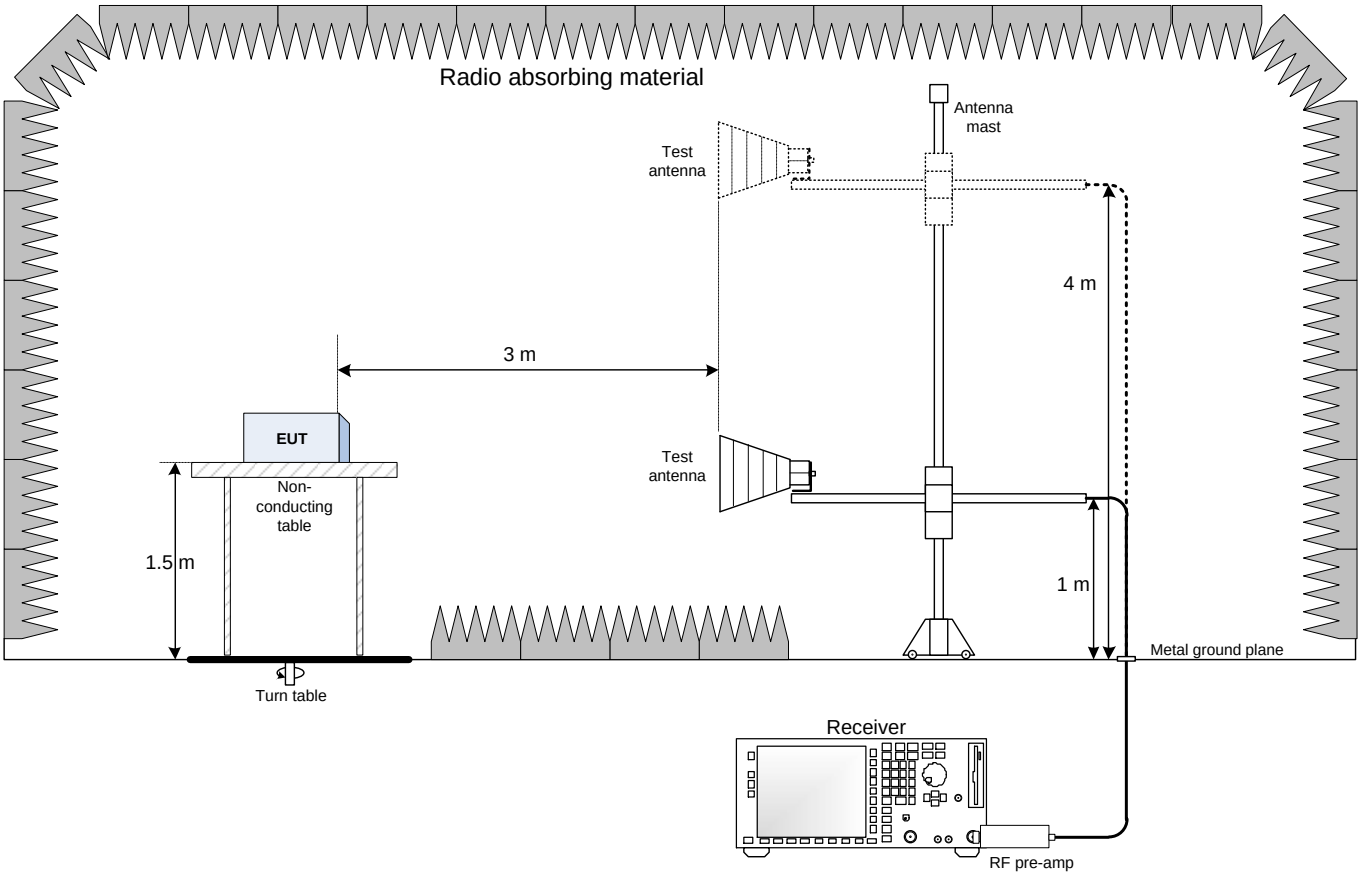
The frequency drifts in above table are within these minimum margins, the emissions are deemed to maintain within the band of operation.

Section 9. Block diagrams of test set-ups

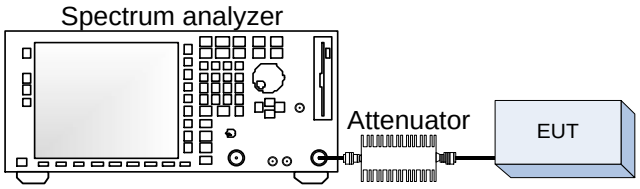
9.1 Radiated emissions set-up for frequencies below 1 GHz



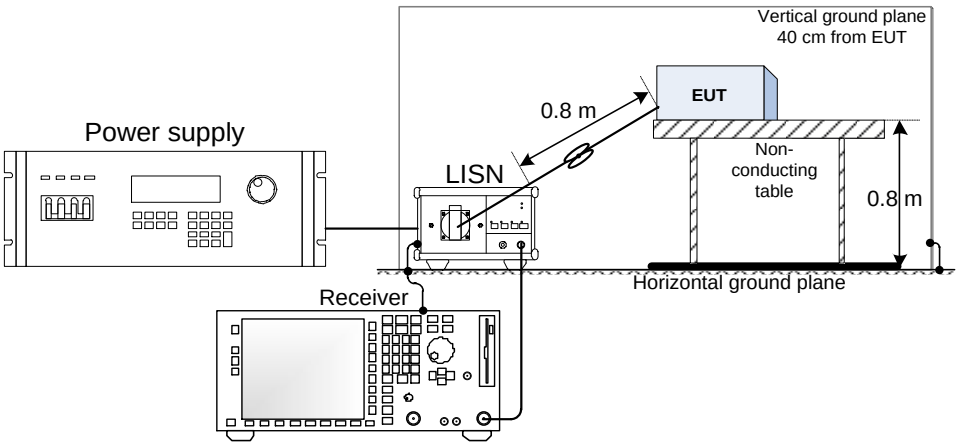
9.2 Radiated emissions set-up for frequencies above 1 GHz



9.3 Antenna port conducted measurements set-up



9.4 Conducted emissions on AC line set-up



(End of report)