FCC / IC Test Report

FOR:
Juniper Systems, Inc.

Model Name:
MS3

Product Description:
Ultra-rugged handheld computer with Windows 10, providing long battery life, 7-inch touchscreen display, programmable keys, 802.11ac, Bluetooth, camera

FCC ID: VSFMS3
IC ID: 7980A-MS3

Applied Rules and Standards:
47 CFR Part 15.247 (DTS)
RSS-247 Issue 2 (DTS) & RSS-Gen Issue 5

REPORT #: EMC_JUNIP-026-19001 _15.247_WLAN

DATE: 2019-03-25

A2LA Accredited

IC recognized # 3462B-1

***CETECOM* Inc.**
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1 Assessment

The following device was evaluated against the applicable criteria specified in FCC rules Parts 15.247 of Title 47 of the Code of Federal Regulations and the relevant ISED Canada standard RSS-247.

No deviations were ascertained.

Company	Description	Model #
Juniper Systems, Inc.	Ultra-rugged handheld computer with Windows 10, providing long battery life, 7-inch touchscreen display, programmable keys, 802.11ac, Bluetooth, camera	MS3

Responsible for Testing Laboratory:

Date	Section	Name	Signature
2019-03-25	Compliance	Cindy Li (EMC Lab Manager)	Cindy Li Digitally signed by Cindy Li DN: cn=Cindy Li, o=Cetecom Inc., ou=EMC, email=cindy.li@cetecom.com, c=US Date: 2019.04.12 11:26:54 -07'00'

Responsible for the Report:

Date	Section	Name	Signature
2019-03-25	Compliance	Yuchan Lu (Test Engineer)	Yuchan Lu Digitally signed by: Yuchan Lu DN: CN = Yuchan Lu email = Yuchan.Lu@cetecom.com C = US O = CETECOM Inc. OU = EMC Date: 2019.04.12 11:20:27 -07'00'

2 Administrative Data

2.1 Identification of the Testing Laboratory Issuing the EMC Test Report

Company Name:	CETECOM Inc.
Department:	Compliance
Street Address:	411 Dixon Landing Road
City/Zip Code	Milpitas, CA 95035
Country	USA
Telephone:	+1 (408) 586 6200
Fax:	+1 (408) 586 6299
EMC Lab Manager:	Cindy Li
Responsible Project Leader:	Sangeetha Sivaraman

2.2 Identification of the Client

Applicant's Name:	Juniper Systems, Inc.
Street Address:	1132 W 1700 N
City/Zip Code:	Logan, UT 84321
Country:	USA

2.3 Identification of the Manufacturer

Manufacturer's Name:	The same as client
Manufacturers Address:	N/A
City/Zip Code	N/A
Country	N/A

3 Equipment under Test (EUT)

3.1 EUT Specifications

Model No:	MS3
HW Version :	MS3_00
SW Version :	MS3_SW_00
FCC-ID:	VSFMS3
IC-ID:	7980A-MS3
HVIN:	MS3
PMN:	Mesa 3
Product Description:	Ultra-rugged handheld computer with Windows 10, providing long battery life, 7-inch touchscreen display, programable keys, 802.11ac, Bluetooth, camera
Frequency Range / number of channels:	Nominal band: 2400 MHz – 2483.5 MHz; Center to center: 2412 MHz (ch 1) – 2462 MHz (ch 11), 11 channels
Type(s) of Modulation:	DSSS, OFDM
Modes of Operation:	802.11b/g/n, 20MHz, 40MHz, 80MHz SISO & MIMO (2X2)
Antenna Information as declared:	PCB Trace, Primary chain: 2.4dBi@2412MHz, -0.1dBi@2437MHz, 1.1dBi@2462MHz Second chain: -2.5dBi@2412MHz, 0.7dBi@2437MHz, -5.6dBi@2462MHz
Max. Peak Output Power:	Conducted Power 18.16 dBm
Power Supply/ Rated Operating Voltage Range:	Battery: Vmin: 6 VDC/ Vnom: 7.3 VDC / Vmax: 7.3 VDC Charger: Vmin: 9.9 VDC/ Vnom: 12 VDC / Vmax: 15.6 VDC
Operating Temperature Range:	-20 ºC to +50 ºC
Other Radios included in the device:	Bluetooth BR / EDR, BLE WIFI 802.11a/ac; WCDMA; LTE; GPS; RFID
Sample Revision:	☐Prototype Unit; ■Production Unit; ☐Pre-Production

3.2 EUT Sample details

EUT #	Serial Number	HW Version	SW Version	Notes/Comments
1	MS3W-C01	MS3_00	MS3_SW_00	Radiated Emissions
2	MS3W-C03	MS3_00	MS3_SW_00	Conducted RF

3.3 Accessory Equipment (AE) details

AE #	Type	Model	Manufacturer	Serial Number
1	Switching power supply	PSAA30R-120	Phihong Technology	P74900943A1

3.4 Test Sample Configuration

EUT Set-up #	Combination of AE used for test set up	Comments
1	EUT#1 + AE#1	The radio of the EUT was configured to a fixed channel transmission with highest possible duty cycle using software provided by client that is not available to the end user. The measurement equipment was connected to the 50 ohm RF port of the EUT.
2	EUT#2 + AE#1	The radio of the EUT was configured to a fixed channel with highest possible duty cycle using software provided by client that is not available to the end user.

3.5 Justification for Worst Case Mode of Operation

During the testing process, the EUT was tested with transmitter sets on low, mid and high channels with the highest possible duty cycle. For radiated measurements, all data in this report shows the worst case between horizontal and vertical antenna polarizations and for all orientations of the EUT.

The EUT were configured by software provided by client (not available to the end user). The output power was fixed in the configuration file and can't be changed during testing

4 Subject of Investigation

The objective of the measurements done by CETECOM Inc. was to assess the performance of the EUT according to the relevant requirements specified in FCC rules Part 15.247 of Title 47 of the Code of Federal Regulations and Radio Standard Specification RSS-247 of ISED Canada.

Testing procedures are based on 558074 D01 DTS Meas Guidance v04 – "GUIDANCE FOR PERFORMING COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEMS (DTS) OPERATING UNDER SECTION 15.247" - April 5, 2017, by the Federal Communications Commission, Office of Engineering and Technology, Laboratory Division.

5 Measurement Results Summary

Test Specification	Test Case	Temperature and Voltage Conditions	Mode	Pass	NA	NP	Result
§15.247(a)(1) RSS-247 5.2(1)	Emission Bandwidth	Nominal	802.11 b/g/n	■	☐	☐	Complies
§15.247(e) RSS-247 5.2(2)	Power Spectral Density	Nominal	802.11 b/g/n	■	☐	☐	Complies
§15.247(b)(1) RSS-247 5.4(4)	Maximum Conducted Output Power and EIRP	Nominal	802.11 b/g/n	■	☐	☐	Complies
§15.247(d) RSS-247 5.5	Band edge compliance Unrestricted Band Edges	Nominal	802.11 b/g/n	■	☐	☐	Complies
§15.247; 15.209; 15.205 RSS-Gen 8.9; 8.10	Band edge compliance Restricted Band Edges	Nominal	802.11 b/g/n	■	☐	☐	Complies
§15.247(d); §15.209 RSS-Gen 6.13	TX Spurious emissions-Radiated	Nominal	802.11g_ 2x Tx	■	☐	☐	Complies
§15.207(a) RSS Gen 8.8	AC Conducted Emissions	Nominal	802.11g-2x Tx	■	☐	☐	Complies

Note: NA= Not Applicable; NP= Not Performed.

6 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus, with 95% confidence interval (in dB delta to result), based on a coverage factor k=1.

Radiated measurement

9 kHz to 30 MHz	±2.5 dB (Magnetic Loop Antenna)
30 MHz to 1000 MHz	±2.0 dB (Biconilog Antenna)
1 GHz to 40 GHz	±2.3 dB (Horn Antenna)

Conducted measurement

150 kHz to 30 MHz	±0.7 dB (LISN)
RF conducted measurement	±0.5 dB

According to TR 102 273 a multiplicative propagation of error is assumed for RF measurement systems. For this reason the RMS method is applied to dB values and not to linear values as appropriate for additive propagation of error. Also used: http://physics.nist.gov/cuu/Uncertainty/typeb.html. The above calculated uncertainties apply to direct application of the Substitution method. The Substitution method is always used when the EUT comes closer than 3 dB to the limit.

6.1 Environmental Conditions during Testing:

The following environmental conditions were maintained during the course of testing:

- Ambient Temperature: 20-25° C
- Relative humidity: 40-60%

6.2 Dates of Testing:

03/11/2019 - 03/20/2019

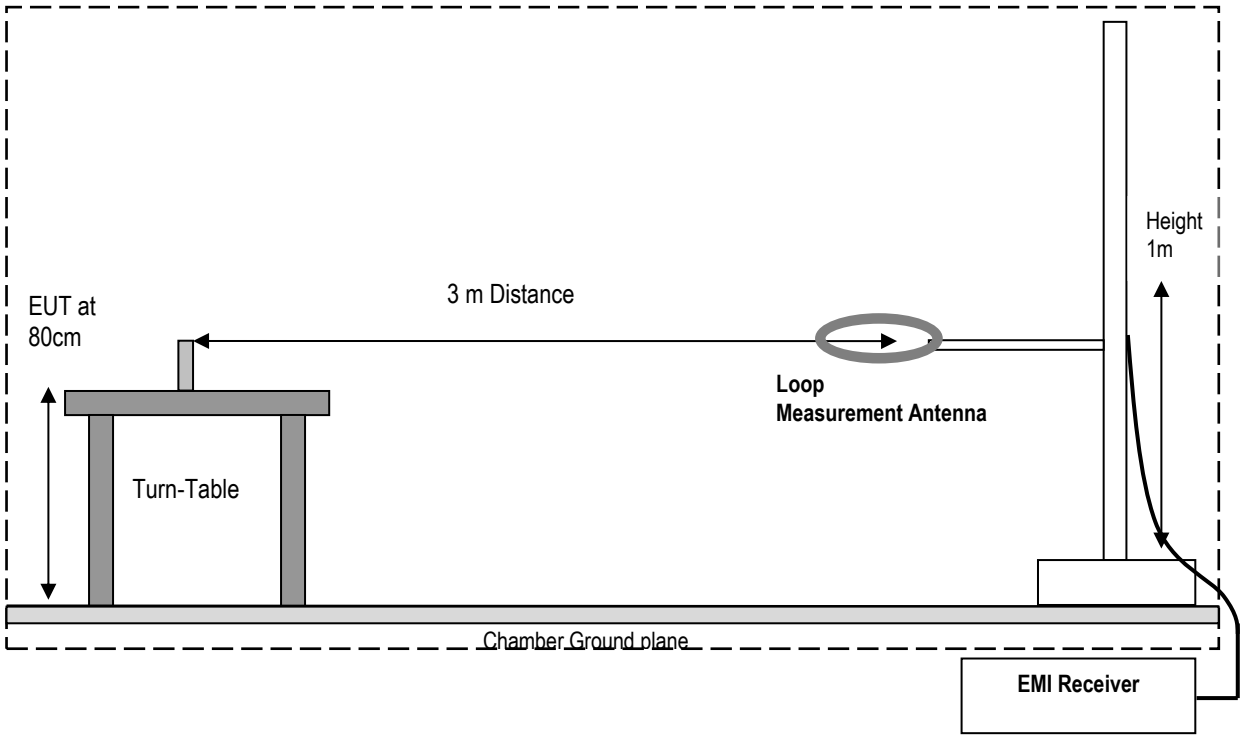
7 Measurement Procedures

7.1 Radiated Measurement

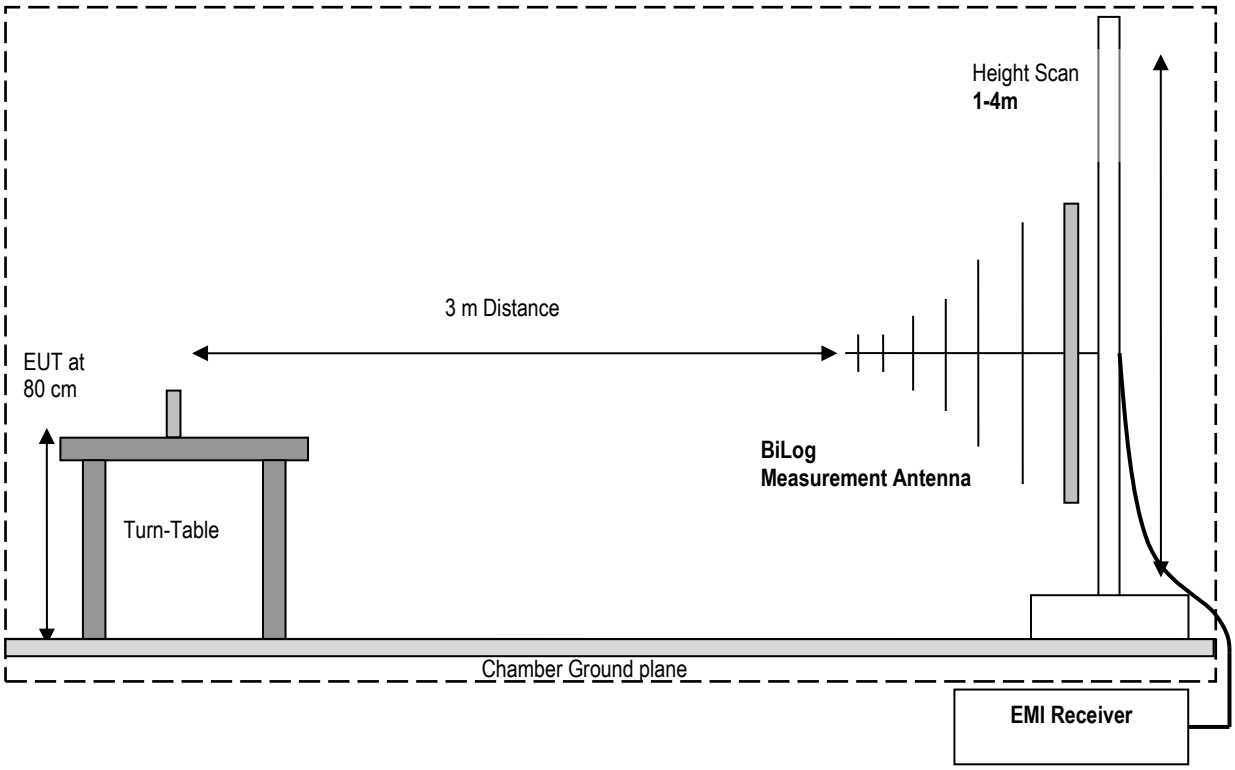
The radiated measurement is performed according to ANSI C63.10 (2013)

- The exploratory measurement is accomplished by running a matrix of 16 sweeps over the required frequency range with R&S Test-SW EMC32 for 4 positions of the turntable, two orthogonal positions of the EUT and both antenna polarizations. This procedure exceeds the requirement of the above standards to cover the 3 orthogonal axis of the EUT. A max peak detector is utilized during the exploratory measurement. The Test-SW creates an overall maximum trace for all 12 sweeps and saves the settings for each point of this trace. The maximum trace is part of the test report.
- The 10 highest emissions are selected with an automatic algorithm of EMC32 searching for peaks in the noise floor and ensuring that broadband signals are not selected multiple times.
- The maxima are then put through the final measurement and again maximized in a 90deg range of the turntable, fine search in frequency domain and height scan between 1m and 4m.
- The above procedure is repeated for all possible ways of power supply to EUT and for all supported modulations.
- In case there are no emissions above noise floor level only the maximum trace is reported as described above.
- The results are split up into up to 4 frequency ranges due to antenna bandwidth restrictions. A magnetic loop is used from 9 kHz to 30 MHz, a Biconilog antenna is used from 30 MHz to 1 GHz, and two different horn antennas are used to cover frequencies up to 40 GHz.

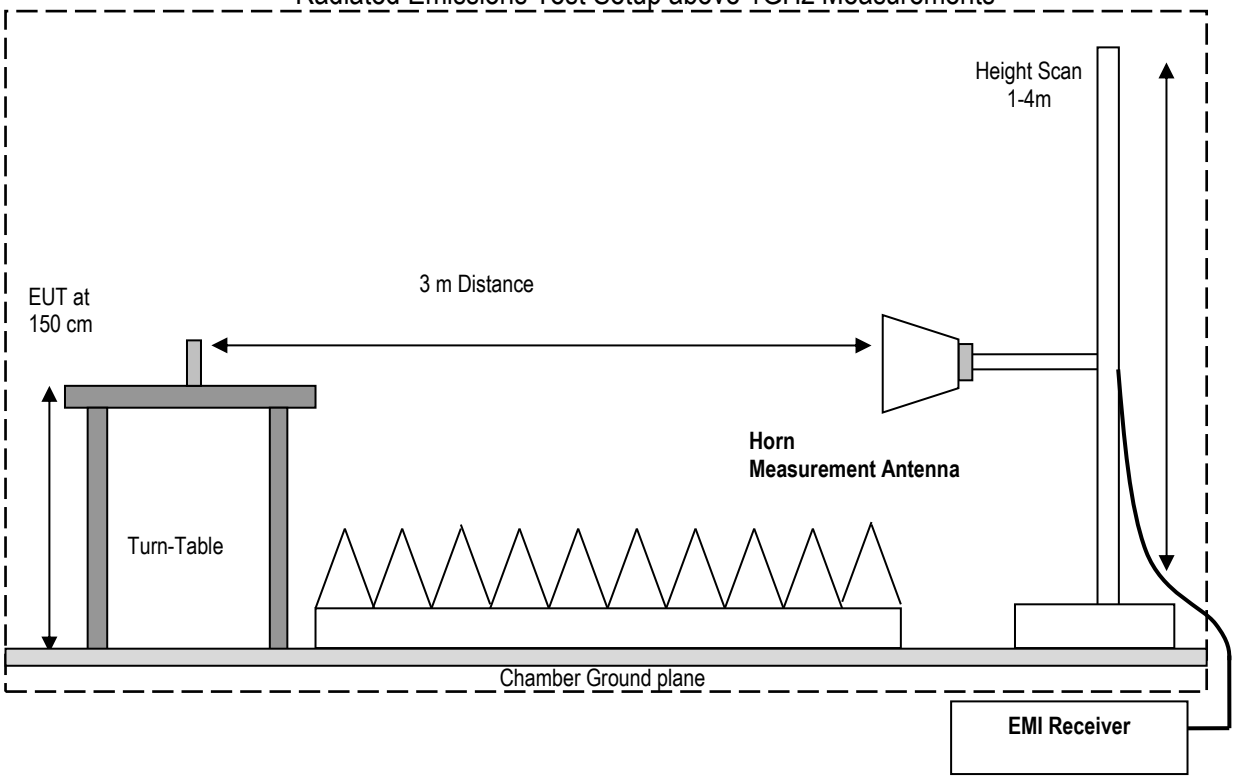
Radiated Emissions Test Setup below 30MHz Measurements



Radiated Emissions Test Setup 30MHz-1GHz Measurements



Radiated Emissions Test Setup above 1GHz Measurements



7.1.1 Sample Calculations for Field Strength Measurements

Field Strength is calculated from the Spectrum Analyzer/ Receiver readings, taking into account the following parameters:

1. Measured reading in dBµV
2. Cable Loss between the receiving antenna and SA in dB and
3. Antenna Factor in dB/m

All radiated measurement plots in this report are taken from a test SW that calculates the Field Strength based on the following equation:

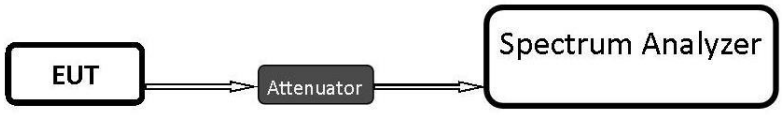
FS (dBµV/m) = Measured Value on SA (dBµV)- Cable Loss (dB)+ Antenna Factor (dB/m)

Example:

Frequency (MHz)	Measured SA (dBµV)	Cable Loss (dB)	Antenna Factor Correction (dB)	Field Strength Result (dBµV/m)
1000	80.5	3.5	14	98.0

7.2 RF Conducted Measurement Procedure

Testing procedures are based on 558074 D01 DTS Meas Guidance v04 – "GUIDANCE FOR PERFORMING COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEMS (DTS) OPERATING UNDER SECTION 15.247" - April 5, 2017, by the Federal Communications Commission, Office of Engineering and Technology, Laboratory Division.



- Connect the equipment as shown in the above diagram.
- Adjust the settings of the SA (Rohde-Schwarz Spectrum Analyzer) to connect the EUT at the required mode of test.
- Measurements are to be performed with the EUT set to the low, middle and high channels and for worst case modulation schemes.
- Calculate the conducted power by taking into account attenuation of the cable and the attenuator

8 Test Result Data

8.1 Duty cycle

8.1.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v04

Spectrum Analyzer settings:

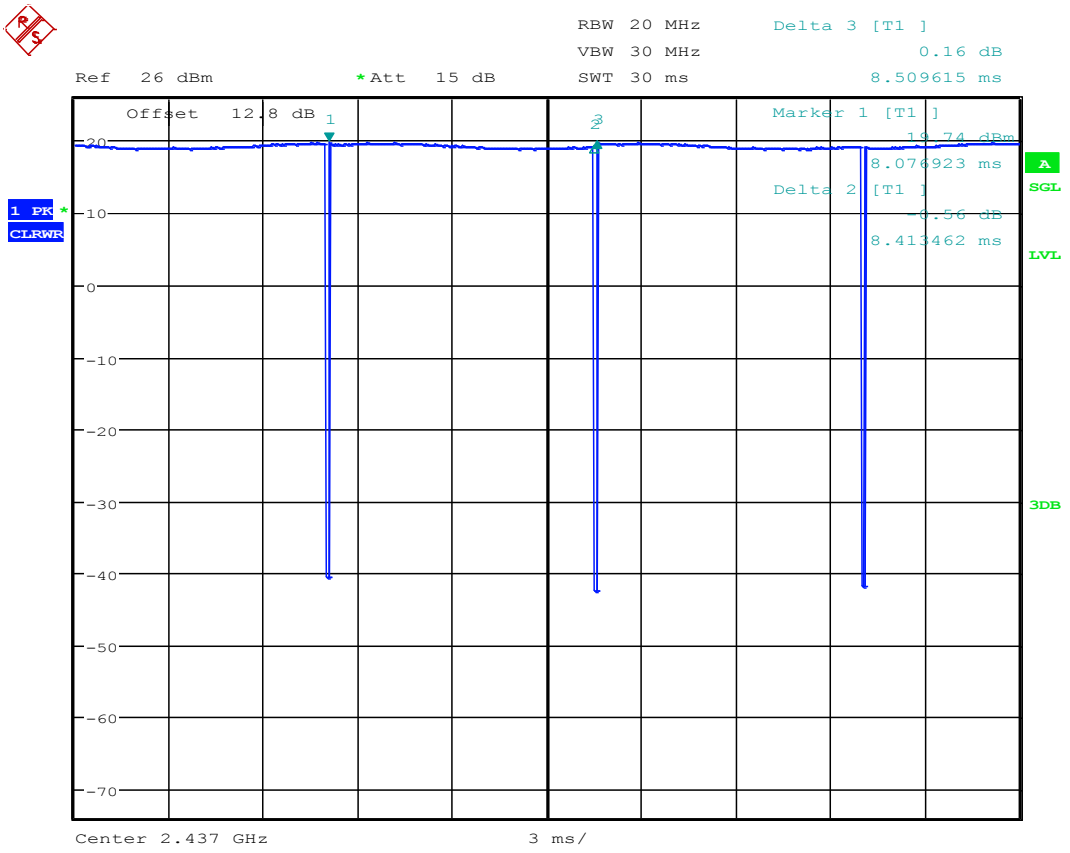
- Set the center frequency and of the instrument to the center frequency of the transmission
- Zero span
- Set RBW >=OBW if possible; otherwise, set RBW to the largest available value
- Detector = Peak or average

8.1.2 Measurement result

Plot #	Mode	Data Rate	Duty Cycle	Duty Cycle Correction Factor (dB)
1	802.11b	1Mpbs	98.94%	0.05
2	802.11g	6Mbps	92.62%	0.33
3	802.11n_HT20	MCS0	92.91%	0.32

Plot #1

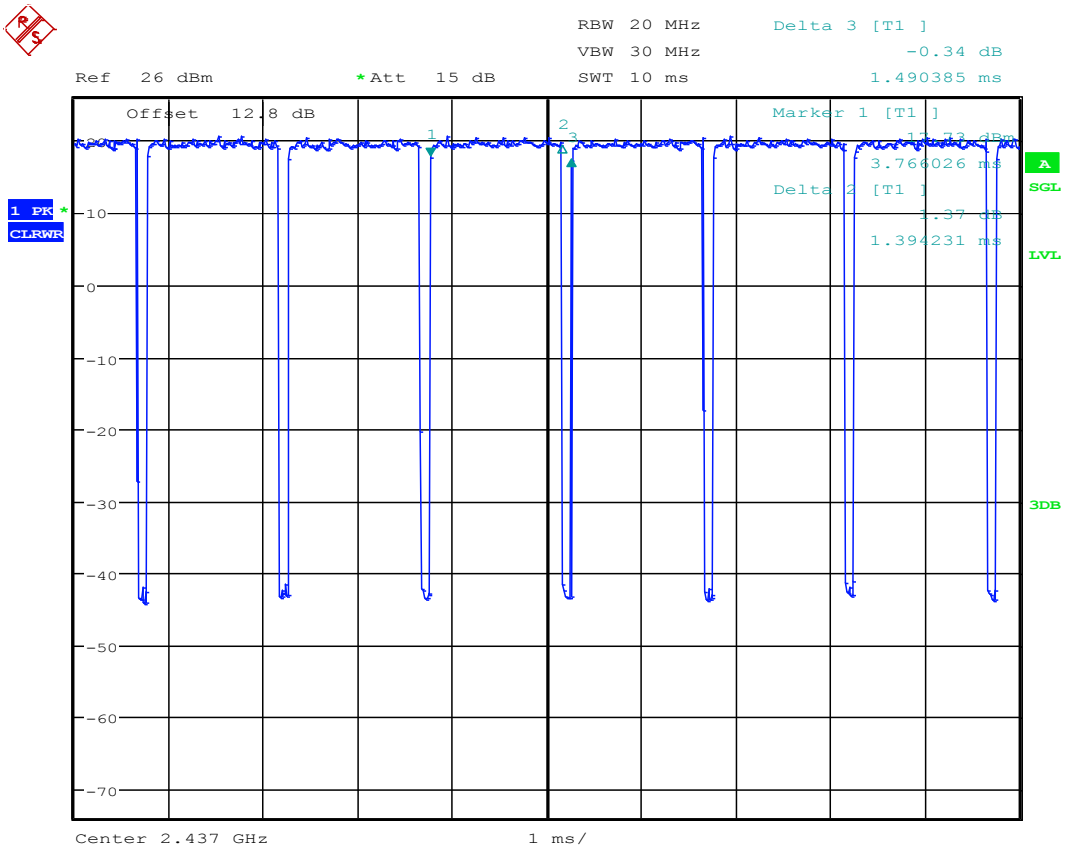
Mid channel / 2437 MHz	Modulation/Packet Type: 802.11b 1 Mbps



Date: 18.MAR.2019 14:31:43

Plot #2

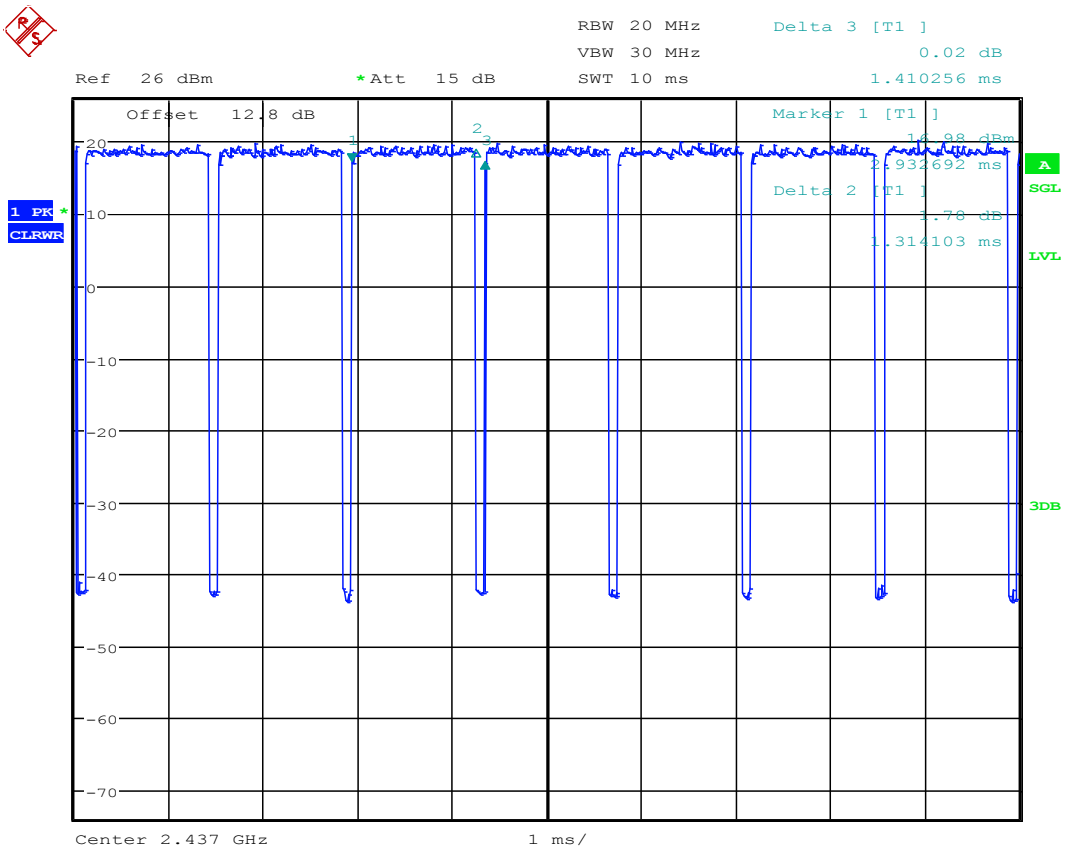
Mid channel / 2437 MHz	Modulation/Packet Type: 802.11g 6 Mbps



Date: 18.MAR.2019 14:33:04

Plot #3

Mid channel / 2437 MHz	Modulation/Packet Type: 802.11n HT20 MCS0



Date: 18.MAR.2019 14:34:49

8.2 Maximum Conducted Output Power

8.2.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v04

Spectrum Analyzer settings:

- Measure the duty cycle, x, of the transmitter output signal.
- Set span to at least 1.5 □ OBW.
- Set RBW = 1 % to 5 % of the OBW, not to exceed 1 MHz.
- Set VBW ≥ 3 □ RBW.
- Number of points in sweep ≥ 2 □ span / RBW. (This gives bin-to-bin spacing ≤ RBW/2, so that narrowband signals are not lost between frequency bins.)
- Sweep time = auto.
- Detector = RMS (i.e., power averaging), if available. Otherwise, use sample detector mode.
- Allow the sweep to "free run". RBW ≥ DTS bandwidth
- Trace average at least 100 traces in power averaging (i.e., RMS) mode; however, the number of traces to be averaged shall be increased above 100 as needed such that the average accurately represents the true average over the on and off periods of the transmitter.
- Compute power by integrating the spectrum across the OBW of the signal using the instrument's band power measurement function with band limits set equal to the OBW band edges. If the instrument does not have a band power function, sum the spectrum levels (in power units) at intervals equal to the RBW extending across the entire OBW of the spectrum.
- Add 10 log (1/x), where x is the duty cycle, to the measured power in order to compute the average power during the actual transmission times (because the measurement represents an average over both the on- and off-times of the transmission). For example, add 10 log (1/0.25) = 6 dB if the duty cycle is 25 %.

8.2.2 Limits:

Maximum Peak Output Power:

- FCC §15.247 (b)(1): 1 W
- IC RSS-247: 1 W

8.2.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Single Antenna Gain
22° C	1	802.11b/g/n	120 VAC/Battery	Section 3.1

8.2.4 Measurement result:

Attenuation of cable and attenuator (already taken into account): 12.8 dB

Mode	DR	Channel/Frequency			Actual test result/dBm		corrected by path loss/dBm		Duty	Max conducted power/dBm			Corrected by antenna gain/dBm			Beamforming	EIRP/dB	Limit
					Primary	Secondary	Primary	Secondary	Cycle	Primary	Secondary	Sum	Primary	Secondary	Sum	gain	m	dBm
802.11b	1Mbps	Low	1	2412	15.34	15.98	16.41	16.6	0.989	16.46	**16.65**	\	18.86	14.55	\	0	**14.55**	30 / 36 (EIRP)
		mid	6	2437	15.72	16.15	16.84	16.87	0.989	16.89	**16.92**	\	16.79	13.92	\	0	**13.92**	31 / 36 (EIRP)
		High	11	2462	15.75	16.22	16.74	17.02	0.989	16.79	**17.07**	\	17.89	14.47	\	0	**14.47**	32 / 36 (EIRP)
802.11g	6Mbps	Low	1	2412	13.54	14.13	14.61	14.75	0.926	14.94	15.08	**18.02**	17.34	12.98	18.70	0	**18.70**	33 / 36 (EIRP)
		mid	6	2437	13.49	14.21	14.61	14.93	0.926	14.94	15.26	**18.12**	14.84	12.26	16.75	0	**16.75**	34 / 36 (EIRP)
		High	11	2462	13.64	14.19	14.63	14.99	0.926	14.96	15.32	**18.16**	16.06	12.72	17.72	0	**17.72**	35 / 36 (EIRP)
802.11 n20	MCS0	Low	1	2412	12.41	13.05	13.48	13.67	0.929	13.80	13.99	**16.91**	16.20	11.89	17.57	3	**20.57**	36 / 36 (EIRP)
		mid	6	2437	12.53	13.12	13.65	13.84	0.929	13.97	14.16	**17.08**	13.87	11.16	15.73	3	**18.73**	37 / 36 (EIRP)
		High	11	2462	12.57	13.03	13.56	13.83	0.929	13.88	14.15	**17.03**	14.98	11.55	16.61	3	**19.61**	38 / 36 (EIRP)

EIRP= Conducted output power + Antenna gain
Directional antenna gain of MIMO = Gain of antenna element + 10log(Nant)

8.3 Power Spectral Density

8.3.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v04

Spectrum Analyzer settings for Peak PSD method:

- Set analyzer center frequency to DTS channel center frequency
- Set the span to 1.5 x DTS bandwidth
- Set RBW to: 3 kHz ≤ RBW ≤ 100 kHz
- Set the VBW ≥ 3 x RBW
- Detector = Peak
- Sweep time = Auto couple
- Trace mode = Max hold
- Allow trace to fully stabilize
- Use the peak marker function to determine the maximum amplitude level within the RBW
- If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat

8.3.2 Limits:

FCC§15.247(e) & RSS-247 5.2(2)

- For digitally modulated systems, the peak 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.

8.3.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Single Antenna Gain
23° C	1	802.11b/g/n	120 VAC/Battery	Section 3.1

8.3.4 Measurement result:

Attenuation of cable and attenuator (already taken into account): 12.9 dB

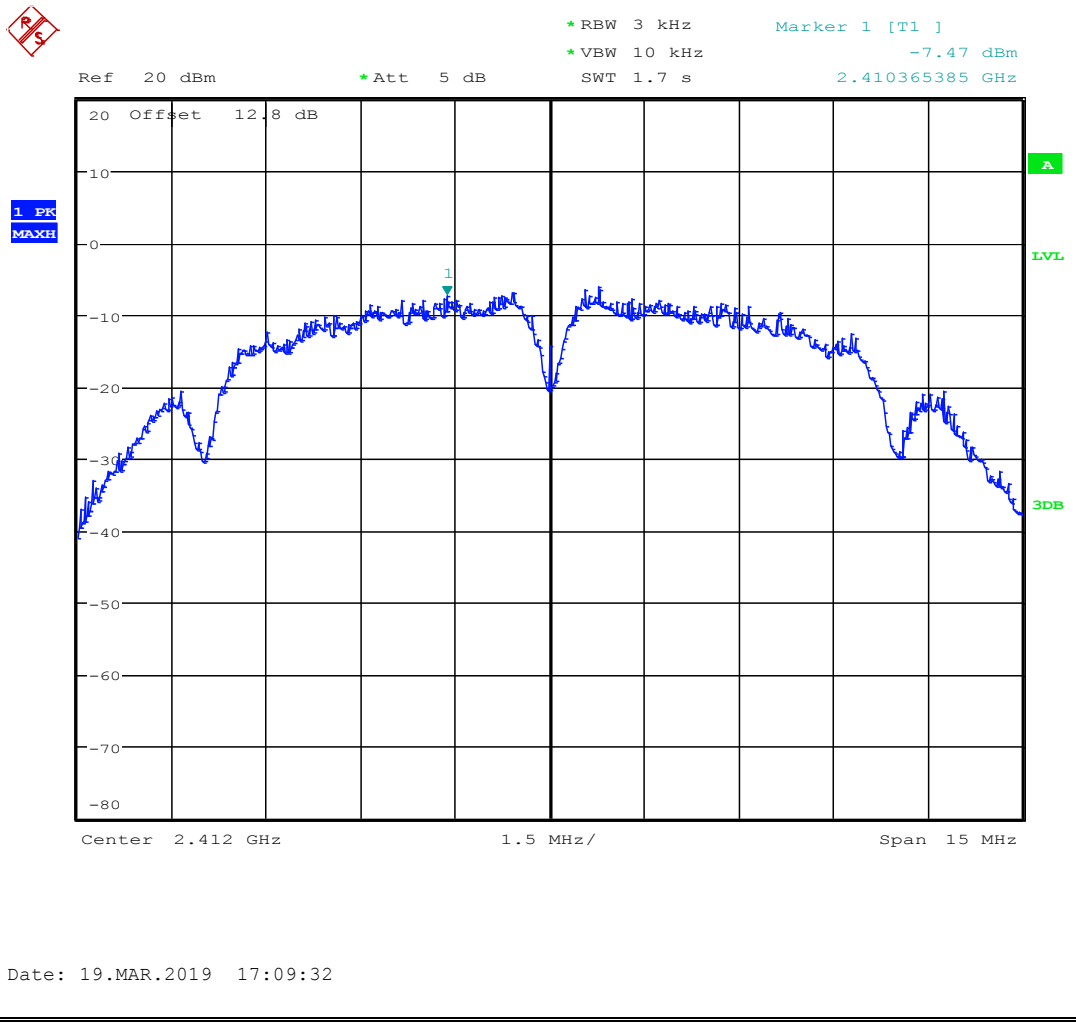
Plot #	Mode	Data Rate	Tx chain	channel	Measured Power Spectral Density (dBm/3 kHz)	Corrected by path loss and duty cycle (dBm/3 kHz)	Corrected by simultaneous transmission or MIMO	Limit (dBm / 3 kHz)	Result
1	802.11b	1Mpbs	Primary	1	-7.47	-6.35	-6.35	8	Pass
2				6	-7.11	-5.94	-5.94	8	Pass
3				11	-7.31	-6.27	-6.27	8	Pass
4	802.11g	6Mpbs	Primary	1	-10.97	-9.57	-6.57	8	Pass
5				6	-10.59	-9.14	-6.14	8	Pass
6				11	-11.7	-10.38	-7.38	8	Pass
7	802.11n_HT20	MCS0	Primary	1	-11.69	-10.30	-7.30	8	Pass
8				6	-12.69	-11.25	-8.25	8	Pass
9				11	-12.39	-11.08	-8.08	8	Pass

Note1: 3 dB was added for 11g/n mode for simultaneous transmission or MIMO
Note2: Primary tx chain was tested for worst case judgement

8.3.5 Measurement Plots:

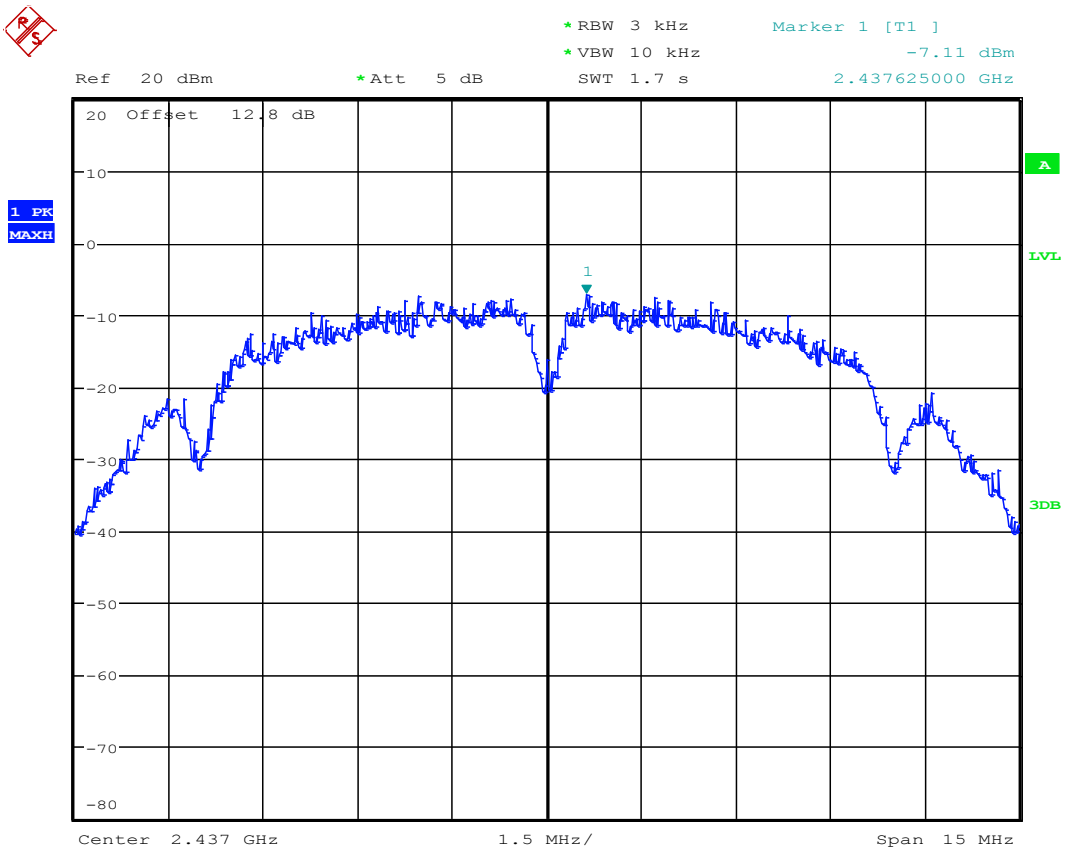
Plot #1

Low channel	Modulation/Packet Type: 802.11b 1Mbps



Plot #2

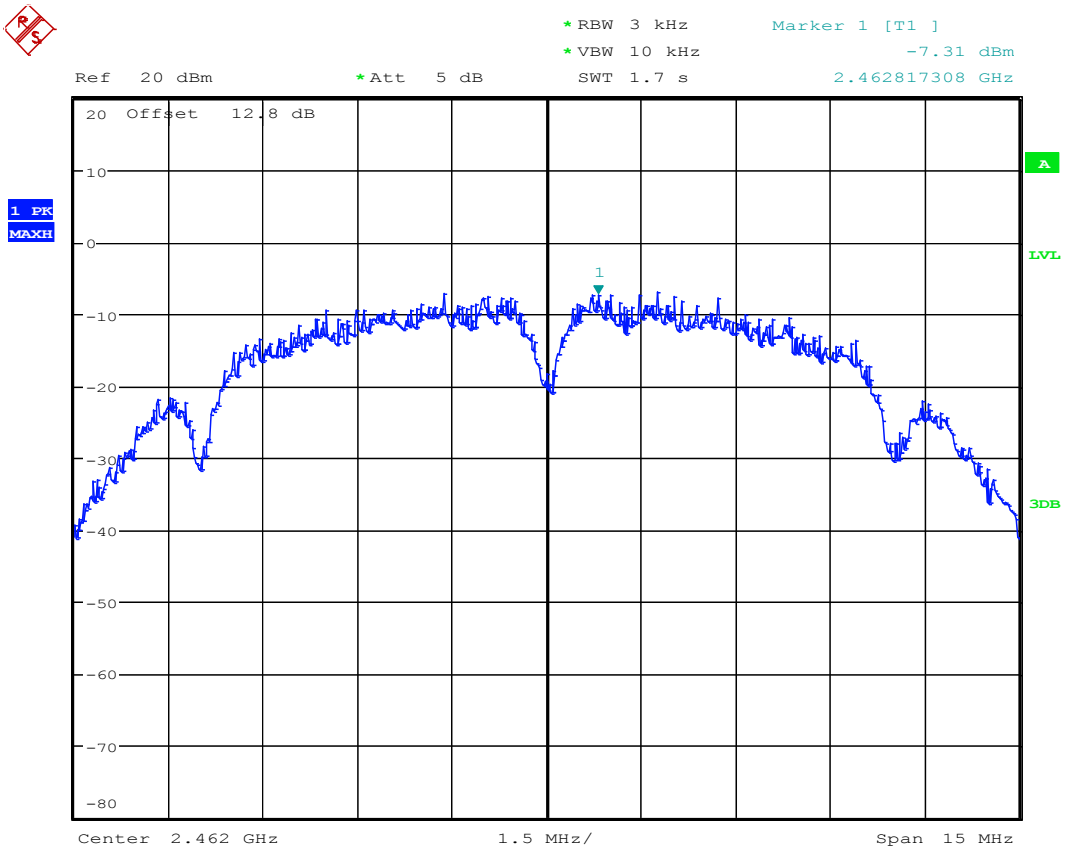
Mid channel	Modulation/Packet Type: 802.11b 1Mbps



Date: 19.MAR.2019 17:11:34

Plot #3

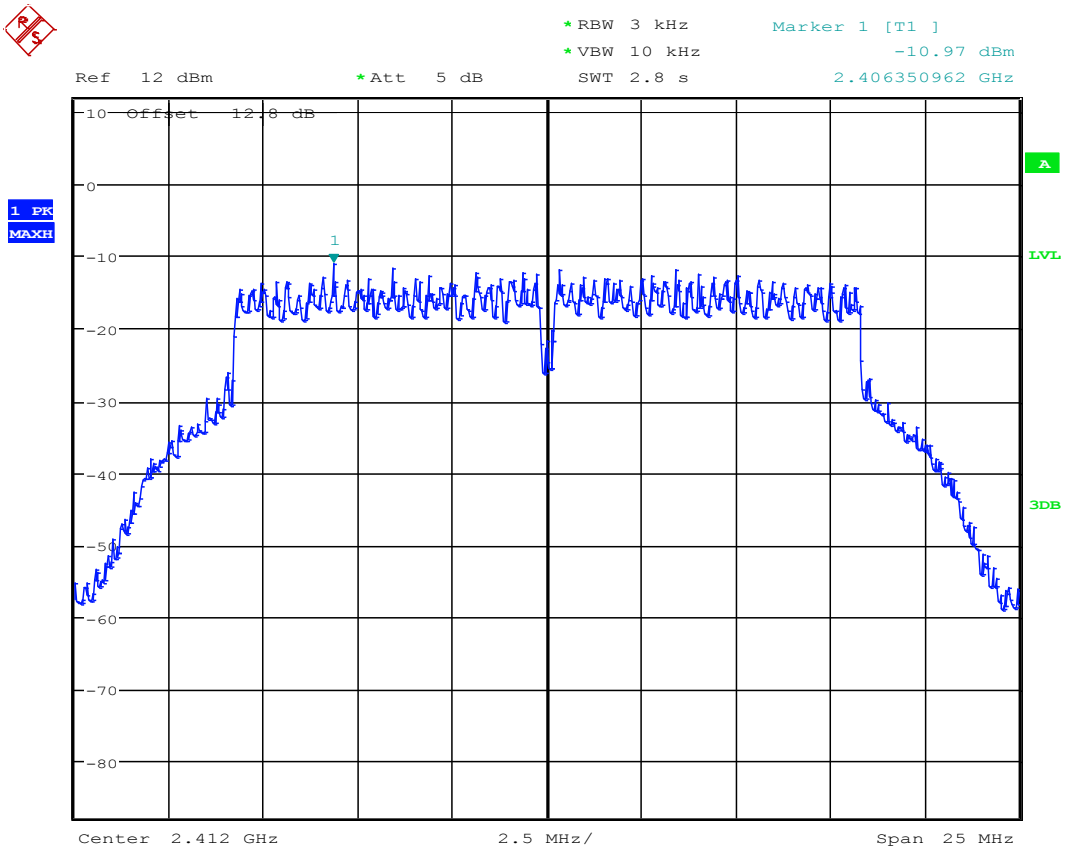
High channel	Modulation/Packet Type: 802.11b 1Mbps



Date: 19.MAR.2019 17:12:24

Plot #4

Low channel	Modulation/Packet Type: 802.11g 6Mbps



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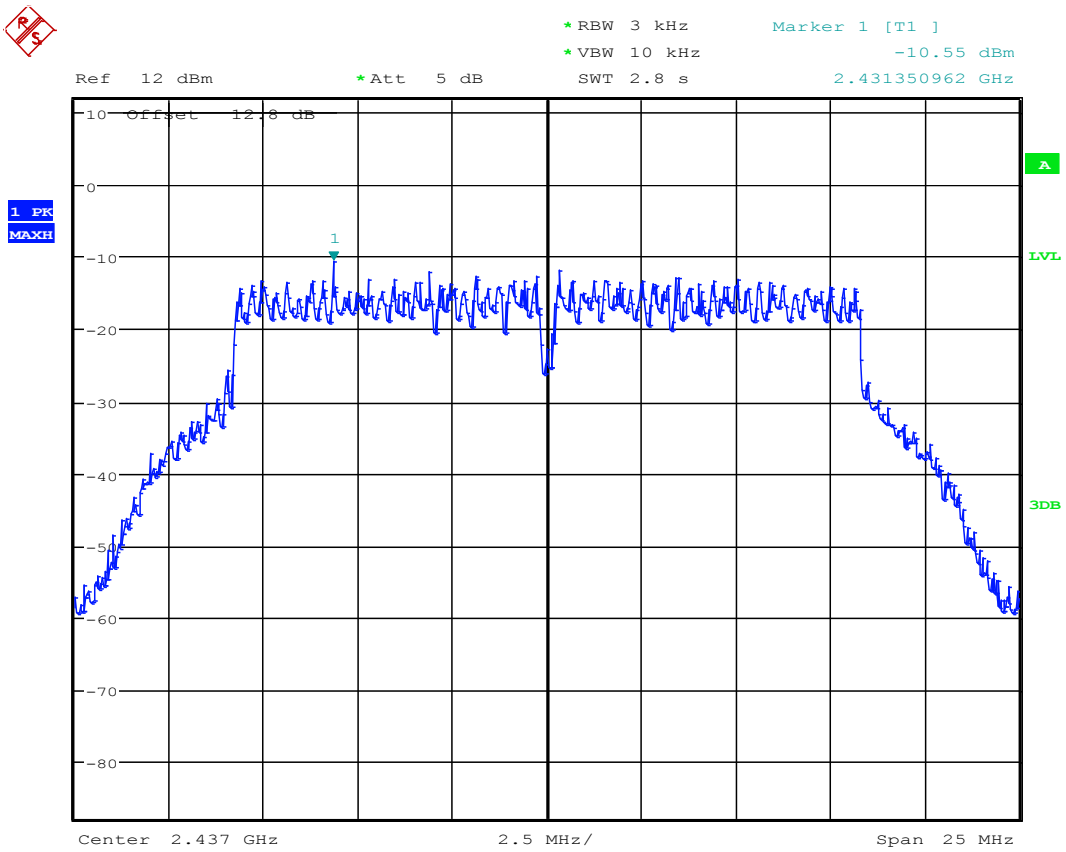
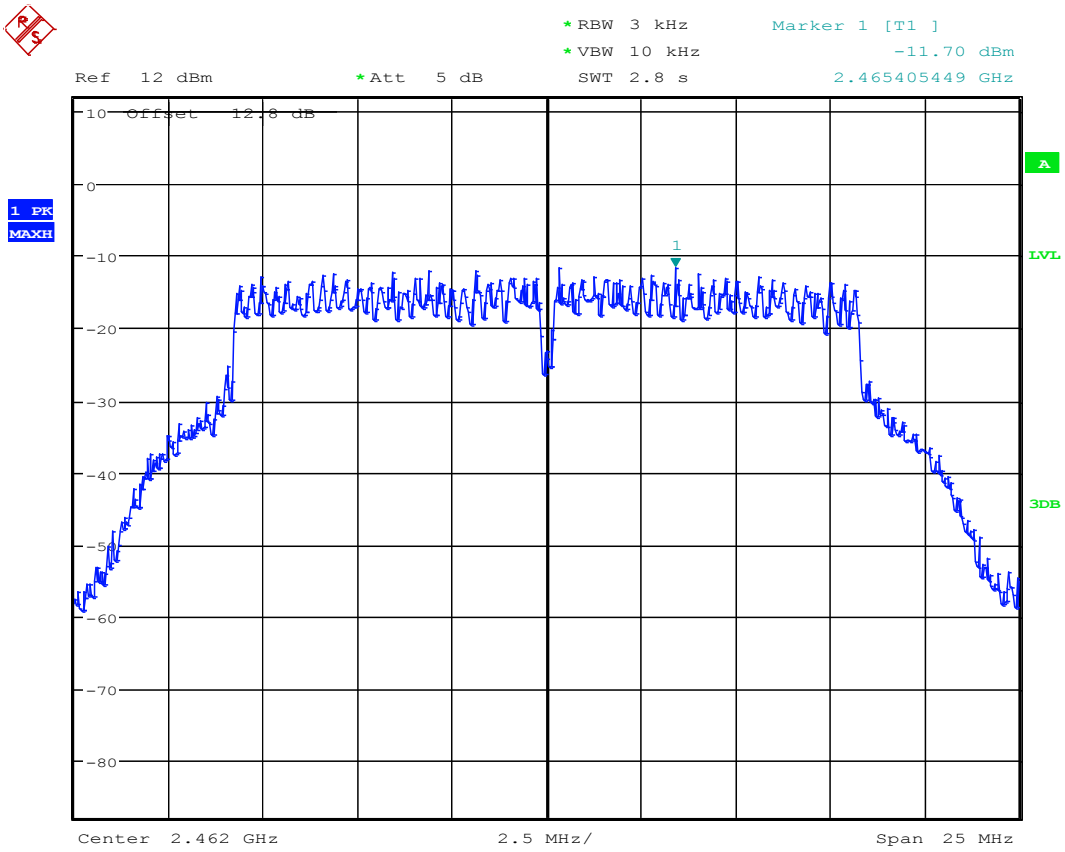
Plot #5

Mid channel	Modulation/Packet Type: 802.11g 6Mbps



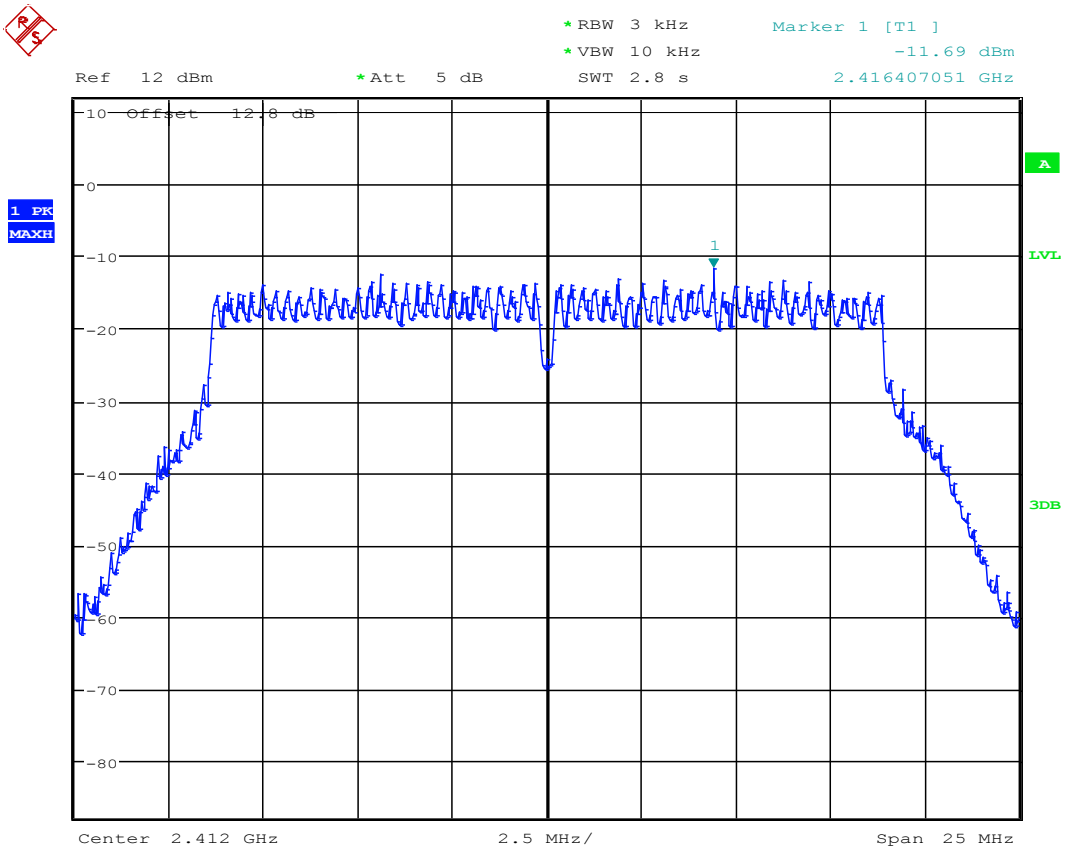
Plot #6

High channel	Modulation/Packet Type: 802.11g 6Mbps



Plot #7

Low channel	Modulation/Packet Type: 802.11n_HT20 MCS0



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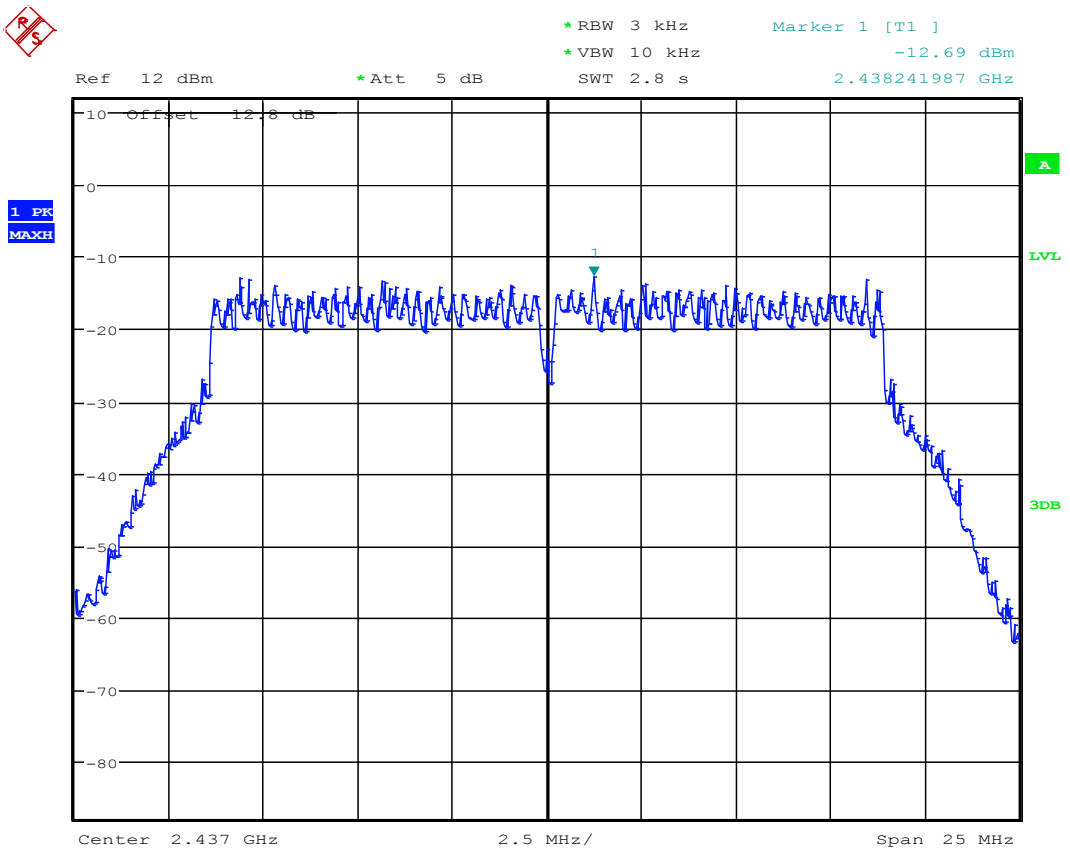
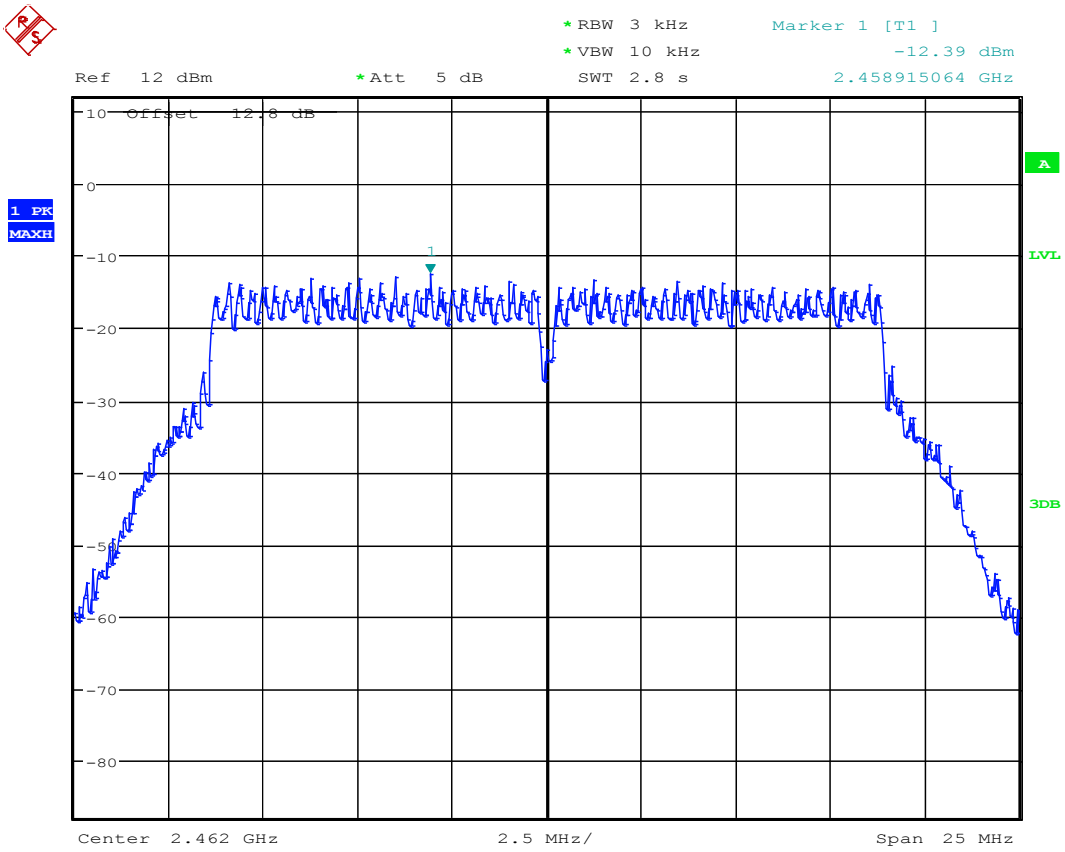
Plot #8

Mid channel	Modulation/Packet Type: 802.11n_HT20 MCS0



Plot #9

High channel	Modulation/Packet Type: 802.11n_HT20 MCS0



Date: 19.MAR.2019 17:21:10

8.4 Band Edge Compliance

8.4.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v04

Spectrum Analyzer settings for band edge:

- Set the center frequency and span to encompass frequency range to be measured
- RBW = 100 kHz
- VBW ≥ 3 x RBW
- Sweep Time: Auto couple
- Detector = Peak
- Trace = Max hold
- Allow trace to fully stabilize
- Use the peak marker function to determine the maximum amplitude level
- Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge

8.4.2 Limits non restricted band:

FCC§15.247 (d)

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

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- 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 30dB instead of 20dB.

Spectrum Analyzer settings for restricted band:

- Peak measurements are made using a peak detector and RBW=1 MHz

8.4.3 Limits restricted band §15.247/15.209/15.205 and RSS-Gen 8.9/8.10

- *PEAK LIMIT= 74 dBµV/m @3m =-21.23 dBm
- *AVG LIMIT= 54 dBµV/m @3m =-41.23 dBm
- Start frequency & stop frequency according to frequency range specified in the restricted band table in FCC section 15.205 & RSS-Gen 8.10
- Measurements with a peak detector were used to show compliance to average limits, thus showing compliance to both peak and average limits.

(a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

(b)

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
[1]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			

8.4.4 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Single Antenna Gain
22° C	1	802.11b/g/n	120 VAC/Battery	Section 3.1

8.4.5 Measurement result:

Plot #	Tx Chain	EUT operating mode	Band Edge	Band Edge Delta (dBc)	Limit (dBc)	Result
1	Primary	802.11b	Lower, Non-restricted	-42.41	20	Pass
2	Primary	802.11g	Lower, Non-restricted	-37.24	20	Pass
3	Primary	802.11n_HT20	Lower, Non-restricted	-37.74	20	Pass

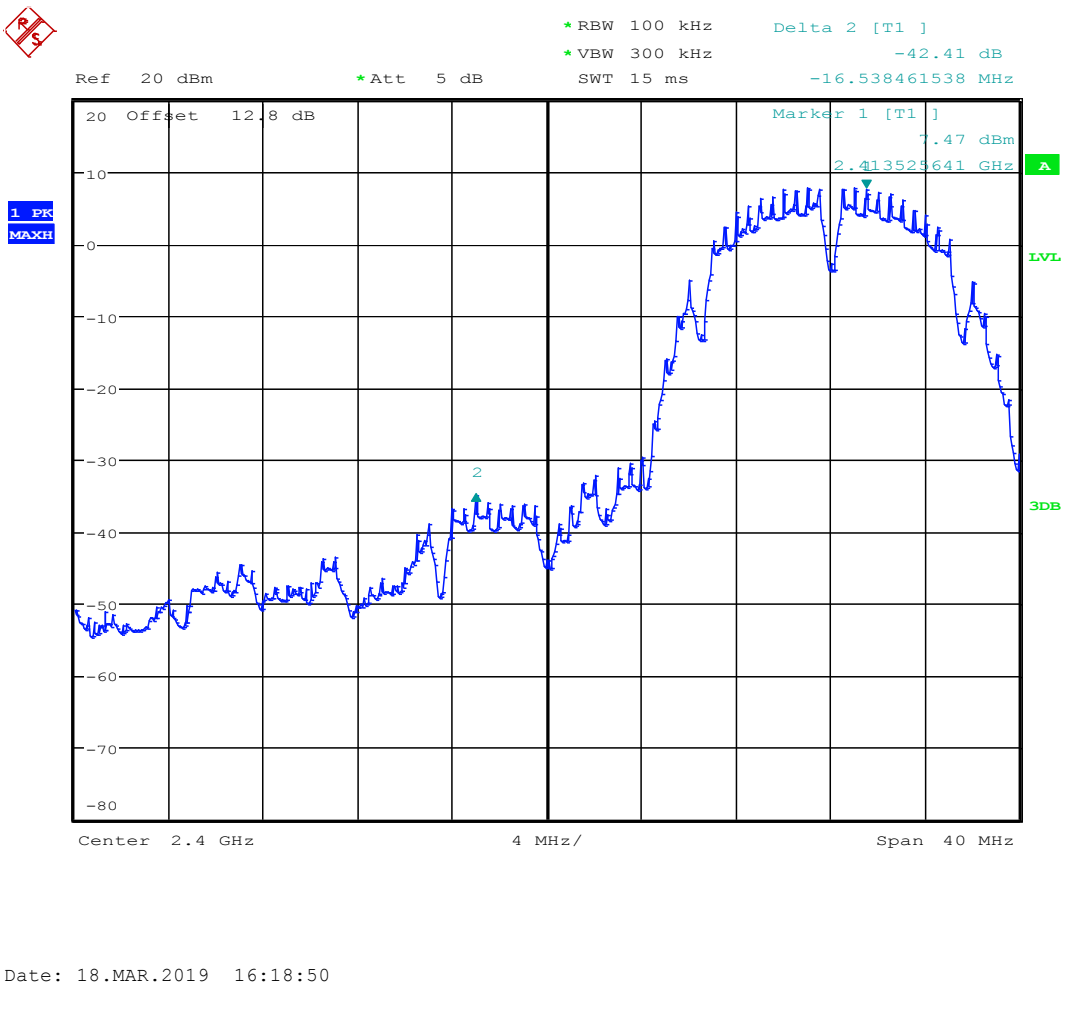
Plot #	Tx Chain	EUT operating mode	Band Edge	Frequency (MHz)	Measured Peak Value (dBm)	Corrected by duty cycle	Corrected by path loss, Antenna Gain and MIMO/simultaneous transmission (dBm)	Limit (dBm)	Result
4	Primary	802.11b	Upper Restricted peak	2483.6	-39.17	-39.17	-37.08	-21.23 Peak	Pass
5	Primary	802.11b	Upper Restricted Average	2483.5	-48.21	-48.16	-46.072	-41.23 AVG	Pass
6	Primary	802.11g	Upper Restricted peak	2483.5	-31.86	-31.86	-26.77	-21.23 Peak	Pass
7	Primary	802.11g	Upper Restricted Average	2483.5	-46.98	-46.65	-41.56	-41.23 AVG	Pass
8	Primary	802.11n_HT20	Upper Restricted peak	2483.6	-32.62	-32.62	-27.53	-21.23 Peak	Pass
9	Primary	802.11n_HT20	Upper Restricted Average	2483.7	-49.6	-49.28	-44.19	-41.23 AVG	Pass

Note1: 3 dB was added for 11g/n mode for simultaneous transmission or MIMO
Note2: Primary tx chain was tested for worst case judgement
Note3: The value of above table shows worst case of each mode.

8.4.6 Measurement Plots:

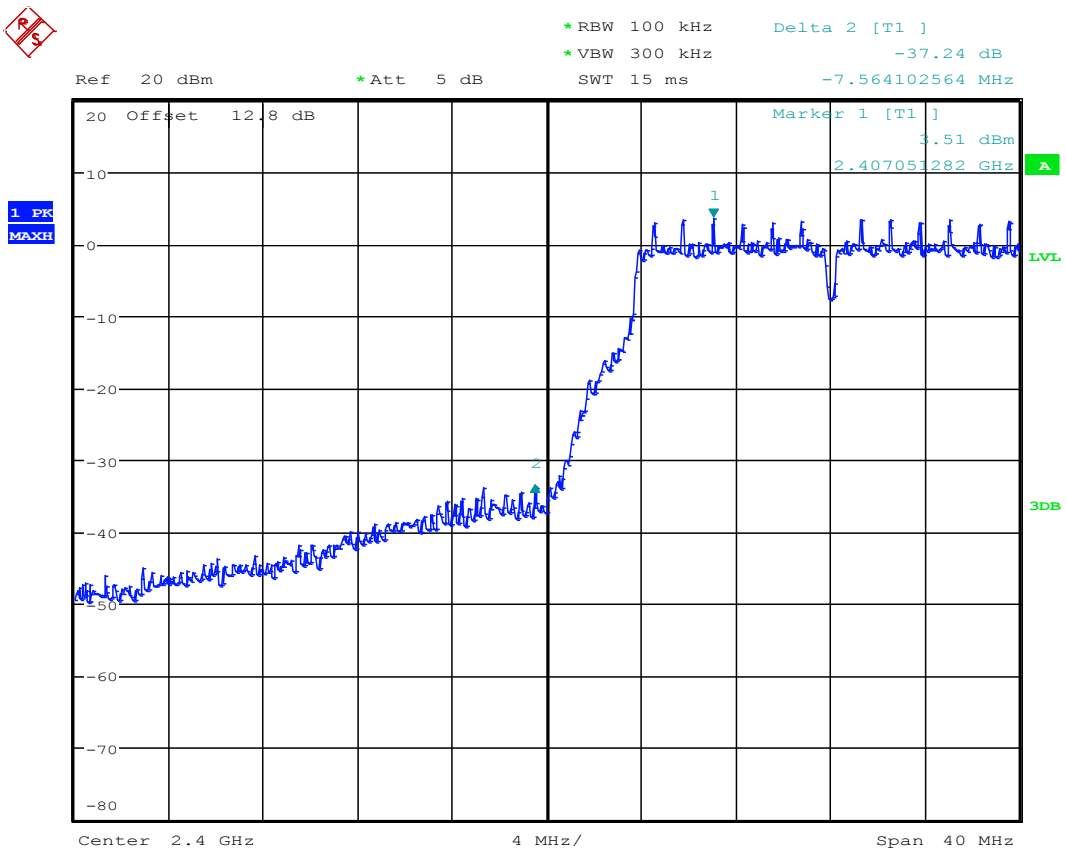
Plot #1

Low channel / 2412 MHz	Modulation/Packet Type: 802.11b 1Mbps



Plot #2

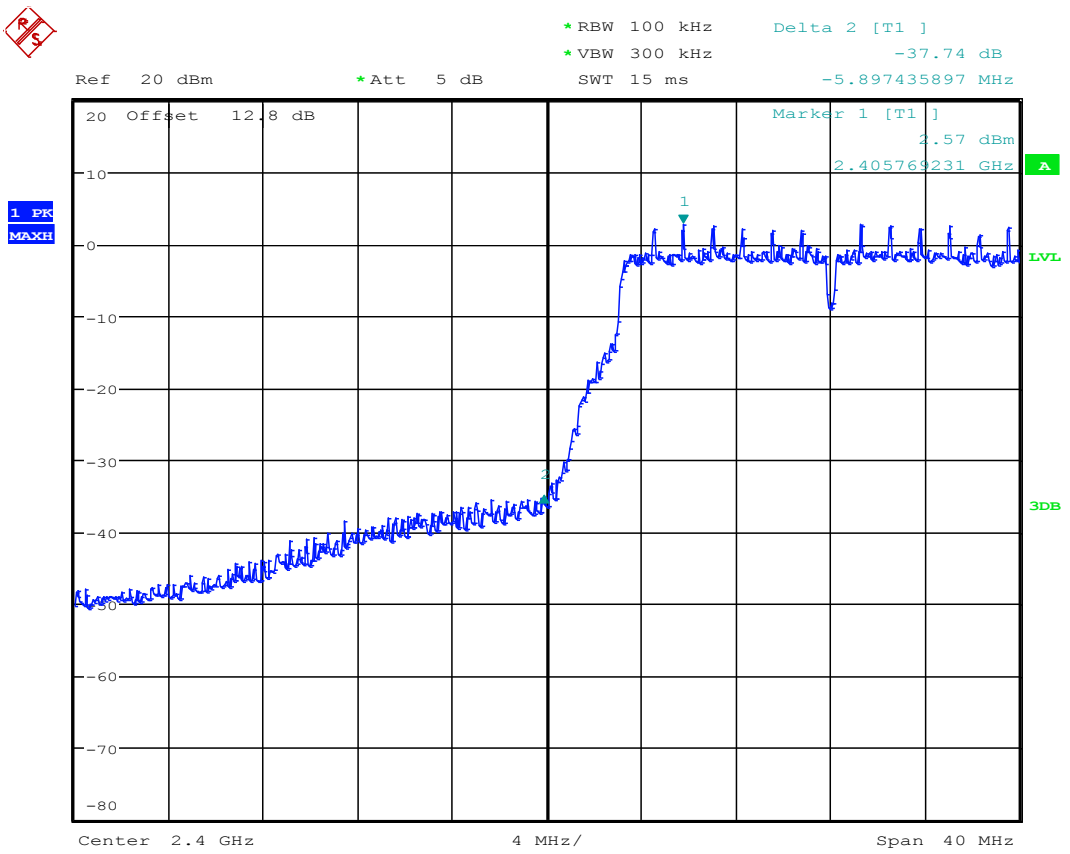
Low channel / 2412 MHz	Modulation/Packet Type: 802.11g 6Mpbs



Date: 18.MAR.2019 16:20:25

Plot #3

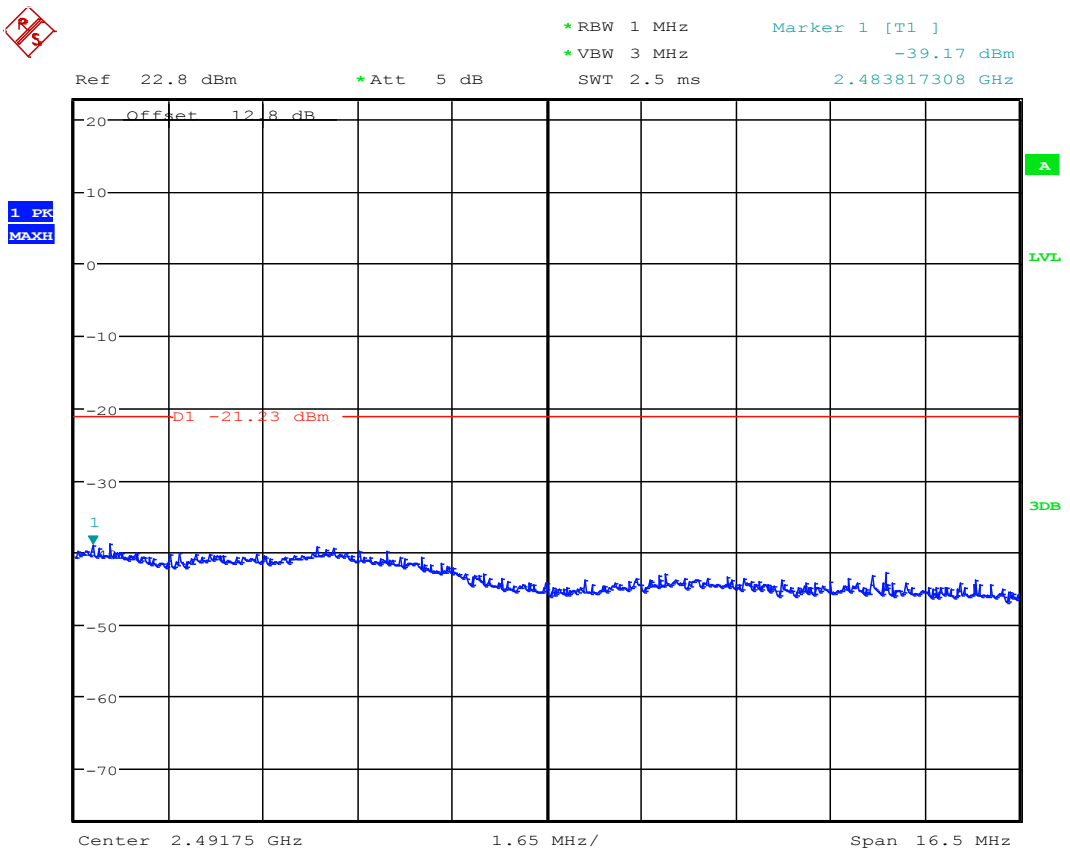
Low channel / 2412 MHz	Modulation/Packet Type: 802.11n_HT20 MCS0



Date: 18.MAR.2019 16:21:27

Plot #4

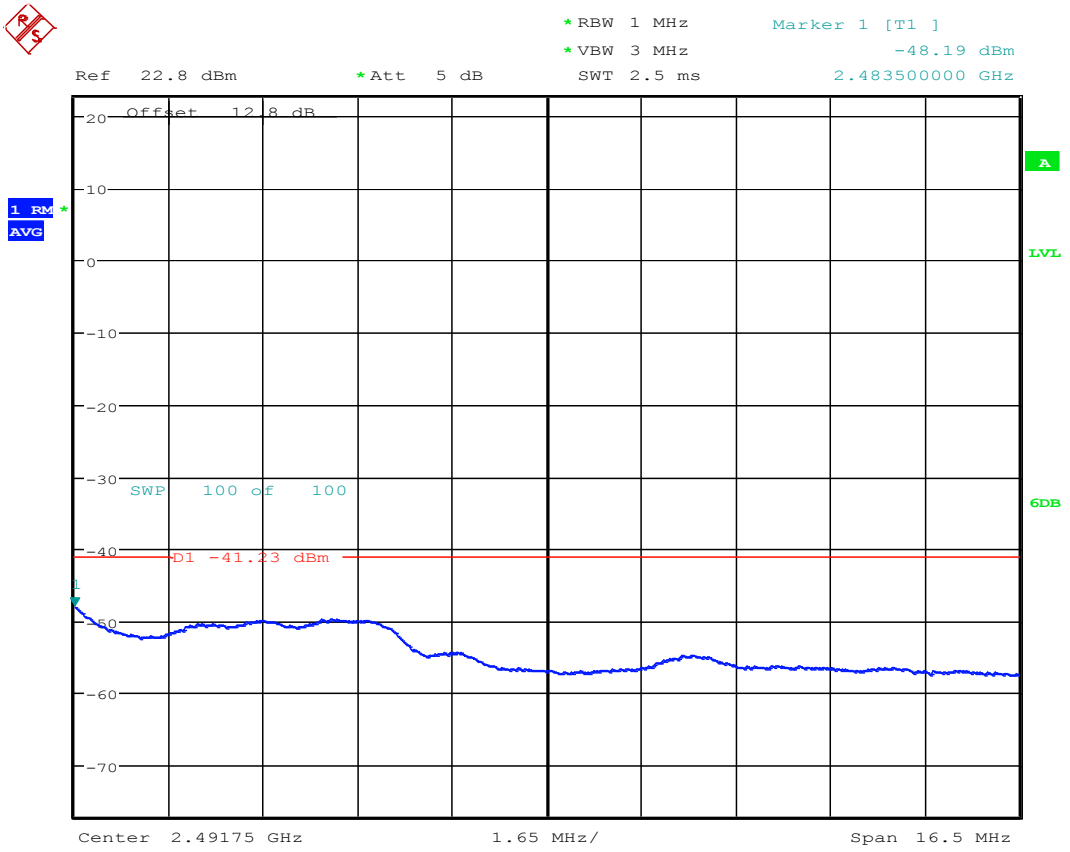
High channel/ 2462 MHz	Modulation/Packet Type: 802.11b 1Mbps Peak



Date: 19.MAR.2019 15:27:13

Plot #5

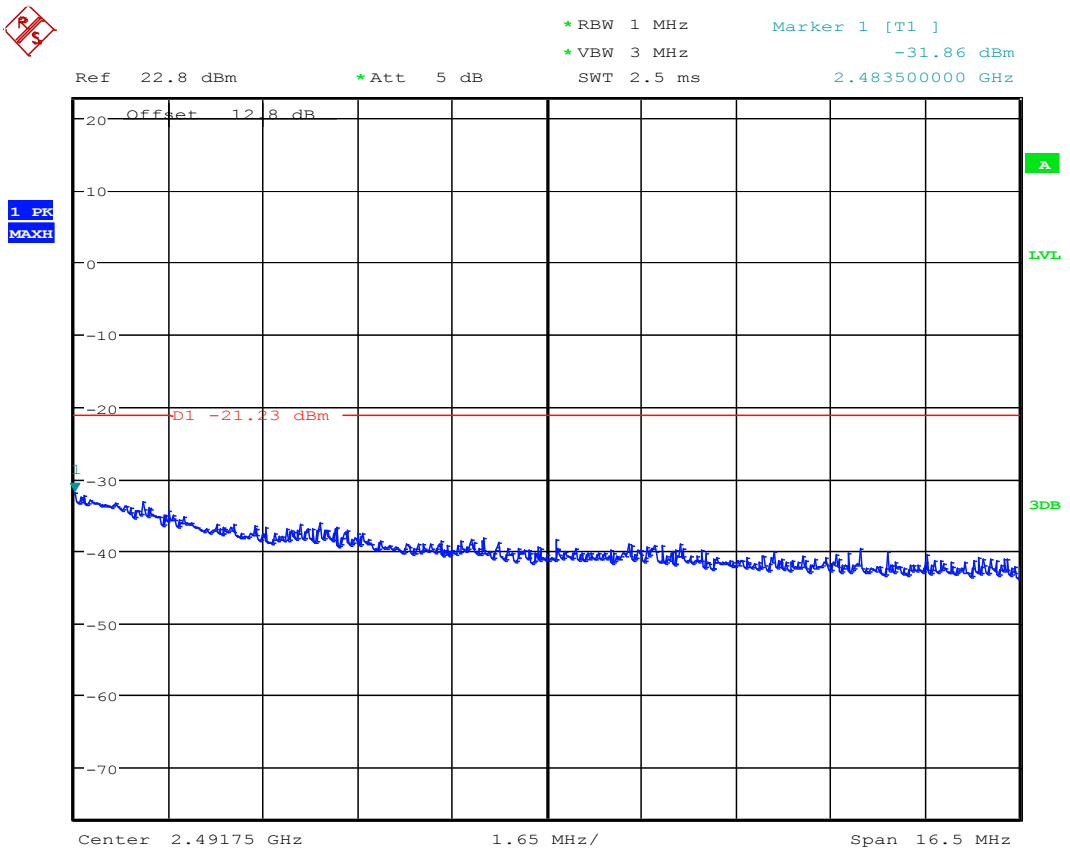
High channel/ 2462 MHz	Modulation/Packet Type: 802.11b 1Mbps Avg



Date: 19.MAR.2019 15:21:12

Plot #6

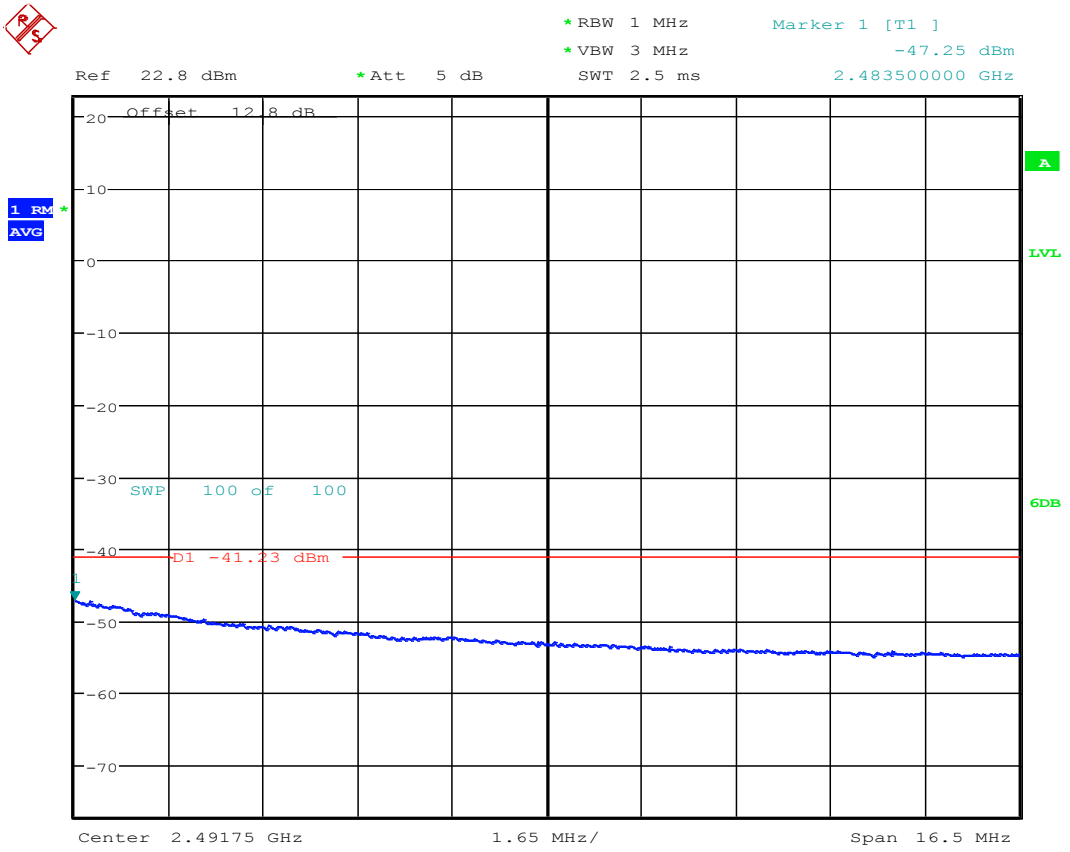
High channel/ 2462 MHz	Modulation/Packet Type: 802.11g 6Mbps Peak



Date: 19.MAR.2019 15:28:07

Plot #7

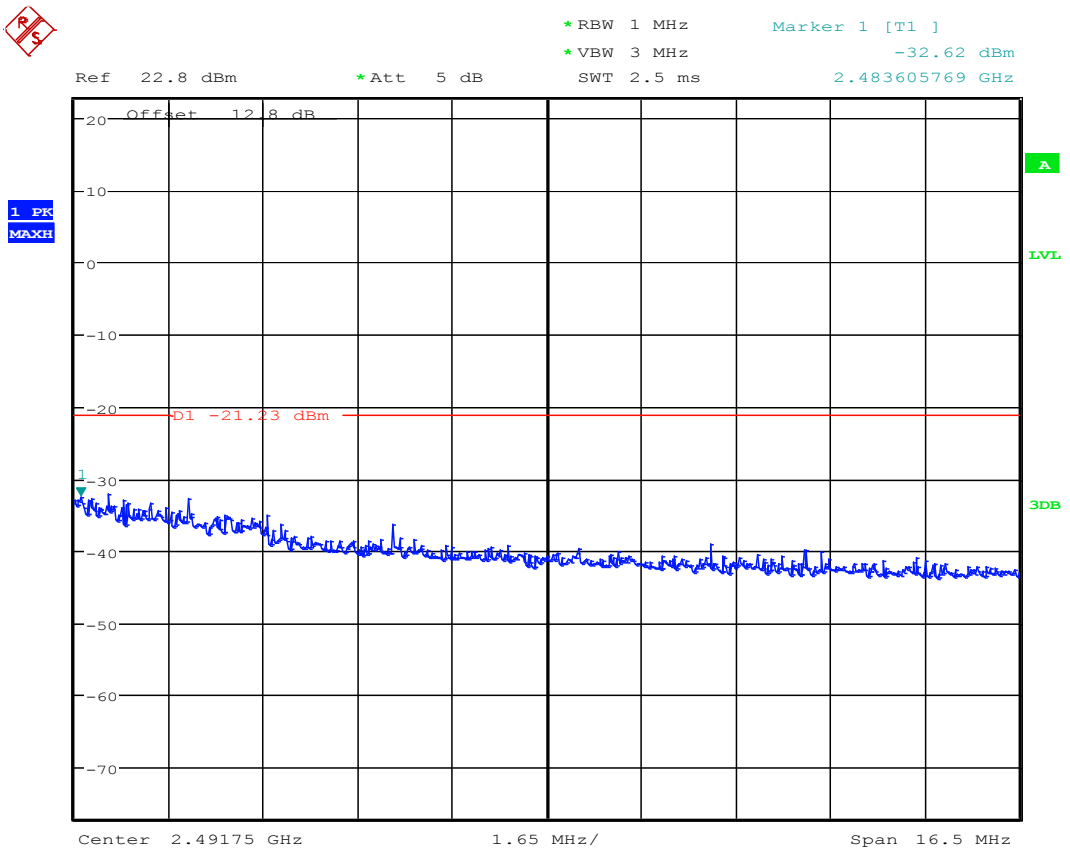
High channel/ 2462 MHz	Modulation/Packet Type: 802.11b 6Mbps Avg



Date: 19.MAR.2019 15:23:46

Plot #8

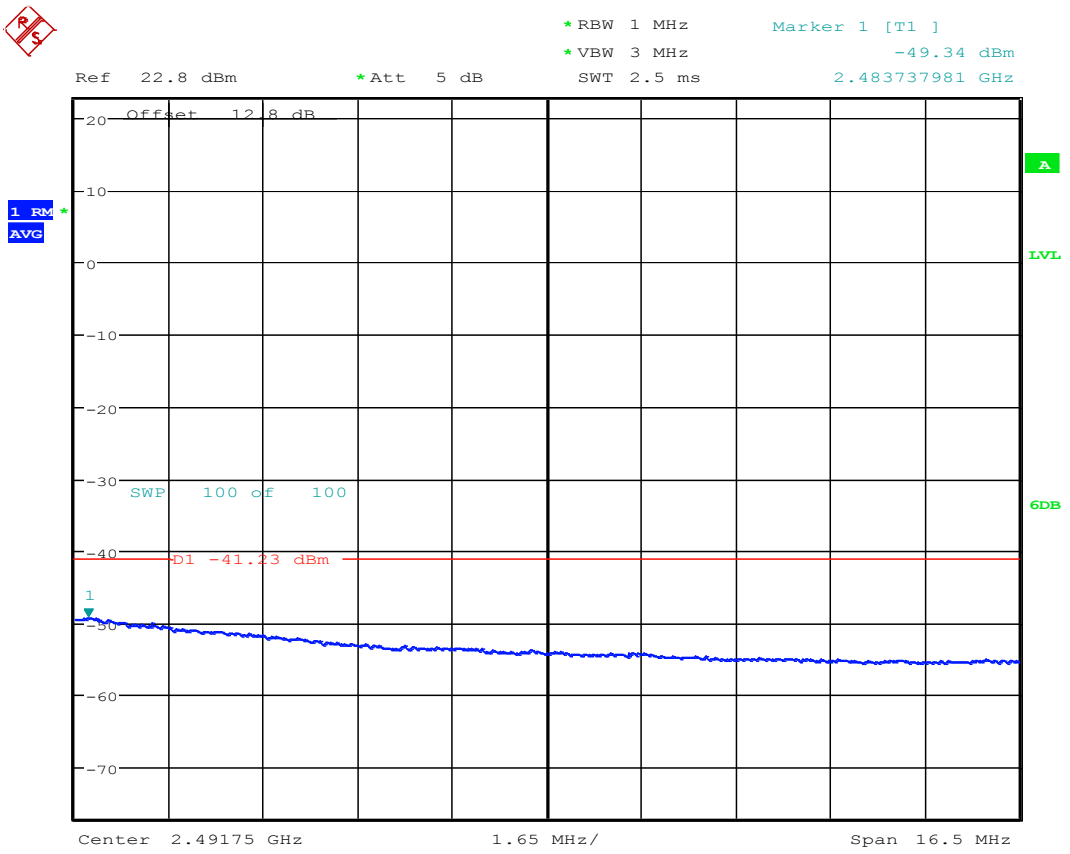
High channel/ 2462 MHz | **Modulation/Packet Type: 802.11n_HT20 MCS0 Peak**



Date: 19.MAR.2019 15:29:15

Plot #9

High channel/ 2462 MHz	Modulation/Packet Type: 802.11n_HT20 MCS0 Avg



Date: 19.MAR.2019 15:25:18

8.5 Emission Bandwidth 6 dB and 99% Occupied Bandwidth

8.5.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v04

Spectrum Analyzer settings:

- Set RBW = 100 kHz
- Set the video bandwidth (VBW) ≥ 3 x RBW
- Detector = Peak
- Trace mode = Max hold
- Sweep = Auto couple
- Allow the trace to stabilize
- Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

8.5.2 Limits:

FCC §15.247(a)(1) and RSS-247 5.2(1)

- 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.

8.5.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
22° C	1	802.11 b/g/n	120VAC/Battery

8.5.4 Measurement result:

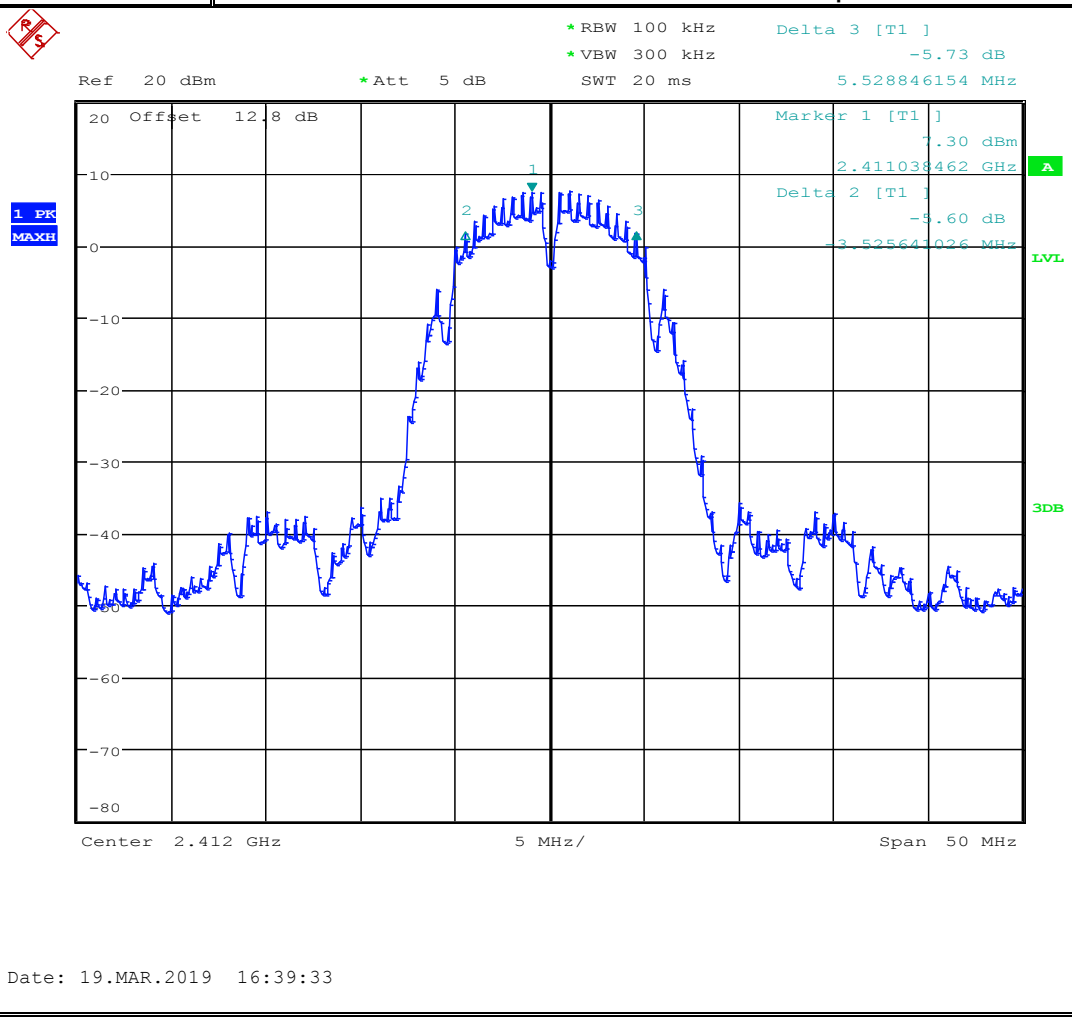
Plot #	Mode	Channel	6 dB Emissions Bandwidth (MHz)	Limit (MHz)	Result
1	802.11b	1	9	> 0.5	Pass
2	802.11b	6	9	> 0.5	Pass
3	802.11b	11	9	> 0.5	Pass
4	802.11g	1	16.4	> 0.5	Pass
5	802.11g	6	16.4	> 0.5	Pass
6	802.11g	11	16.4	> 0.5	Pass
7	802.11n_HT20	1	17.5	> 0.5	Pass
8	802.11n_HT20	6	17.7	> 0.5	Pass
9	802.11n_HT20	11	17.7	> 0.5	Pass

Plot #	Mode	Channel	99% Occupied Bandwidth (MHz)	Limit (MHz)	Result
10	802.11b	1	11.6	> 0.5	Pass
11	802.11b	6	11.6	> 0.5	Pass
12	802.11b	11	11.5	> 0.5	Pass
13	802.11g	1	16.9	> 0.5	Pass
14	802.11g	6	16.9	> 0.5	Pass
15	802.11g	11	16.8	> 0.5	Pass
16	802.11n_HT20	1	18	> 0.5	Pass
17	802.11n_HT20	6	18	> 0.5	Pass
18	802.11n_HT20	11	18	> 0.5	Pass

8.5.5 Measurement Plots:

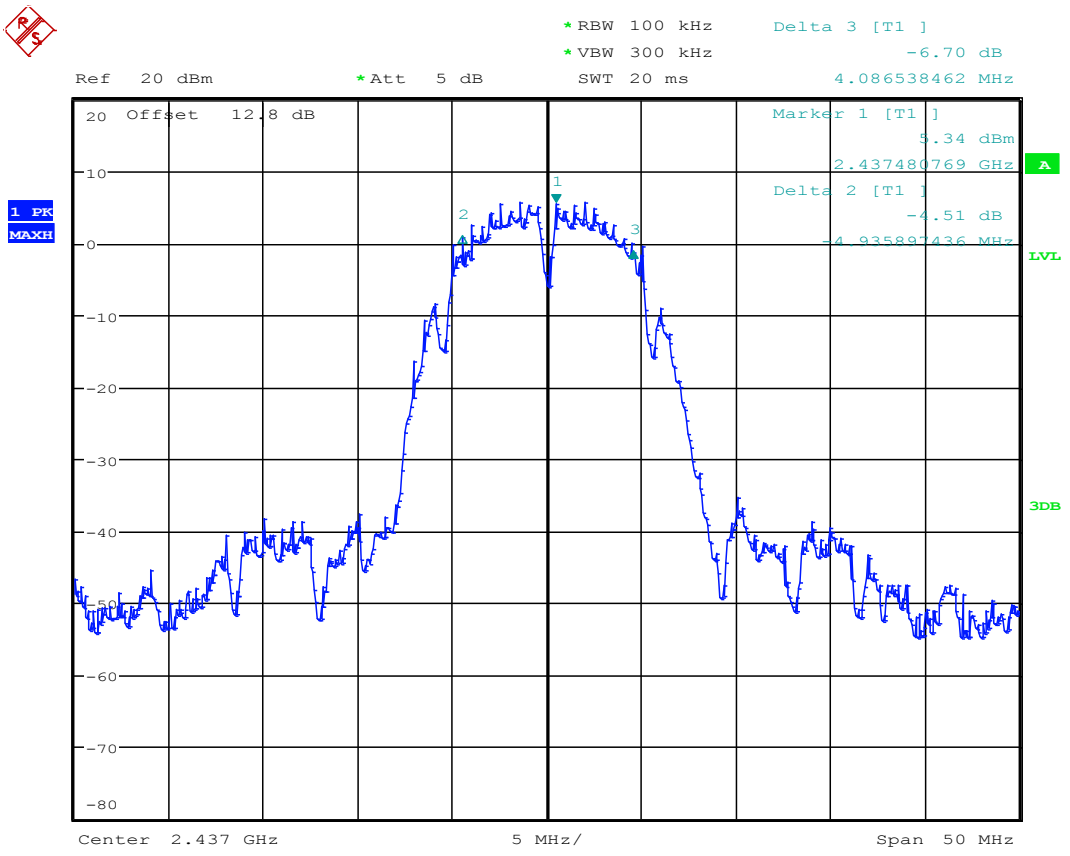
Plot #1

Low channel	Mode: 802.11b 1Mbps



Plot #2

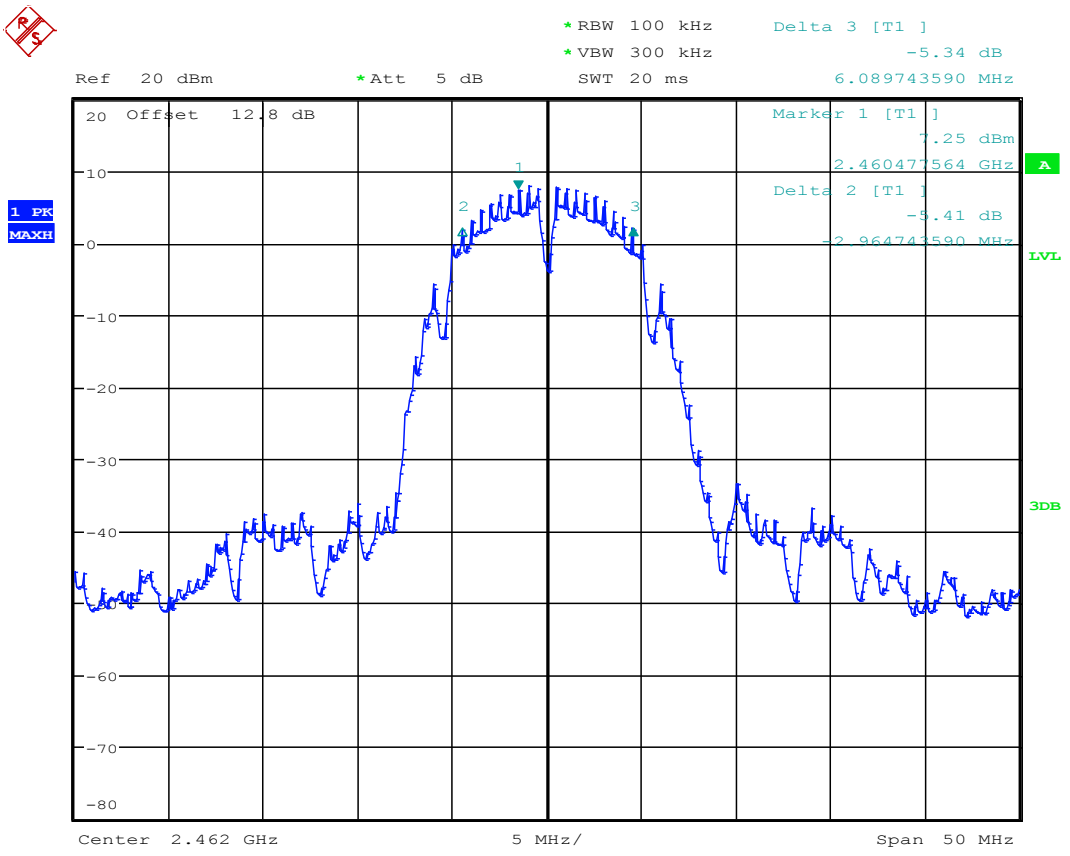
Mid channel	Mode: 802.11b 1Mbps



Date: 19.MAR.2019 16:41:17

Plot #3

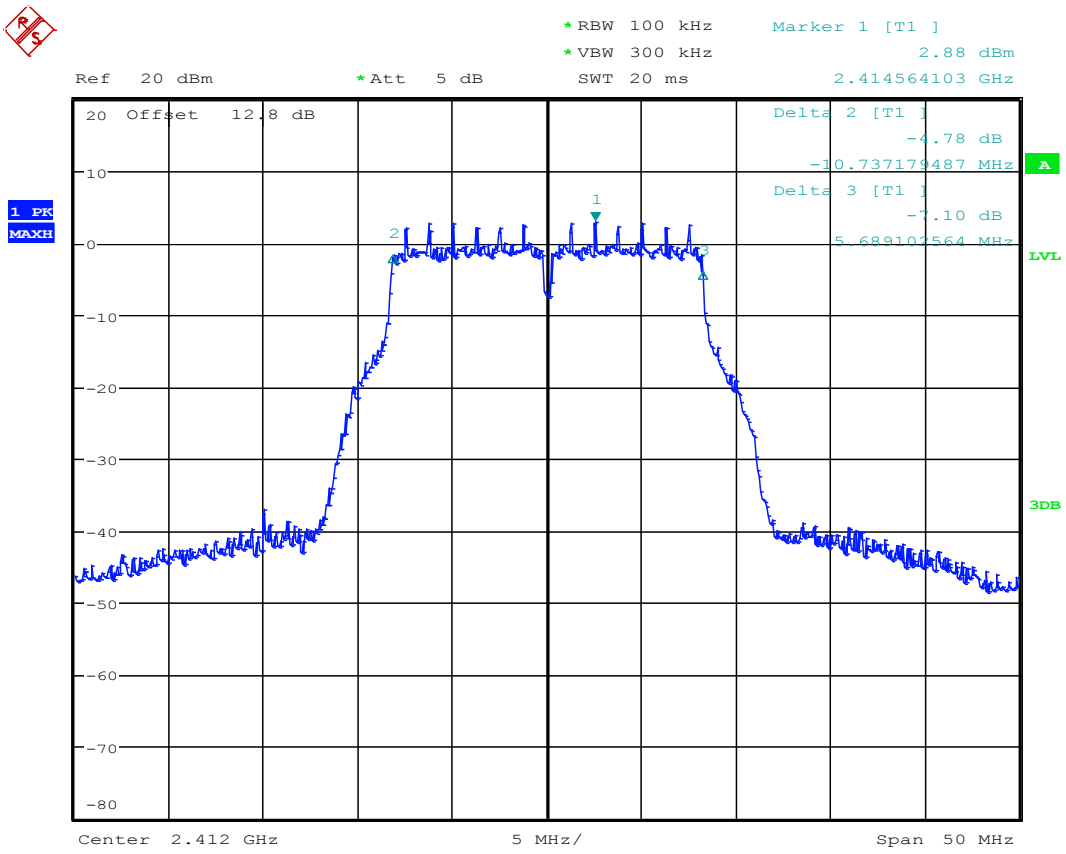
High channel	Mode: 802.11b 1Mbps



Date: 19.MAR.2019 16:43:19

Plot #4

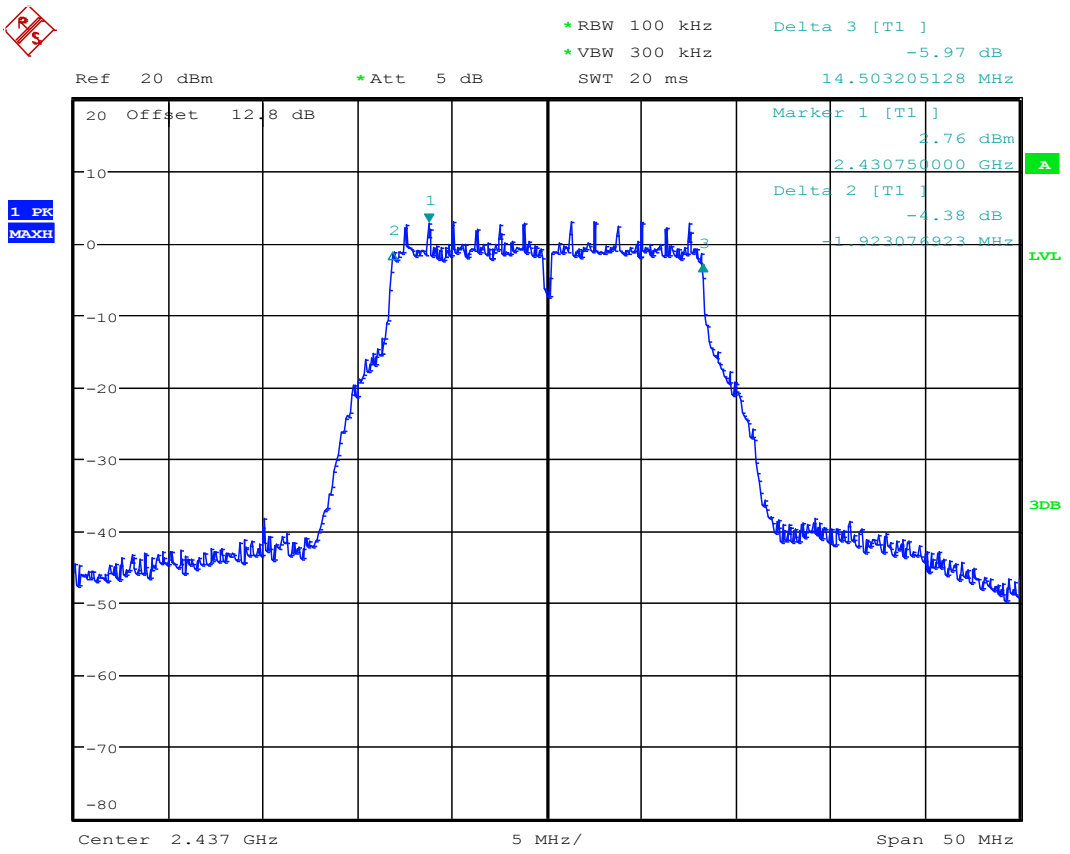
Low channel	Mode: 802.11g 6Mbps



Date: 19.MAR.2019 16:47:32

Plot #5

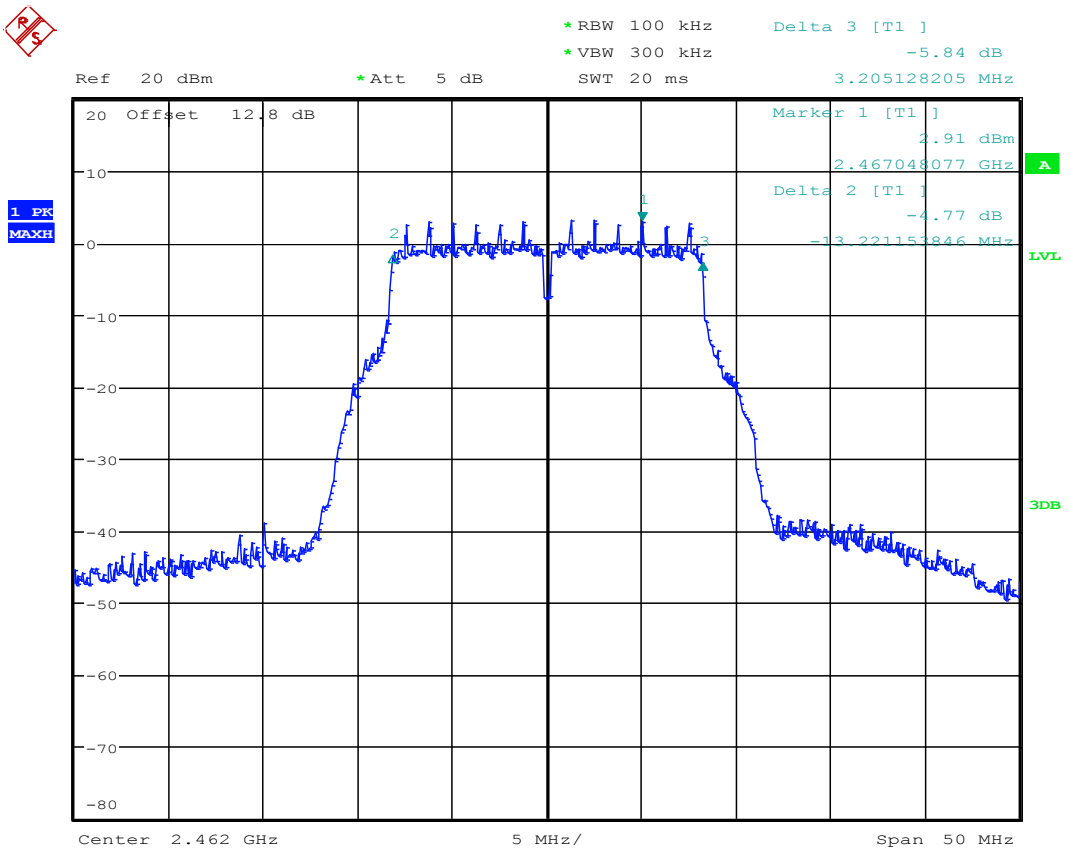
Mid channel	Mode: 802.11g 6Mbps



Date: 19.MAR.2019 16:48:49

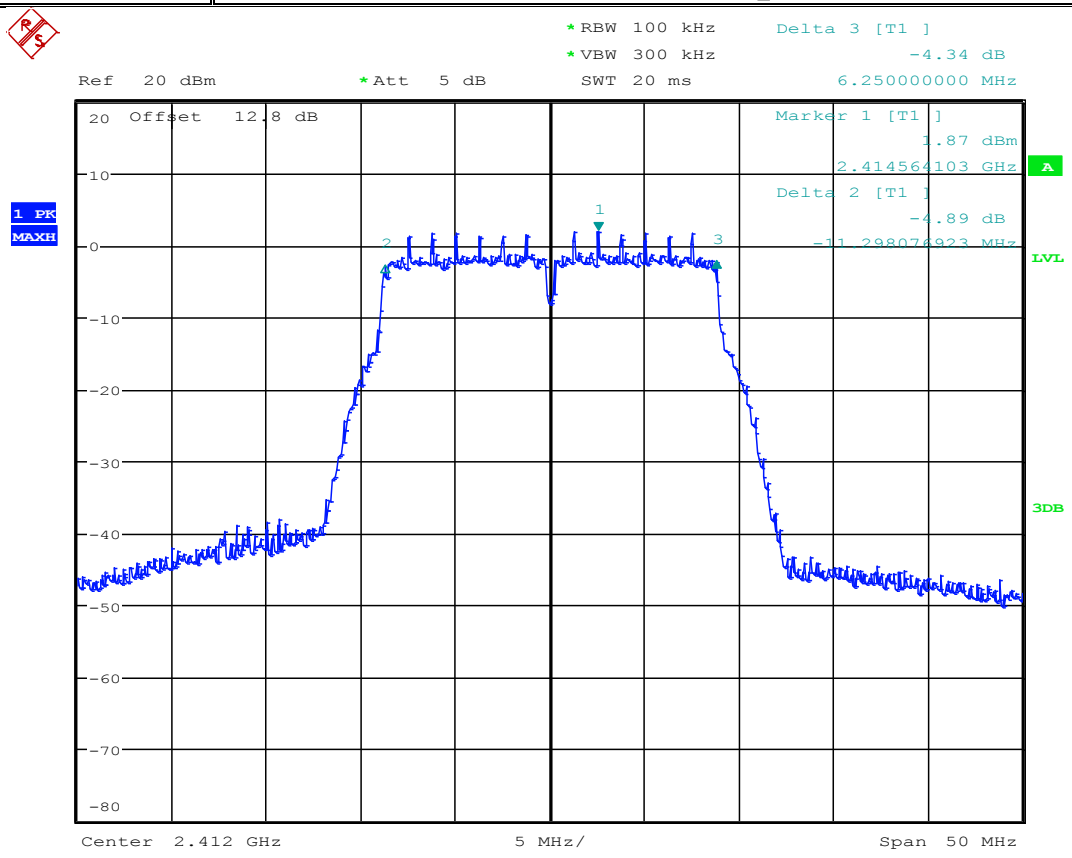
Plot #6

High channel	Mode: 802.11g 6Mbps



Plot #7

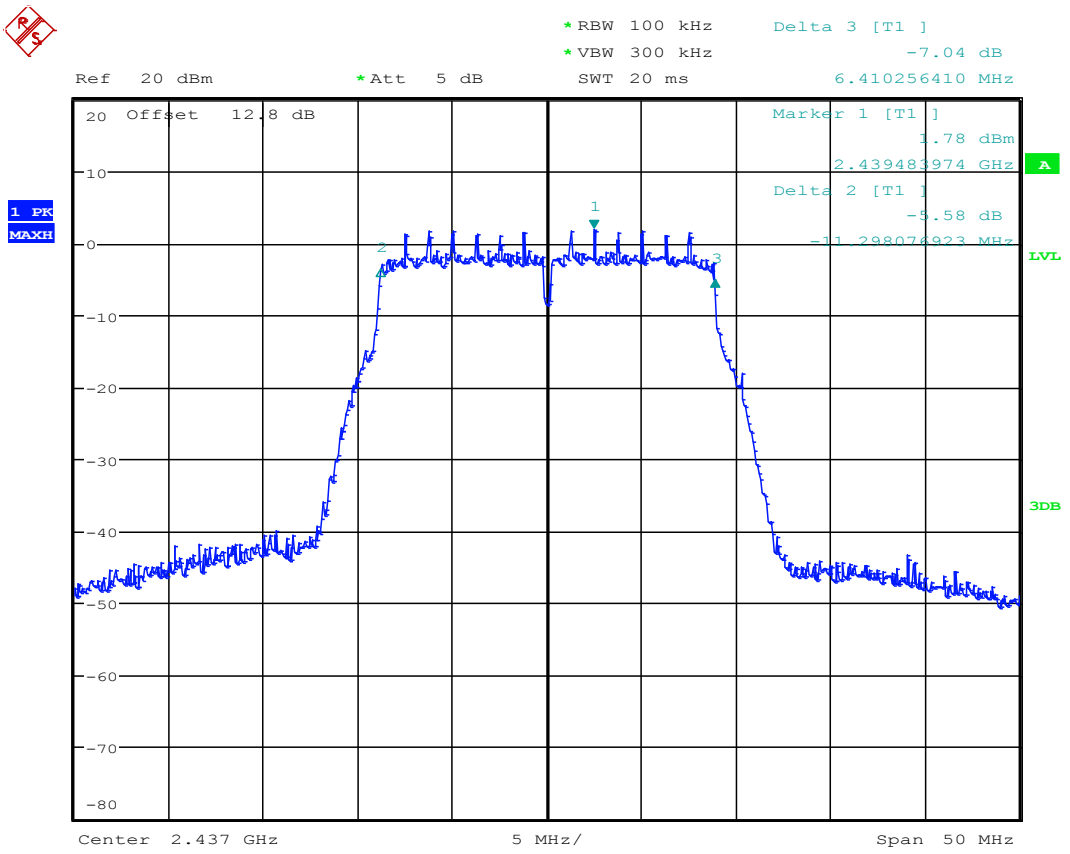
Low channel	Mode: 802.11n_HT20 MCS0



Date: 19.MAR.2019 16:55:50

Plot #8

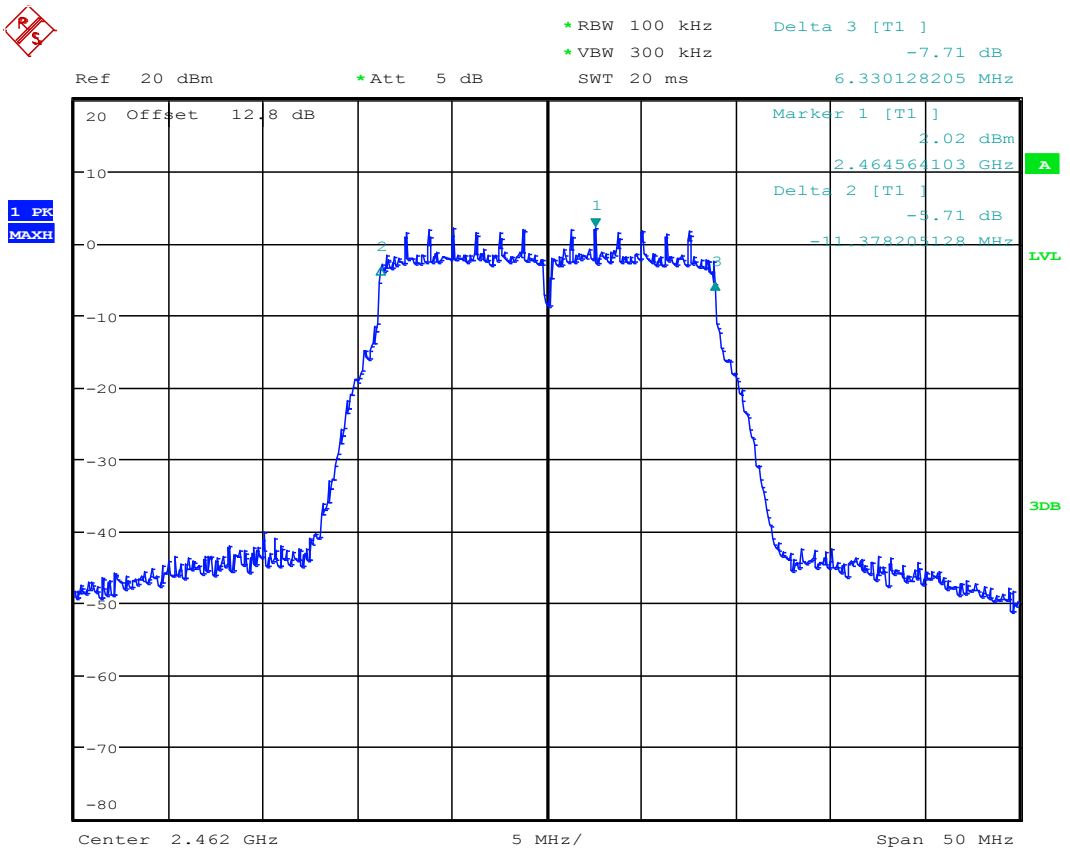
Mid channel	Mode: 802.11n_HT20 MCS0



Date: 19.MAR.2019 16:57:09

Plot #9

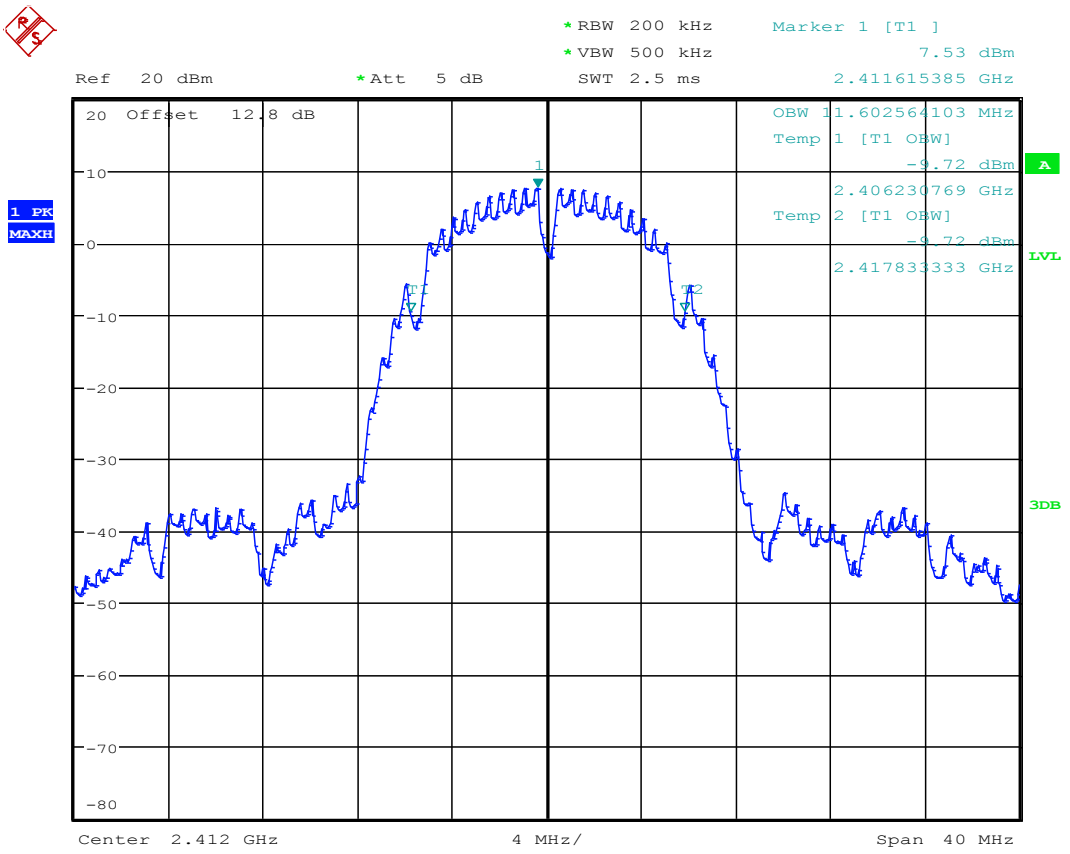
High channel	Mode: 802.11n_HT20 MCS0



Date: 19.MAR.2019 16:58:24

Plot #10

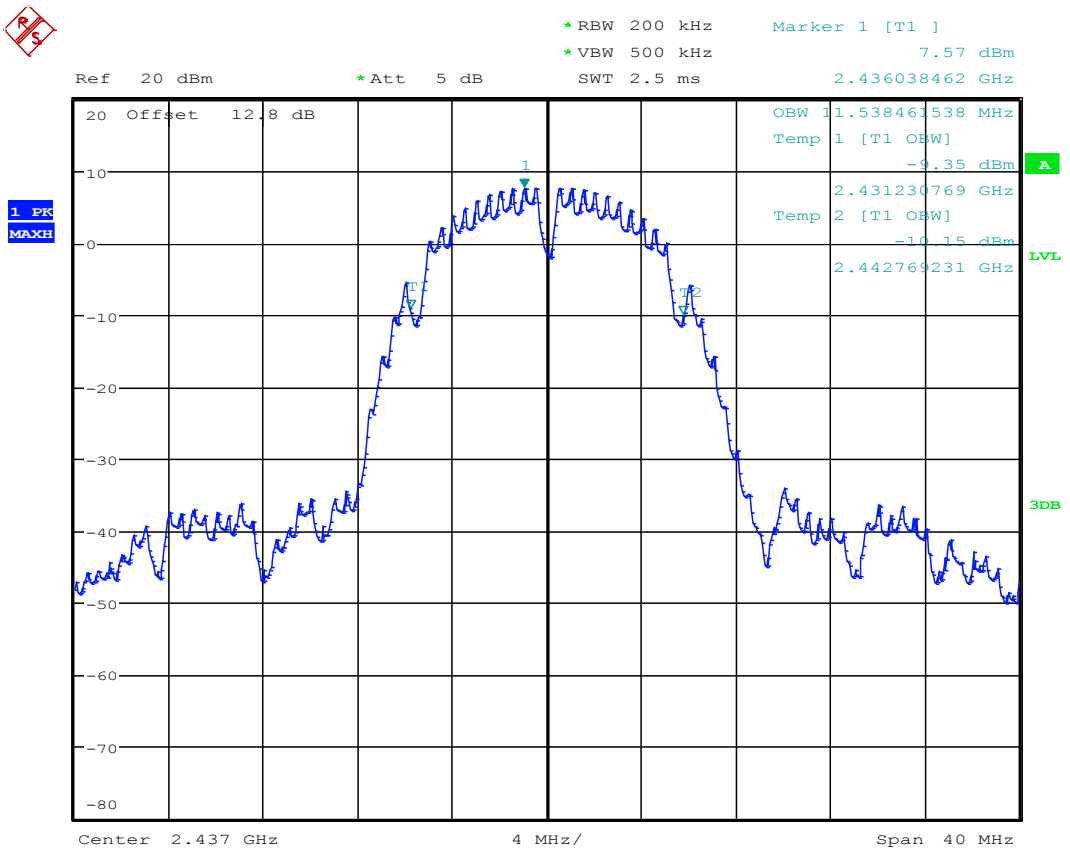
Low channel	Mode: 802.11b 1Mbps



Date: 18.MAR.2019 13:46:16

Plot #11

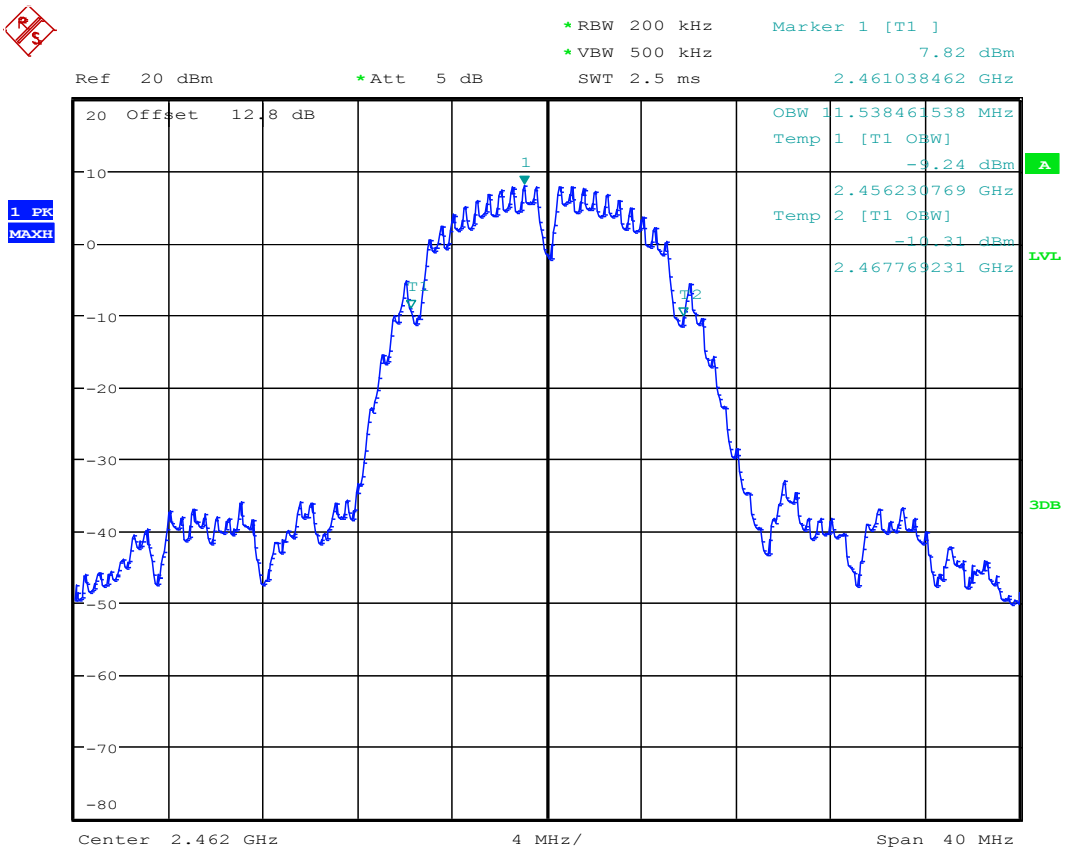
Mid channel	Mode: 802.11b 1Mbps



Date: 18.MAR.2019 13:47:36

Plot #12

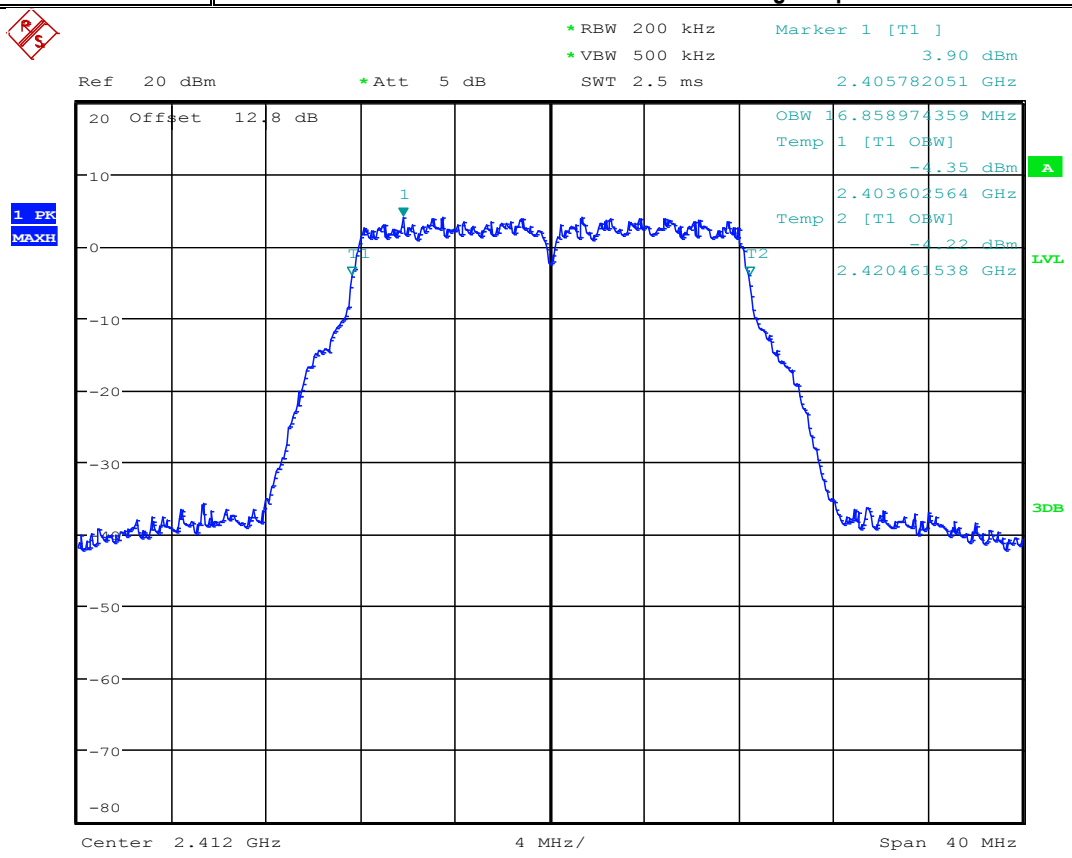
High channel	Mode: 802.11b 1Mbps



Date: 18.MAR.2019 13:48:27

Plot #13

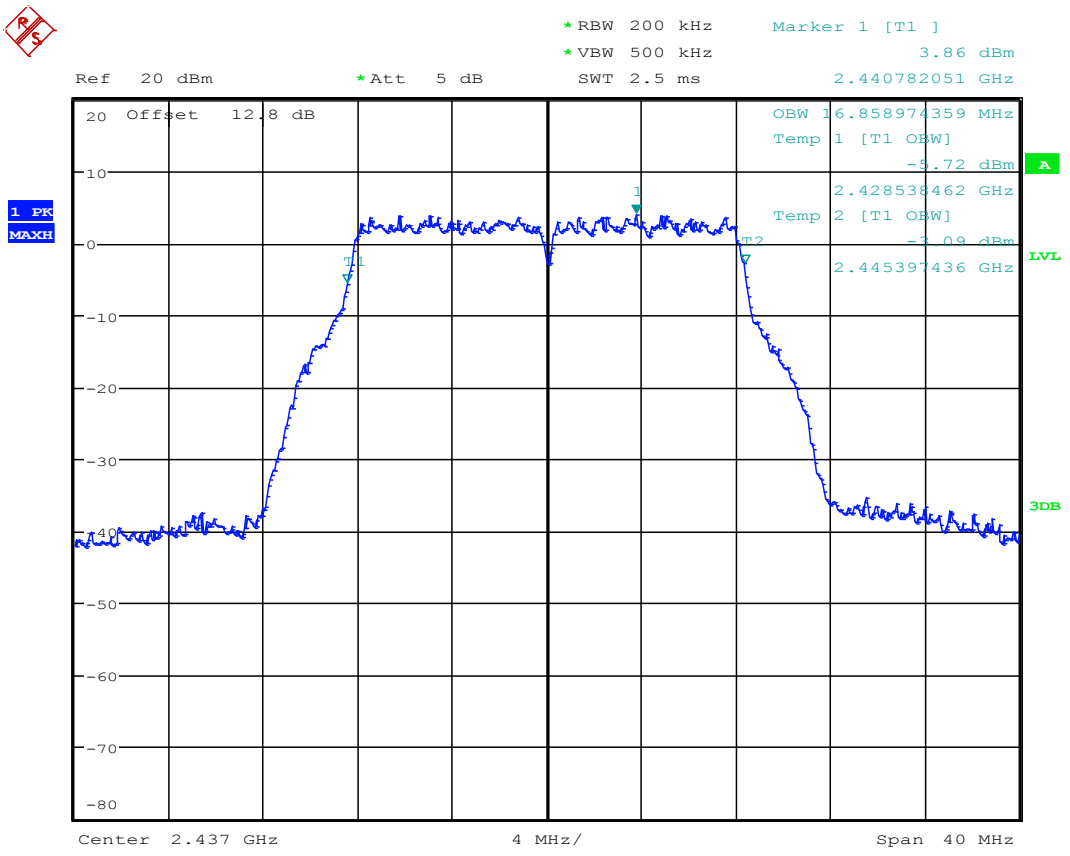
Low channel | **Mode: 802.11g 6Mbps**



Date: 18.MAR.2019 13:52:19

Plot #14

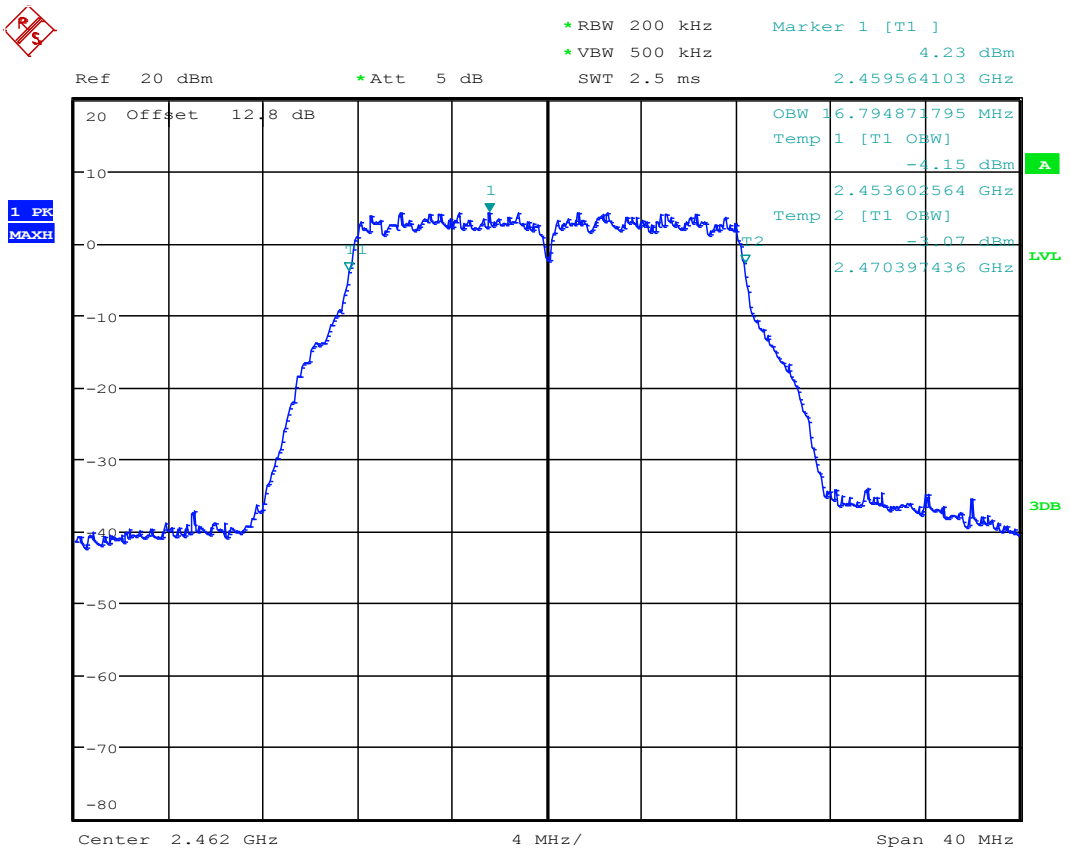
Mid channel	Mode: 802.11g 6Mbps



Date: 18.MAR.2019 13:53:06

Plot #15

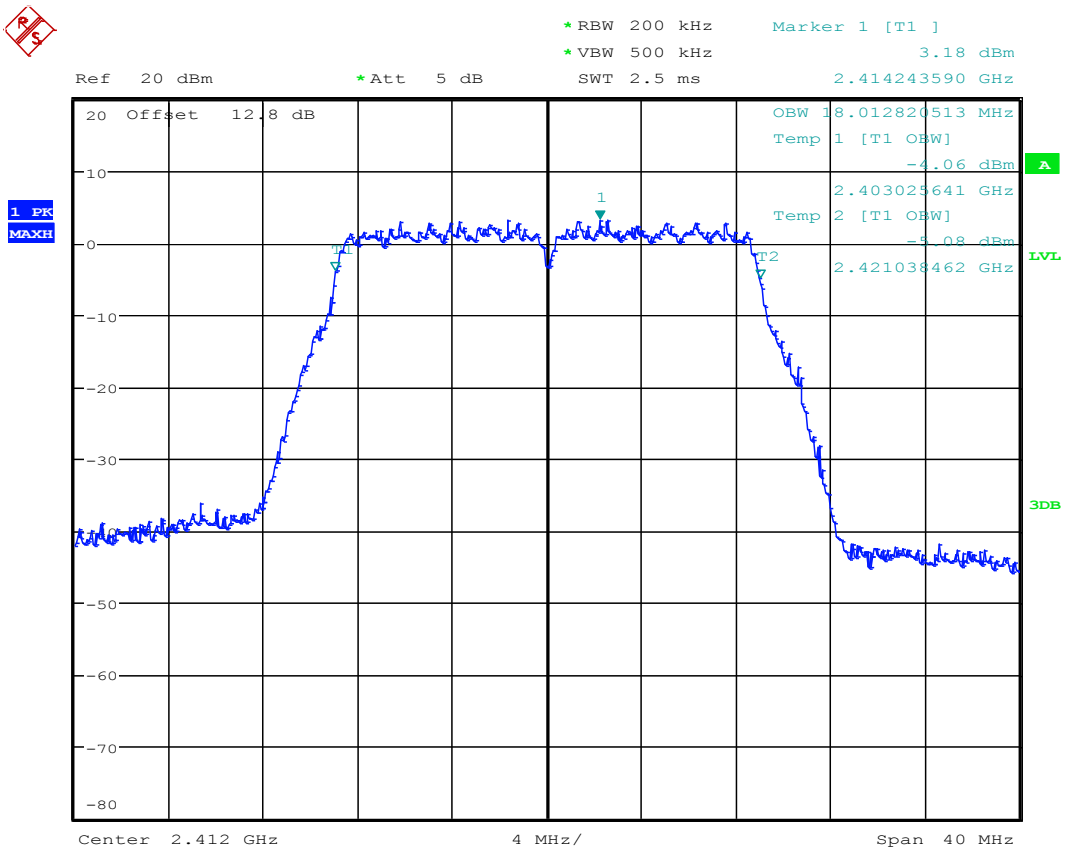
High channel	Mode: 802.11g 6Mbps



Date: 18.MAR.2019 13:53:59

Plot #16

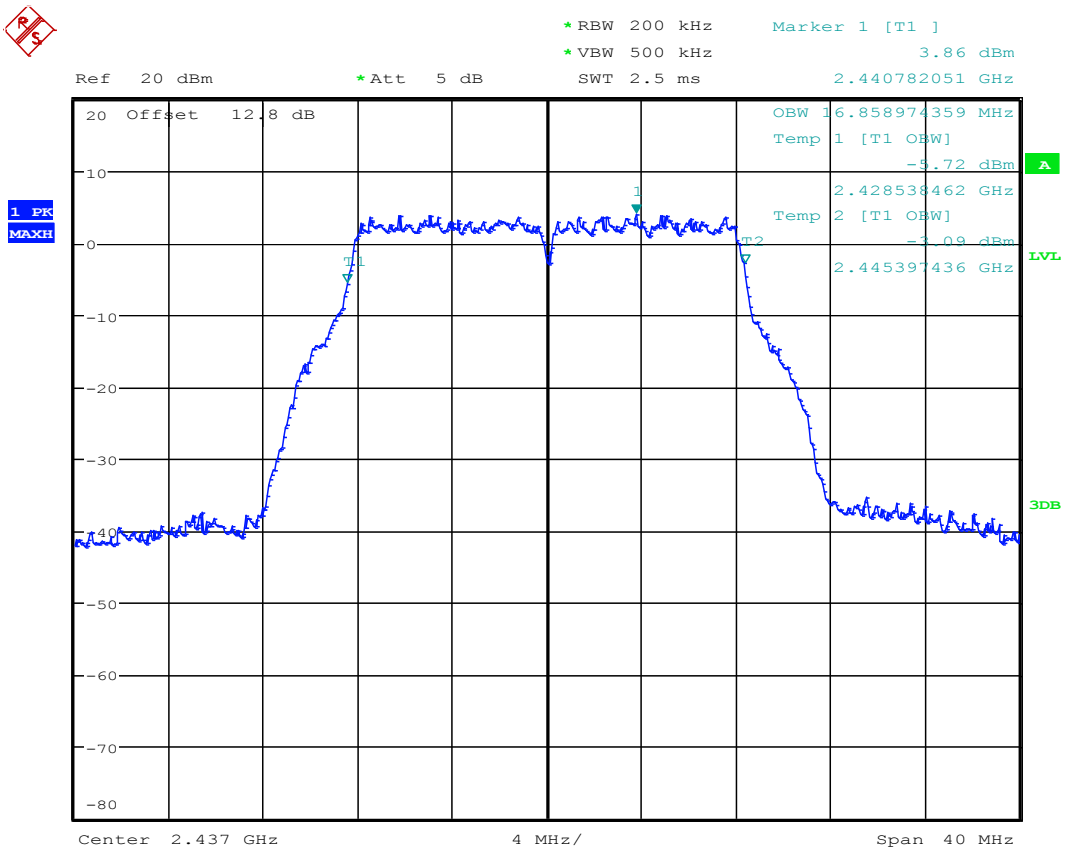
Low channel	Mode: 802.11n_HT20 MCS0



Date: 18.MAR.2019 13:56:30

Plot #17

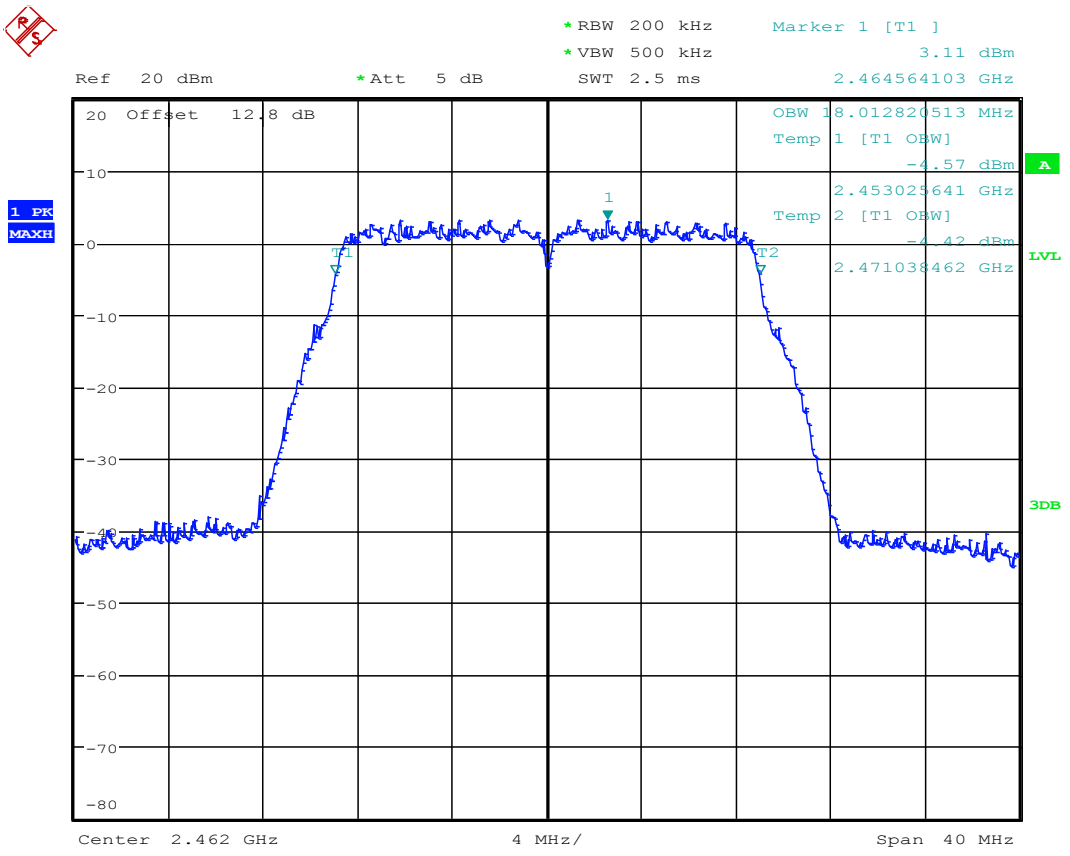
Mid channel	Mode: 802.11n_HT20 MCS0



Date: 18.MAR.2019 13:53:06

Plot #18

High channel	Mode: 802.11n_HT20 MCS0



8.6 Radiated Transmitter Spurious Emissions and Restricted Bands

8.6.1 Measurement according to ANSI C63.10 (2013)

Spectrum Analyzer Settings:

- Frequency = 9 KHz – 30 MHz
- RBW = 9 KHz
- Detector: Peak

- Frequency = 30 MHz – 1 GHz
- Detector = Peak / Quasi-Peak
- RBW= 120 KHz (<1GHz)

- Frequency > 1 GHz
- Detector = Peak / Average
- RBW = 1 MHz

- Radiated spurious emissions shall be measured for the transmit frequencies, transmit power, and data rate for the lowest, middle and highest channel in each frequency band of operation and for the highest gain antenna for each antenna type, and using the appropriate parameters and test requirements.
- The highest (or worst-case) data rate shall be recorded for each measurement.
- For testing at distance other than the specified in the standard, the limit conversion is calculated by using 40 dB/decade extrapolation factor as follow: Conversion factor (CF) = 40 log (D/d) = 40 log (300m / 3m) = 80dB

8.6.2 Limits:

FCC §15.247

- 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)).

FCC §15.209 & RSS-Gen 8.9

- Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency of emission (MHz)	Field strength (µV/m)	Measurement Distance (m)	Field strength @ 3m (dBµV/m)
0.009–0.490	2400/F(kHz) / ---------	300	-
0.490–1.705	24000/F(kHz) / --------	30	-
1.705–30.0	30 / (29.5)	30	-
30–88	100	3	40 dBµV/m
88–216	150	3	43.5 dBµV/m
216–960	200	3	46 dBµV/m
Above 960	500	3	54 dBµV/m

FCC §15.205 & RSS-Gen 8.10

- Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
[1]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			

- 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)).
  *PEAK LIMIT= 74 dBµV/m
  *AVG. LIMIT= 54 dBµV/m

8.6.3 Test conditions and setup:

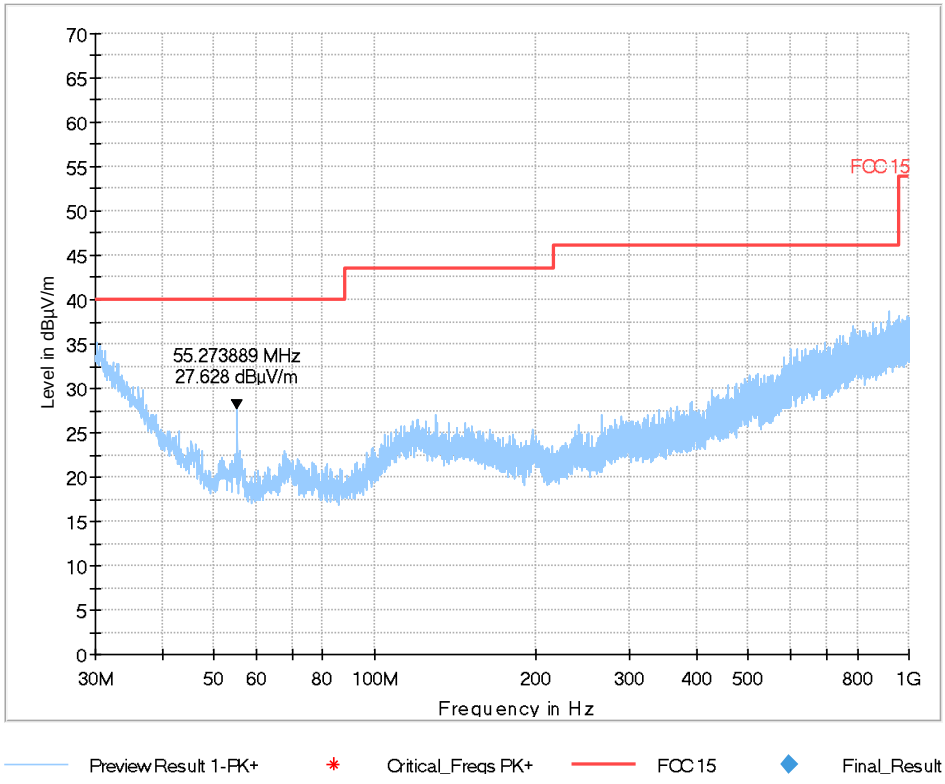
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	2	802.11g_2x Tx	120VAC/Battery

8.6.4 Measurement result:

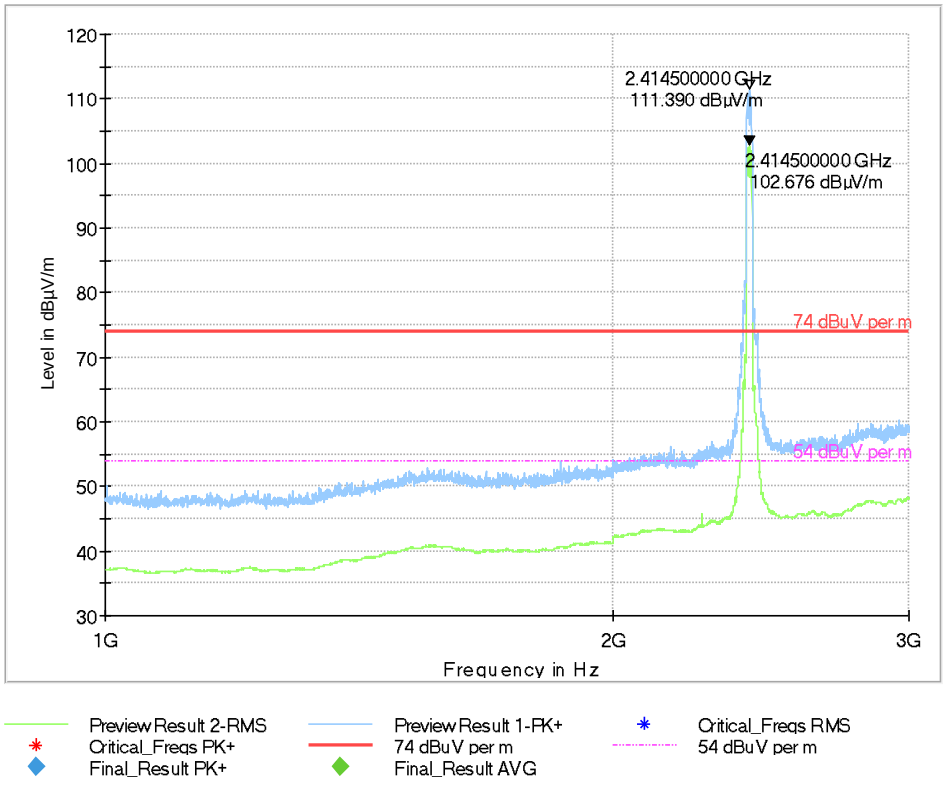
Plot #	Channel #	Scan Frequency	Limit	Result
1-3	Low	30 MHz – 18 GHz	See section 8.6.2	Pass
4-8	Mid	9 kHz – 26 GHz	See section 8.6.2	Pass
9-11	High	30 MHz – 18 GHz	See section 8.6.2	Pass

8.6.5 Measurement Plots:

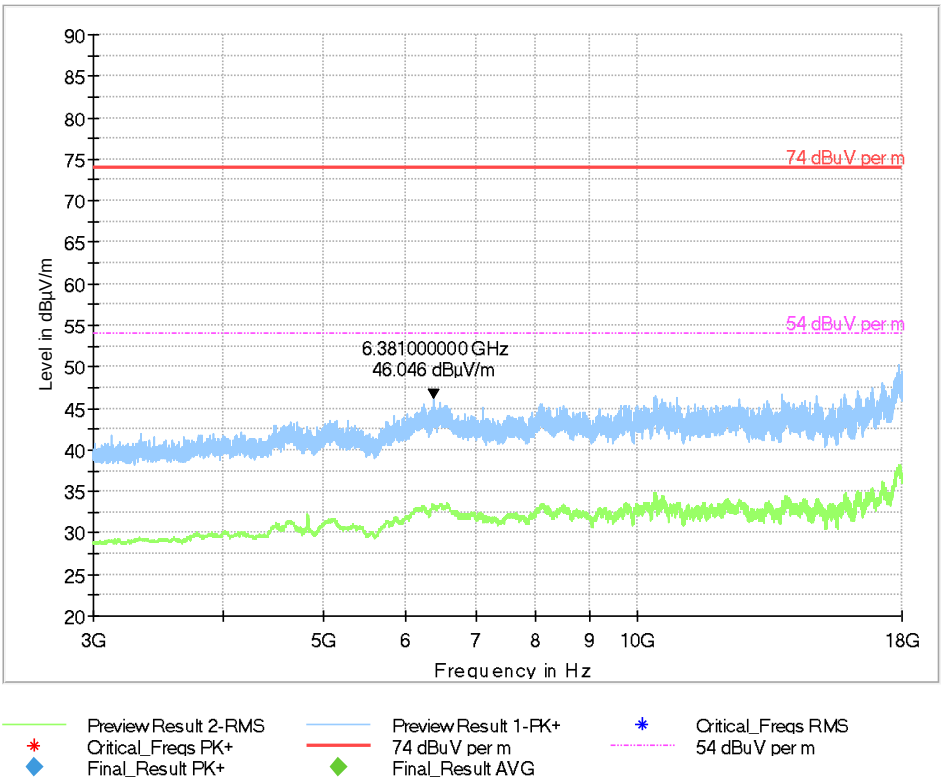
Plot #1 Radiated Emissions: 30 MHz – 1GHz		
Modulation: 802.11g_2x Tx	**Channel: Low**	**92.6% Duty Cycle**



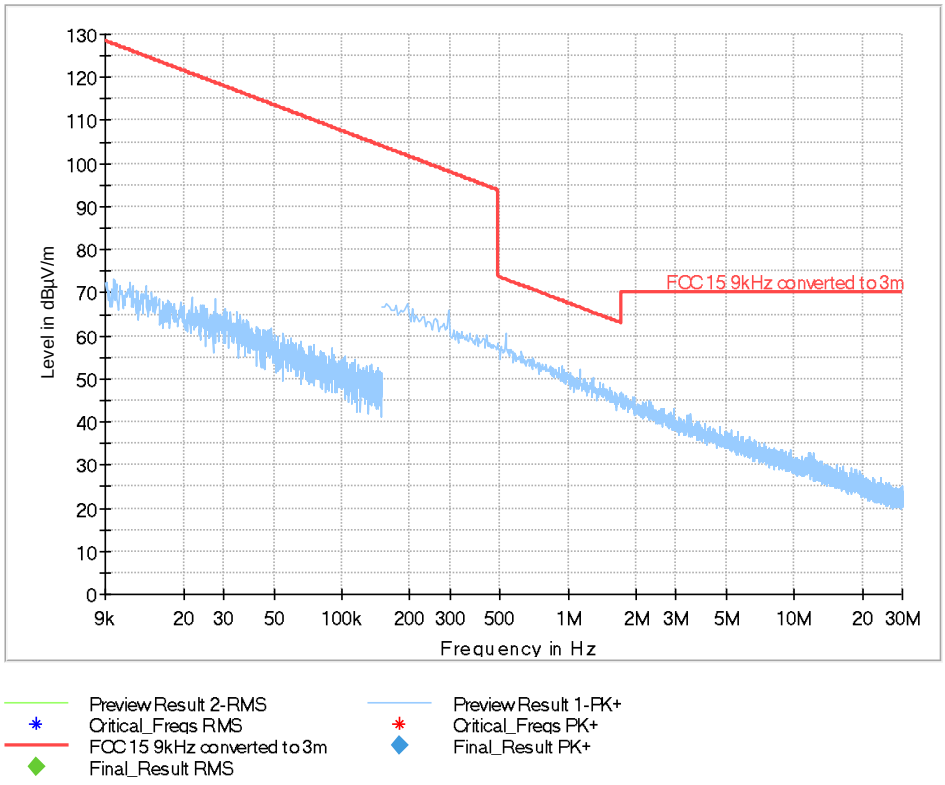
Plot #2 Radiated Emissions: 1-3 GHz		
Modulation: 802.11g_2x Tx	**Channel: Low**	**92.6% Duty Cycle**



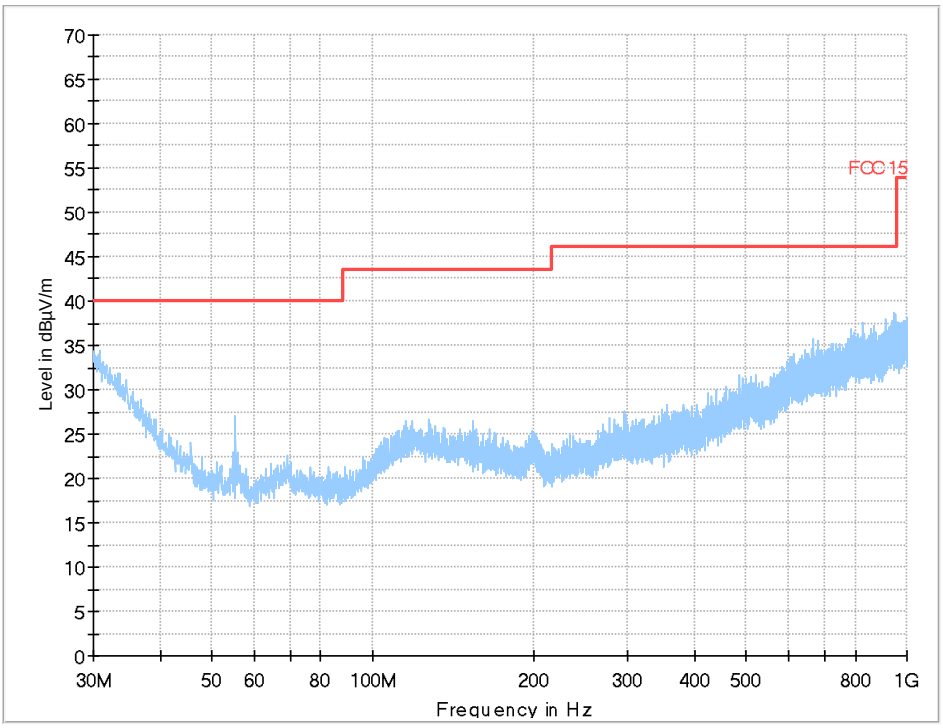
Plot #3 Radiated Emissions: 3-18 GHz		
Modulation: 802.11g_2x Tx	**Channel: Low**	**92.6% Duty Cycle**



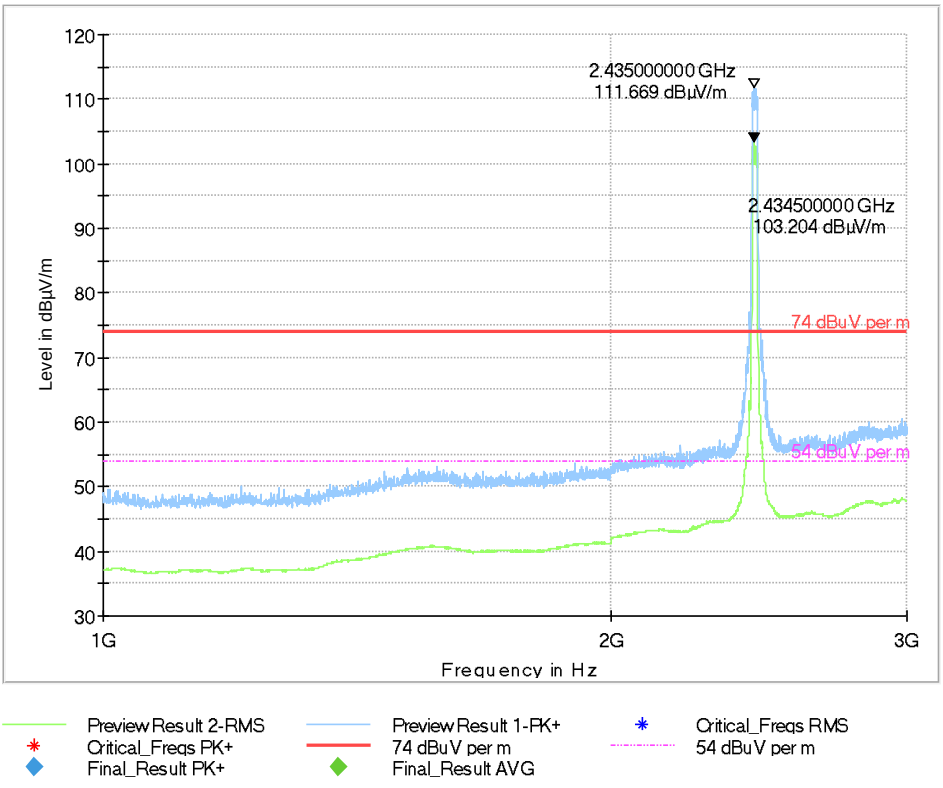
Plot #2 Radiated Emissions: 9 KHz – 30 MHz		
Modulation: 802.11g_2x Tx	**Channel: Mid**	**92.6% Duty Cycle**



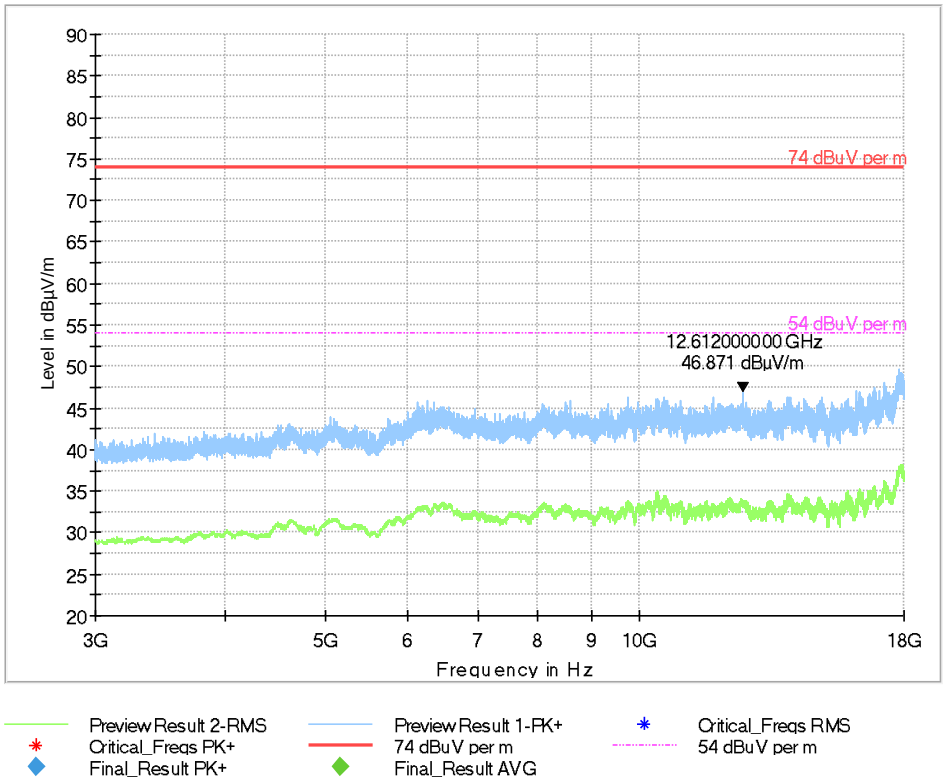
Plot #5 Radiated Emissions: 30 MHz – 1GHz		
Modulation: 802.11g_2x Tx	**Channel: Mid**	**92.6% Duty Cycle**



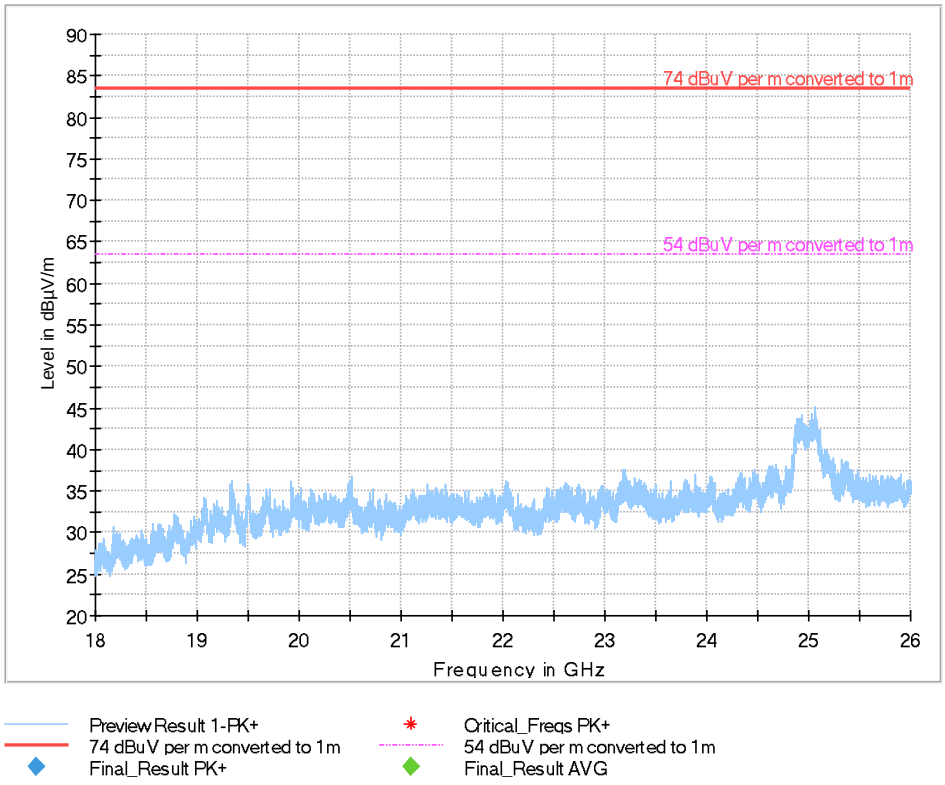
Plot #6 Radiated Emissions: 1-3 GHz		
Modulation: 802.11g_2x Tx	**Channel: Mid**	**92.6% Duty Cycle**



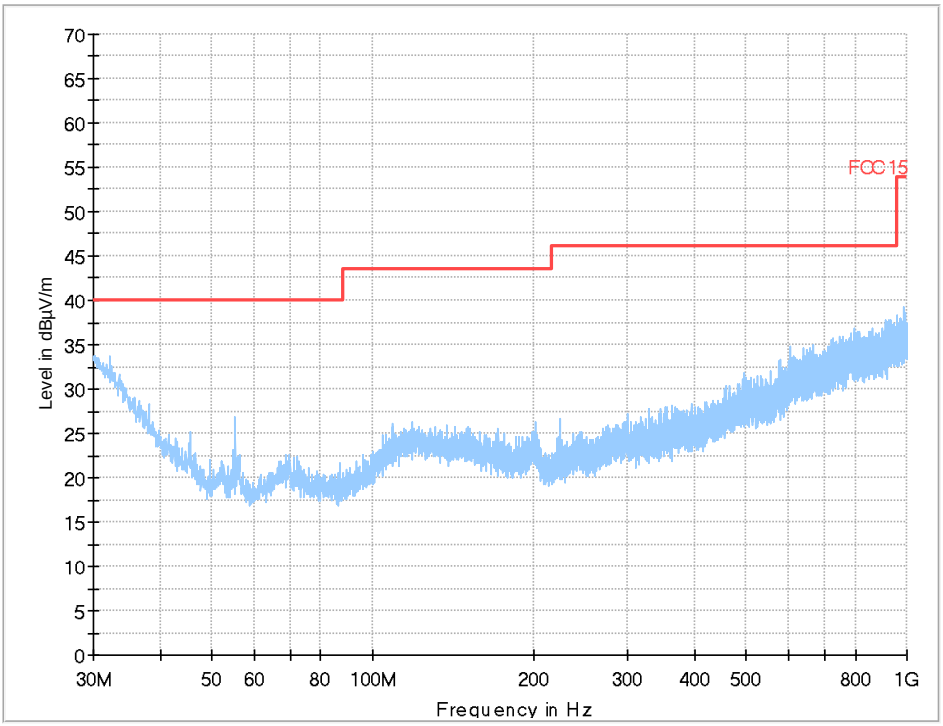
Plot #7 Radiated Emissions: 3-18 GHz		
Modulation: 802.11g_2x Tx	**Channel: Mid**	**92.6% Duty Cycle**



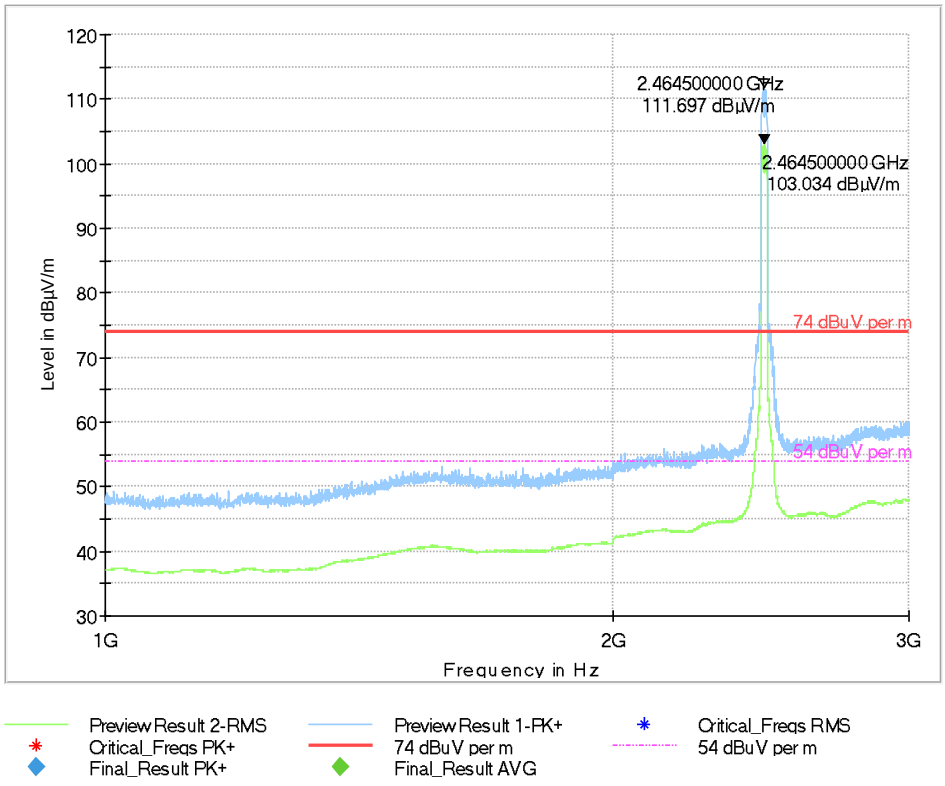
Plot #8 Radiated Emissions: 18-26 GHz		
Modulation: 802.11g_2x Tx	**Channel: Mid**	**92.6% Duty Cycle**



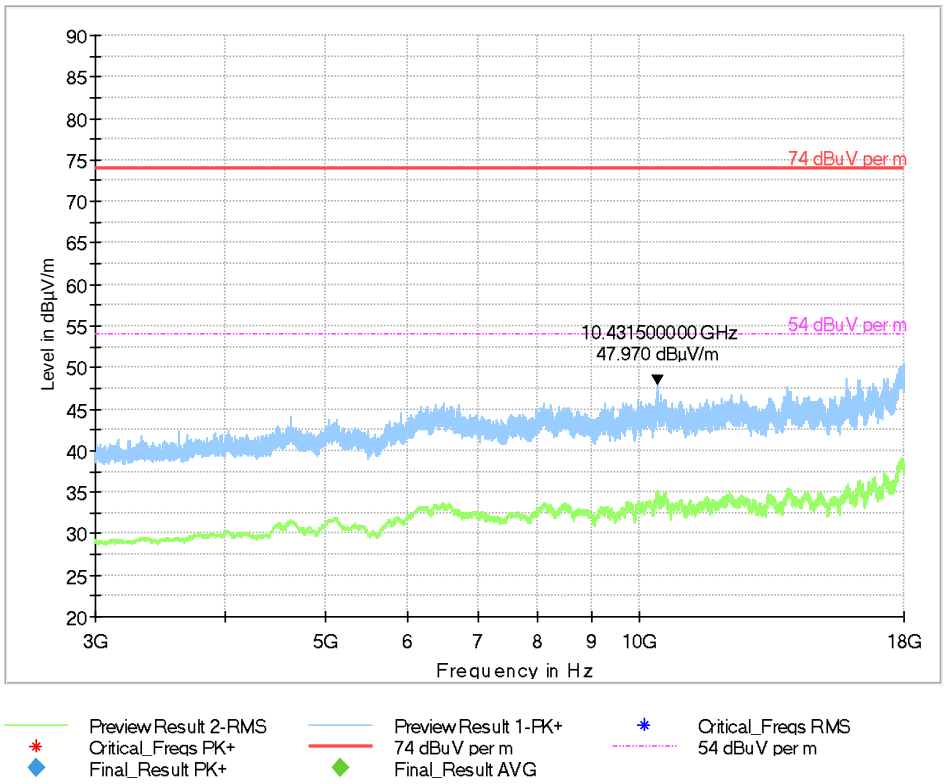
Plot #9 Radiated Emissions: 30 MHz – 1GHz		
Modulation: 802.11g_2x Tx	**Channel: High**	**92.6% Duty Cycle**



Plot #10 Radiated Emissions: 1-3 GHz		
Modulation: 802.11g_2x Tx	**Channel: High**	**92.6% Duty Cycle**



Plot #11 Radiated Emissions: 3-18 GHz		
Modulation: 802.11g_2x Tx	**Channel: High**	**92.6% Duty Cycle**



8.7 AC Power Line Conducted Emissions

8.7.1 Measurement according to ANSI C63.10 (2013)

Analyzer Settings:

- RBW = 9 KHz (CISPR Bandwidth)
- Detector: Peak / Average for Pre-scan
- Quasi-Peak/Average for Final Measurements

8.7.2 Limits: §15.207 & RSS-Gen 8.8

FCC §15.207(a) & RSS-Gen 8.8

- Except as shown in paragraphs (b) and (c) of this section of the CFR, 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 (1), as measured using a 50 μH/50 ohms 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 frequency ranges.

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

*Decreases with the logarithm of the frequency.

8.7.3 Test conditions and setup:

Ambient Temperature ©	EUT Set-Up #	EUT operating mode	Power line (L1, L2, L3, N)	Power Input
22	2	802.11g_2x Tx	Line & Neutral	110V / 60Hz

8.7.4 Measurement Result:

Plot #	Port	EUT Set-Up #:	EUT operating mode	Scan Frequency	Limit	Result
1	AC Mains	2	802.11g_2x Tx	150 kHz – 30 MHz	See section 8.7.2	Pass

8.7.5 Measurement Plots:

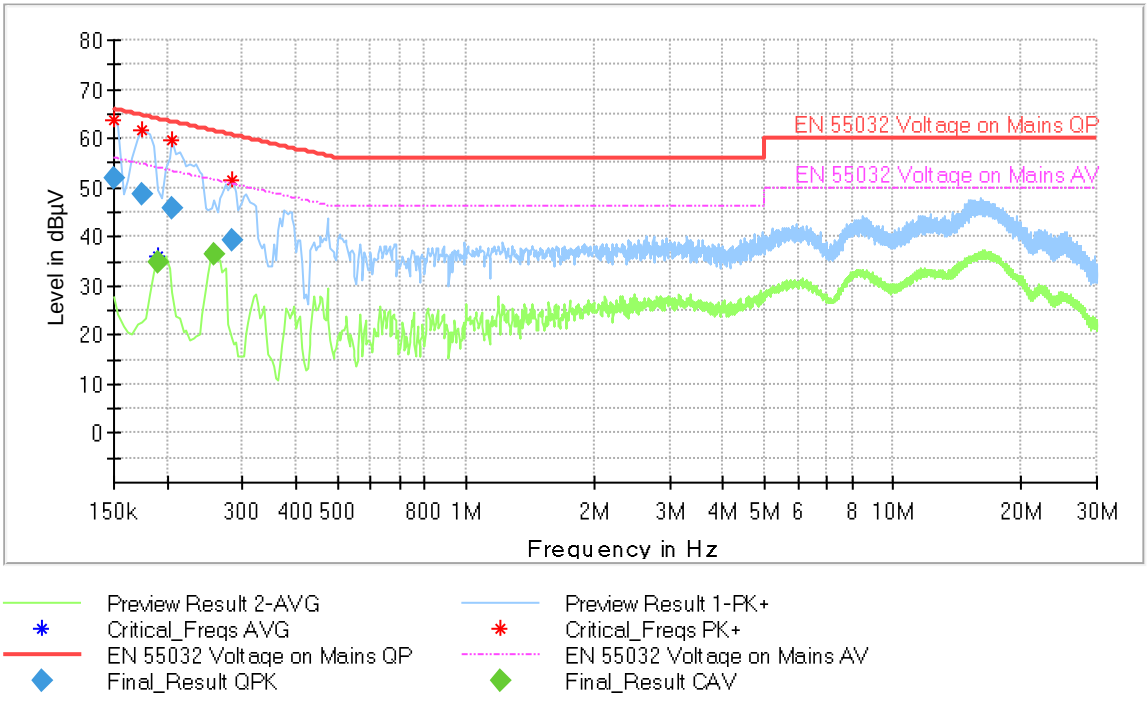
Plot #1

Final_Result

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)
0.150000	51.92	---	66.00	14.08	500.0	9.000	N	GND	10.7
0.174000	48.81	---	64.77	15.96	500.0	9.000	L1	GND	10.8
0.190000	---	34.79	54.04	19.25	500.0	9.000	L1	GND	10.5
0.206000	45.98	---	63.37	17.39	500.0	9.000	N	GND	10.5
0.258000	---	36.38	51.50	15.11	500.0	9.000	L1	GND	10.5
0.282000	39.15	---	60.76	21.61	500.0	9.000	N	GND	10.4

(continuation of the "Final_Result" table from column 15 ...)

Frequency (MHz)	Comment
0.150000	11:49:03 AM - 3/19/2019
0.174000	11:49:29 AM - 3/19/2019
0.190000	11:50:29 AM - 3/19/2019
0.206000	11:49:55 AM - 3/19/2019
0.258000	11:50:33 AM - 3/19/2019
0.282000	11:49:59 AM - 3/19/2019



9 Test setup photos

Setup photos are included in supporting file name: “EMC_JUNIP-026-19001_15.247_Setup_Photos.pdf”

10 Test Equipment and Ancillaries Used For Testing

Equipment Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
Biconlog Antenna	EMCO	3142E	166067	3 years	6/28/2017
Loop Antenna	ETS Lindgren	6507	161344	3 years	10/26/2017
Horn Antenna	EMCO	3115	35114	3 years	7/31/2017
Horn Antenna	ETS Lindgren	3117 PA	169547	3 years	8/8/2017
Compact Digital Barometer	Control Company	35519-055	91119547	2 Years	6/20/2017
Spectrum Analyzer	R&S	FSU26	200065	3 years	7/3/2017
Spectrum Analyzer	R&S	FSV40	101022	3 years	7/5/2017
Thermometer Humidity	Dickson	TM320	5280063	3 Year	11/2/2017

Note: Equipment used meets the measurement uncertainty requirements as required per applicable standards for 95% confidence levels. Calibration due dates, unless defined specifically, falls on the last day of the month. Items indicated “N/A” for cal status either do not specifically require calibration or is internally characterized before use.

11 Revision History

Date	Report Name	Changes to report	Report prepared by
2019/03/25	EMC_JUNIP-026-19001_15.247_WLAN	Initial version	Yuchan Lu