FCC / IC Test Report

FOR:
Virscient Limited

Model Name:
Trimble Comm board Tornado

Product Description:
WIFI/BT Module

FCC ID: YK5-73350047
IC ID: ----------

Applied Rules and Standards:
47 CFR Part 15.407 (UNII) & 5GHz (UNII)
RSS-247 Issue 2 (DTSs) & (LE-LAN), and RSS-Gen Issue 5

REPORT #: EMC_VIRSC-001-17001_15.407_UNII-3

DATE: 2019-02-08

A2LA Accredited

IC recognized #
3462B-2

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1 Assessment

The following device was evaluated against the applicable criteria specified in FCC rules Parts 15.407 of Title 47 of the Code of Federal Regulations and the relevant ISED Canada standard RSS-247.

No deviations were ascertained.

Company	Description	Model #
Virscient Limited	WIFI/BT Module	V0009F

Responsible for Testing Laboratory:

Date	Section	Name	Signature
2019-02-08	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: 2019.02.08 16:03:29 -08'00'

Responsible for the Report:

Date	Section	Name	Signature
2019-02-08	Compliance	Kevin Wang (Senior EMC Engineer)	kevin.wang@cetecom.com Digitally signed by: kevin.wang@cetecom.com DN: CN = kevin.wang@cetecom.com Date: 2019.02.08 15:43:10 -08'00'

s

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
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EMC Lab Manager:	Cindy Li
Responsible Project Leader:	Rami Saman

2.2 Identification of the Client

Applicant's Name:	Virscient Limited
Street Address:	Ruakura Research Centre, 10 Bisley Road
City/Zip Code:	Hamilton/3214
Country:	New Zealand

2.3 Identification of the Manufacturer

Manufacturer's Name:	Trimble Jena GmbH
Manufacturers Address:	Carl-Zeiss-Promenade 10
City/Zip Code	Jena/07745
Country	Germany

3 Equipment under Test (EUT)

3.1 EUT Specifications

Model No:	Trimble Comm board Tornado
HW Version :	F
SW Version :	v4.5.10.016.DFS
FCC-ID:	YK5-73350047
IC-ID:	--------
HVIN:	--------
PMN:	--------
Product Description:	WIFI/BT Module
Frequency Range / number of channels:	Center to center: 5725 MHz (ch 149) – 5850 MHz (ch 165), 5 channels
Type(s) of Modulation:	BPSK, QPSK, 16-QAM, 64QAM
Modes of Operation:	802.11a/n, 20MHz and 40MHz
Antenna Information as declared:	Pulse W3334B0150, 2.4G 4dBi 5G 5.5dBi
Max. Peak Output Power:	Conducted Power 9.54 dBm
Power Supply/ Rated Operating Voltage Range:	USB / Vmin: 4.75 VDC/ Vnom: 5 VDC / Vmax: 5.5 VDC
Operating Temperature Range:	-20 °C to +70 °C
Other Radios included in the device:	Bluetooth BR / EDR WIFI 802.11b/g/n/ac
Sample Revision:	☐Prototype Unit; ■Production Unit; ☐Pre-Production

3.2 EUT Sample details

EUT #	Serial Number	HW Version	SW Version	Notes/Comments
1	311	F	V4.5.10.016.DFS	Radiated Emissions
2	351	F	V4.5.10.016.DFS	Conducted RF

3.3 Accessory Equipment (AE) details

AE #	Type	Model	Manufacturer	Serial Number
1	Laptop	Dell	Latitude E6440	00186-242-768-970
2	Laptop	Dell	Latitude E6430s	00186-210-105-587

3.4 Test Sample Configuration

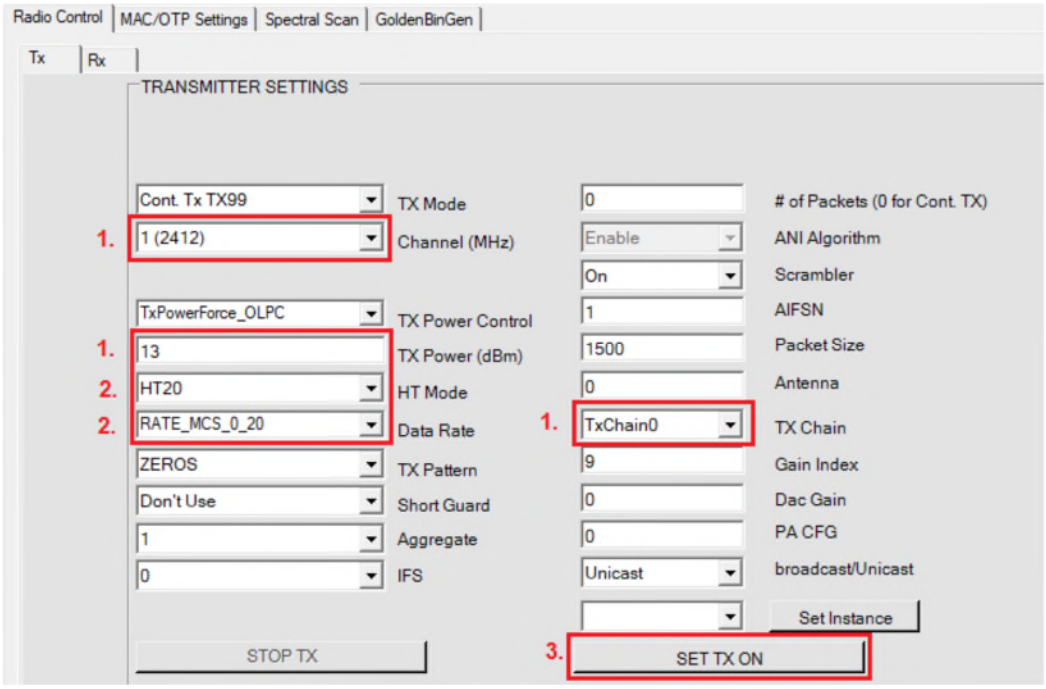
EUT Set-up #	Combination of AE used for test set up	Comments
1	EUT#2 + AE#1 + AE#2	The radio of the EUT was configured to a fixed channel transmission with highest possible duty cycle using software “QRCT” provided by client that is not available to the end user. The measurement equipment was connected to the 50 ohm RF port of the EUT.
2	EUT#1 + AE#1 + AE#2	The radio of the EUT was configured to a fixed channel with highest possible duty cycle using software “QRCT” provided by client that is not available to the end user. The external antenna “Pulse W3334B0150” provided by client was used for radiated testing.

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 "QRCT" provided by client (not available to the end user).

QRCT Tool:



The target power index in below table was set in QRCT provided by client

802.11a:

Test Frequency	6 – 24 Mbps	36 Mbps	48 Mbps	54 Mbps
5180	7	7	7	7
5220	13	13	12	12
5320	7	7	7	7
5500	11	11	11	11
5600	13	13	11	11
5725	4	4	4	4
5745	4	4	4	4
5765	3	3	3	3
5785	3	3	3	3
5805	3	3	3	3
5825	3	3	3	3

802.11n HT20 1SS:

Test Frequency (MHz)	MCS0		MCS1 MCS2		MCS3 MCS4		MCS5		MCS6		MCS7	
Chain	0	1	0	1	0	1	0	1	0	1	0	1
5180	8	7	8	7	8	7	8	7	8	7	8	7
5220	13	14	13	14	12	12	11	12	10	11	8	9
5320	9	7	9	7	9	7	9	7	9	7	9	7
5500	13	11	13	11	13	10	12	10	11	9	10	8
5600	13	12	13	12	12	10	11	10	11	10	9	8
5725	4	5	4	5	4	5	4	5	4	5	4	5
5745	4	5	4	5	4	5	4	5	4	5	4	5
5765	3	6	3	6	3	6	3	6	3	6	3	6
5785	3	7	3	7	3	7	3	7	3	7	3	7
5805	3	7	3	7	3	7	3	7	3	7	3	7
5825	3	6	3	6	3	6	3	6	3	6	3	6

802.11n HT20 2SS:

Test Frequency (MHz)	MCS8		MCS9 MCS10		MCS11 MCS12		MCS13		MCS14		MCS15	
Chain	0	1	0	1	0	1	0	1	0	1	0	1
5180	8	7	8	7	8	7	8	7	8	7	8	7
5220	13	14	13	14	12	12	11	12	10	11	8	9
5320	9	7	9	7	9	7	9	7	9	7	9	7
5500	13	11	13	11	13	10	12	10	11	9	10	8
5600	13	12	13	12	12	10	11	10	11	10	9	8
5725	4	5	4	5	4	5	4	5	4	5	4	5
5745	4	5	4	5	4	5	4	5	4	5	4	5
5765	3	6	3	6	3	6	3	6	3	6	3	6
5785	3	7	3	7	3	7	3	7	3	7	3	7
5805	3	7	3	7	3	7	3	7	3	7	3	7
5825	3	6	3	6	3	6	3	6	3	6	3	6

802.11n HT40 1SS:

Test Frequency (MHz)	MCS0		MCS1 MCS2		MCS3 MCS4		MCS5		MCS6		MCS7	
Chain	0	1	0	1	0	1	0	1	0	1	0	1
5180	7	7	7	7	7	7	7	7	7	7	7	7
5220	13	12	13	12	11	10	10	9	10	9	9	8
5320	8	7	8	7	8	7	8	7	8	7	8	7
5500	10	8	10	8	10	8	10	8	10	8	10	8
5600	12	13	11	12	10	11	10	11	9	10	7	8
5725	5	6	5	6	5	6	5	6	5	6	5	6
5745	5	6	5	6	5	6	5	6	5	6	5	6
5765	4	5	4	5	4	5	4	5	4	5	4	5
5785	4	4	4	4	4	4	4	4	4	4	4	4
5805	4	4	4	4	4	4	4	4	4	4	4	4
5825	4	4	4	4	4	4	4	4	4	4	4	4

802.11n HT40 2SS:

Test Frequency (MHz)	MCS8		MCS9 MCS10		MCS11 MCS12		MCS13		MCS14		MCS15	
Chain	0	1	0	1	0	1	0	1	0	1	0	1
5180	7	7	7	7	7	7	7	7	7	7	7	7
5220	13	12	13	12	11	10	10	9	10	9	9	8
5320	8	7	8	7	8	7	8	7	8	7	8	7
5500	10	8	10	8	10	8	10	8	10	8	10	8
5600	12	13	11	12	10	11	10	11	9	10	7	8
5725	5	6	5	6	5	6	5	6	5	6	5	6
5745	5	6	5	6	5	6	5	6	5	6	5	6
5765	4	5	4	5	4	5	4	5	4	5	4	5
5785	4	4	4	4	4	4	4	4	4	4	4	4
5805	4	4	4	4	4	4	4	4	4	4	4	4
5825	4	4	4	4	4	4	4	4	4	4	4	4

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 15.407 of Title 47 of the Code of Federal Regulations and Radio Standard Specification RSS-247 of ISED Canada.

Testing procedures are based on 789033 D02 DTS UN-II Test Procedures New Rules v02r01 – "GUIDELINES FOR COMPLIANCE TESTING OF UNLICENSED NATIONAL INFORMATION INFRASTRUCTURE (U-NII) DEVICES (PART 15, SUBPART E)" - May 2, 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
§15.407(e) RSS-247 6	Emission Bandwidth	Nominal	802.11 a/n	■	☐	☐	Complies
§15.407(a) RSS-247 6	Power Spectral Density	Nominal	802.11 a/n	■	☐	☐	Complies
§15.407(a) RSS-247 6	Maximum Conducted Output Power and EIRP	Nominal	802.11 a/n	■	☐	☐	Complies
§15.407(b) RSS-247 6; RSS-Gen 8.9; 8.10	Band edge compliance Unrestricted Band Edges	Nominal	802.11 a/n	■	☐	☐	Complies
§15.407(b); 15.209; 15.205 RSS-247 6; RSS-Gen 8.9; 8.10	Band edge compliance Restricted Band Edges	Nominal	802.11 a/n	■	☐	☐	Complies
§15.407(b); §15.209; 15.205 RSS-247 6; RSS-Gen 8.9; 8.10	TX Spurious emissions-Radiated	Nominal	802.11 n_HT20 MIMO	■	☐	☐	Complies
§15.407(g)	Frequency stability	Extreme temperature -20°C-70°C	802.11 n_HT20	■	☐	☐	Complies
§15.207(a) RSS Gen 8.8	AC Conducted Emissions	Nominal	N/A	☐	■	☐	N/A[2]

Note1: NA= Not Applicable; NP= Not Performed.
Note2: EUT is powered by USB

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:

07/16/2018 - 10/14/2018

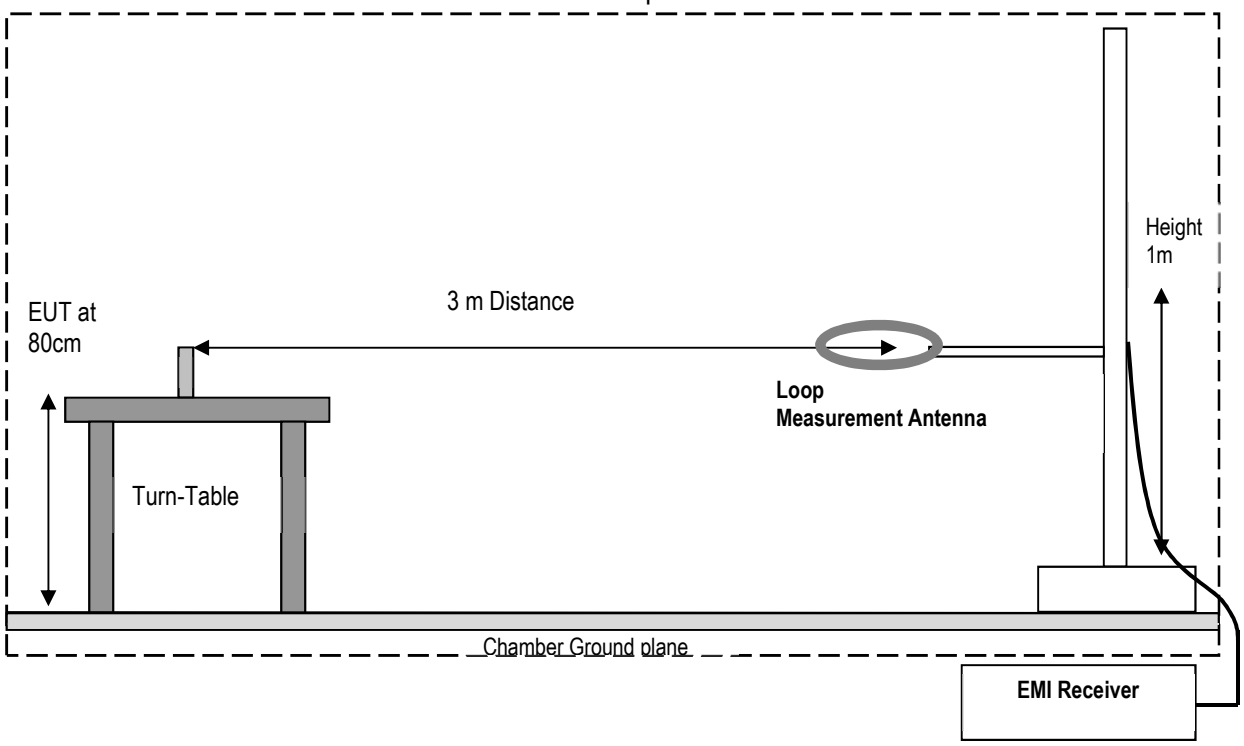
7 Measurement Procedures

7.1 Radiated Measurement

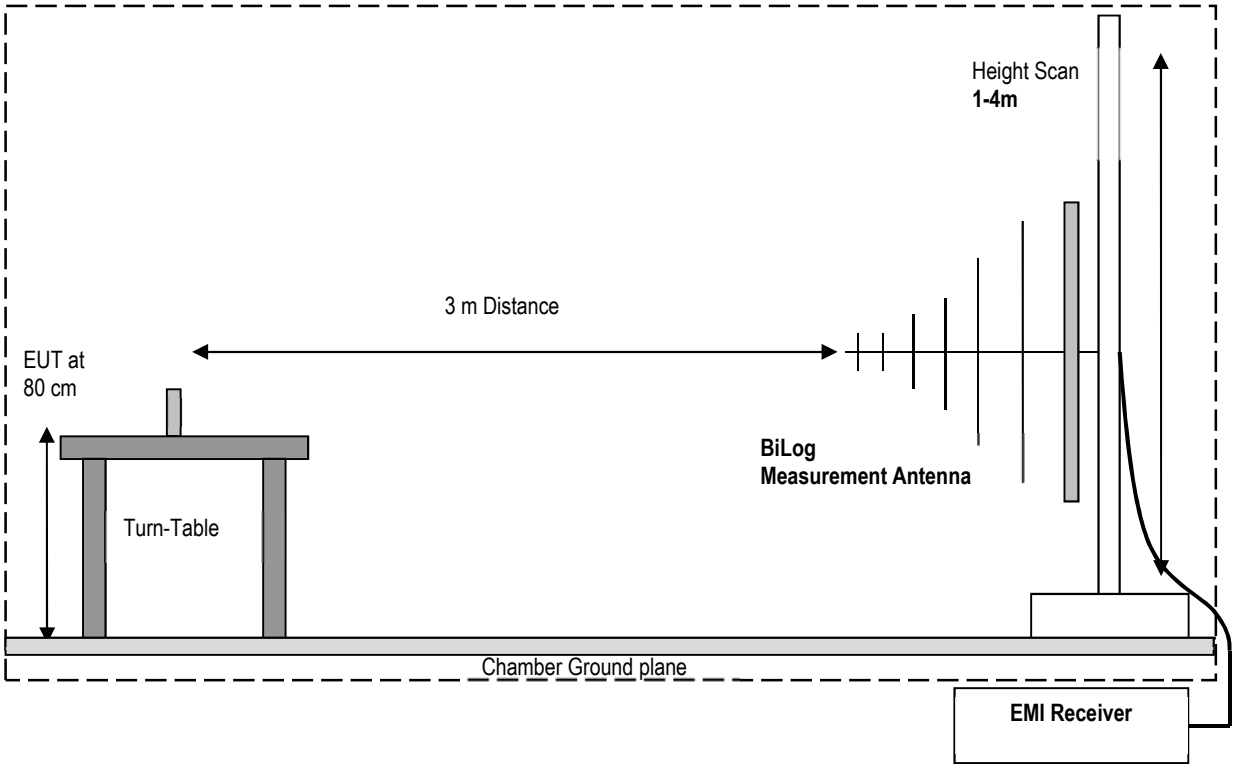
The radiated measurement is performed according to ANSI C63.10 (2013)

- 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.

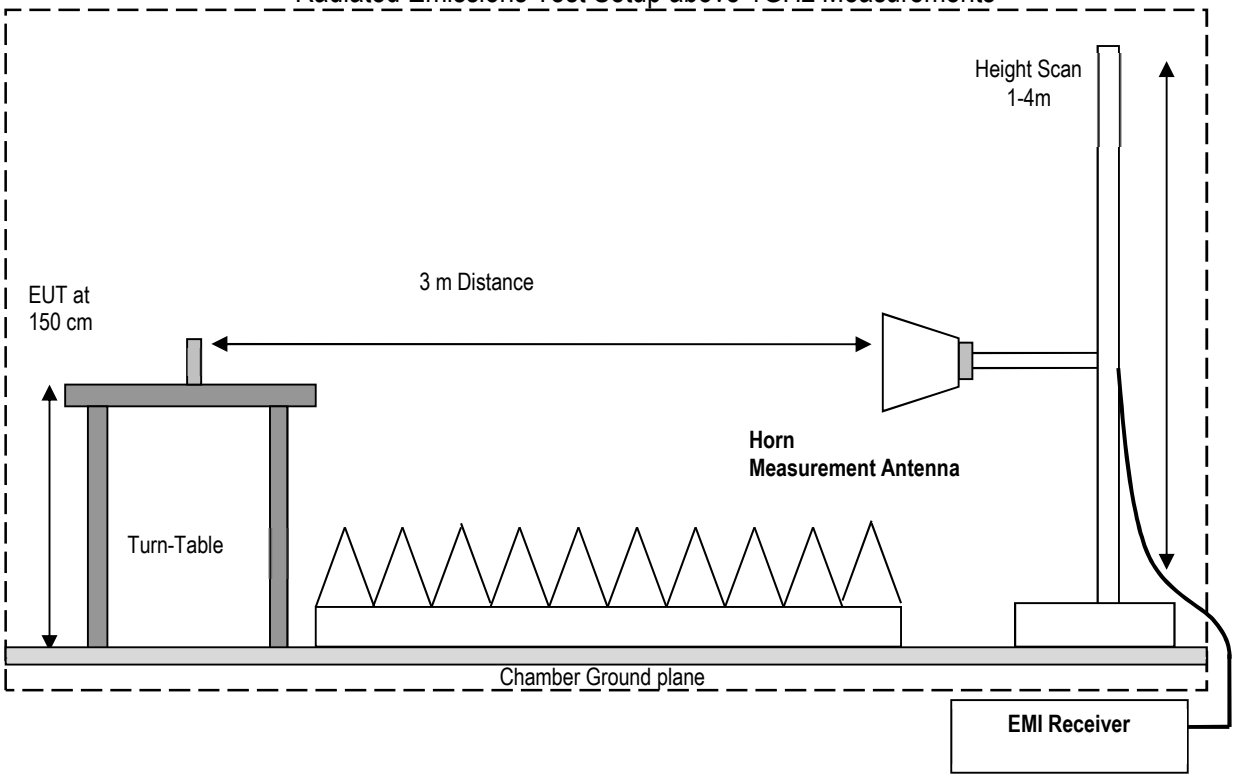
Radiated Emissions Test Setup below 30MHz Measurements



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:

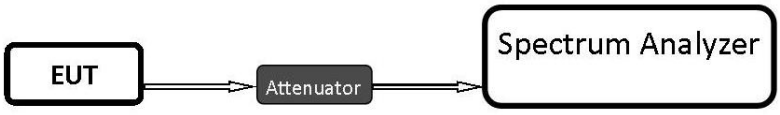
FS (dBµV/m) = Measured Value on SA (dBµV)- Cable Loss (dB)+ Antenna Factor (dB/m)

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 789033 D02 DTS UN-II Test Procedures New Rules v02r01 – "GUIDELINES FOR COMPLIANCE TESTING OF UNLICENSED NATIONAL INFORMATION INFRASTRUCTURE (U-NII) DEVICES (PART 15, SUBPART E)" - May 2, 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 789033 D02 General UNII Test Procedures New Rules v02r01

Spectrum Analyzer settings:

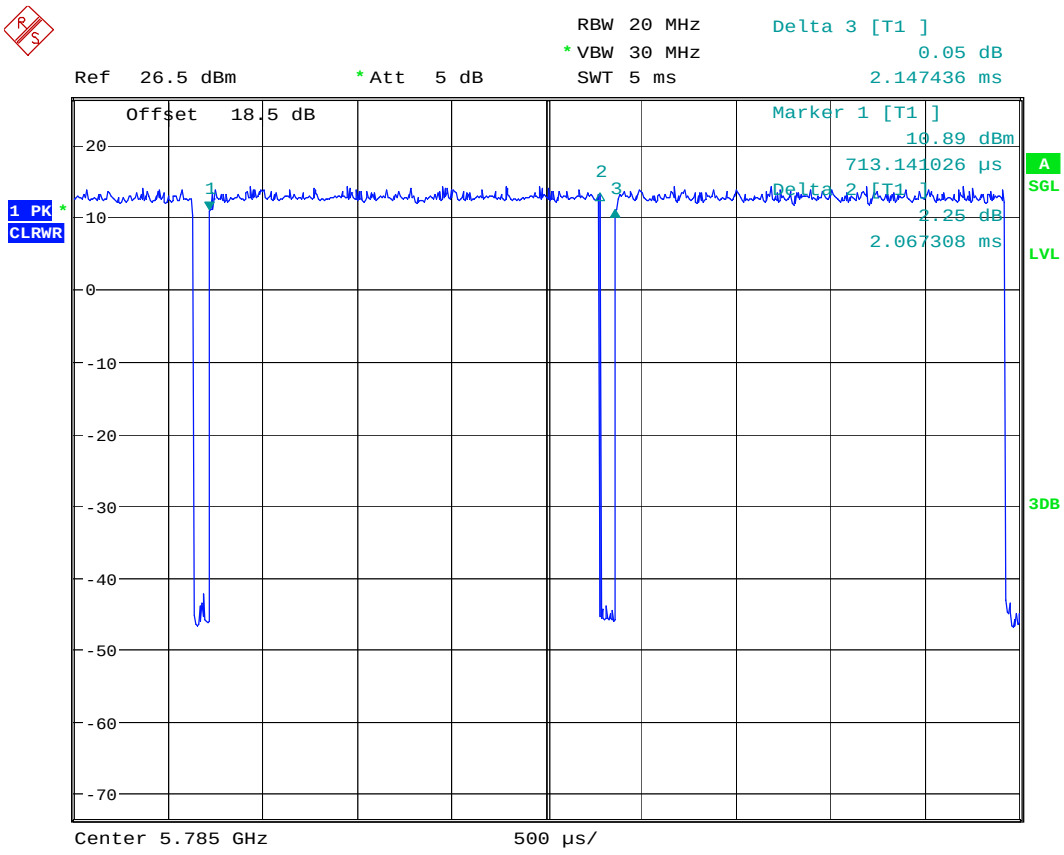
- Set the center frequency and of the instrument to the center frequency of the transmission
- Zero span
- Set RBW >=EBW if possible; otherwise, set RBW to the largest available value
- Detector = Peak or average

8.1.2 Measurement result

Plot #	Mode	Data Rate	Duty Cycle	Transmission Duration T(ms)	Duty Cycle Correction Factor (dB)
1	802.11a	6Mpbs	96.27%	2.067	0.17
2	802.11a	54Mbps	75.12%	0.252	1.24
3	802.11n_HT20	MCS0	95.86%	1.934	0.18
4	802.11n_HT40	MCS0	92.56%	0.957	0.34

Plot #1

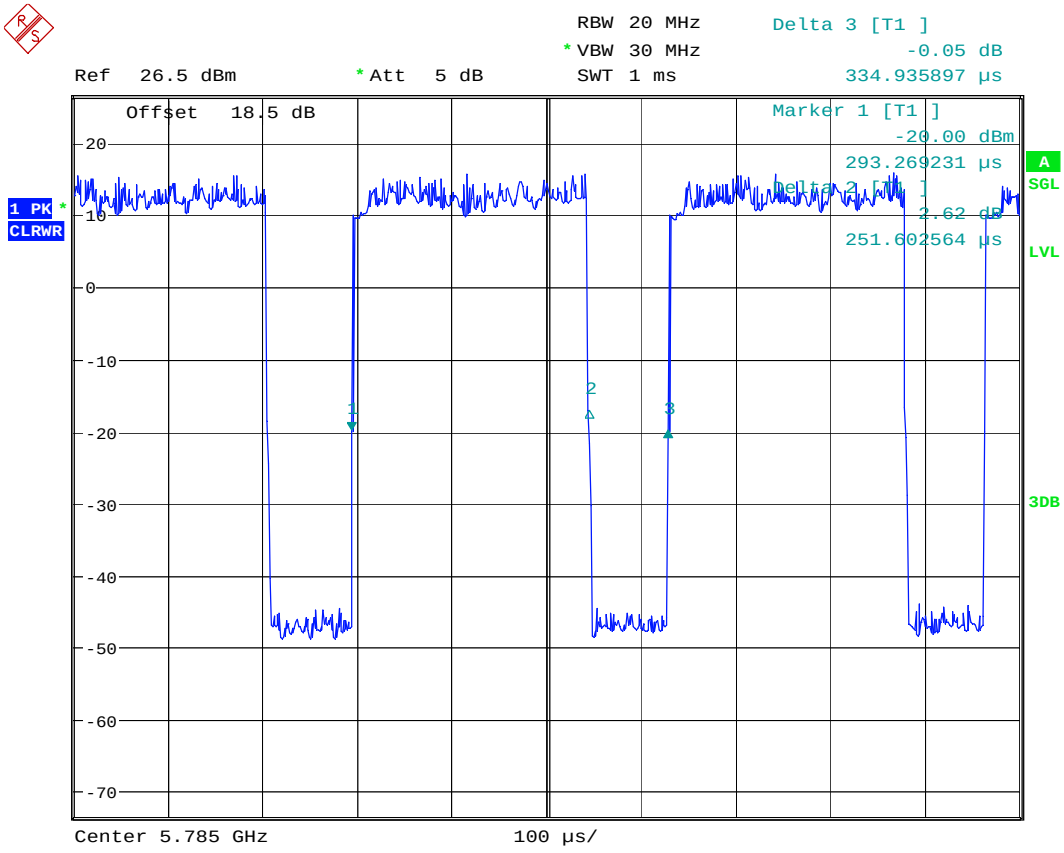
Mid channel / 5785 MHz | **Modulation/Packet Type: 802.11a 6Mbps**



Date: 17.JUL.2018 10:51:13

Plot #2

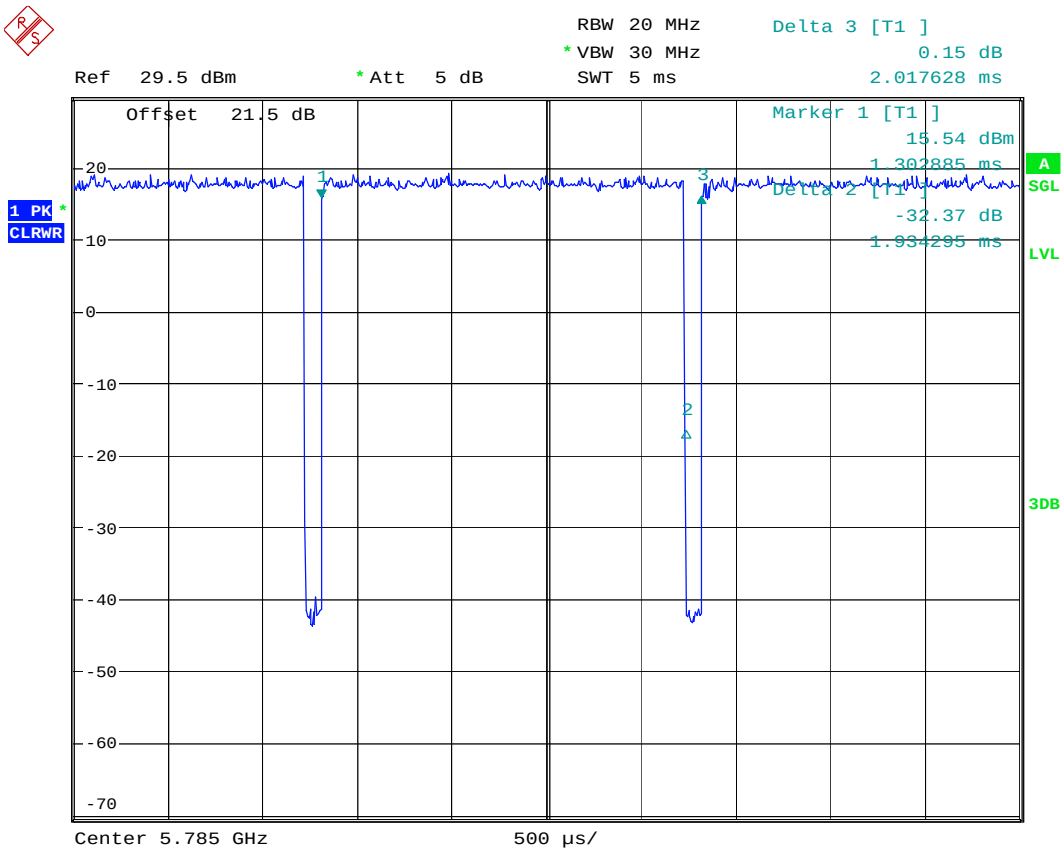
Mid channel / 5785 MHz	Modulation/Packet Type: 802.11a 54Mbps



Date: 17.JUL.2018 10:54:23

Plot #3

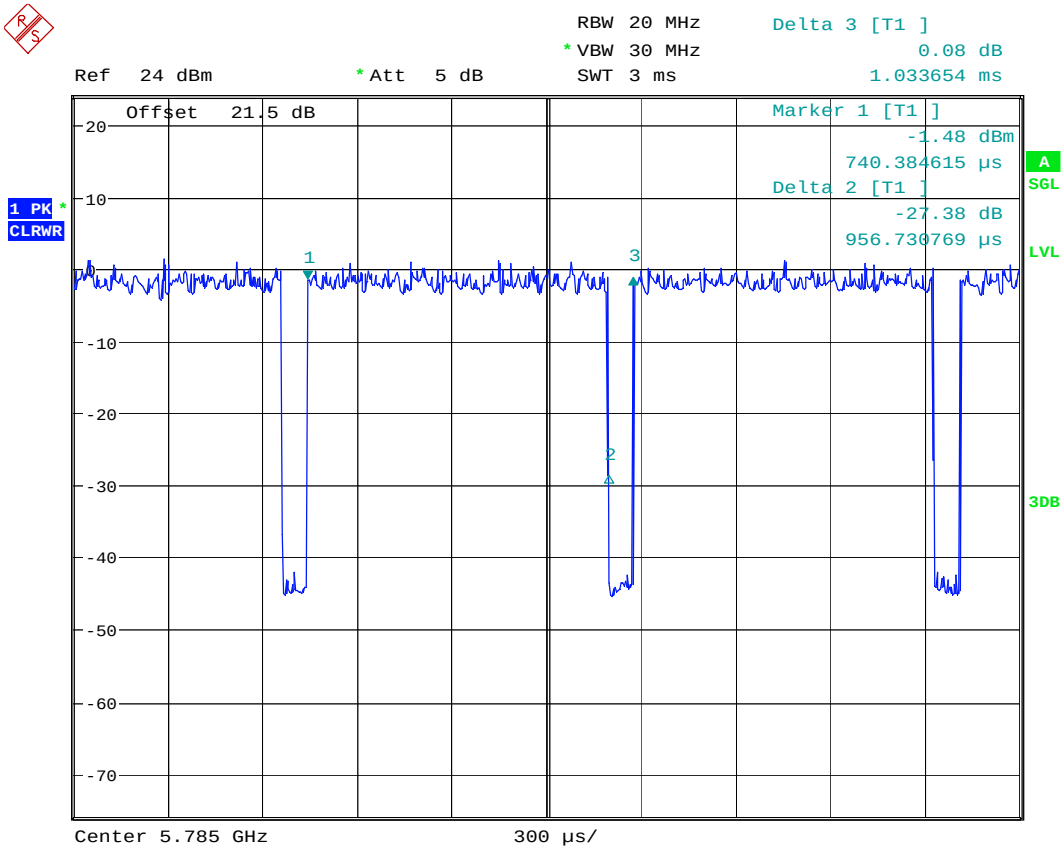
Mid channel / 5785 MHz | **Modulation/Packet Type: 802.11n_HT20 MCS0**



Date: 17.JUL.2018 10:58:00

Plot #4

Mid channel / 5785 MHz | **Modulation/Packet Type: 802.11n_HT40 MCS0**



8.2 Maximum Conducted Output Power

8.2.1 Measurement according to FCC 789033 D02 General UNII Test Procedures New Rules v02r01

Spectrum Analyzer settings:

- Measure the duty cycle, x, of the transmitter output signal.
- Set span to at encompass the EBW.
- Set RBW = 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".
- 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 EBW of the signal using the instrument's band power measurement function with band limits set equal to the EBW band edges. If the instrument does not have a band power function, sum the spectrum levels (in power units) at 1MHz intervals extending across the EBW of the signal.
- 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 Conducted Output Power:

- FCC §15.407: 1 W
- IC RSS-247: 1 W
- All limits are conducted. 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.

8.2.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Single Antenna Gain
22° C	1	802.11 a/n	USB 5 VDC	5.5dBi

8.2.4 Measurement result:

Attenuation of cable and attenuator (already taken into account): 13 dB

Mode	Tx Chain	Date Rate	Channel	Measured conducted powered(dBm)	Corrected by DCCF(dBm)	EIRP (dBm)	Limit (dBm)	Result
802.11a	0	6Mbps	149	1.25	1.42	6.92	30 / 36 (EIRP)	Pass
			157	0.18	0.35	5.85	30 / 36 (EIRP)	Pass
			165	-0.46	-0.29	5.21	30 / 36 (EIRP)	Pass
	1	6Mbps	149	2.48	2.65	8.15	30 / 36 (EIRP)	Pass
			157	0.98	1.15	6.65	30 / 36 (EIRP)	Pass
			165	-0.22	-0.05	5.45	30 / 36 (EIRP)	Pass

Mode	Tx Chain	Date Rate	Channel	Measured conducted powered(dBm)	Corrected by DCCF(dBm)	Summed power MIMO(dBm)	EIRP (dBm)	Limit (dBm)	Result
802.11n_HT20 MIMO	0	MCS0	149	1.33	1.51	5.70	14.20	27.49 / 36 (EIRP)	Pass
			157	0.08	0.26	6.13	14.63	27.49 / 36 (EIRP)	Pass
			165	-0.79	-0.61	4.12	12.62	27.49 / 36 (EIRP)	Pass
	1	MCS0	149	3.43	3.61	-	-	27.49 / 36 (EIRP)	-
			157	4.65	4.83	-	-	27.49 / 36 (EIRP)	-
			165	2.16	2.34	-	-	27.49 / 36 (EIRP)	-
802.11n_HT40 MIMO	0	MCS0	151	1.97	2.31	6.49	14.99	27.49 / 36 (EIRP)	Pass
			159	0.53	0.87	4.23	12.73	27.49 / 36 (EIRP)	Pass
	1	MCS0	151	4.06	4.4	-	-	27.49 / 36 (EIRP)	-
			159	1.21	1.55	-	-	27.49 / 36 (EIRP)	-

- For 802.11a, 6Mbps was chosen as the worst case to test, since it has the highest target power level declared by client; For 802.11n HT20&40 MIMO, MCS0 was chose as the worst case to test, since it has the highest target power level and one spacial stream
- EIRP= Conducted output power + Antenna gain
- Directional antenna gain of MIMO = Gain of antenna element + 10log(N_{ant})
- Limit of MIMO: 30dBm – (8.51 -6 dBi) = 27.49 dBm

8.3 Power Spectral Density

8.3.1 Measurement according to FCC 789033 D02 General UNII Test Procedures New Rules v02r01

Spectrum Analyzer settings:

- Use the same setting in section 8.2.1 but not include the step labeled , “Compute power….”
- Set RBW = 500 kHz
- Set the VBW ≥ 3 x RBW
- Use the peak search function on the instrument to find the peak of the spectrum and record its value
- Add 10 log(1/x), where x is the duty cycle, to the peak of the spectrum

8.3.2 Limits:

FCC§15.407(a) & RSS-247 6

- The maximum power spectral density shall not exceed 30 dBm in any 500 kHz band
- All limits are conducted. 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.

8.3.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Single Antenna Gain
22° C	1	802.11a/n	USB 5 VDC	5.5dBi

8.3.4 Measurement result:

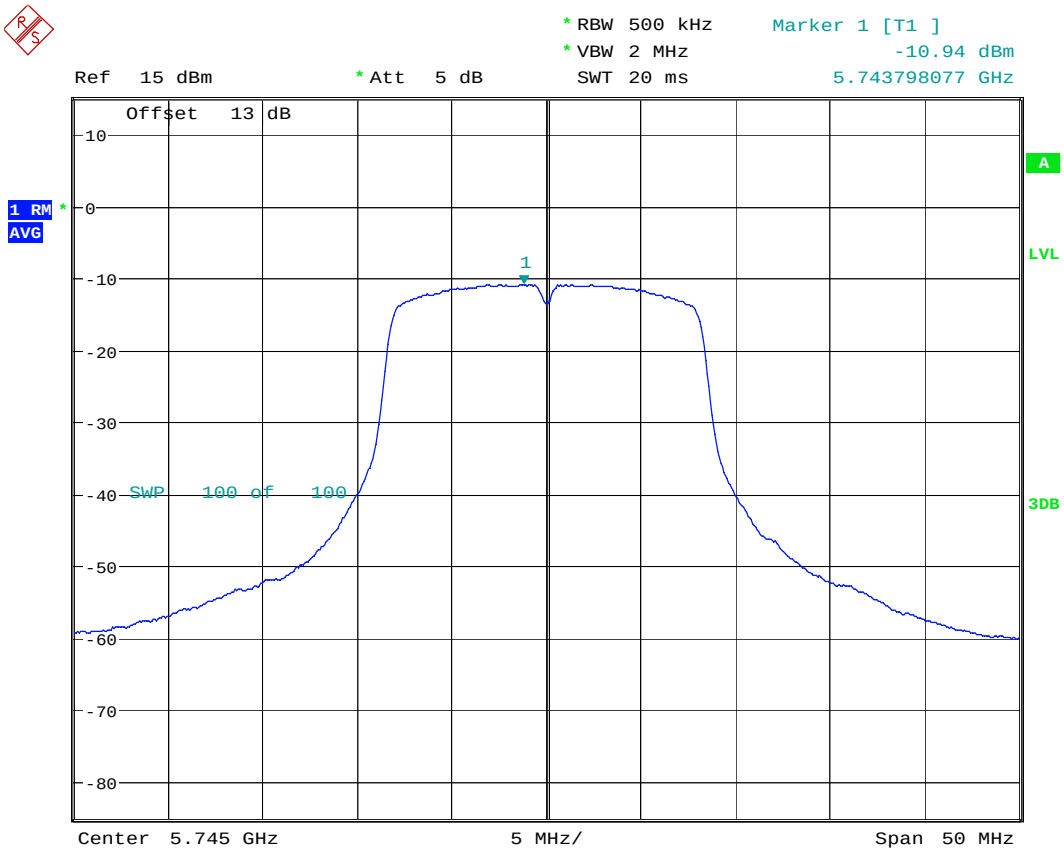
Attenuation of cable and attenuator (already taken into account): 13 dB

Plot #	Mode	Data Rate	Tx chain	channel	Maximum Power Spectral Density (dBm/3 kHz)	PSD corrected by DCCF	PSD Adjusted for Antenna Gain (dBm/3 kHz)	Limit (dBm / 500 kHz)	Result
1	802.11a	6Mpbs	1	149	-10.94	-10.77	-5.27	30	Pass
2				157	-12.79	-12.62	-7.12	30	Pass
3				165	-14.01	-13.84	-8.34	30	Pass
4	802.11n_HT20	MCS0	1	149	-10.99	-10.81	-2.3	27.49	Pass
5				157	-9.32	-9.14	-0.63	27.49	Pass
6				165	-11.67	-11.49	-2.98	27.49	Pass
7	802.11n_HT20	MCS0	1	151	-13.37	-13.03	-4.52	27.49	Pass
8				159	-15.75	-15.41	-6.9	27.49	Pass

- For MIMO, Directional antenna gain = 5.5 + 10*log(Nant) = 8.51dB
- Limit for MIMO: 30dBm – (8.51 -6dBi) = 27.49dBm

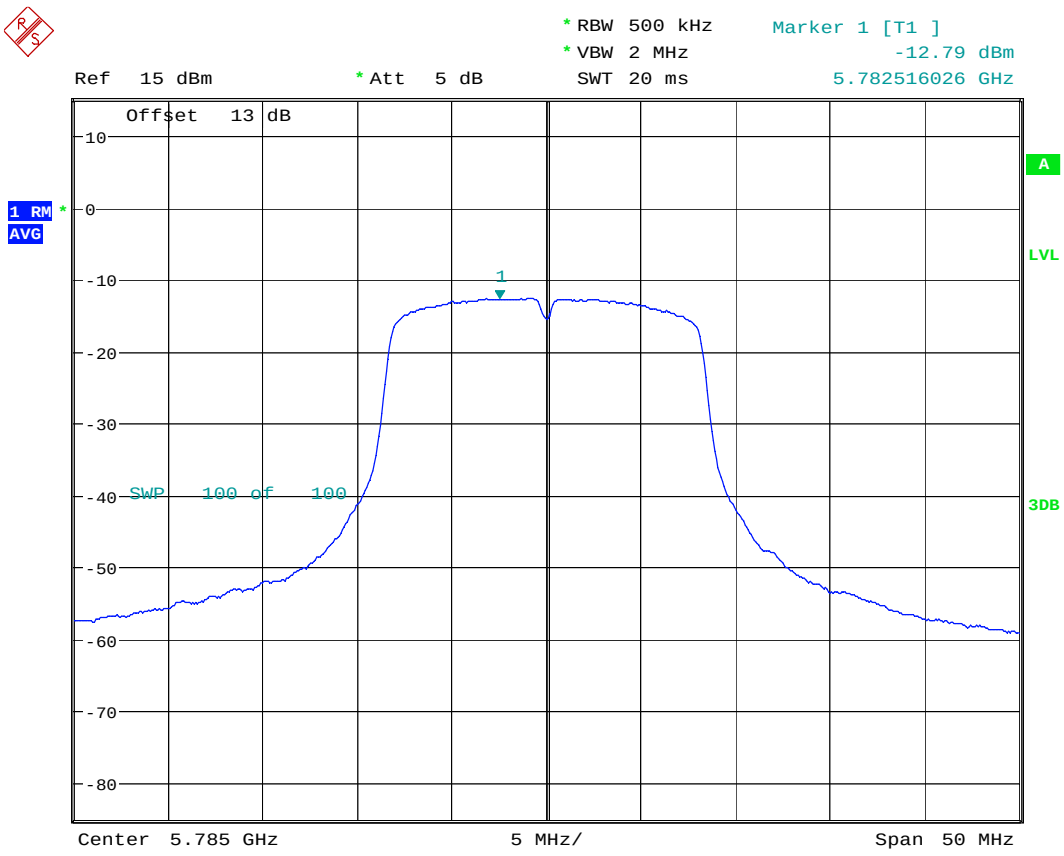
8.3.5 Measurement Plots:

Plot #1	
Low channel	Modulation/Packet Type: 802.11a 6Mbps



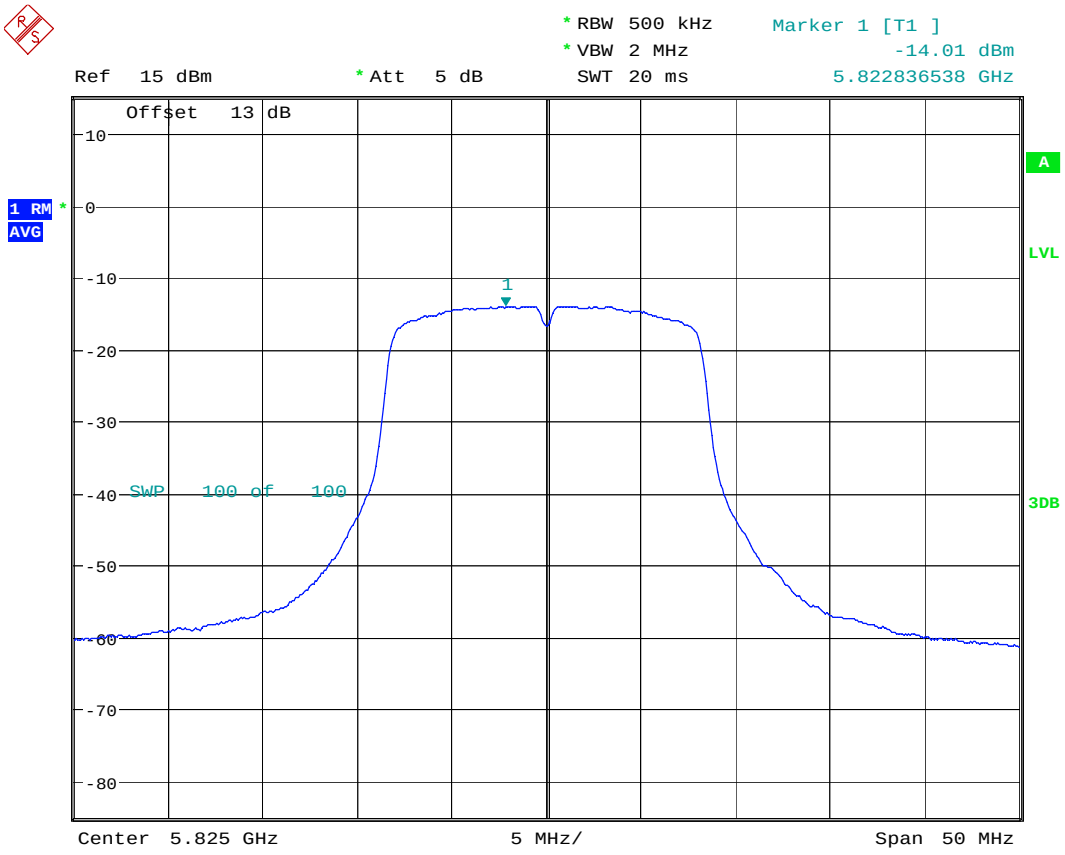
Plot #2

Mid channel	Modulation/Packet Type: 802.11a 6Mbps



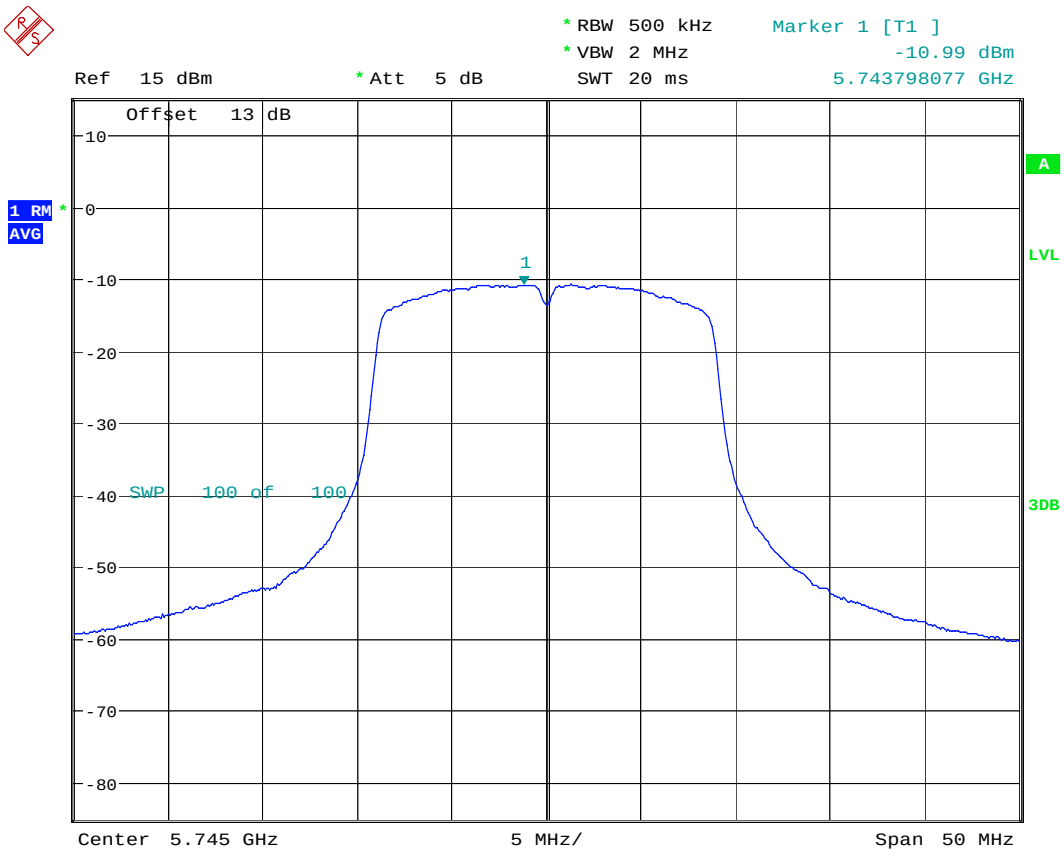
Plot #3

High channel	Modulation/Packet Type: 802.11a 6Mbps



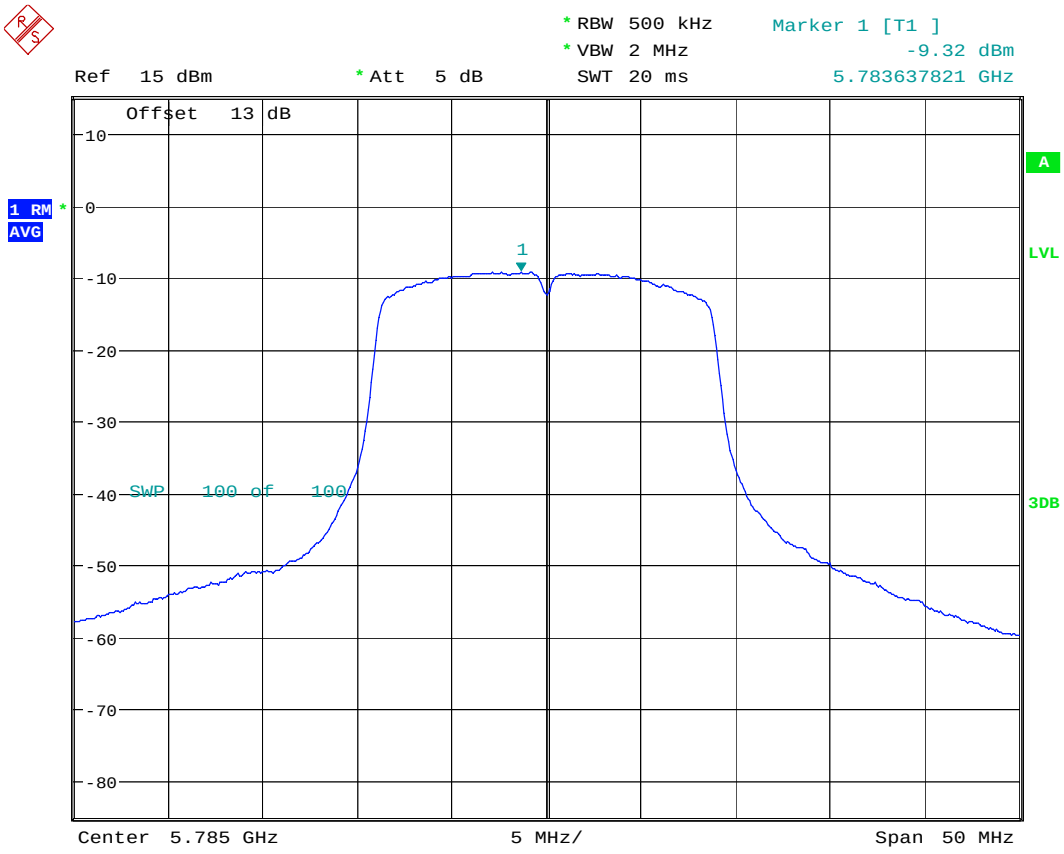
Plot #4

Low channel	Modulation/Packet Type: 802.11n_HT20 MCS0



Plot #5

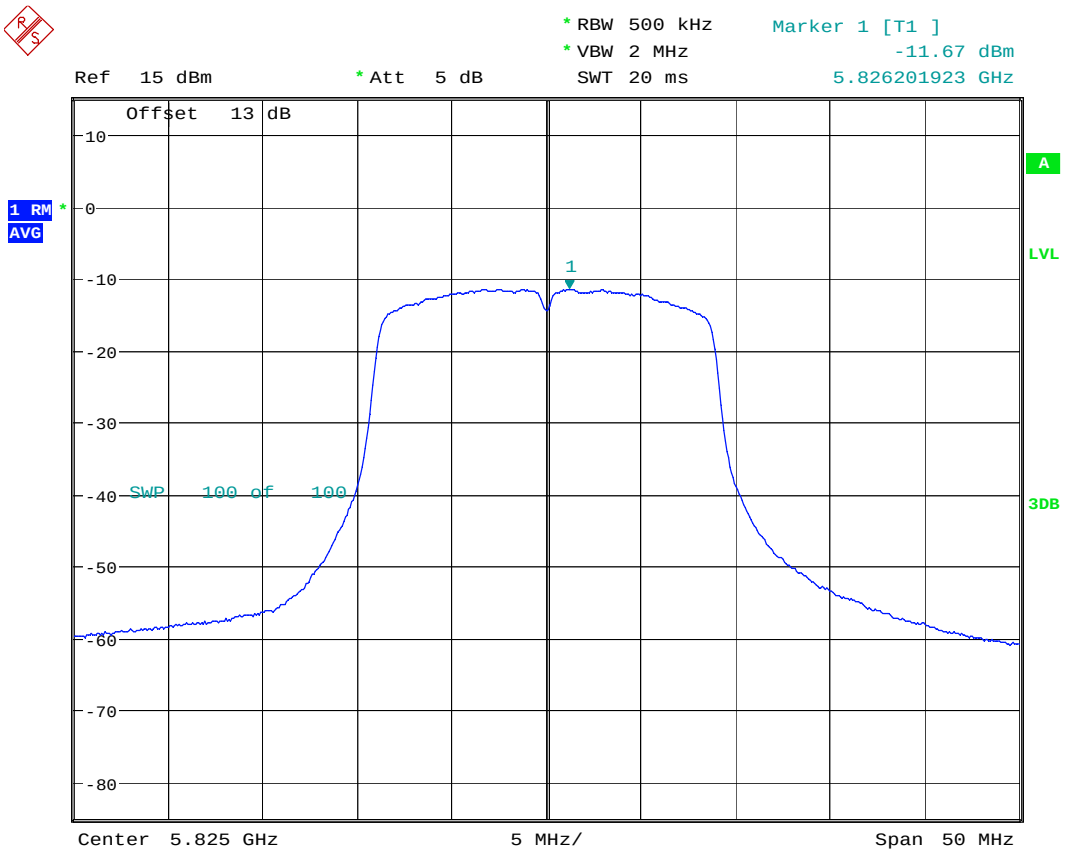
Mid channel	Modulation/Packet Type: 802.11n_HT20 MCS0



Date: 3.OCT.2018 13:21:30

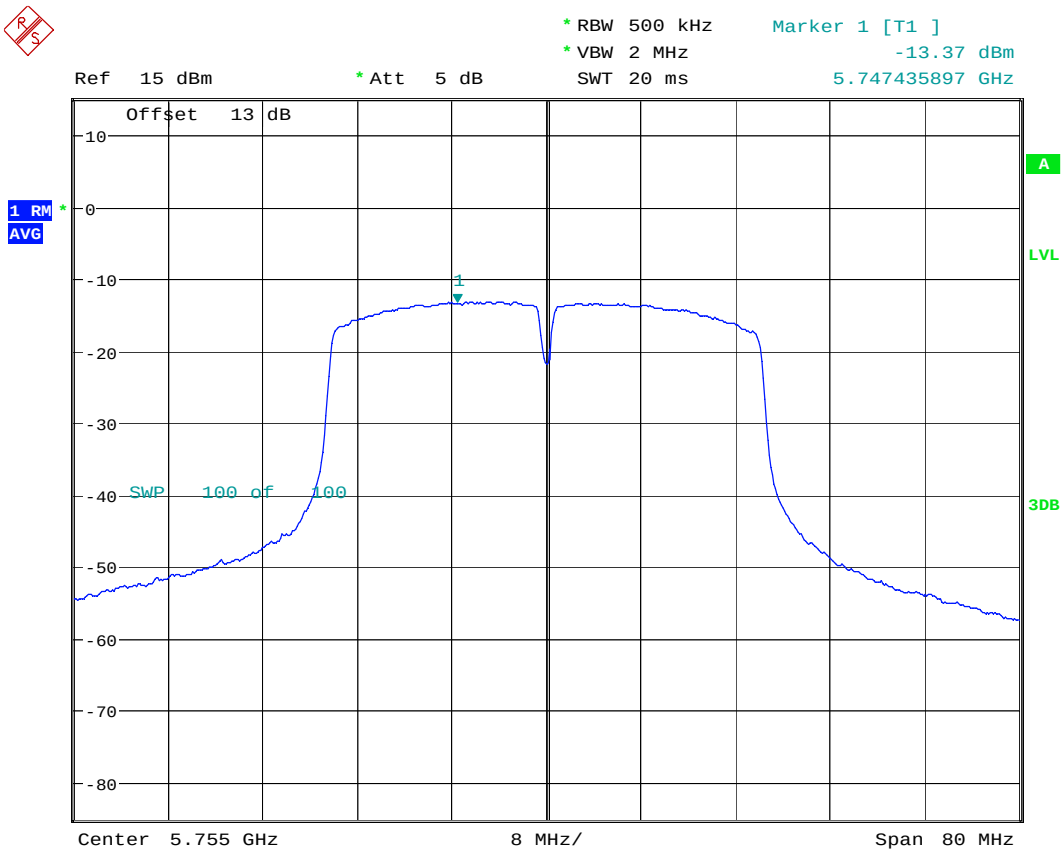
Plot #6

High channel	Modulation/Packet Type: 802.11n_HT20 MCS0



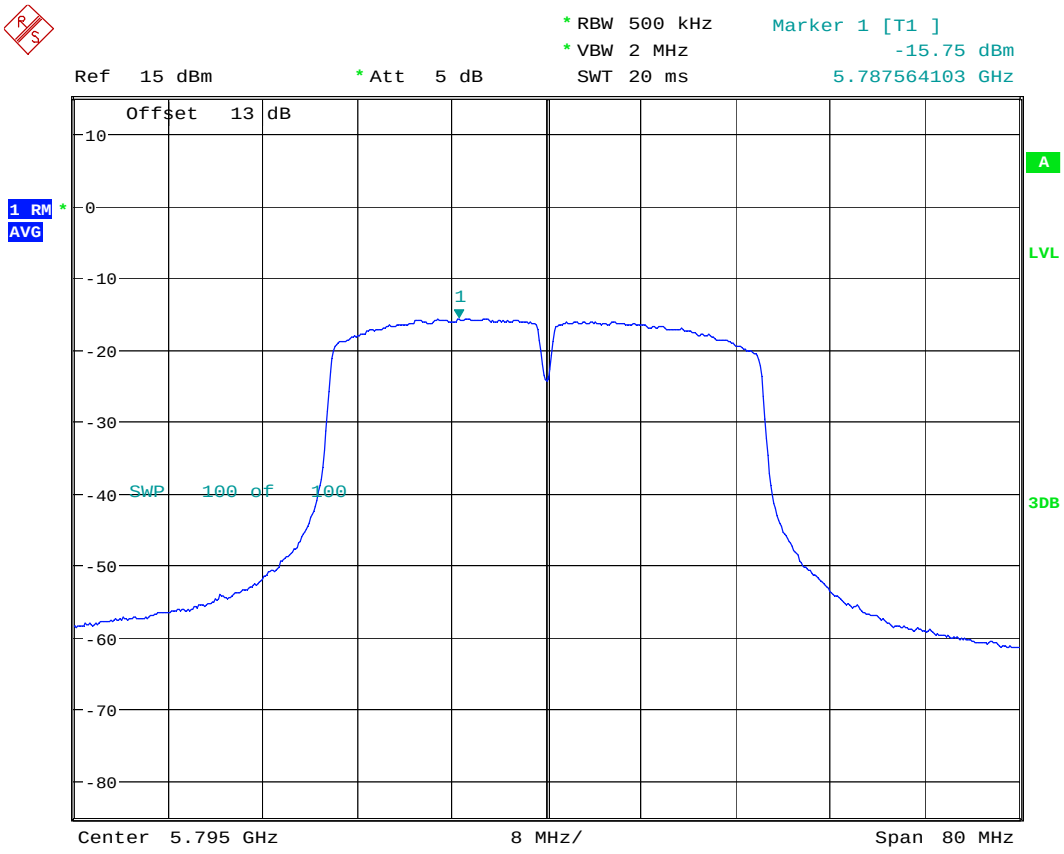
Plot #7

Low channel	Modulation/Packet Type: 802.11n_HT40 MCS0



Plot #8

Mid channel	Modulation/Packet Type: 802.11n_HT40 MCS0



8.4 Band Edge Compliance

8.4.1 Measurement according to FCC 789033 D02 General UNII Test Procedures New Rules v02r01

Non Restricted Band Edge and Restricted Band Edge Peak Measurement Spectrum Analyzer Settings:

- Follow the requirements in II.G.3, "General Requirements for Unwanted Emissions Measurements."
- Maximum emission levels are measured by setting the analyzer as follows:
- RBW = 1 MHz.
- VBW ≥ 3 MHz.
- Detector = Peak.
- Sweep time = auto.
- Trace mode = max hold.
- Allow sweeps to continue until the trace stabilizes. Note that if the transmission is not continuous, the time required for the trace to stabilize will increase by a factor of approximately 1/x, where x is the duty cycle. For example, at 50% duty cycle, the measurement time will increase by a factor of two relative to measurement time for continuous transmission
- Upper control line is set to show the compliance of band emission mask according to 15.407(b)(4)(i)

Restricted Band Edge Average Measurement Spectrum Analyzer Settings:

- Follow the requirements in II.G.3. "General Requirements for Unwanted Emissions Measurements."
- RBW = 1 MHz.
- VBW ≥ 3 MHz.
- Detector = power averaging (rms), if span/(# of points in sweep) <= RBW/2. Satisfying this condition may require increasing the number of points in the sweep or reducing the span. If the condition is not satisfied, the detector mode shall be set to peak.
- Averaging type = power averaging (rms)
- Sweep time = auto.
- Perform a trace average of at least 100 traces if the transmission is continuous. If the transmission is not continuous, the number of traces shall be increased by a factor of 1/x, where x is the duty cycle. For example, with 50% duty cycle, at least 200 traces shall be averaged. (If a specific emission is demonstrated to be continuous—i.e., 100% duty cycle—rather than turning on and off with the transmit cycle, at least 100 traces shall be averaged.)
- If tests are performed with the EUT transmitting at a duty cycle less than 98%, a correction factor shall be added to the measurement results prior to comparing to the emission limit in order to compute the emission level that would have been measured had the test been performed at 100% duty cycle. The correction factor is computed as follows:
- If power averaging (rms) mode was used in II.G.6.c)(iv), the correction factor is 10 log (1/x), where x is the duty cycle. For example, if the transmit duty cycle was 50%, then 3 dB must be added to the measured emission levels.

8.4.2 Limits non restricted band:

FCC§15.407 (b), RSS-247 6

- For transmitters operating in the 5.725-5.85 GHz band: 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.

8.4.3 Limits restricted band §15.407/15.209/15.205 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.
- 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			

8.4.4 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Single Antenna Gain
22° C	1	802.11a/n	USB 5 VDC	5.5dBi

8.4.5 Measurement result:

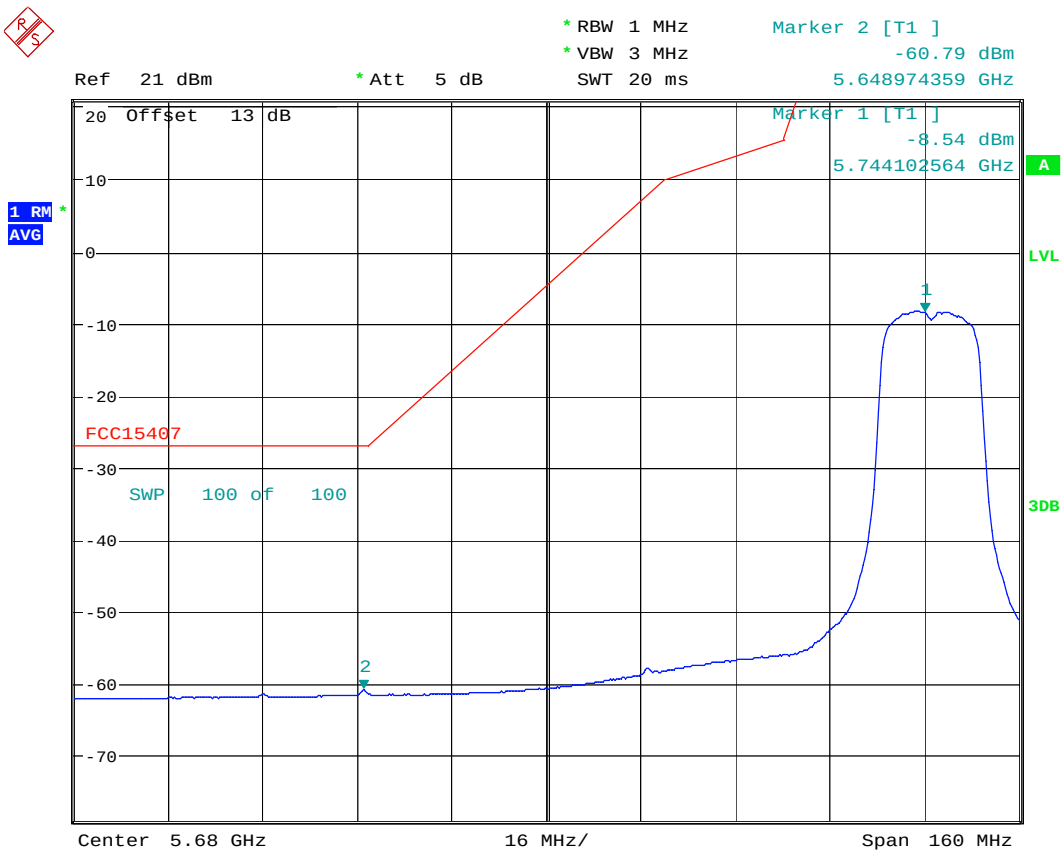
- The value of below table shows worst case of each mode.

Plot #	EUT operating mode	Tx Chain	Band Edge	Frequency (MHz)	Measured Emission Level(dBm)	Corrected by duty cycle (dBm)	Corrected by Antenna Gain (dBm)	Limit (dBm)	Result
1	802.11a	1	Lower, Non-restricted	5648.97	-60.79	-60.62	-55.12	-27	Pass
2	802.11a	1	Upper, Non-restricted	5648.97	-60.85	-60.68	-55.18	-27	Pass
3	802.11n_HT20	1	Lower, Non-restricted	5631.67	-61.36	-61.18	-52.67	-27	Pass
4	802.11n_HT20	1	Upper, Non-restricted	5983.97	-62.37	-62.19	-53.68	-27	Pass
5	802.11n_HT40	1	Lower, Non-restricted	5983.97	-62.34	-62	-53.49	-27	Pass
6	802.11n_HT40	1	Upper, Non-restricted	5983.97	-62.37	-62.03	-53.52	-27	Pass

Plot #	EUT operating mode	Tx Chain	Band Edge	Frequency (MHz)	Measured Peak Value (dBm)	Corrected by duty cycle (dBm)	Corrected by Antenna Gain (dBm)	Limit (dBm)	Result
7	802.11a	1	Lower Restricted peak	5425.63	-51.29	-51.29	-45.79	-21.23 Peak	Pass
8	802.11a	1	Lower Restricted Average	5392.84	-58.65	-58.48	-52.98	-41.23 AVG	Pass
9	802.11n_HT20	1	Lower Restricted peak	5408.53	-47.14	-47.14	-38.63	-21.23 Peak	Pass
10	802.11n_HT20	1	Lower Restricted Average	5392.84	-58.74	-58.56	-50.05	-41.23 AVG	Pass
11	802.11n_HT40	1	Lower Restricted peak	5396.36	-46.99	-46.99	-38.48	-21.23 Peak	Pass
12	802.11n_HT40	1	Lower Restricted Average	5403.24	-58.65	-58.31	-49.8	-41.23 AVG	Pass

8.4.6 Measurement Plots:

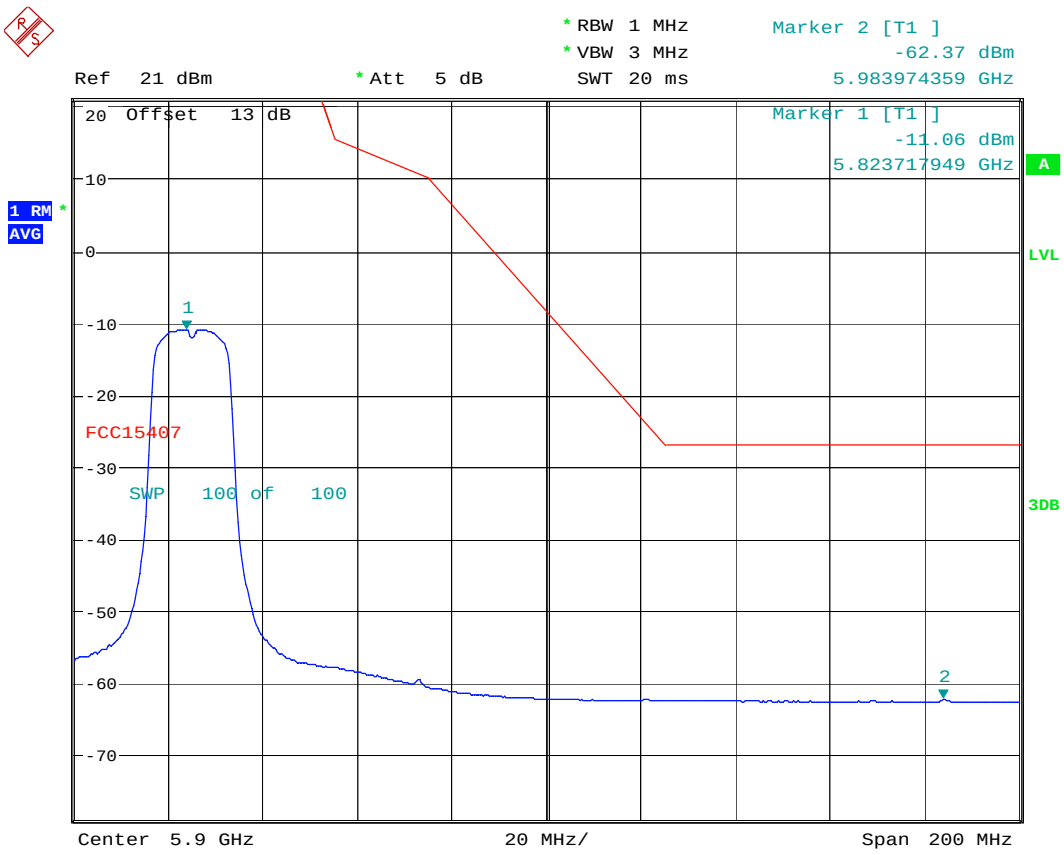
Plot #1	
Low channel / 5745 MHz	Modulation/Packet Type: 802.11a 6Mbps



Date: 3.OCT.2018 14:36:27

Plot #2

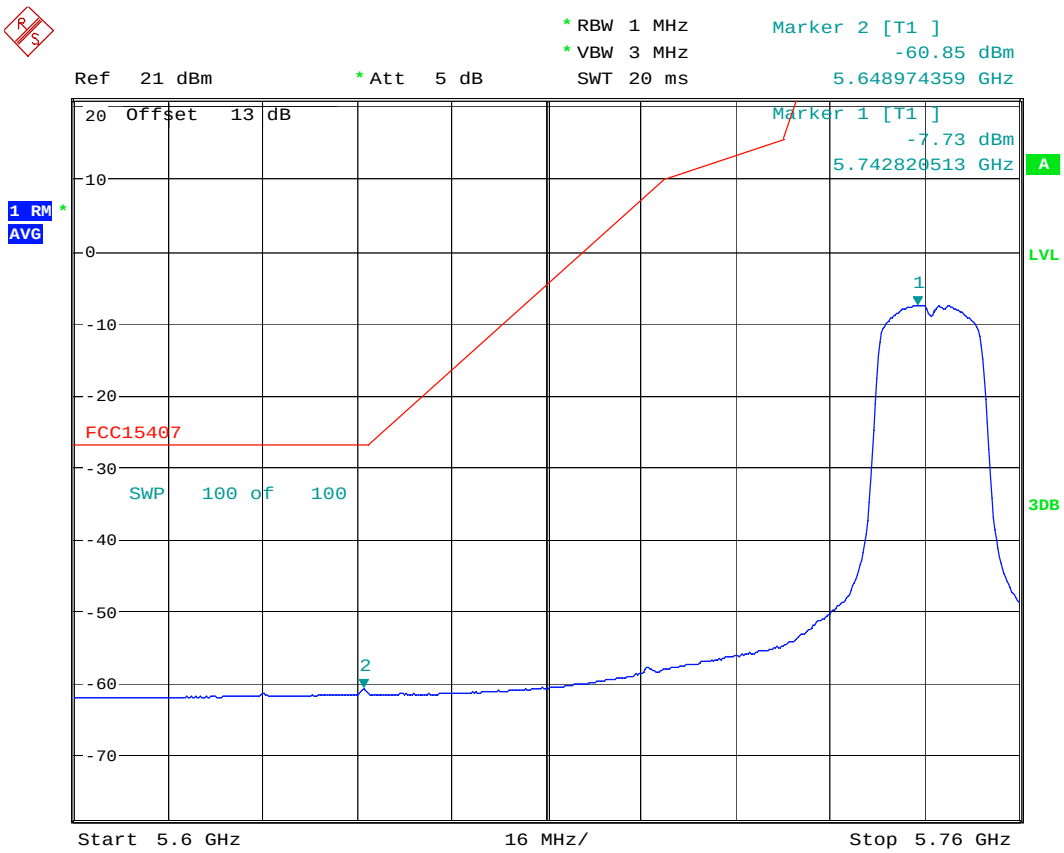
High channel / 5825 MHz	Modulation/Packet Type: 802.11a 6Mbps



Date: 3.OCT.2018 14:42:09

Plot #3

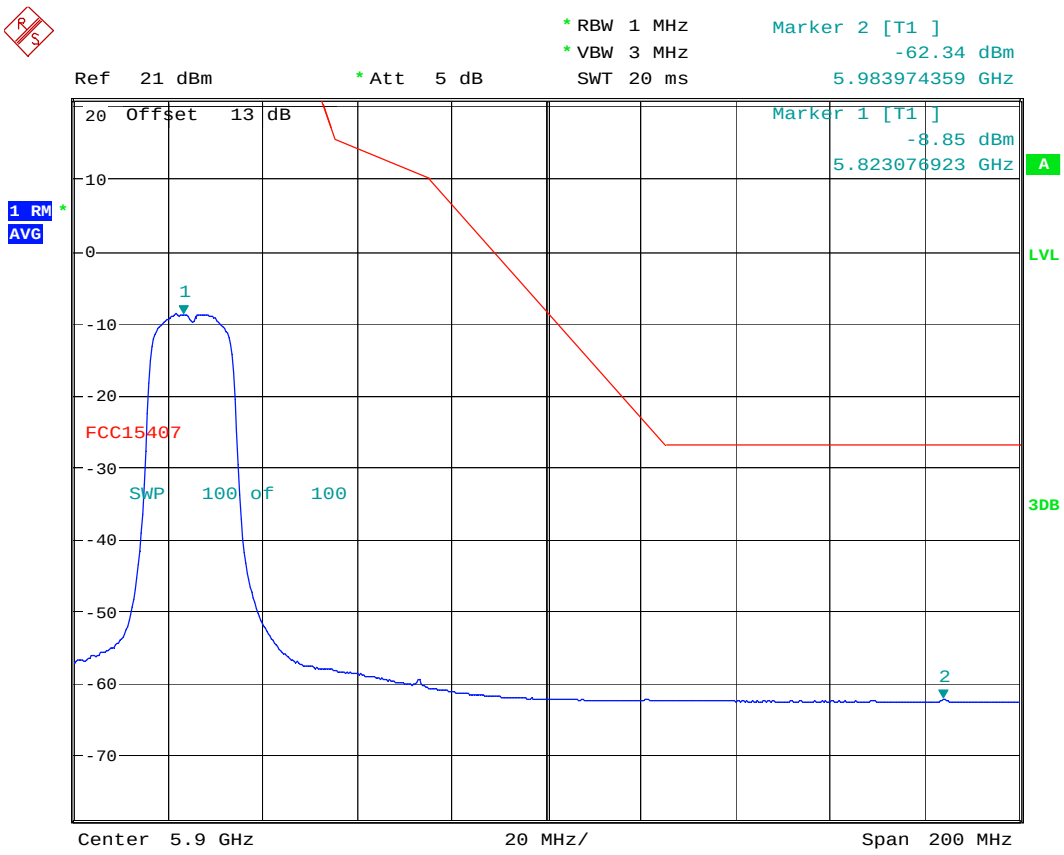
Low channel / 5745 MHz	Modulation/Packet Type: 802.11n_HT20 MCS0



Date: 3.OCT.2018 14:37:27

Plot #4

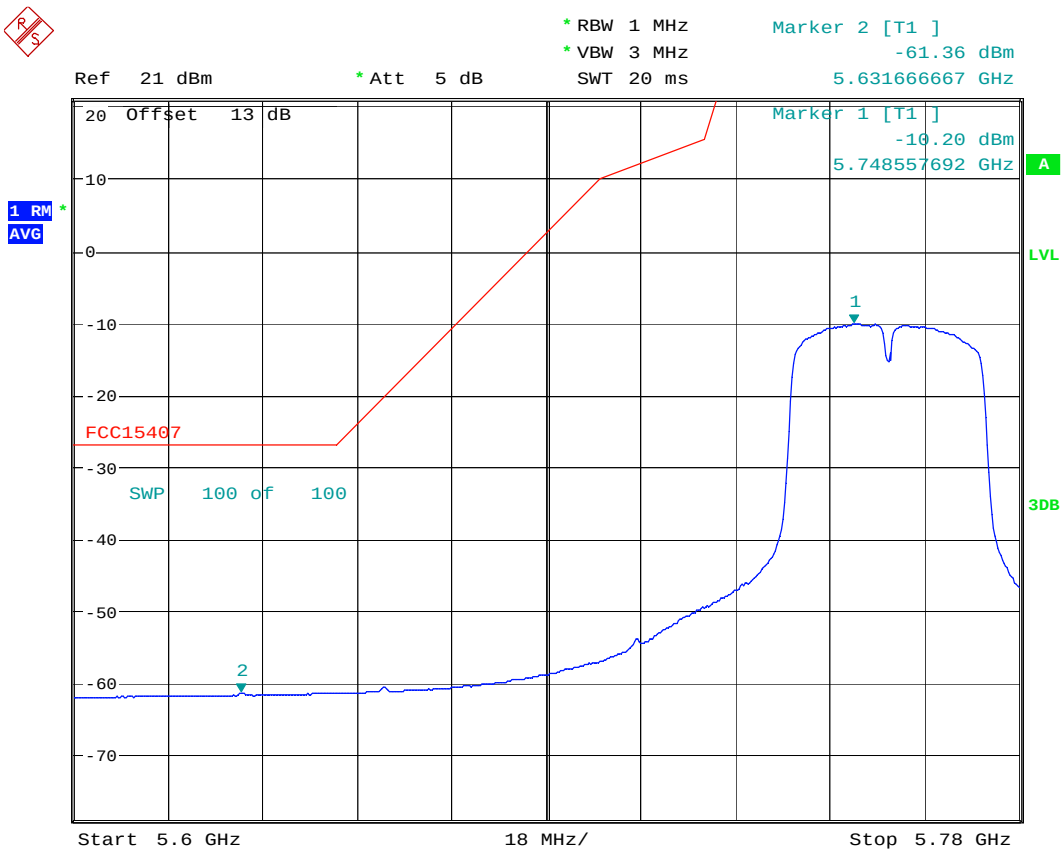
High channel / 5825 MHz	Modulation/Packet Type: 802.11n_HT20 MCS0



Date: 3.OCT.2018 14:51:47

Plot #5

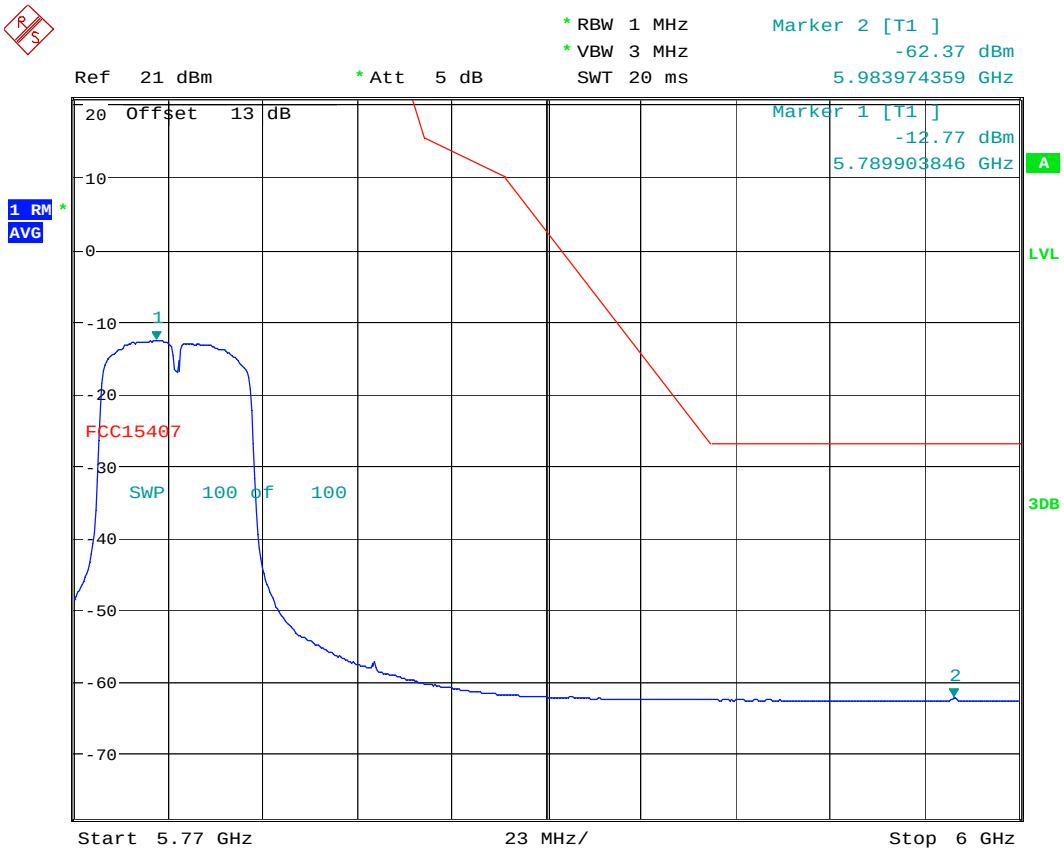
Low channel / 5755 MHz	Modulation/Packet Type: 802.11n_HT40 MCS0



Date: 3.OCT.2018 14:39:27

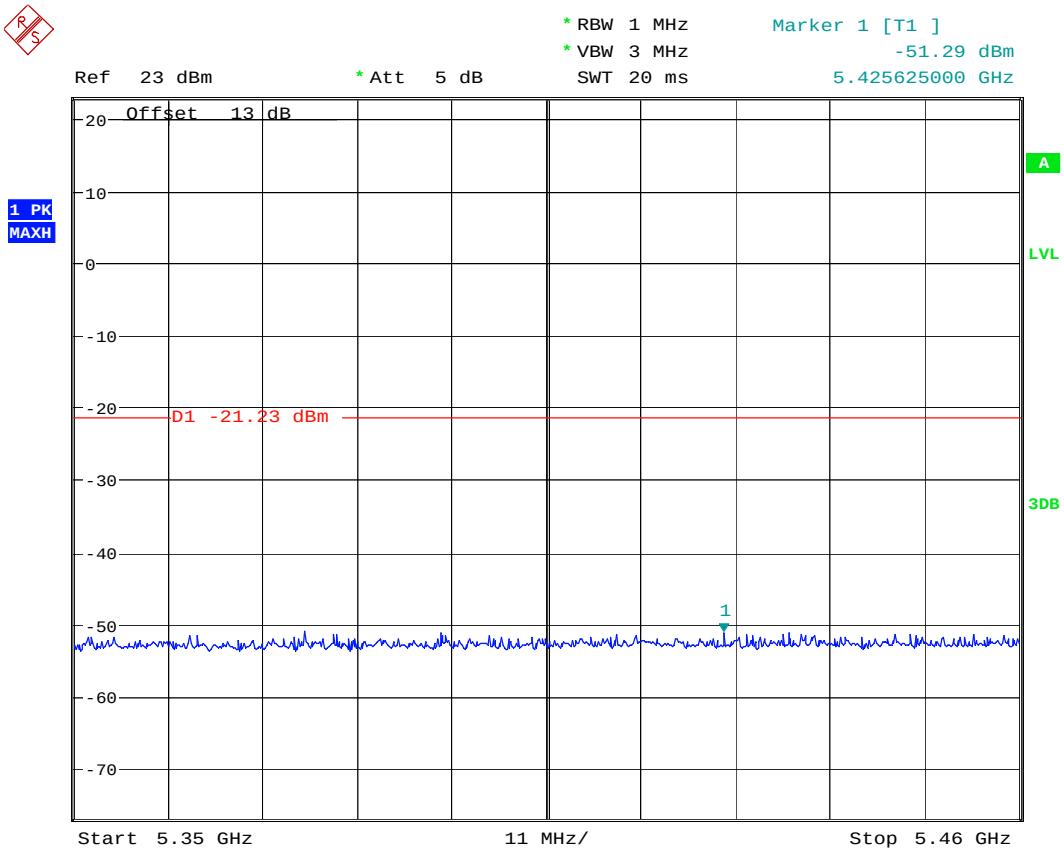
Plot #6

High channel / 5795 MHz | **Modulation/Packet Type: 802.11n_HT40 MCS0**



Plot #7

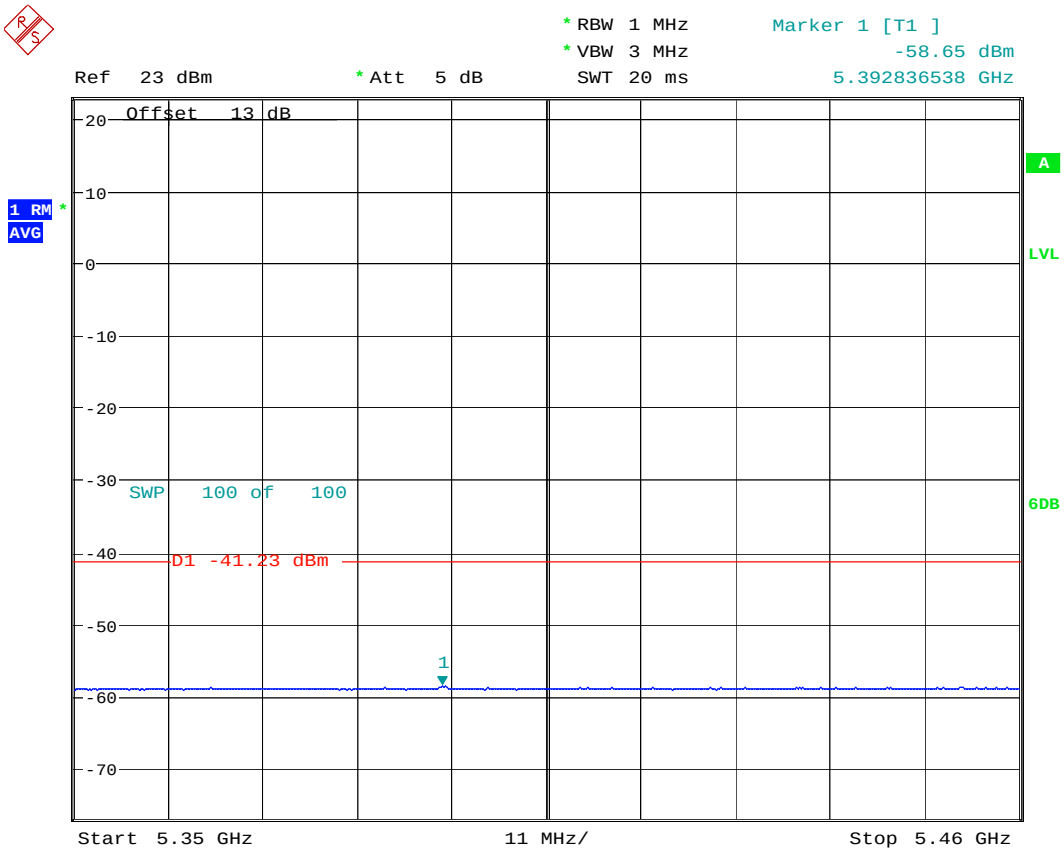
Low channel / 5745 MHz | **Modulation/Packet Type: 802.11a 6Mbps Peak**



Date: 3.OCT.2018 13:45:20

Plot #8

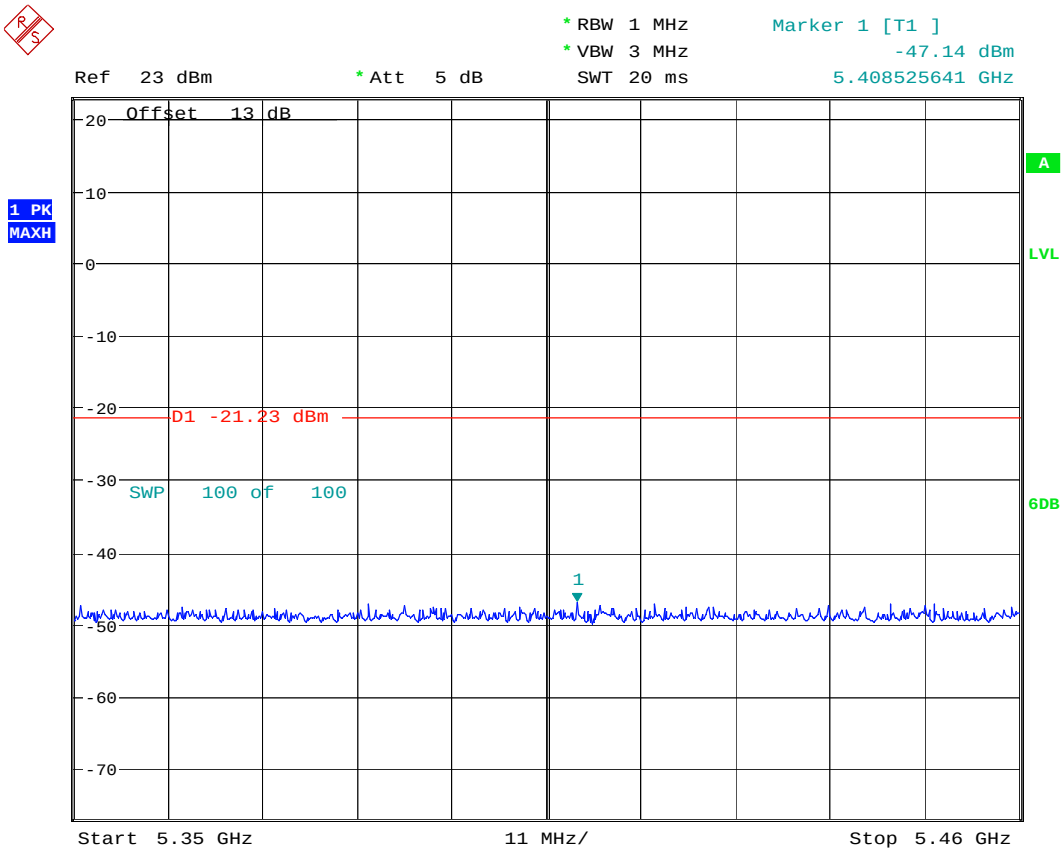
Low channel / 5745 MHz | **Modulation/Packet Type: 802.11a 6Mbps Avg**



Date: 3.OCT.2018 13:45:58

Plot #9

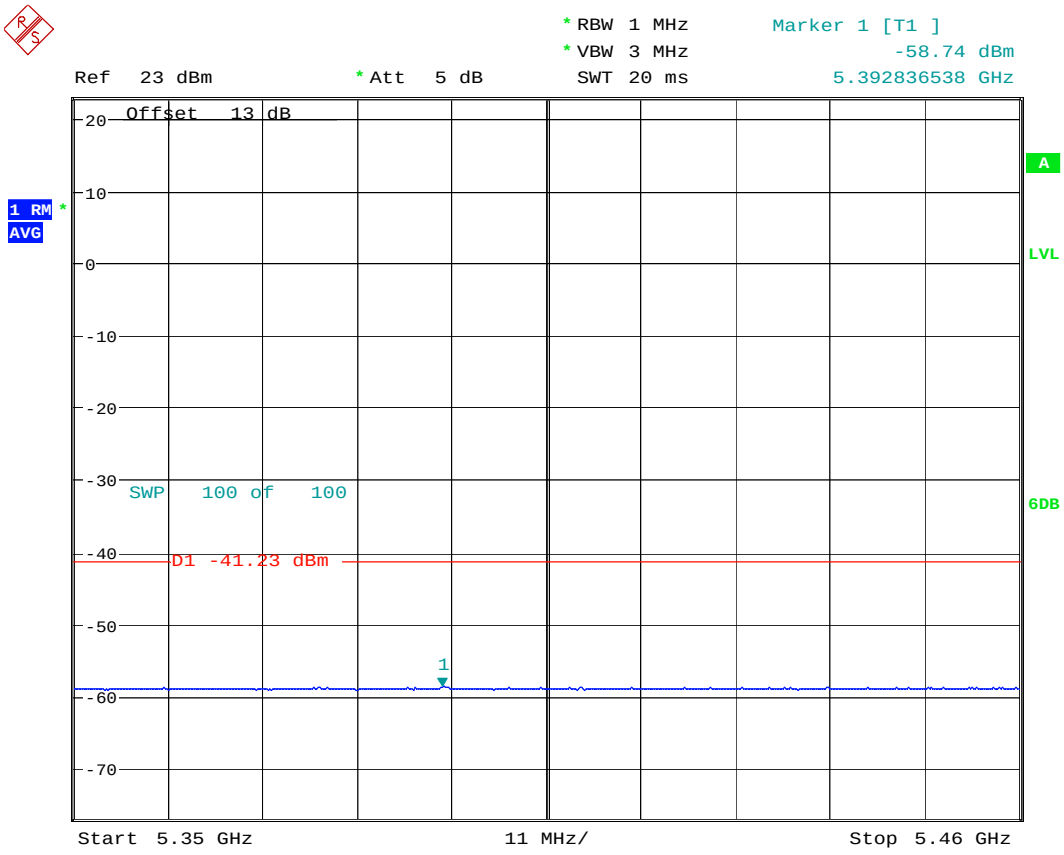
Low channel / 5745 MHz | **Modulation/Packet Type: 802.11n_HT20 MCS0 Peak**



Date: 3.OCT.2018 13:48:08

Plot #10

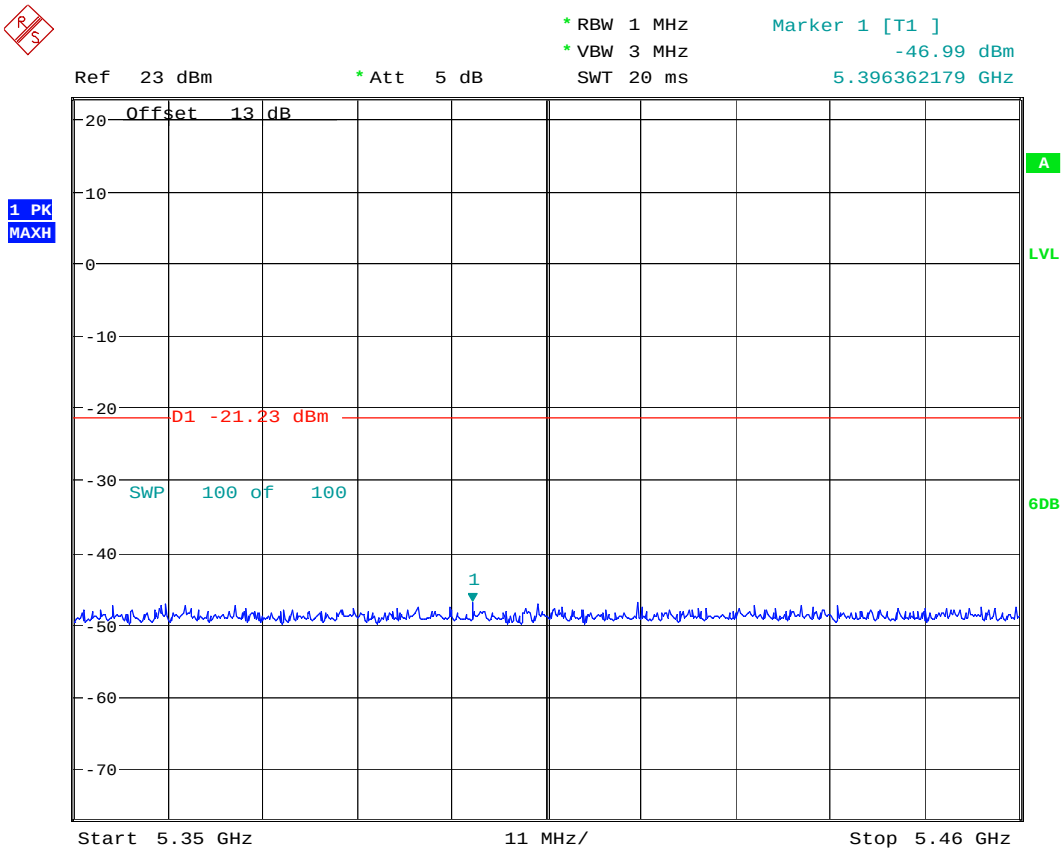
Low channel / 5745 MHz | **Modulation/Packet Type: 802.11n_HT20 MCS0 Avg**



Date: 3.OCT.2018 13:47:43

Plot #11

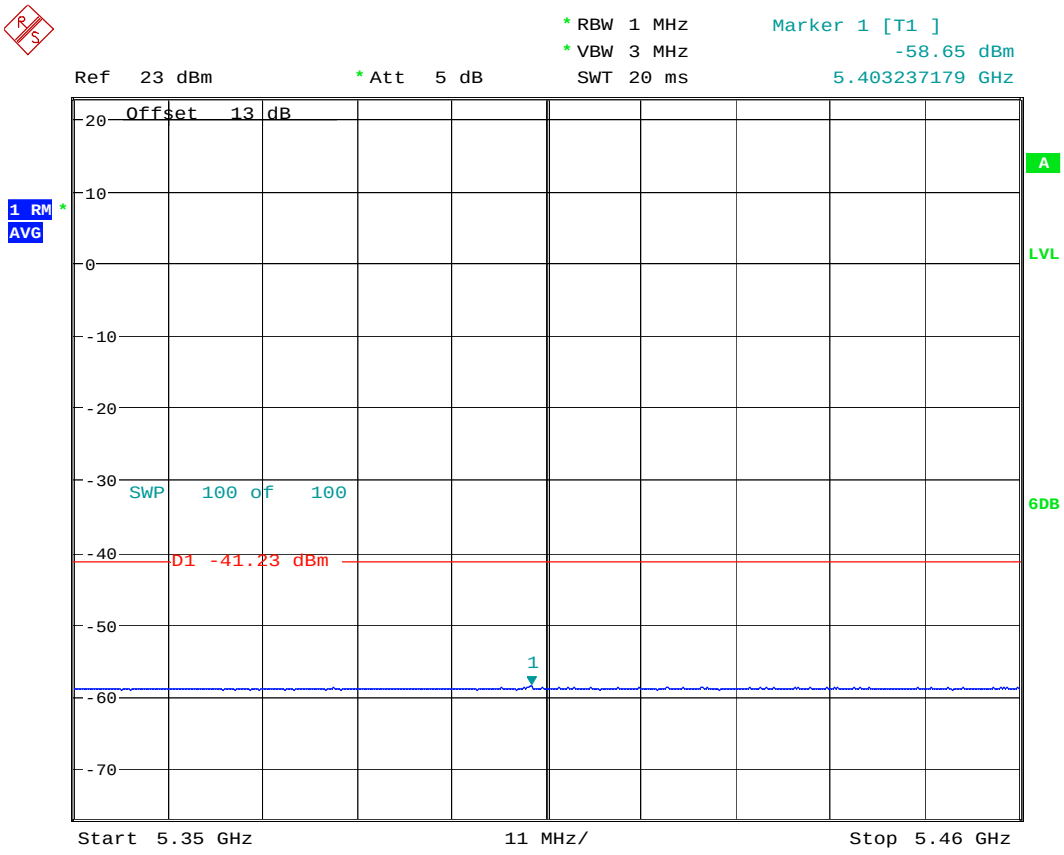
Low channel / 5755 MHz | **Modulation/Packet Type: 802.11n_HT40 MCS0 Peak**



Date: 3.OCT.2018 13:49:04

Plot #12

Low channel / 5755 MHz | **Modulation/Packet Type: 802.11n_HT40 MCS0 Avg**



Date: 3.OCT.2018 13:49:29

8.5 Emission Bandwidth 6 dB, 26dB and 99% Occupied Bandwidth

8.5.1 Measurement according to FCC 789033 D02 General UNII Test Procedures New Rules v02r01

Spectrum Analyzer Settings for 26 dB EBW:

- Set RBW = approximately 1% of the emission bandwidth
- Set the VBW > RBW
- Detector = Peak
- Trace mode = Max Hold
- Sweep = Auto Couple
- Allow the trace to stabilize
- Measure the maximum width of the emission that is 26 dB down from the maximum of the emission. Compare this with the RBW setting of the analyzer. Readjust RBW and repeat measurement as needed until the RBW/EBW ratio is approximately 1%

Spectrum Analyzer Settings for 6 dB EBW:

- 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

Spectrum Analyzer Settings for 99% Occupied Bandwidth

- Set center frequency to the nominal EUT channel center frequency
- Set span = 1.5 times to 5.0 times the OBW
- Set RBW = 1% to 5% of the OBW
- Set VBW ≥ 3 x RBW
- Video averaging is not permitted. Where practical, a sample detection and single sweep mode shall be used. Otherwise, peak detection and max hold mode (until the trace stabilizes) shall be used
- Use the 99% power bandwidth function of the instrument (if available)
- If the instrument does not have a 99% power bandwidth function, the trace data points are recovered and directly summed in power units. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached; that frequency is recorded as the lower frequency. The process is repeated until 99.5% of the total is reached; that frequency is recorded as the upper frequency. The 99% occupied bandwidth is the difference between these two frequencies

8.5.2 Limits:

FCC §15.407(e)and RSS-247 6

- Within the 5.725-5.85 GHz band, the minimum 6 dB bandwidth of U-NII devices 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	USB 5VDC

8.5.4 Measurement result:

Plot #	Mode	Channel	6 dB Emissions Bandwidth (MHz)	Limit (MHz)	Result
1	802.11a	149	15.37	> 0.5	Pass
2	802.11a	157	15.3	> 0.5	Pass
3	802.11a	165	15.53	> 0.5	Pass
4	802.11n_HT20	149	15.46	> 0.5	Pass
5	802.11n_HT20	157	15.45	> 0.5	Pass
6	802.11n_HT20	165	15.46	> 0.5	Pass
7	802.11n_HT40	151	35.25	> 0.5	Pass
8	802.11n_HT40	159	35.25	> 0.5	Pass

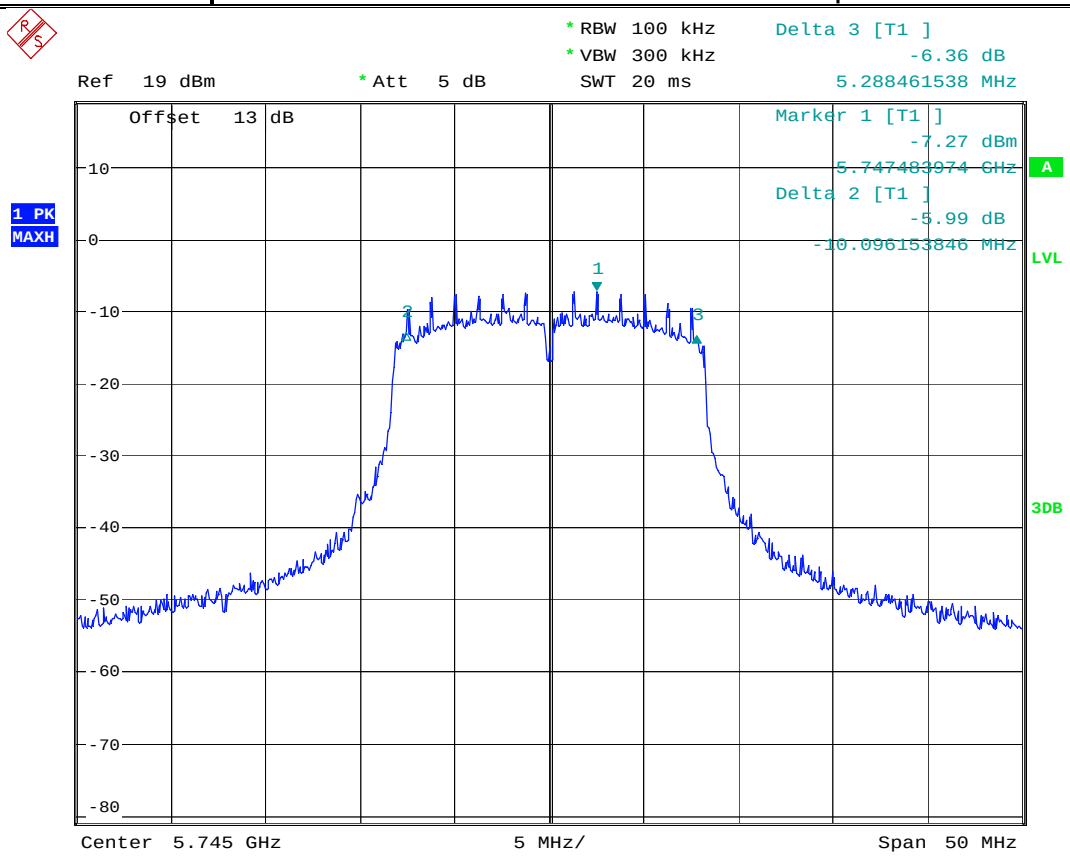
Plot #	Mode	Channel	26 dB Emissions Bandwidth (MHz)	Limit (MHz)	Result
9	802.11a	149	19.16	> 0.5	Pass
10	802.11a	157	19.07	> 0.5	Pass
11	802.11a	165	19.07	> 0.5	Pass
12	802.11n_HT20	149	19.95	> 0.5	Pass
13	802.11n_HT20	157	19.95	> 0.5	Pass
14	802.11n_HT20	165	19.95	> 0.5	Pass
15	802.11n_HT40	151	39.62	> 0.5	Pass
16	802.11n_HT40	159	39.49	> 0.5	Pass

Plot #	Mode	Channel	99% Occupied Bandwidth (MHz)	Limit (MHz)	Result
17	802.11a	149	16.35	> 0.5	Pass
18	802.11a	157	16.27	> 0.5	Pass
19	802.11a	165	16.27	> 0.5	Pass
20	802.11n_HT20	149	17.39	> 0.5	Pass
21	802.11n_HT20	157	17.39	> 0.5	Pass
22	802.11n_HT20	165	17.47	> 0.5	Pass
23	802.11n_HT40	151	35.77	> 0.5	Pass
24	802.11n_HT40	159	35.77	> 0.5	Pass

8.5.5 Measurement Plots:

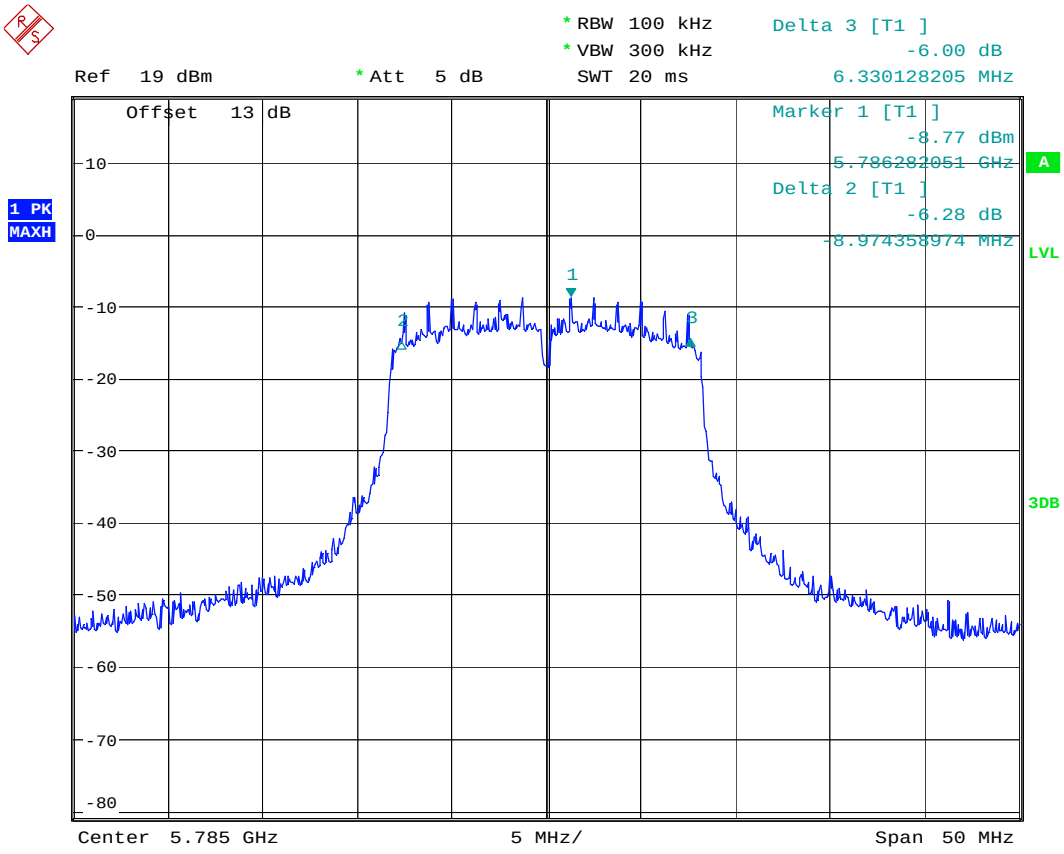
Plot #1

Low channel	Mode: 802.11a 6Mbps



Plot #2

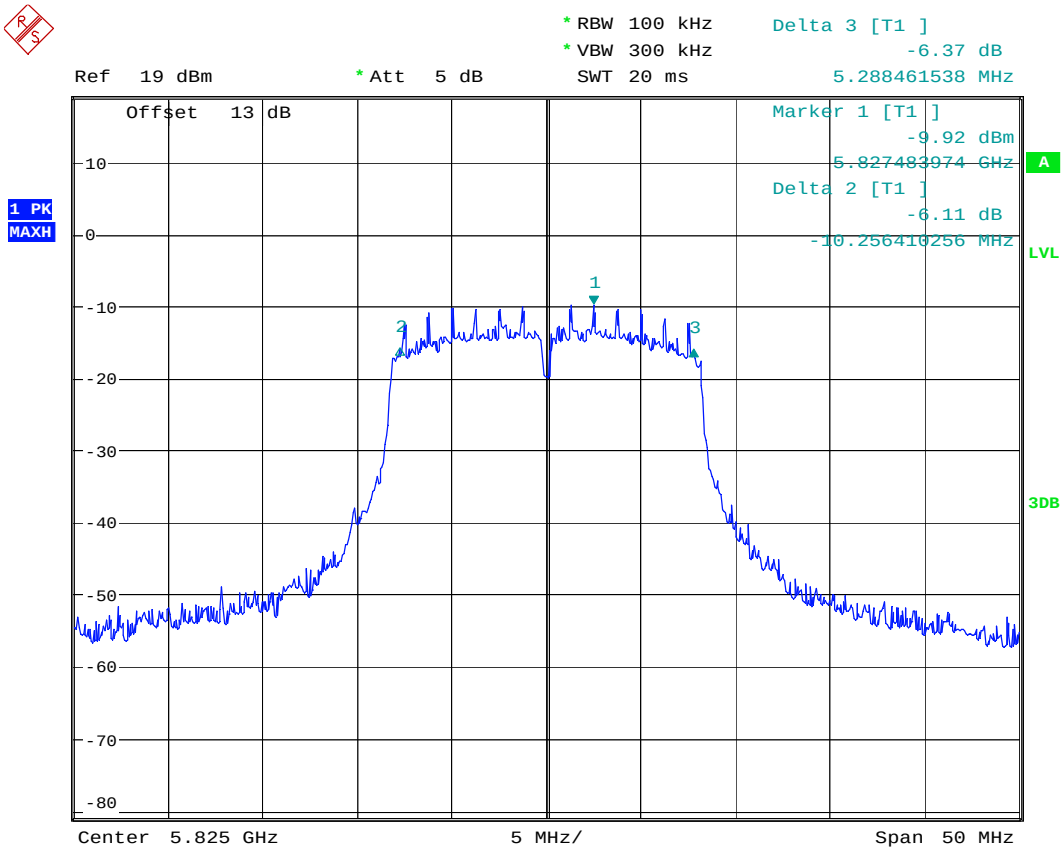
Mid channel	Mode: 802.11a 6Mbps



Date: 3.OCT.2018 17:04:21

Plot #3

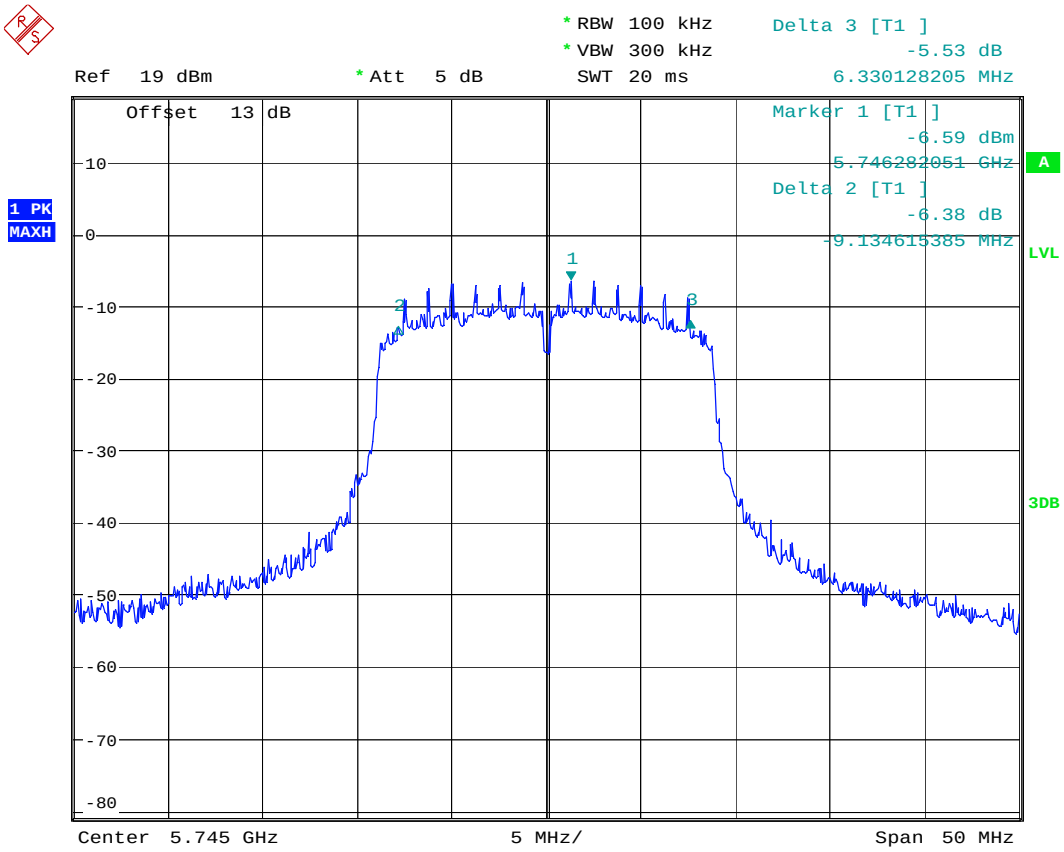
High channel | **Mode: 802.11a 6Mbps**



Date: 3.OCT.2018 17:05:23

Plot #4

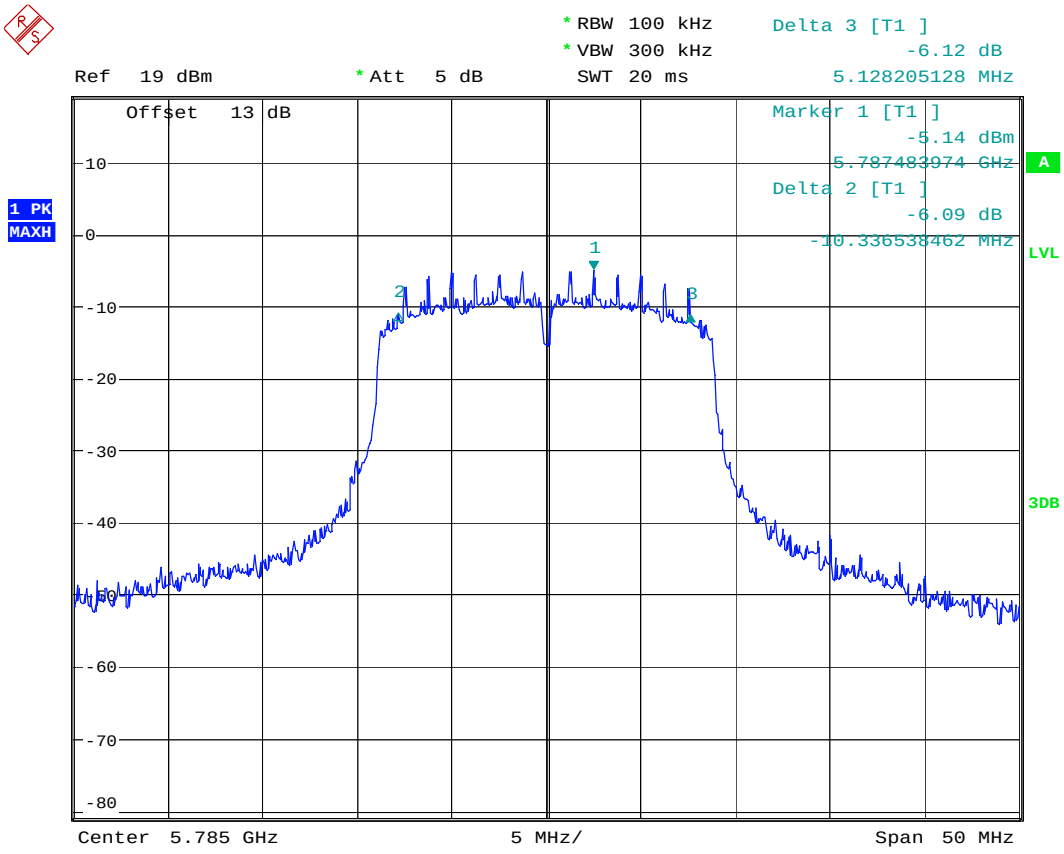
Low channel	Mode: 802.11n_HT20 MCS0



Date: 3.OCT.2018 17:06:40

Plot #5

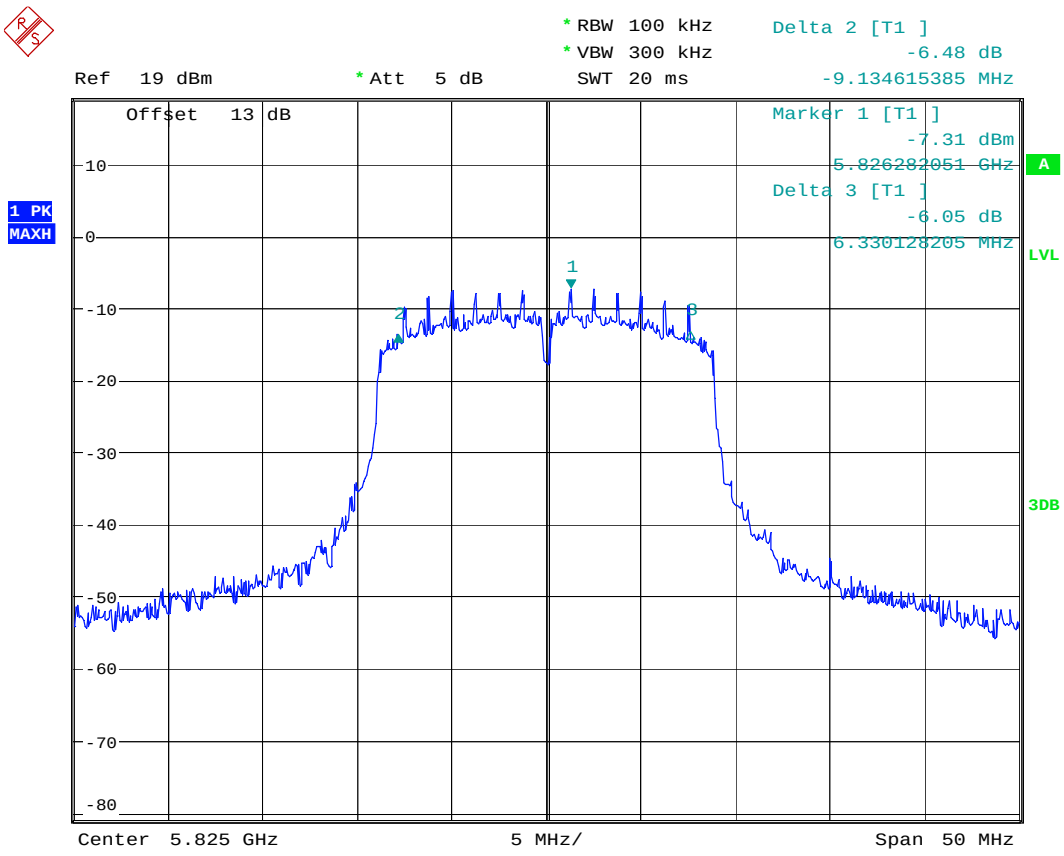
Mid channel	Mode: 802.11n_HT20 MCS0



Date: 3.OCT.2018 17:07:46

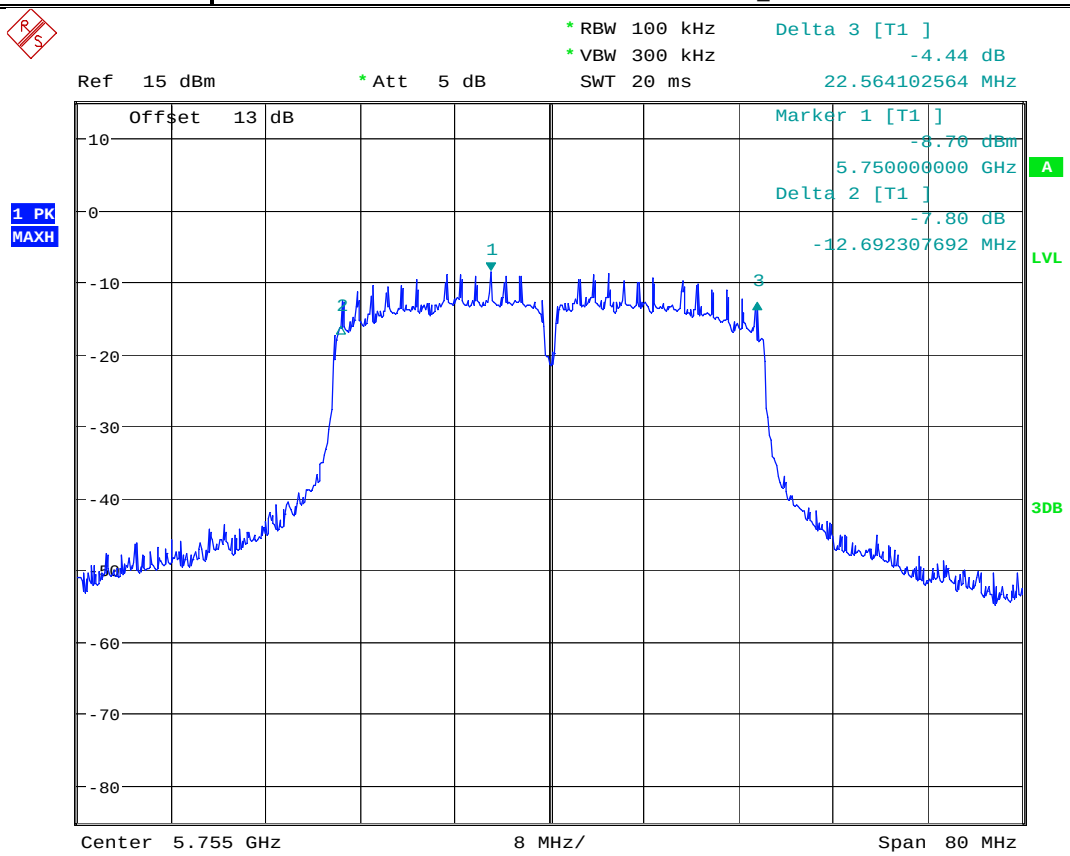
Plot #6

High channel	Mode: 802.11n_HT20 MCS0



Plot #7

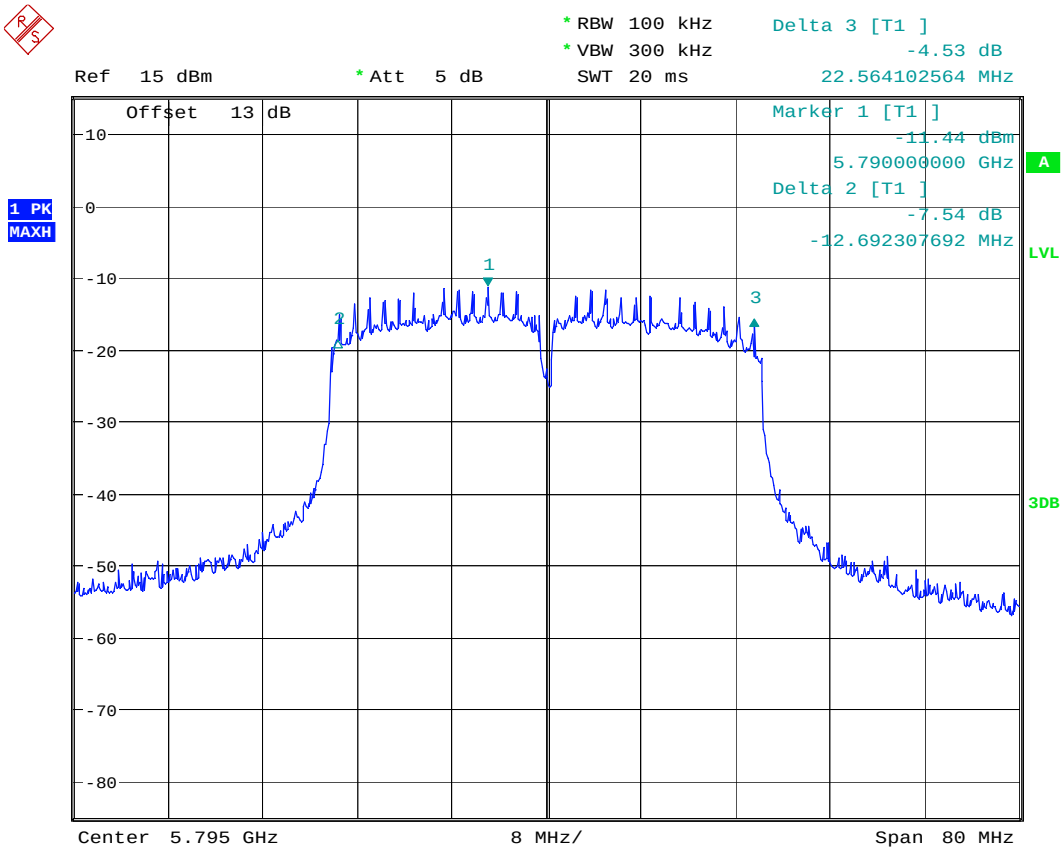
Low channel | **Mode: 802.11n_HT40 MCS0**



Date: 3.OCT.2018 17:11:11

Plot #8

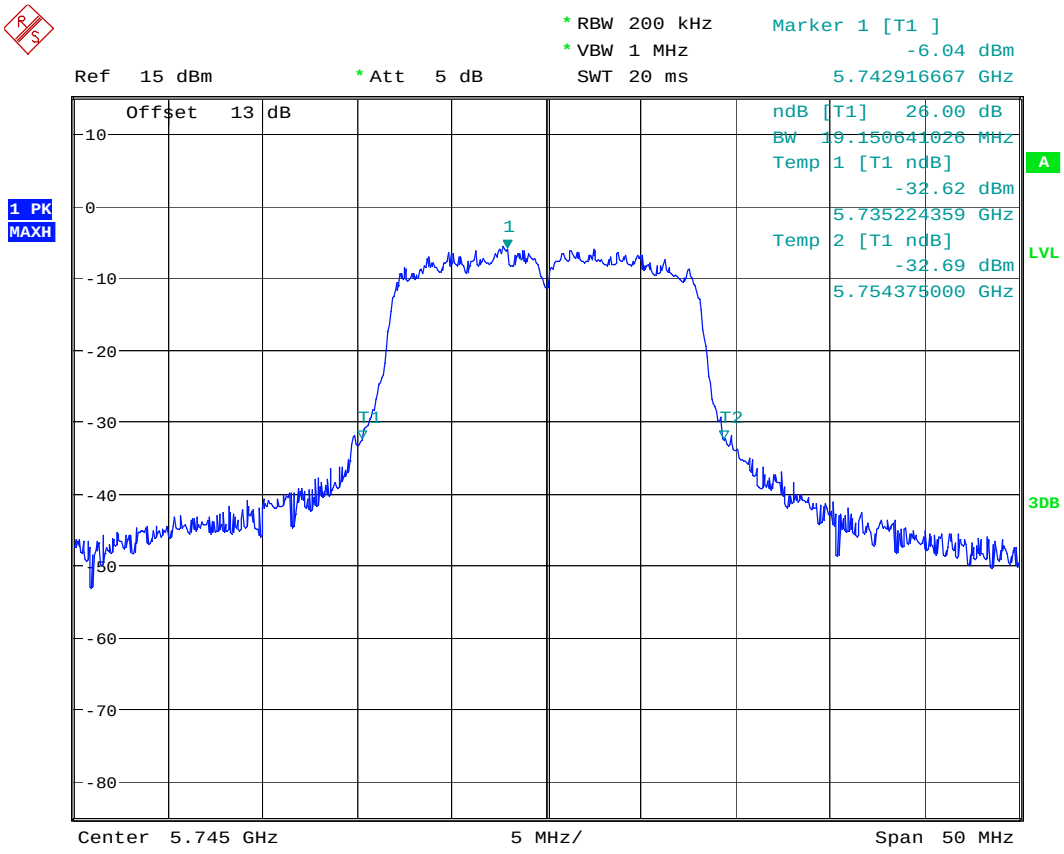
High channel | **Mode: 802.11n_HT40 MCS0**



Date: 3.OCT.2018 17:12:16

Plot #9

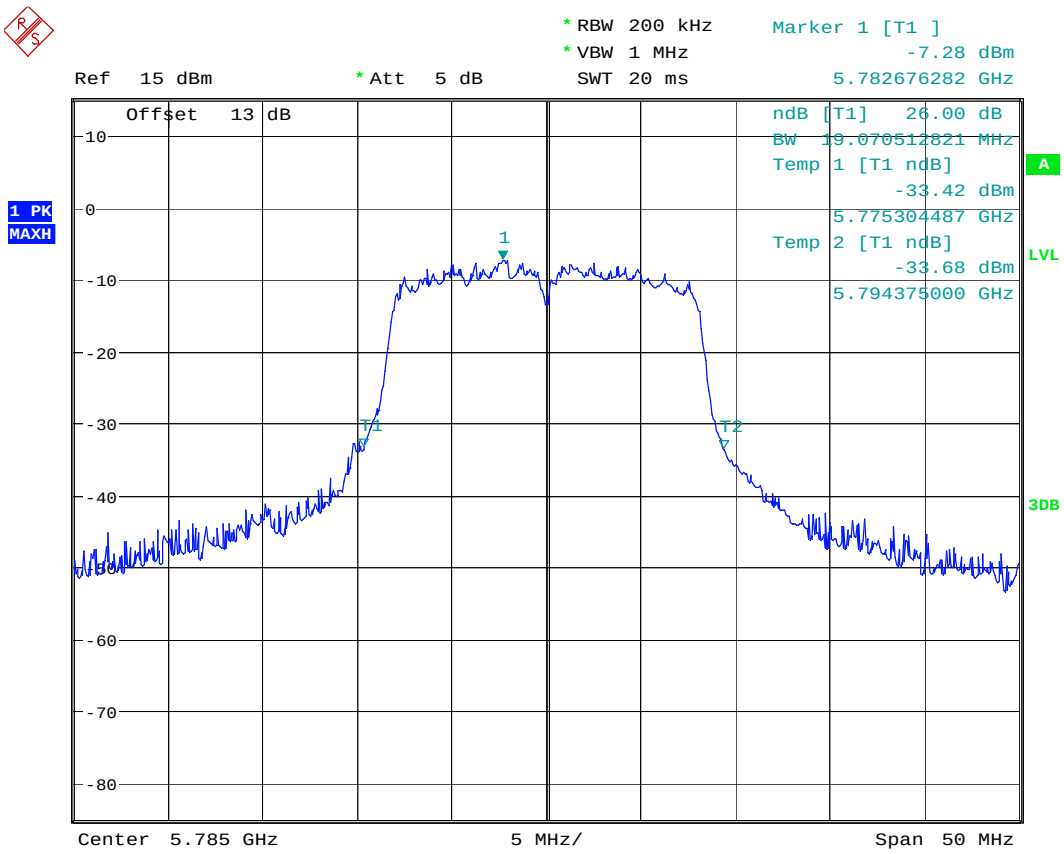
Low channel | **Mode: 802.11a 6Mbps**



Date: 3.OCT.2018 17:19:45

Plot #10

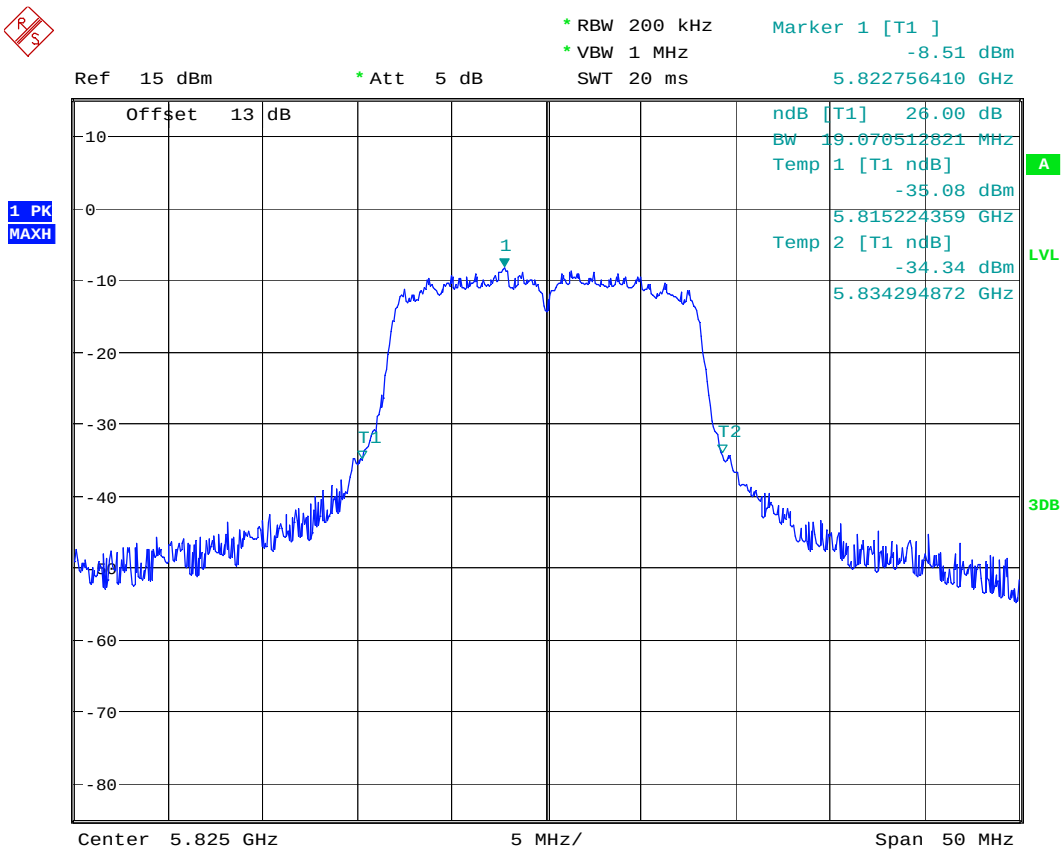
Mid channel	Mode: 802.11a 6Mbps



Date: 3.OCT.2018 17:20:09

Plot #11

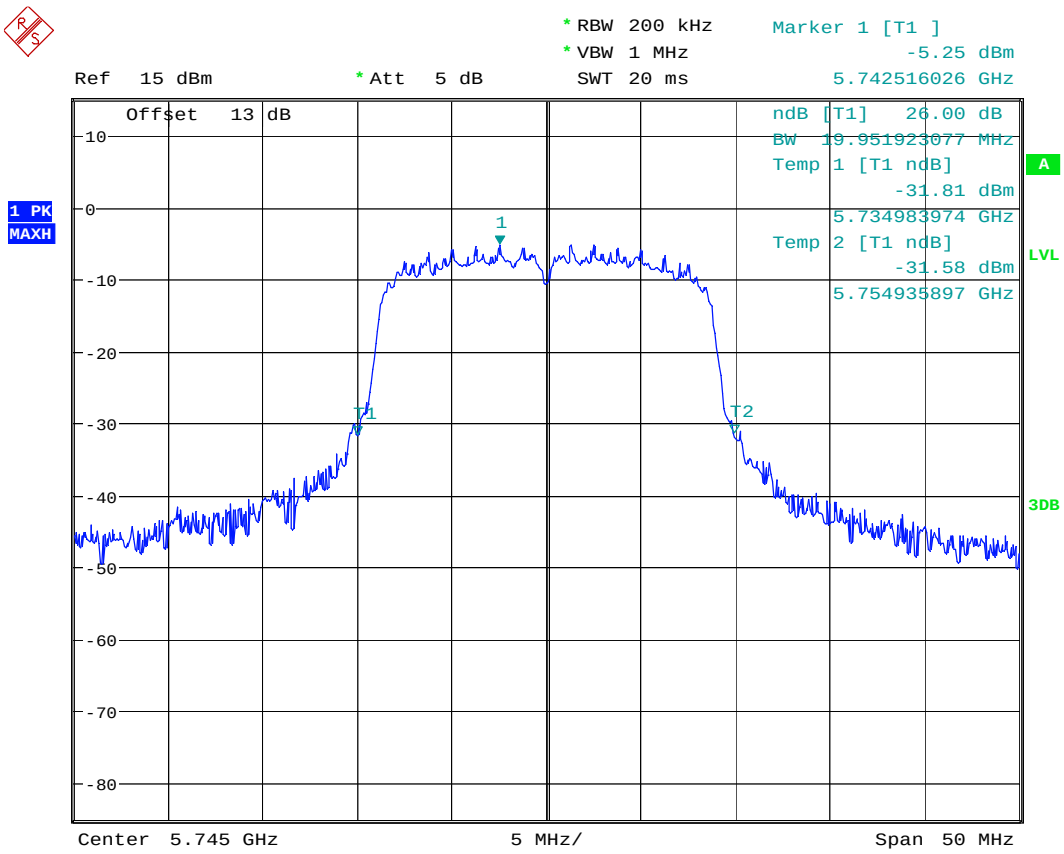
High channel	Mode: 802.11a 6Mbps



Date: 3.OCT.2018 17:20:40

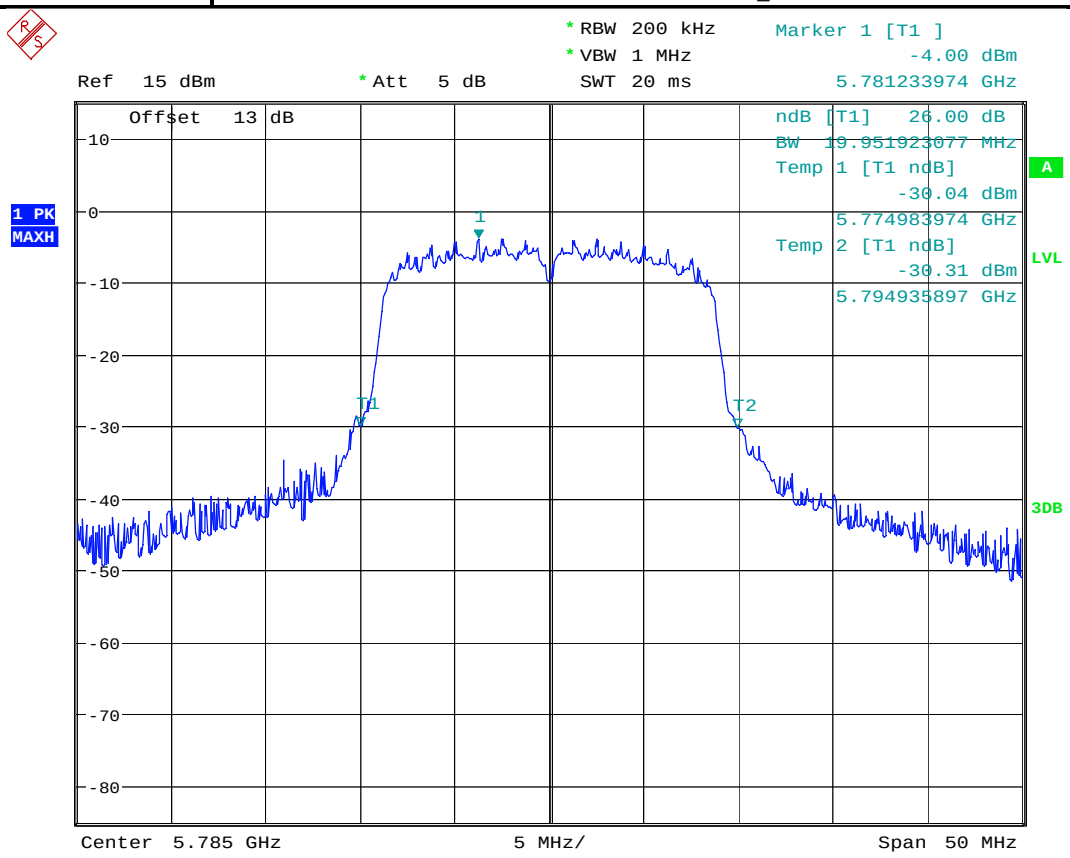
Plot #12

Low channel	Mode: 802.11n_HT20 MCS0



Plot #13

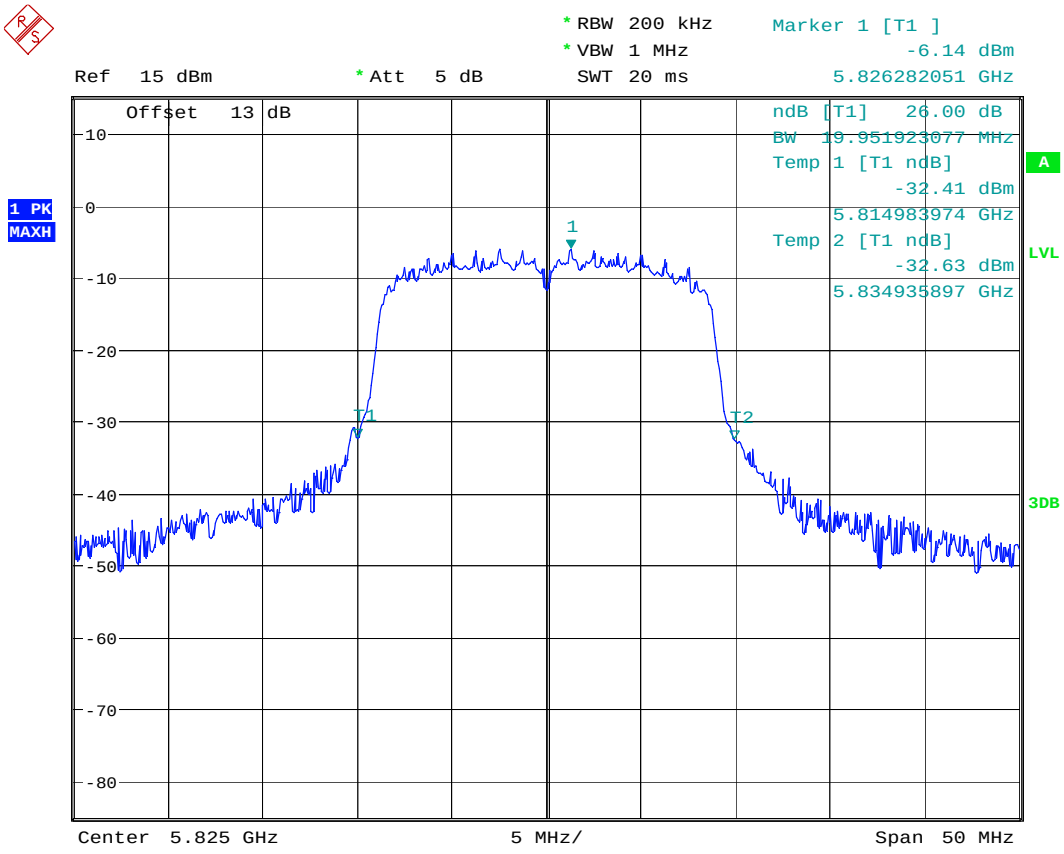
Mid channel | **Mode: 802.11n_HT20 MCS0**



Date: 3.OCT.2018 17:21:54

Plot #14

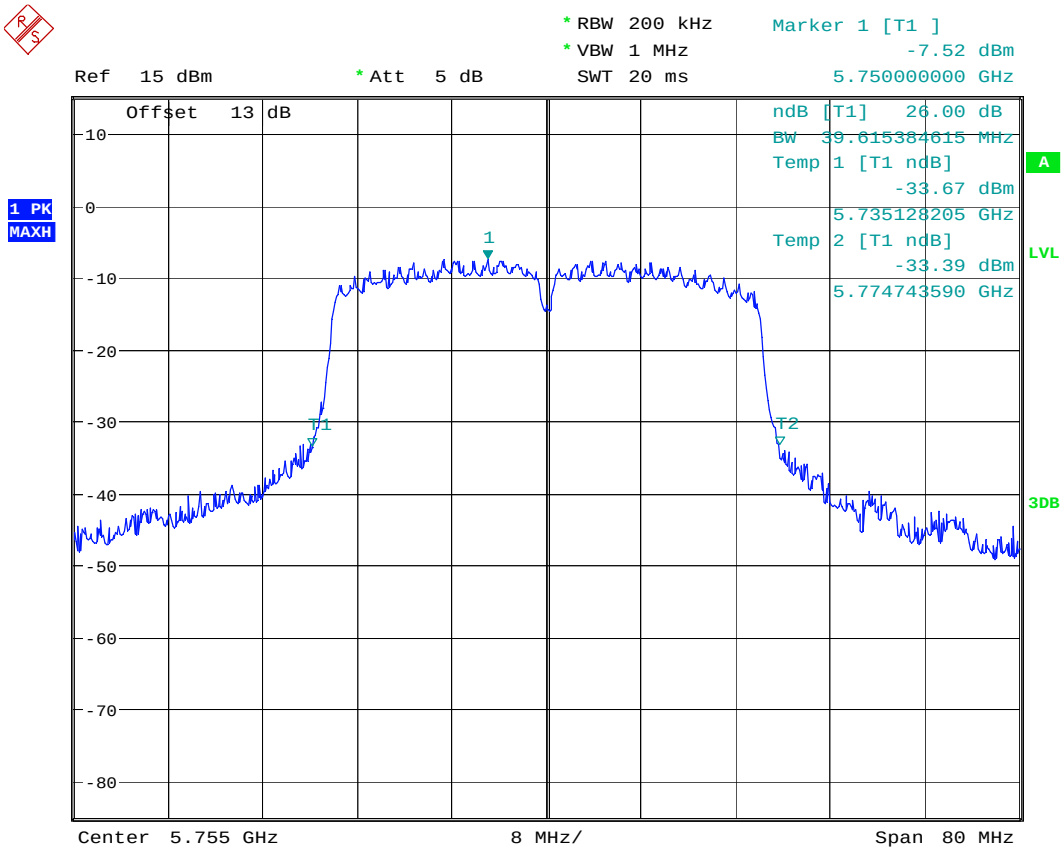
High channel | **Mode: 802.11n_HT20 MCS0**



Date: 3.OCT.2018 17:22:39

Plot #15

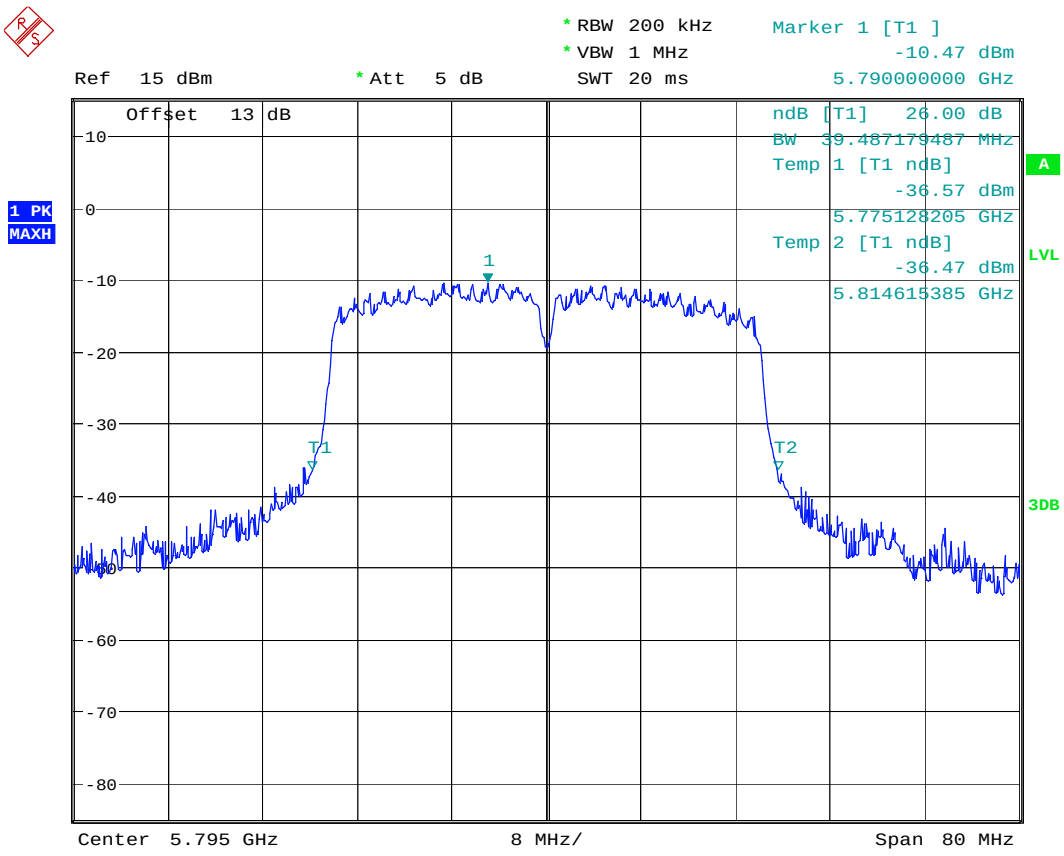
Low channel	Mode: 802.11n_HT40 MCS0



Date: 3.OCT.2018 17:23:49

Plot #16

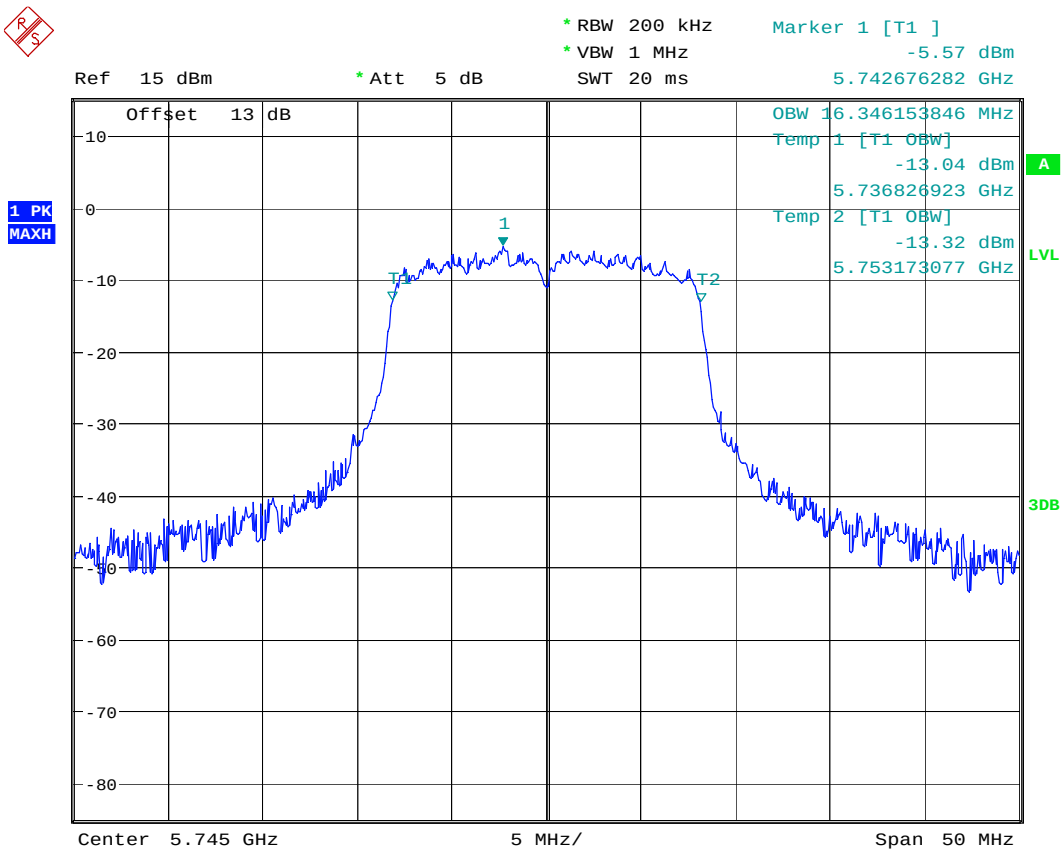
High channel	Mode: 802.11n_HT40 MCS0



Date: 3.OCT.2018 17:24:22

Plot #17

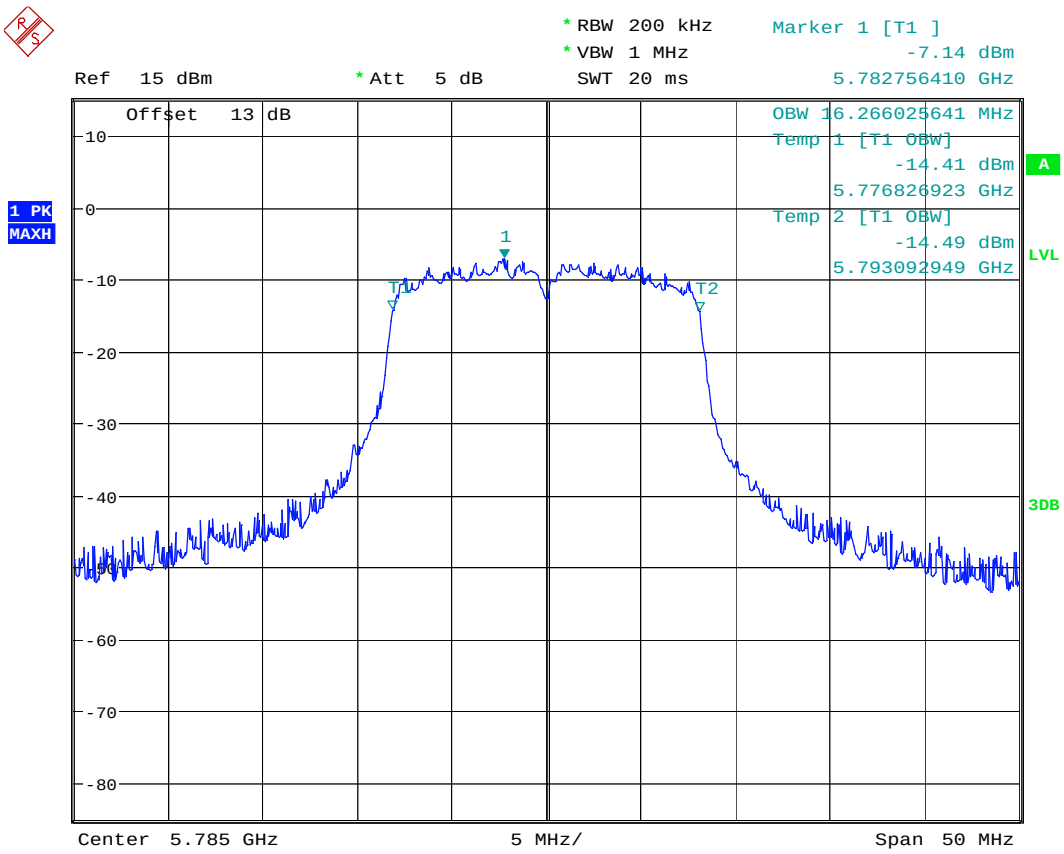
Low channel	Mode: 802.11a 6Mbps



Date: 3.OCT.2018 17:14:34

Plot #18

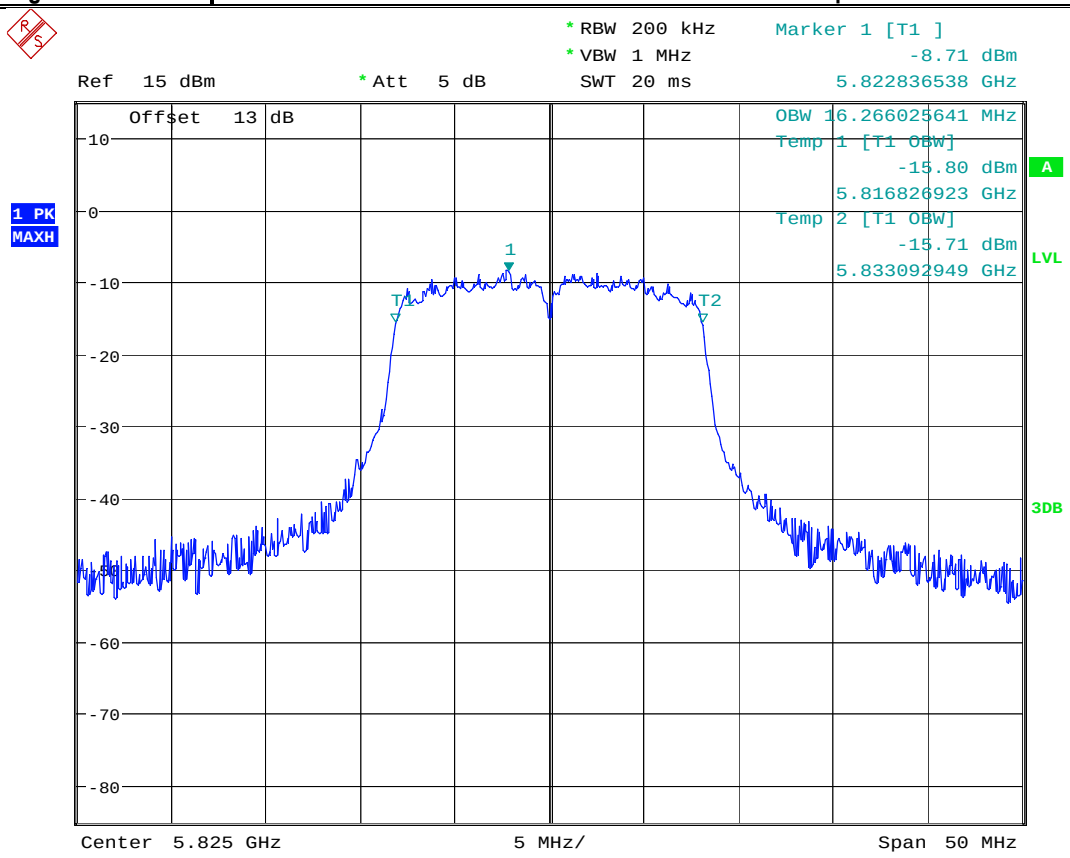
Mid channel	Mode: 802.11a 6Mbps



Date: 3.OCT.2018 17:15:03

Plot #19

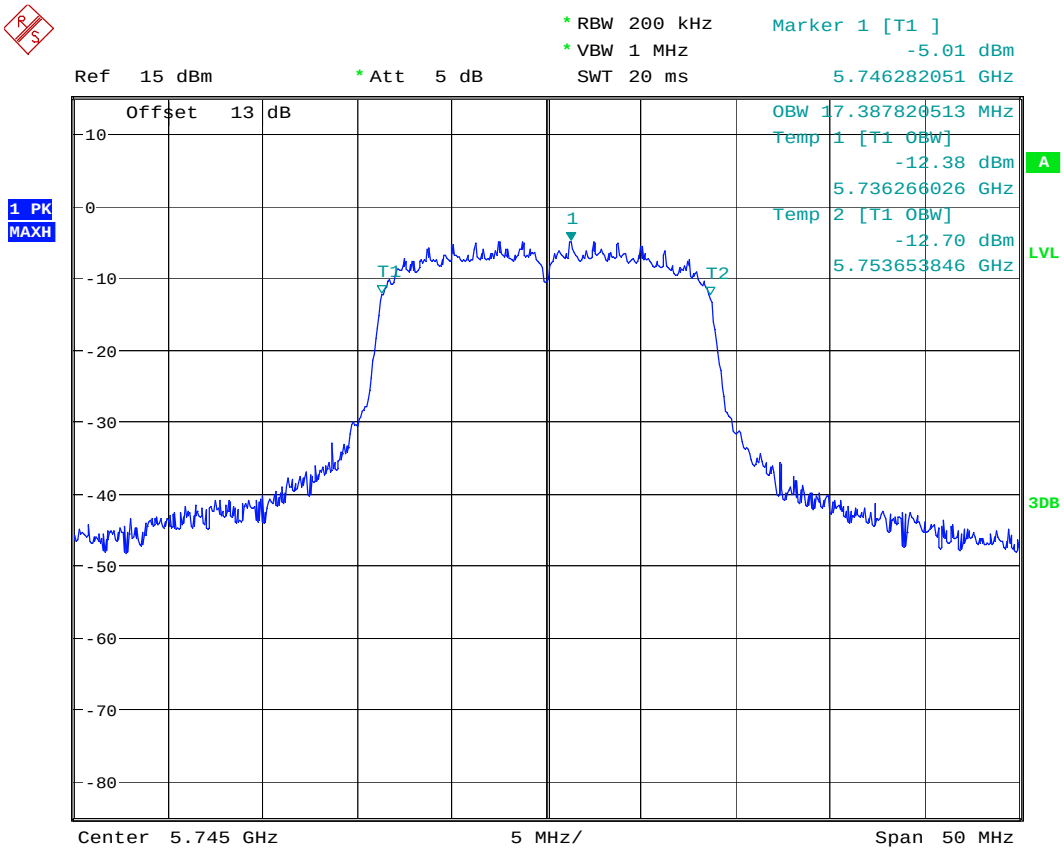
High channel | **Mode: 802.11a 6Mbps**



Date: 3.OCT.2018 17:15:31

Plot #20

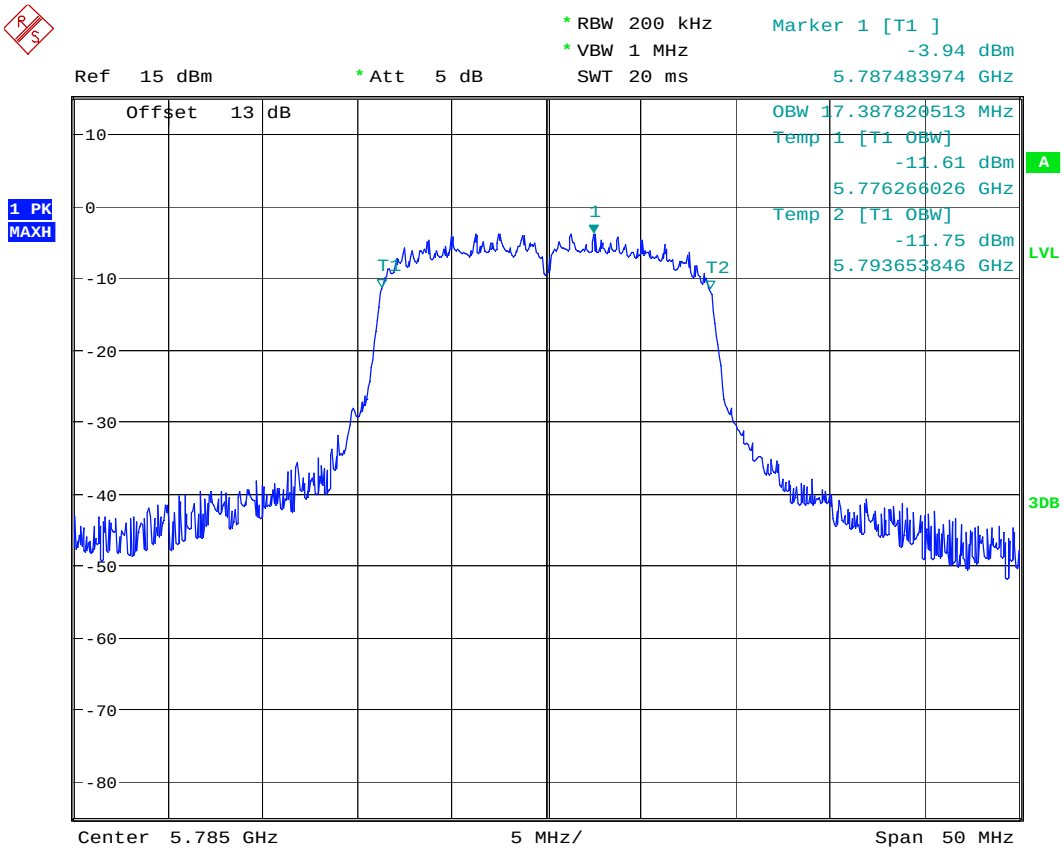
Low channel | **Mode: 802.11n_HT20 MCS0**



Date: 3.OCT.2018 17:16:36

Plot #21

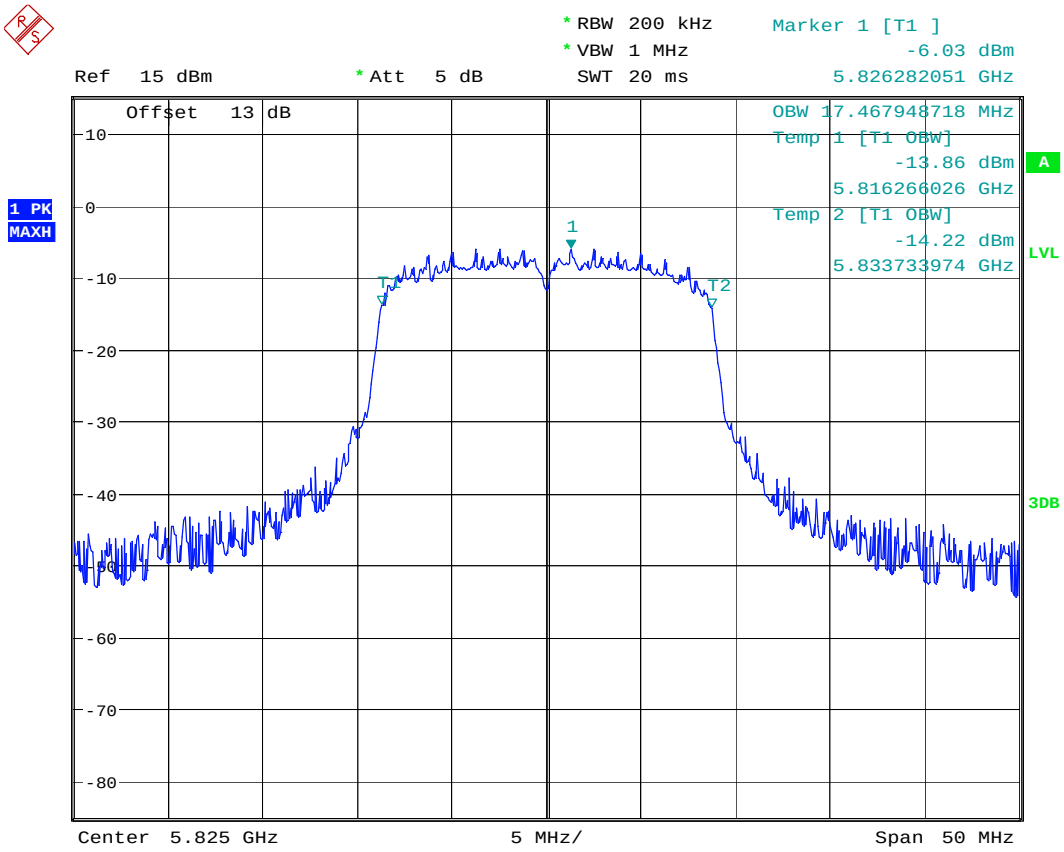
Mid channel | **Mode: 802.11n_HT20 MCS0**



Date: 3.OCT.2018 17:17:04

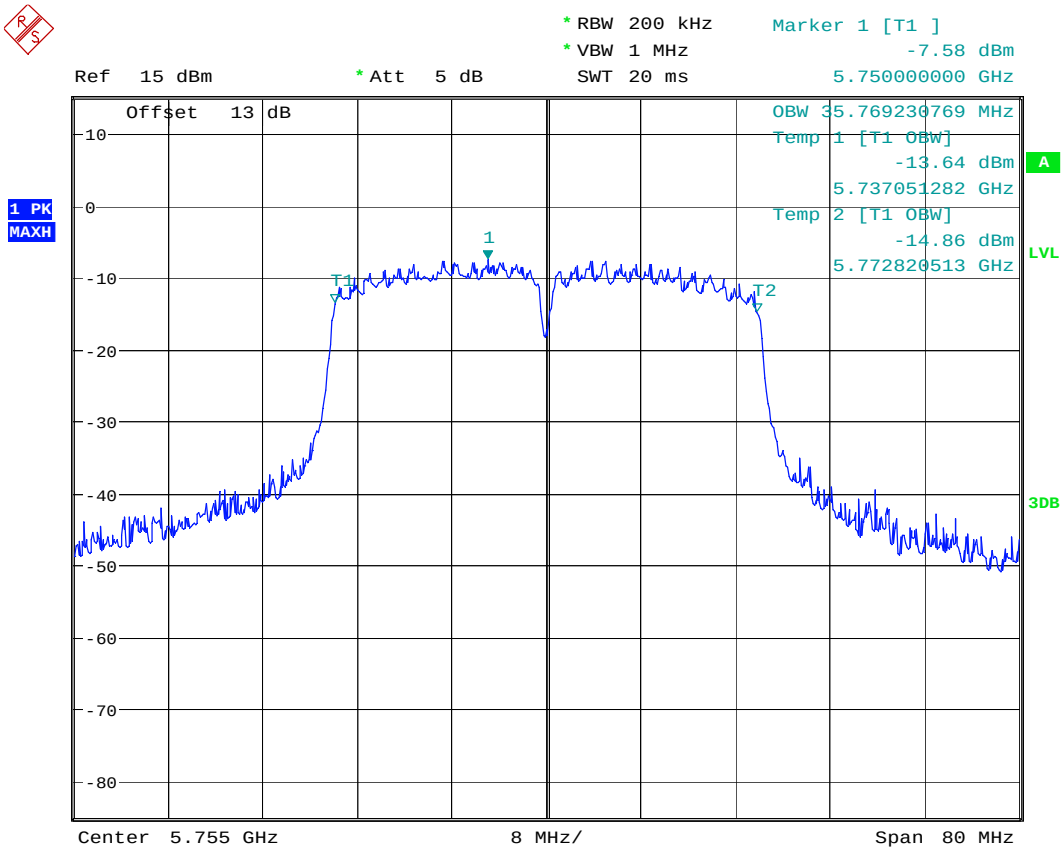
Plot #22

High channel	Mode: 802.11n_HT20 MCS0



Plot #23

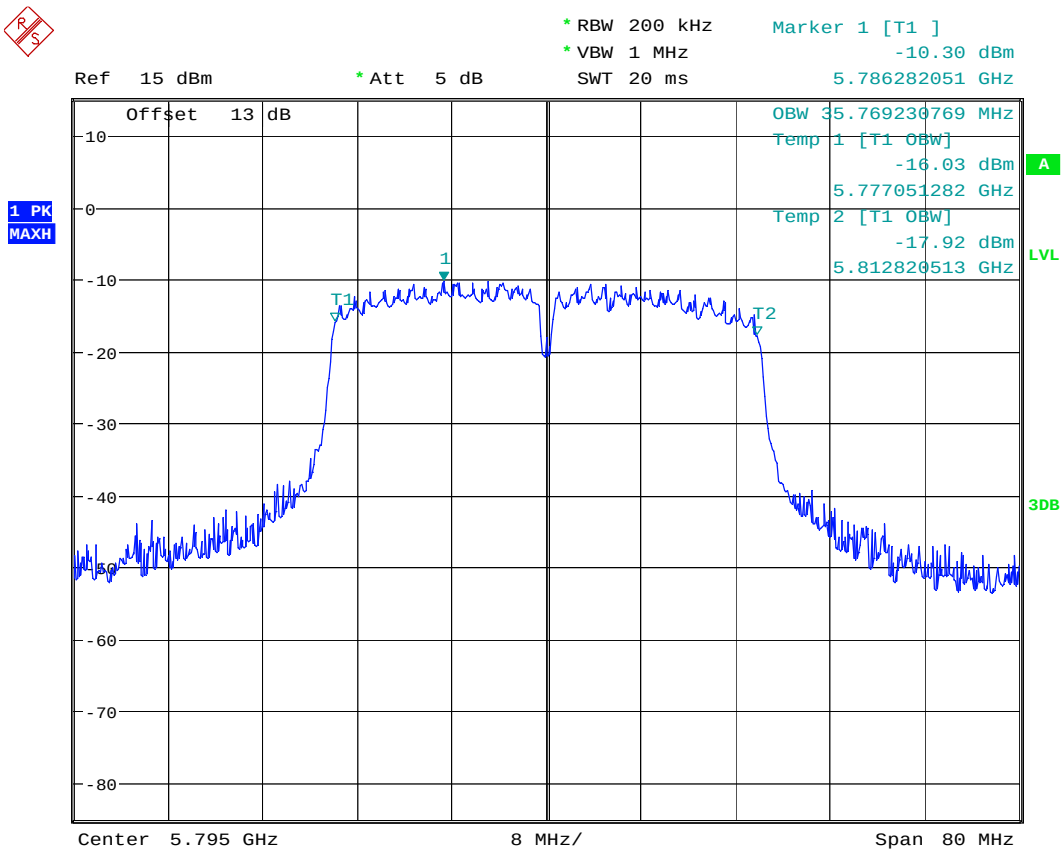
Low channel	Mode: 802.11n_HT40 MCS0



Date: 3.OCT.2018 17:18:09

Plot #24

High channel	Mode: 802.11n_HT40 MCS0



Date: 3.OCT.2018 17:18:35

8.6 Frequency stability

8.6.1 Measurement Procedure

- The EUT was placed inside temperature chamber
- Set the EUT to the operation mode needed
- Set the chamber to the highest temperature specified
- Allow sufficient time for the temperature of the chamber to stabilize, measure the operating frequency
- Repeat step with the temperature chamber set to lowest temperature

8.6.2 Limits:

FCC §15.407(g)

- Manufacturers of U-NII 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 users manual

8.6.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
See section 8.6.4	2	802.11n_HT20 Tx Chain1	USB 5VDC

8.6.4 Measurement result:

Temp	802.11n_HT20	Measured CF	ACF	Frequency Stability (ppm)
25°C	149	5745.013	5745	2.27
	157	5784.98	5785	3.52
	165	5824.962	5825	6.47
-20°C	149	5745.025	5745	4.30
	157	5784.999	5785	0.23
	165	5824.994	5825	1.03
70°C	149	5745.001	5745	0.11
	157	5785.025	5785	4.27
	165	5824.958	5825	7.16

8.7 Radiated Transmitter Spurious Emissions and Restricted Bands

8.7.1 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

8.7.2 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

8.7.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	2	802.11n_HT20 MIMO	USB 5VDC

8.7.4 Measurement result:

Plot #	Channel #	Scan Frequency	Limit	Result
1-4	Low	30 MHz – 18 GHz	See section 8.6.2	Pass
5-10	Mid	9 kHz – 40 GHz	See section 8.6.2	Pass
11-14	High	30 MHz – 18 GHz	See section 8.6.2	Pass

8.7.5 Measurement Plots:

Plot #1 Radiated Emissions: 30 MHz – 1GHz

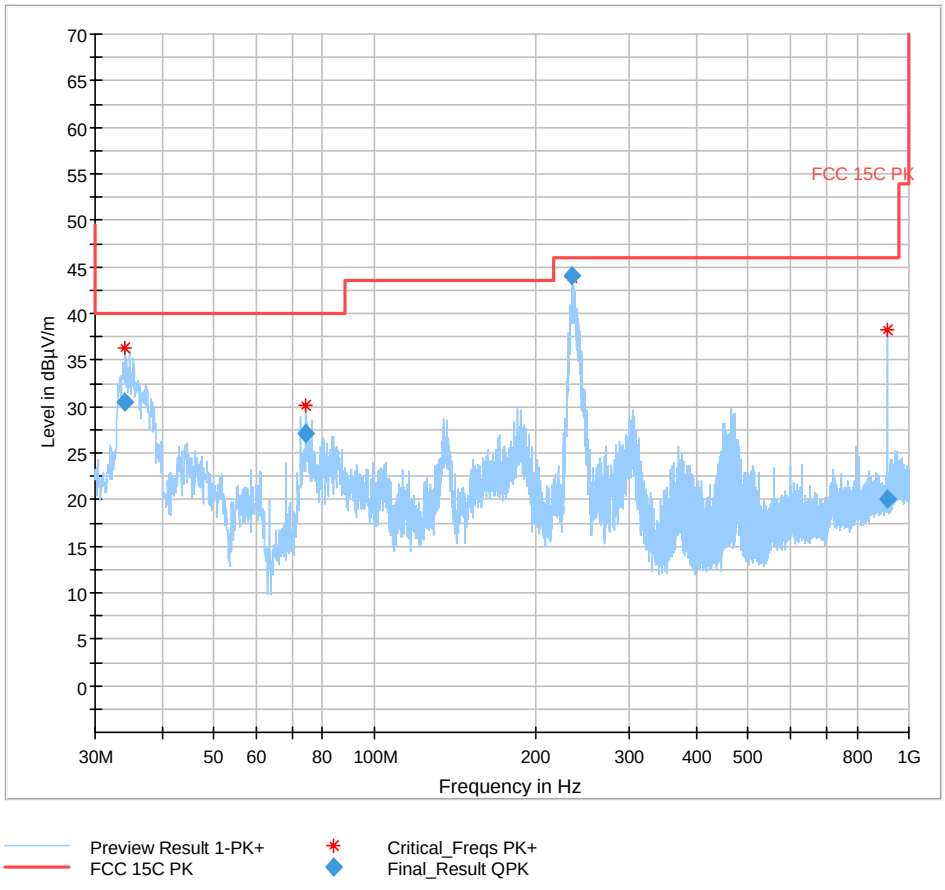
Modulation: 802.11n_HT20 MIMO	Channel: Low	95.86% Duty Cycle

Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azim (de
34.197550	30.50	40.00	9.50	500.0	100.000	120.0	V	2
74.142995	27.11	40.00	12.89	500.0	100.000	250.0	V	2
234.163680	43.99	46.00	2.01	500.0	100.000	142.0	H	1
914.097400	20.14	46.00	25.86	500.0	100.000	196.0	V	1

(continuation of the "Final_Result" table from column 16 ...)

Frequency (MHz)
34.197550
74.142995
234.163680
914.097400



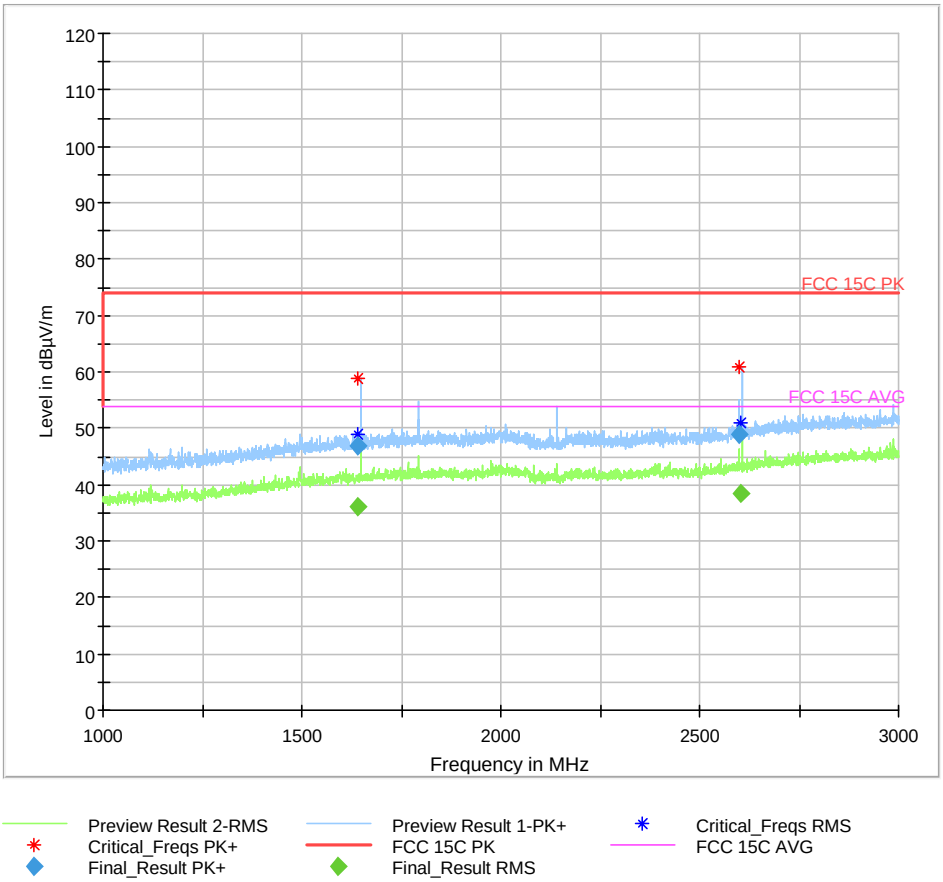
Plot #2 Radiated Emissions: 1-3 GHz		
Modulation: 802.11n_HT20 MIMO	Channel: Low	95.86% Duty Cycle

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)
1640.950000	---	36.16	53.98	17.82	100.0	1000.000	271.0
1641.295000	46.76	---	74.00	27.24	100.0	1000.000	171.0
2600.800000	49.05	---	73.99	24.94	100.0	1000.000	129.0
2604.420000	---	38.32	53.98	15.66	100.0	1000.000	316.0

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

Frequency (MHz)	Corr. (dB)	Comment
1640.950000	7.8	5:09:06 PM - 10/5/2018
1641.295000	7.8	5:02:13 PM - 10/5/2018
2600.800000	8.7	5:05:42 PM - 10/5/2018
2604.420000	8.8	5:12:48 PM - 10/5/2018



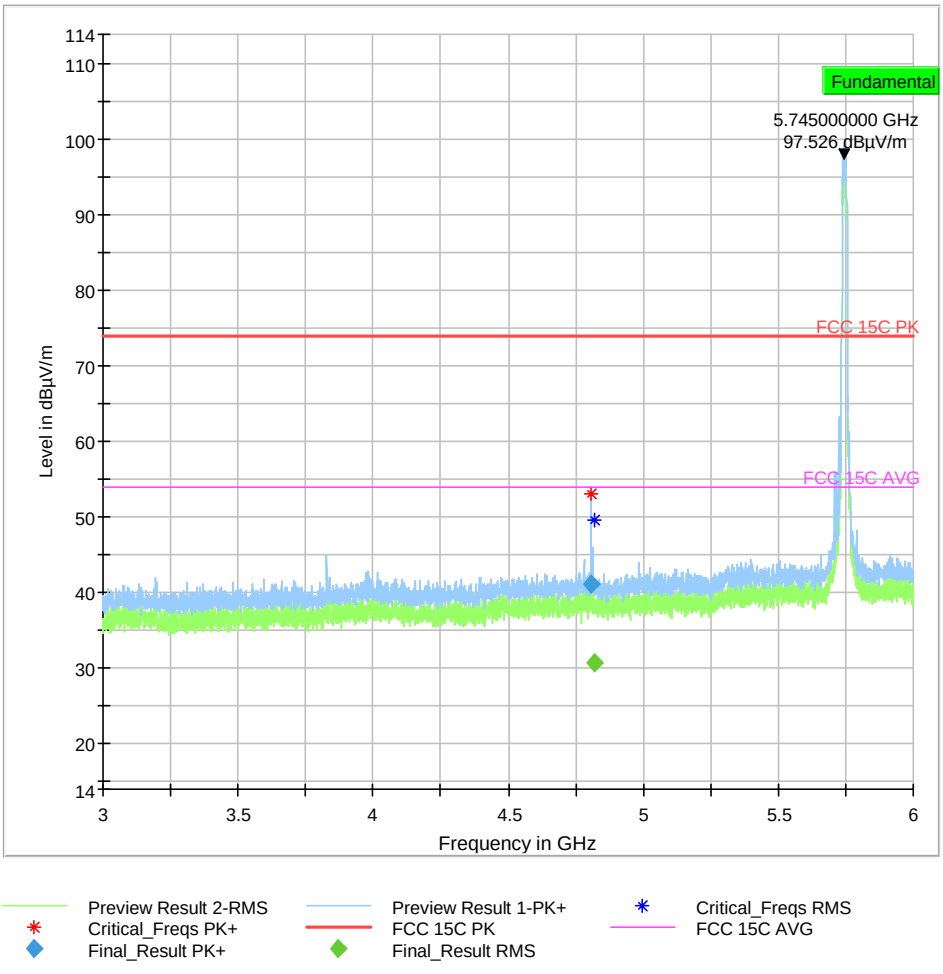
Plot #3 Radiated Emissions: 3-6 GHz		
Modulation: 802.11n_HT20 MIMO	Channel: Low	95.86% Duty Cycle

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)
4805.173333	41.08	---	73.99	32.90	100.0	1000.000	211.0
4817.220000	---	30.65	53.98	23.33	100.0	1000.000	226.0

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

Frequency (MHz)	Corr. (dB)	Comment
4805.173333	-6.5	1:41:56 PM - 10/5/2018
4817.220000	-6.5	1:44:58 PM - 10/5/2018



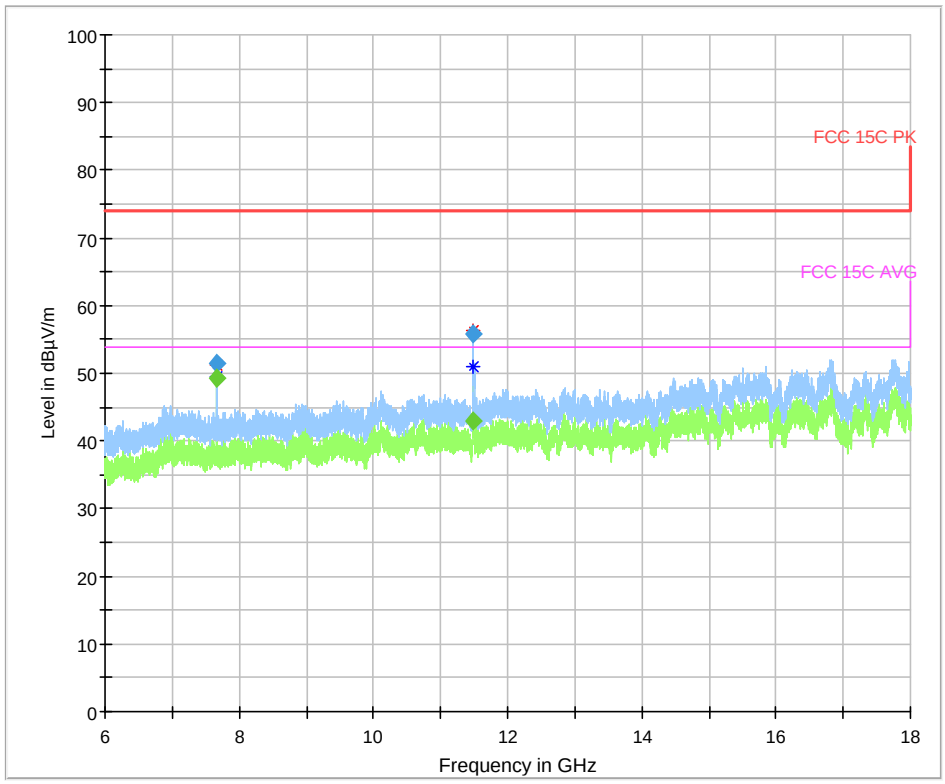
Plot #4 Radiated Emissions: 6-18 GHz		
Modulation: 802.11n_HT20 MIMO	Channel: Low	95.86% Duty Cycle

Final_Result

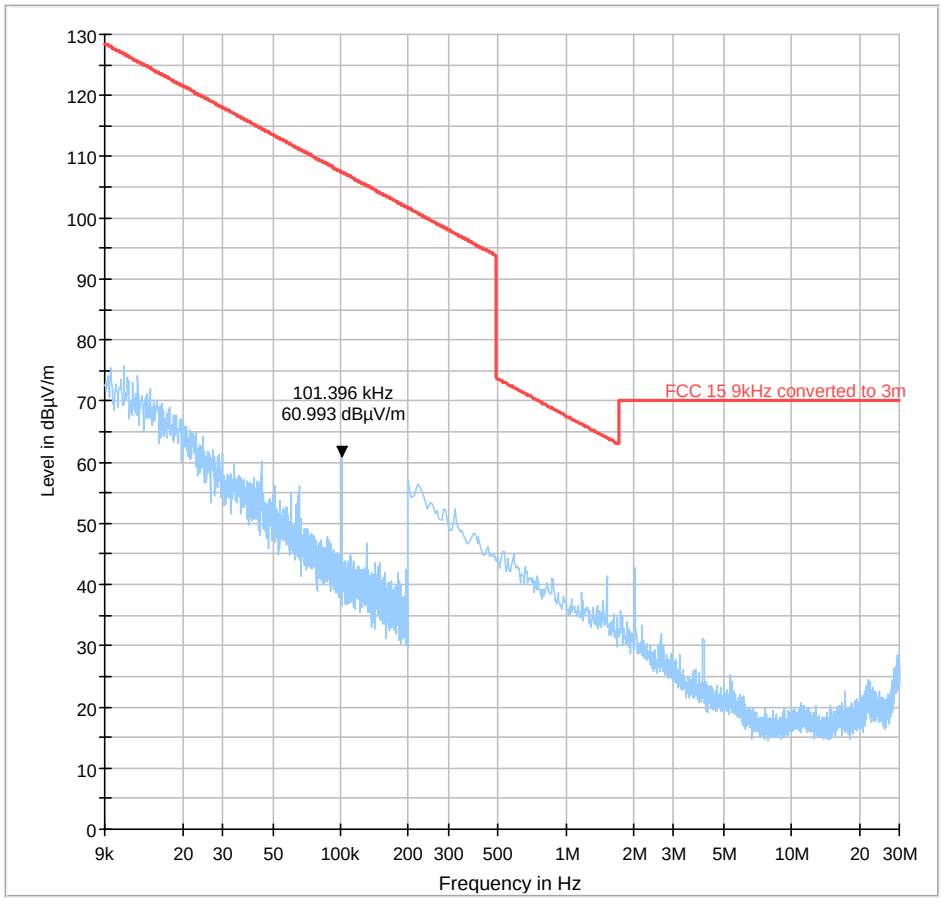
Frequency (MHz)	MaxPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)
7659.887500	51.53	---	73.99	22.46	100.0	1000.000	165.0
7660.018333	---	49.32	53.98	4.66	100.0	1000.000	172.0
11487.428333	---	42.88	53.98	11.10	100.0	1000.000	256.0
11488.403333	55.79	---	73.98	18.20	100.0	1000.000	253.0

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

Frequency (MHz)	Corr. (dB)	Comment
7659.887500	-29.4	1:56:05 PM - 9/28/2018
7660.018333	-29.4	2:02:38 PM - 9/28/2018
11487.428333	-24.0	1:59:14 PM - 9/28/2018
11488.403333	-24.0	1:52:40 PM - 9/28/2018



Plot #5 Radiated Emissions: 9 KHz – 30 MHz		
Modulation: 802.11n_HT20 MIMO	**Channel: Mid**	**95.86% Duty Cycle**



Plot #6 Radiated Emissions: 30 MHz – 1GHz

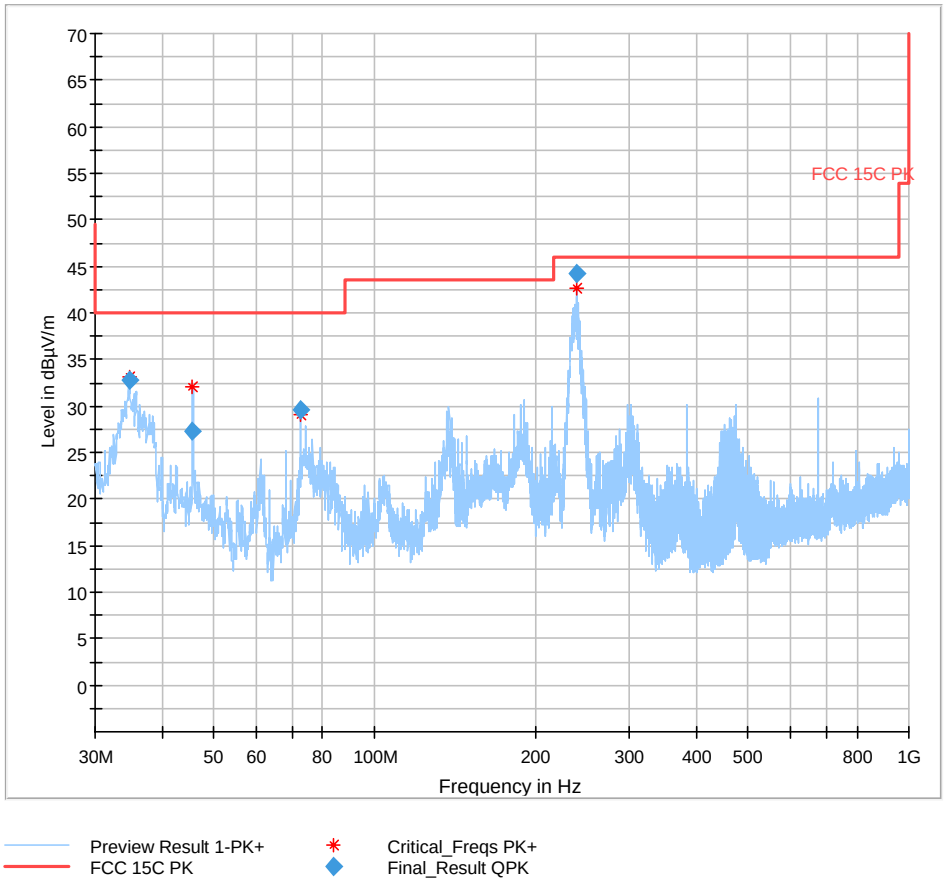
Modulation: 802.11n_HT20 MIMO	Channel: Mid	95.86% Duty Cycle

Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azim (de
34.866795	32.73	40.00	7.27	500.0	100.000	240.0	V	2
45.723885	27.33	40.00	12.67	500.0	100.000	100.0	V	
72.913420	29.51	40.00	10.49	500.0	100.000	260.0	V	1
238.770305	44.23	46.00	1.77	500.0	100.000	141.0	H	1

(continuation of the "Final_Result" table from column 16 ...)

Frequency (MHz)
34.866795
45.723885
72.913420
238.770305



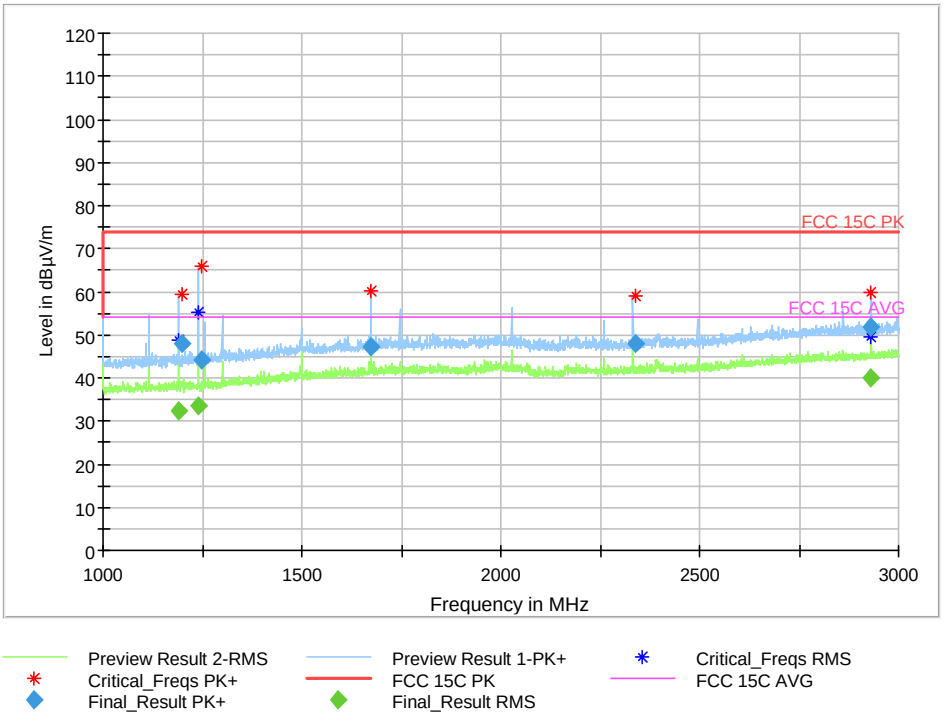
Plot #7 Radiated Emissions: 1-3 GHz		
Modulation: 802.11n_HT20 MIMO	Channel: Mid	95.86% Duty Cycle

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)
1191.305000	---	32.53	53.98	21.45	100.0	1000.000	255.0
1198.705000	47.81	---	74.00	26.18	100.0	1000.000	229.0
1240.365000	---	33.52	53.98	20.46	100.0	1000.000	248.0
1249.260000	44.34	---	74.00	29.65	100.0	1000.000	320.0
1671.665000	47.34	---	74.00	26.66	100.0	1000.000	324.0
2339.400000	48.11	---	73.99	25.88	100.0	1000.000	150.0
2930.180000	---	40.10	53.98	13.88	100.0	1000.000	190.0
2931.515000	51.67	---	73.99	22.33	100.0	1000.000	304.0

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

Frequency (MHz)	Corr. (dB)	Comment
1191.305000	4.8	4:42:19 PM - 10/5/2018
1198.705000	4.9	4:26:36 PM - 10/5/2018
1240.365000	5.0	4:45:43 PM - 10/5/2018
1249.260000	5.1	4:29:42 PM - 10/5/2018
1671.665000	8.1	4:33:06 PM - 10/5/2018
2339.400000	8.3	4:36:08 PM - 10/5/2018
2930.180000	10.9	4:49:20 PM - 10/5/2018
2931.515000	10.9	4:39:07 PM - 10/5/2018



Plot #8 Radiated Emissions: 3-6 GHz

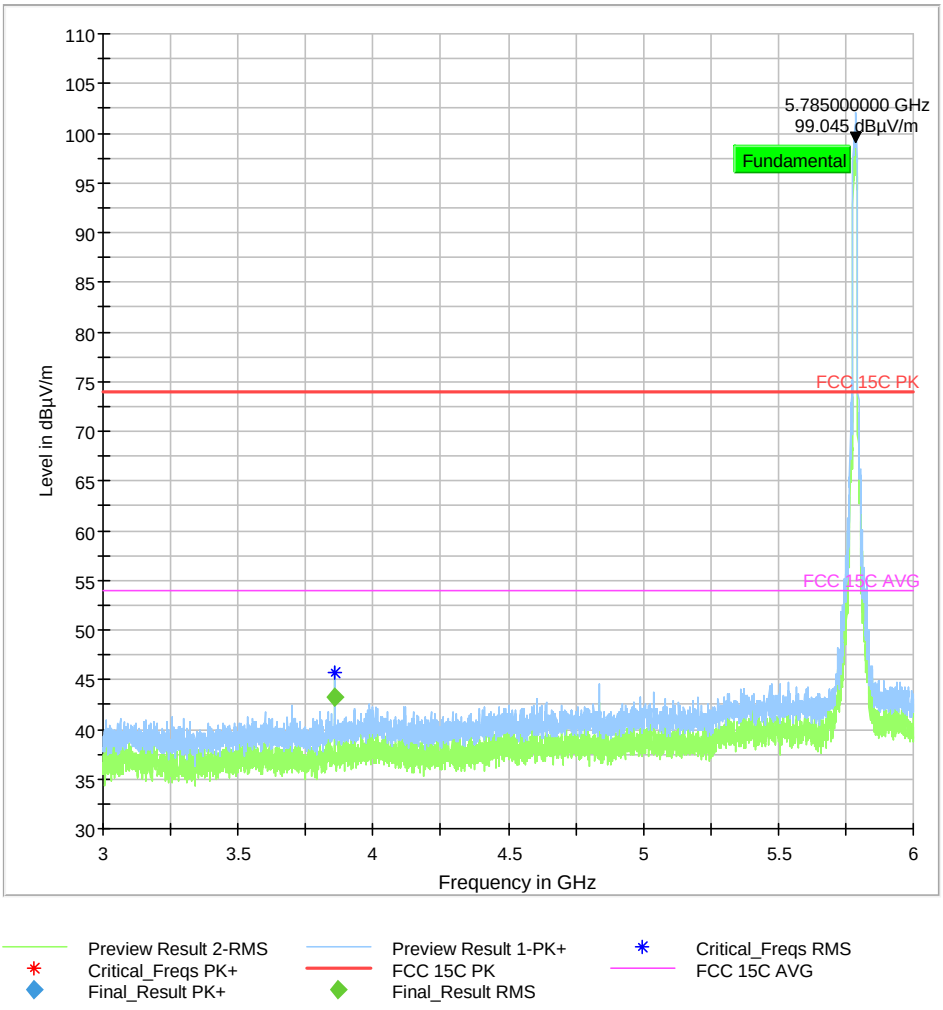
Modulation: 802.11n_HT20 MIMO	Channel: Mid	95.86% Duty Cycle

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)
3856.663333	---	43.26	53.98	10.72	100.0	1000.000	107.0

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

Frequency (MHz)	Corr. (dB)	Comment
3856.663333	-8.0	2:09:09 PM - 10/5/2018



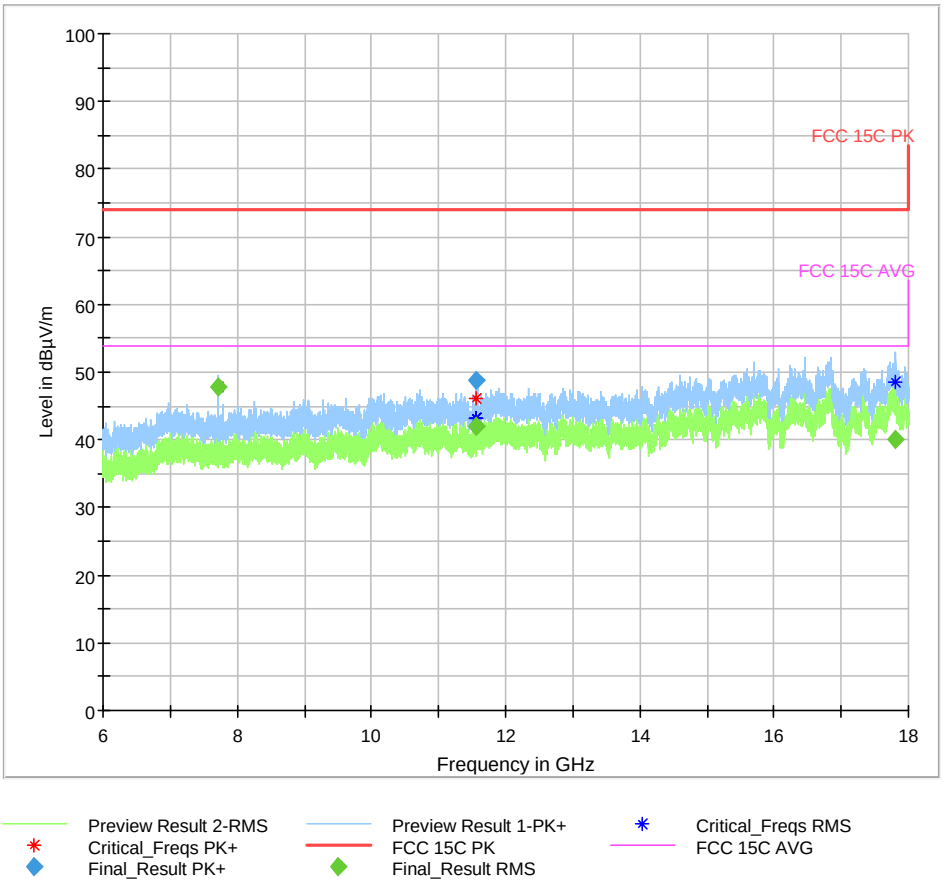
Plot #9 Radiated Emissions: 6-18 GHz		
Modulation: 802.11n_HT20 Tx Chain0	Channel: Mid	95.86% Duty Cycle

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)
7713.405833	---	47.93	53.98	6.05	100.0	1000.000	130.0
11569.660000	48.85	---	73.98	25.14	100.0	1000.000	140.0
11569.900833	---	41.95	53.98	12.03	100.0	1000.000	254.0
17796.090833	---	40.01	53.98	13.97	100.0	1000.000	331.0

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

Frequency (MHz)	Corr. (dB)	Comment
7713.405833	-29.4	10:45:01 AM - 10/1/2018
11569.660000	-23.5	10:30:10 AM - 10/1/2018
11569.900833	-23.5	10:57:20 AM - 10/1/2018
17796.090833	-12.7	10:51:40 AM - 10/1/2018



Plot #9 Radiated Emissions: 6-18 GHz

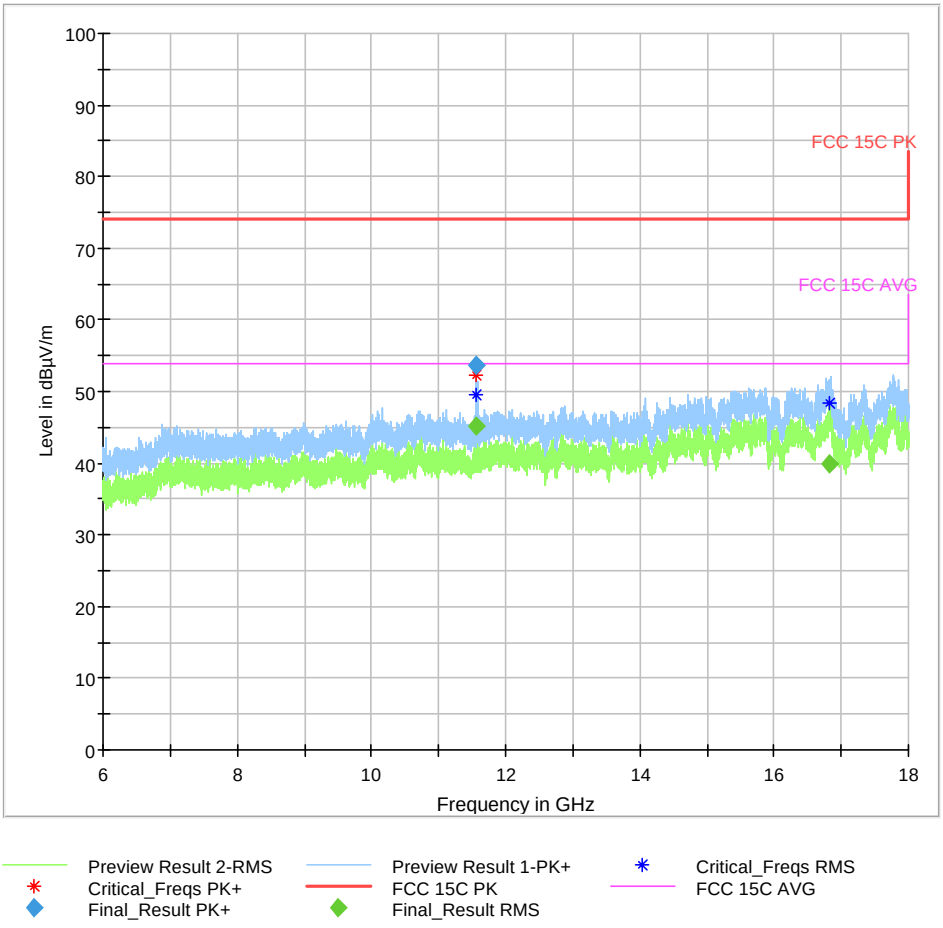
Modulation: 802.11n_HT20 Tx Chain1	Channel: Mid	95.86% Duty Cycle

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)
11569.623333	---	45.15	53.98	8.82	100.0	1000.000	225.0
11569.655000	53.59	---	73.98	20.39	100.0	1000.000	145.0
16821.453333	---	39.83	53.98	14.15	100.0	1000.000	140.0

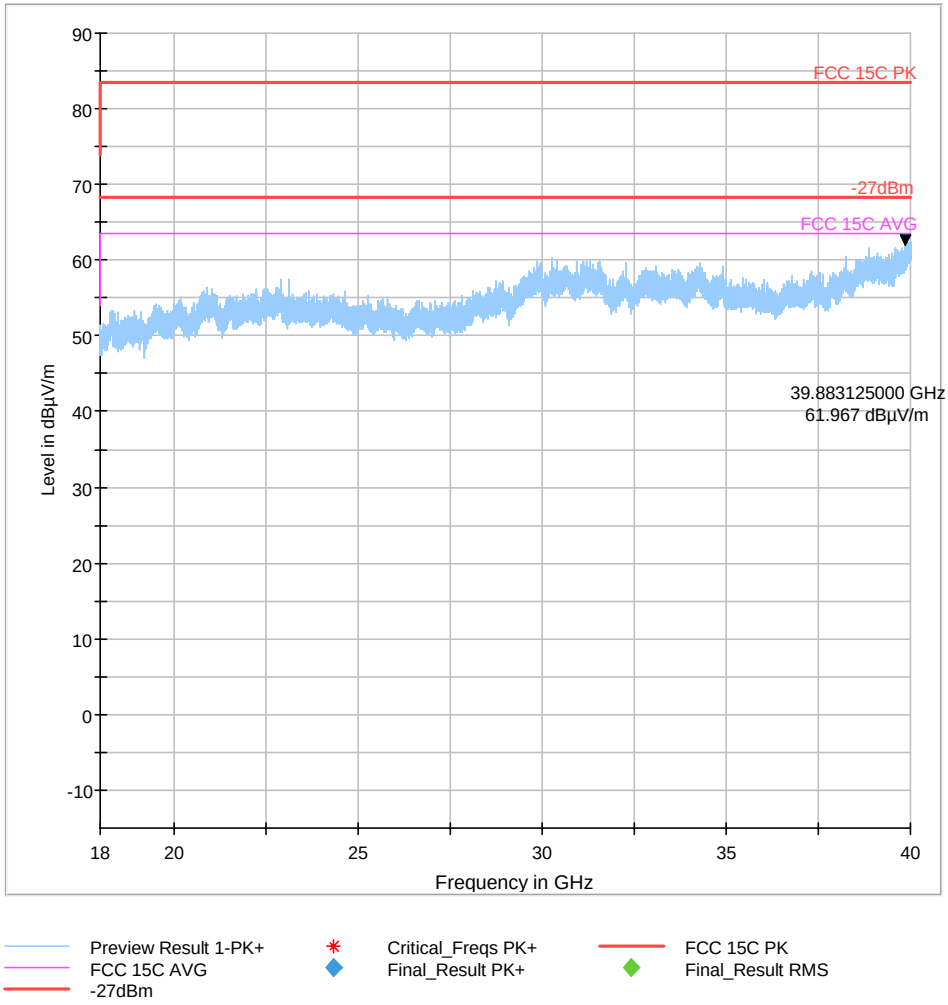
(continuation of the "Final_Result" table from column 15 ...)

Frequency (MHz)	Corr. (dB)	Comment
11569.623333	-23.5	10:07:33 AM - 10/1/2018
11569.655000	-23.5	10:04:15 AM - 10/1/2018
16821.453333	-14.8	10:11:09 AM - 10/1/2018



Note: Two transmit chains were tested separately, the critical point (2nd harmonic) was evaluated after testing for MIMO mode. The added up RMS value(49.76dBuV/m @3m) of 2nd harmonic still meet the requirement

Plot #10 Radiated Emissions: 18-40 GHz		
Modulation: 802.11n_HT20 MIMO	**Channel: Mid**	**95.86% Duty Cycle**



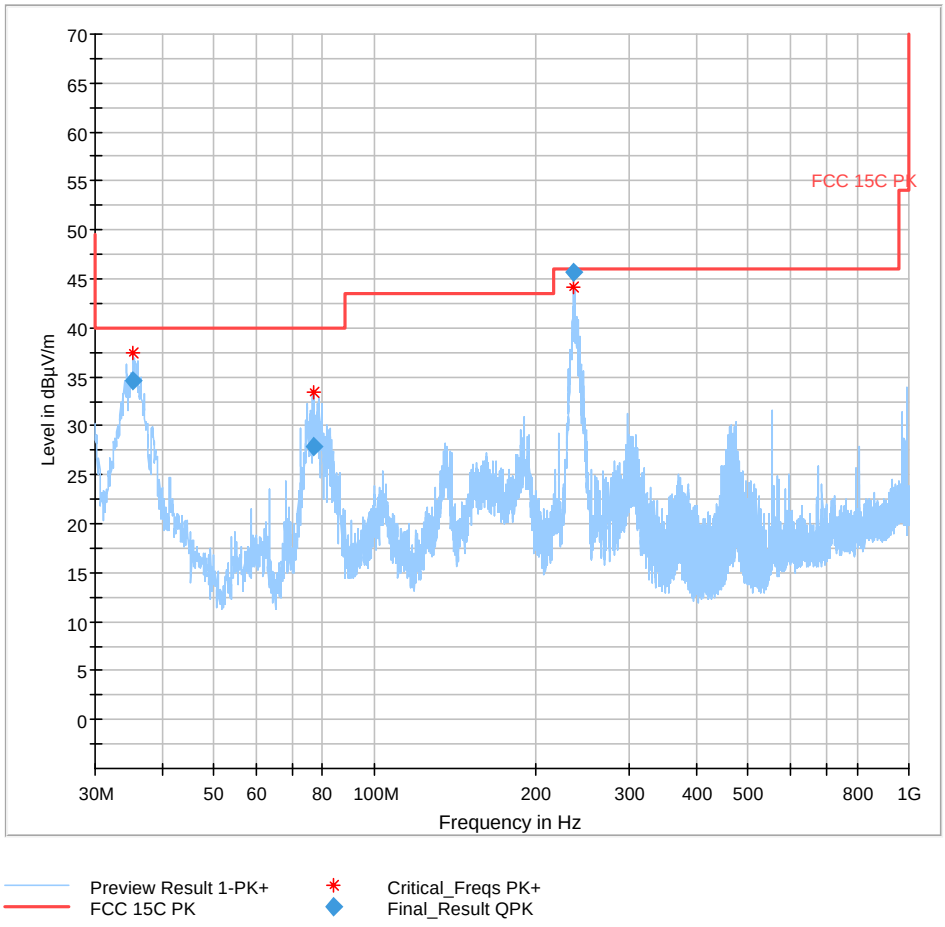
Plot #11 Radiated Emissions: 30 MHz – 1GHz		
Modulation: 802.11n_HT20 MIMO	Channel: High	95.86% Duty Cycle

Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azim (de
35.260940	34.55	40.00	5.45	500.0	100.000	100.0	V	
76.709380	27.81	40.00	12.19	500.0	100.000	153.0	V	
236.192185	45.72	46.00	0.28	500.0	100.000	143.0	H	1

(continuation of the "Final_Result" table from column 16 ...)

Frequency (MHz)
35.260940
76.709380
236.192185



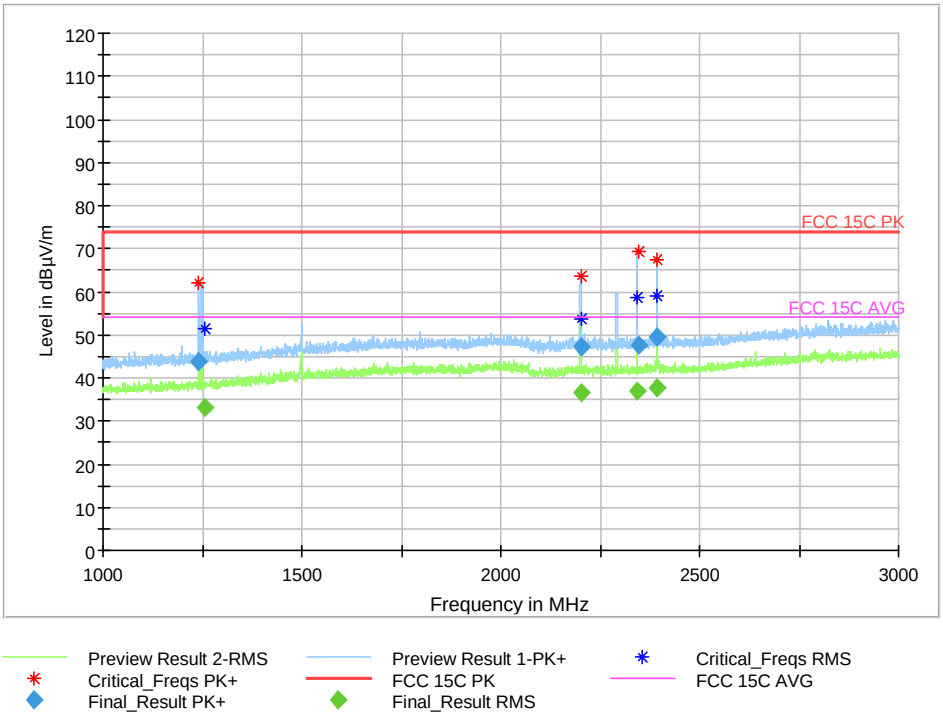
Plot #12 Radiated Emissions: 1-3 GHz		
Modulation: 802.11n_HT20 MIMO	Channel: High	95.86% Duty Cycle

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)
1240.160000	43.78	---	74.00	30.22	100.0	1000.000	350.0
1255.620000	---	33.32	53.98	20.66	100.0	1000.000	182.0
2200.510000	---	36.73	53.98	17.25	100.0	1000.000	324.0
2202.360000	47.26	---	73.99	26.74	100.0	1000.000	125.0
2344.500000	---	36.79	53.98	17.19	100.0	1000.000	324.0
2346.345000	47.69	---	73.99	26.30	100.0	1000.000	292.0
2392.275000	49.60	---	73.99	24.40	100.0	1000.000	280.0
2393.600000	---	37.84	53.98	16.14	100.0	1000.000	242.0

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

Frequency (MHz)	Corr. (dB)	Comment
1240.160000	5.0	3:49:08 PM - 10/5/2018
1255.620000	5.3	4:02:03 PM - 10/5/2018
2200.510000	8.0	4:06:05 PM - 10/5/2018
2202.360000	8.0	3:52:41 PM - 10/5/2018
2344.500000	8.3	4:09:15 PM - 10/5/2018
2346.345000	8.3	3:55:50 PM - 10/5/2018
2392.275000	8.5	3:58:51 PM - 10/5/2018
2393.600000	8.4	4:12:27 PM - 10/5/2018



Plot #13 Radiated Emissions: 3-6 GHz

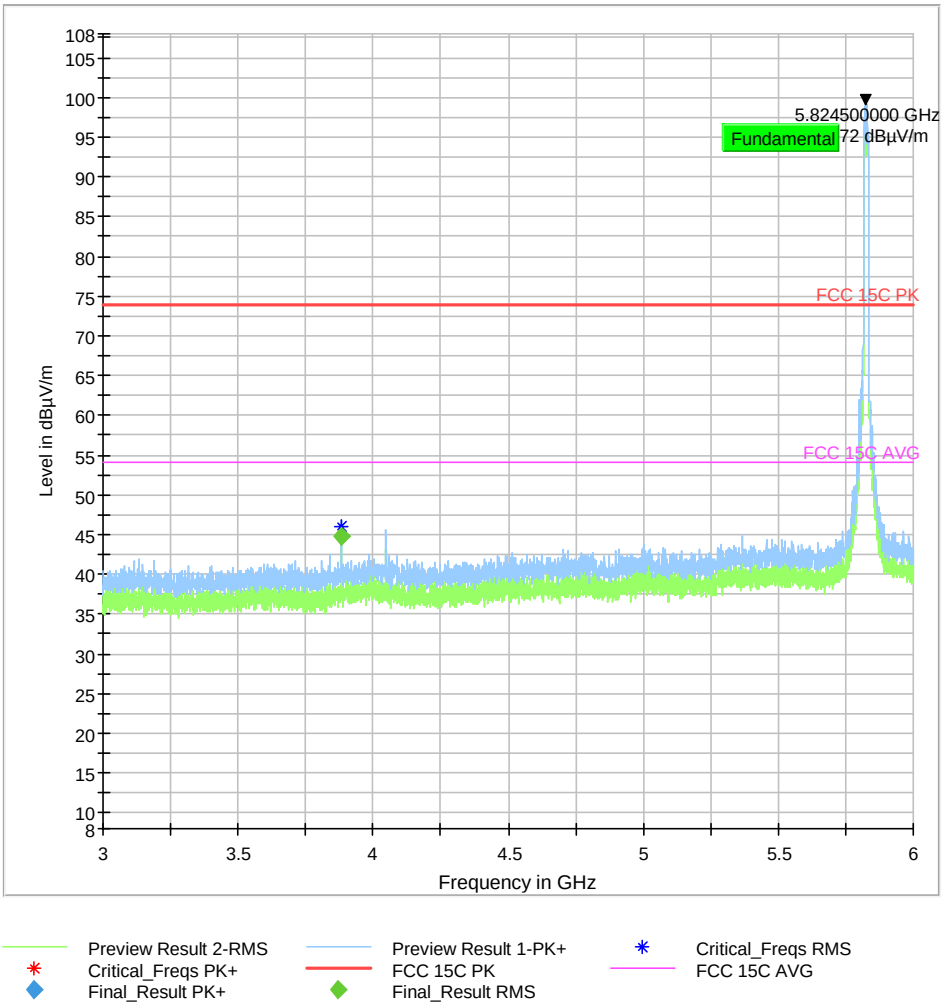
Modulation: 802.11n_HT20 MIMO	Channel: High	95.86% Duty Cycle

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)
3883.366667	---	44.75	53.98	9.23	100.0	1000.000	169.0

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

Frequency (MHz)	Corr. (dB)	Comment
3883.366667	-7.9	2:30:35 PM - 10/5/2018



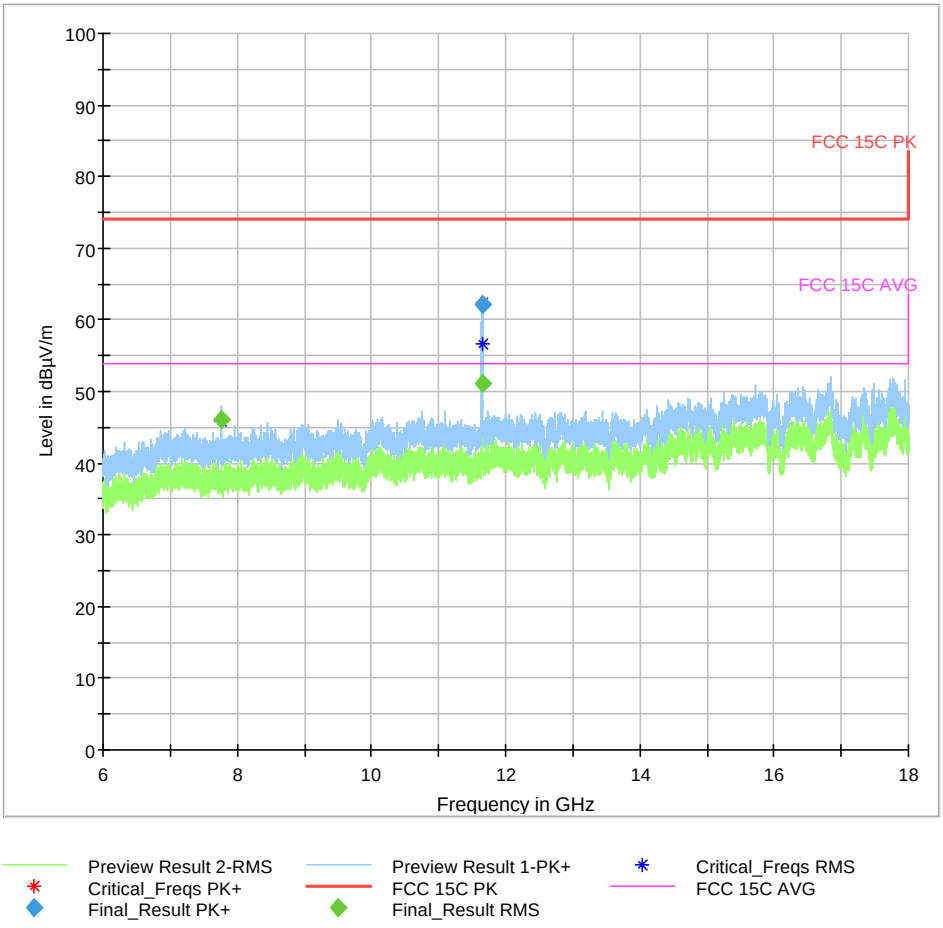
Plot #14 Radiated Emissions: 6-18 GHz		
Modulation: 802.11n_HT20 MIMO	Channel: High	95.86% Duty Cycle

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)
7766.635833	---	46.19	53.98	7.79	100.0	1000.000	151.0
11649.627500	---	51.03	53.98	2.94	100.0	1000.000	145.0
11653.589167	62.12	---	73.98	11.86	100.0	1000.000	150.0

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

Frequency (MHz)	Corr. (dB)	Comment
7766.635833	-29.3	1:32:00 PM - 9/28/2018
11649.627500	-23.1	1:28:29 PM - 9/28/2018
11653.589167	-23.1	1:25:36 PM - 9/28/2018



9 Test setup photos

Setup photos are included in supporting file name: “EMC_VIRSC-001-17001_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	35111	3 years	11/17/2015
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	1 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
2019-02-05	EMC_GARMIN_047_17001VIRSC-001-17001_15.407_UNII-3	Initial version	Kevin Wang