DEKRA Testing and Certification, S.A.U.
Parque Tecnológico de Andalucía,
c/ Severo Ochoa nº 2 · 29590 Campanillas · Málaga · España
C.I.F. A29 507 456

Test report No:
NIE: 69323RRF.003

Test report
USA FCC Part 15.407, 15.209
CANADA RSS-247, RSS-Gen

(*) Identification of item tested	TCAM: Telematics and Connectivity Antenna Module
(*) Trademark	Continental
(*) Model and /or type reference	TCAM1NA2
Other identification of the product	HW version: E4.4 SW version: 11.16.11 FCC ID: KR5TCAM1NA2 IC: 7812D-TCAM1NA2
(*) Features	2G, 3G, LTE, GNSS, WLAN, BLE, ISM Receiver
Applicant	Continental Automotive GmbH Siemensstrasse 12 93055 Regensburg, Germany
Test method requested, standard	USA FCC Part 15.407 (10-1-20) Edition: Unlicensed National Information Infrastructure (U-NII) Devices. General technical requirements. USA FCC Part 15.209 (10-1-20) Edition: Radiated emission limits; general requirements. CANADA RSS-247 Issue 2 (February 2017). CANADA RSS-Gen Issue 5, Amendment 2 (February 2021). Guidance for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices 789033 D02 General U-NII Test Procedures New Rules v02r01 dated Dec 14, 2017. ANSI C63.10-2013: American National Standard for Testing Unlicensed Wireless Devices.
Summary	IN COMPLIANCE
Approved by (name / position & signature)	Rafael López EMC Consumer & RF Lab. Manager 2021.11.04 13:42:06 +01'00'
Date of issue	2021-11-04
Report template No	FDT08_23 (*) "Data provided by the client"

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Uncertainty

Uncertainty (factor k=2) was calculated according to the DEKRA Testing and Certification internal document PODT000.

Data provided by the client

The following data has been provided by the client:

1. Information relating to the description of the sample ("Identification of the item tested", "Trademark", "Model and/or type reference tested").
2. The sample of the TCAM model TCAM1NA2 is a vehicle antenna module for telematic and connectivity purposes.

   It consists of a fin antenna with integrated telematics transceivers for different wireless services as well as several interfaces to the vehicle.

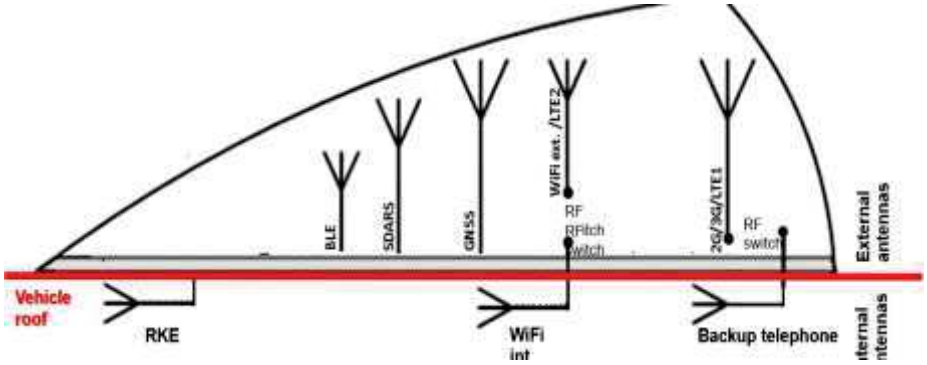
The TCAM1NA2 main parts are:

Antennas for cellular, WLAN, BLE, ISM receiver (RKE), SDARS with LNA
GNSS with LNA for Navigation: Beidou, Galileo, GPS, Glonass
Antenna selection via RF switches
TCAM internal antennas (all are TCAM internal, no extern antenna connections):
Tel1 ant: 2G, 3G, 4G/LTE1 (vehicle outside)
Tel2 ant: LTE2 (Rx only) (vehicle outside)
MIMO with LTE1- and LTE2-antenna. LTE2 is Rx only
Backup telephone antenna: 2G, 3G, 4G/LTE (vehicle inside)
Wi-Fi internal antenna (vehicle inside)
Wi-Fi external antenna (vehicle outside)
BLE antenna (vehicle outside)
Stacked patch antenna featuring GNSS
ISM receiver antenna
SDARS antenna

CAT4 NAD with 2G/3G/4G/LTE and GNSS, FCC certified
VoLTE
ISM receiver module (434MHz) for: RKE (Remote Keyless Entry), PASE (Passive Start and Entry, TPMS (Tire Pressure Monitoring System), FCC tested
Wi-Fi chip
BLE chip
1st internal embedded Sim-IC
Service calls

External interfaces:

Main power supply
External backup battery
External SIM card slot (2nd private customer SIM, optional)
External microphone in the OHC (Overhead Compartment)
A2B
External backup speaker
BroadR-Reach
CEM connection (K-Line)
Infotainment CAN
Airbag input
Debug interfaces (USB, UART)



DEKRA Testing and Certification S.A.U. declines any responsibility with respect to the information provided by the client and that may affect the validity of results.

Usage of samples

Samples undergoing test have been selected by: The client.

- Sample S/01 is composed of the following elements:

Control Nº	Description	Model	Serial Nº	Date of reception
69323/002	Telematics and Connectivity Antenna Module	TCAM1NA2	00076362	2021/07/13
69323/008	Harness	--	--	2021/07/13

Sample S/01 has undergone the following test(s): All RADIATED tests indicated in Appendix A, B and C.

- Sample S/02 is composed of the following elements:

Control Nº	Description	Model	Serial Nº	Date of reception
69323/003	Telematics and Connectivity Antenna Module	TCAM1NA2	00076364	2021/07/13
59830B/225	Harness	--	--	2021/02/24

Sample S/02 has undergone the following test(s): All CONDUCTED tests indicated in Appendix A, B and C.

Test sample description

Ports..... :	Port name and description	Cable					
		Specified max length [m]	Attached during test	Shielded	Coupled to patient(3)		
	USB diagnostic	~3m	☐	☐	☐		
	UART diagnostic	~3m	☐	☐	☐		
	BRR diagnostic	~3m	☐	☐	☐		
	---		☐	☐	☐		
Supplementary information to the ports..... :	---						
Rated power supply .....:	Voltage and Frequency		Reference poles				
			L1	L2	L3	N	PE
	☐	AC:	☐	☐	☐	☐	☐
	☒	DC: 12V					
Rated Power .....:	4.2 W dc (cellular, Wi-Fi, BLE, GNSS active)						
Clock frequencies.....:	32.768kHz, 16MHz, 19.2MHz, 24MHz, 25MHz, 27.6MHz, 48MHz						
Other parameters .....:	Operating temperature Range: -10°C to 55°C Supply Voltage Range: 8 V to 16 V DC						
Software version .....:	11.16.11						
Hardware version .....:	E4.4						
Dimensions in cm (W x H x D) ....:	10.5cm x 15.5cm x 9cm						
Mounting position .....:	☐	Table top equipment					
	☐	Wall/Ceiling mounted equipment					
	☐	Floor standing equipment					
	☐	Hand-held equipment					
	☒	Other: Vehicular environment equipment					
Modules/parts.....:	Module/parts of test item	Type	Manufacturer				
	Network Access Device (NAD), (cellular, GNSS)	Model: BL28NA-RD1	Continental Automotive Systems				
	ISM/RKE 434 MHz RF receiver module	Model: A2C38291300	Continental Automotive Systems				

	--		
Accessories (not part of the test item) .....:	Description	Type	Manufacturer
	1-2 x test harnesses with USB 1 x test harness without USB (if necessary)		Continental
	Laptop (if necessary)	Elite Book	HP
	BLE eval board (if necessary)		TI
	Load boxes (if necessary)	Multiple	Multiple
	--		
Documents as provided by the applicant.....:	Description	File name	Issue date
	RF guide	21cw12_TCAM_Country_RF_Manual	
	Functional Guide	User Guide for Functional Testing on Component Level 2	
	Additional Guides (if necessary)	multiple	
	--		

(3) Only for Medical Equipment

Identification of the client

Continental Automotive GmbH

Siemensstrasse 12, 93055 Regensburg, Germany

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2021-07-22
Date (finish)	2021-09-03

Document history

Report number	Date	Description
69323RRF.003	2021-11-04	First release

Environmental conditions

In the control chamber, the following limits were not exceeded during the test:

Temperature	Min. = 15 ºC Max. = 35 ºC
Relative humidity	Min. = 20 % Max. = 75 %

In the semianechoic chamber, the following limits were not exceeded during the test.

Temperature	Min. = 15 ºC Max. = 35 ºC
Relative humidity	Min. = 20 % Max. = 75 %

In the chamber for conducted measurements, the following limits were not exceeded during the test:

Temperature	Min. = 15 ºC Max. = 35 ºC
Relative humidity	Min. = 20 % Max. = 75 %

Remarks and comments

The tests have been performed by the technical personnel: Pablo Redondo, José Manuel Jiménez, Cristina Calle, Nicolás Salguero and Alfonso Gutierrez.

Used instrumentation:

Conducted Measurements

		Last Calibration	Due Calibration
1.	Shielded Room ETS LINDGREN S101	N/A	N/A
2.	Signal and Spectrum Analyzer 10 Hz - 40 GHz ROHDE AND SCHWARZ FSV40	2021/02	2023/02
3.	Open Switch Unit up to 7.5GHz ROHDE AND SCHWARZ OSP-B157W8 PLUS	2021/08	2023/08
4.	Open Switch Unit up to 40 GHz ROHDE AND SCHWARZ OSP-B157Wx	2019/10	2021/10
5.	Analog Power Supply DC 40V/40A ROHDE AND SCHWARZ NGPE 40/40	N/A	N/A
6.	Digital Multimeter FLUKE 175	2020/11	2021/11

Radiated Measurements:

		Last Calibration	Due Calibration
1.	Semianechoic Absorber Lined Chamber ETS LINDGREN FACT 3 200 STP	N/A	N/A
2.	Shielded Room ETS LINDGREN S101	N/A	N/A
3.	Biconical/Log Antenna 30 MHz - 6 GHz ETS LINDGREN 3142E	2020/04	2023/04
4.	Preamplifier G>40dB 10MHz-6GHz, BONN ELEKTRONIK, BLNA 0160-01N	2021/03	2022/03
5.	EMI Test Receiver, 9kHz-7GHz, ROHDE AND SCHWARZ ESR7	2020/12	2022/12
6.	Horn Antenna 1-18 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9120 D	2019/11	2022/11
7.	RF Preamplifier, G>40 dB ,1-18 GHz BONN ELEKTRONIK BLMA 0118-1M	2021/06	2022/06
8.	Horn Antenna 18-40 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9170	2020/05	2023/05
9	RF Preamplifier, G>30 dB ,18-40 GHz BONN ELEKTRONIK BLMA 1840-3G	2019/11	2021/11
10.	Spectrum Analyzer ROHDE AND SCHWARZ FSW50	2020/07	2022/07
11.	DC Power Supply, 30V/5A KEYSIGHT TECHNOLOGIES U8002A	N/A	N/A
12.	Digital Multimeter FLUKE 175	2020/11	2021/11

Testing verdicts

Not applicable:	N/A
Pass:	P
Fail:	F
Not measured:	N/M

Summary

A. Common requirements for all bands

FCC PART 15 PARAGRAPH / RSS-247 Requirement – Test case		Verdict	Remark
FCC 15.35 (c) / RSS-Gen 8.2	Duty Cycle	P	
RSS-Gen 6.7 / RSS-247 6.2	99% Occupied Bandwidth	P	
FCC 15.403 (i)	26 dB Emission Bandwidth (EBW)	P	
FCC 15.407 (g) / RSS-Gen 6.11	Frequency Stability (Temperature & Voltage Variation)	N/M	(1)
Supplementary information and remarks: (1) The manufacturer is responsible for ensuring frequency stability such that an emission is maintained within the band of operation under all conditions of normal operation as specified in the user manual.			

B. U-NII-1 Band: 5.15 - 5.25 GHz

FCC PART 15 PARAGRAPH / RSS-247 Requirement – Test case		Verdict	Remark
FCC 15.407 (a)(1)(iv)	Transmitter Maximum conducted Output Power	P	
RSS-247 6.2.1.1	Transmitter Maximum Equivalent Isotropically Radiated Power EIRP	P	
FCC 15.407 (a)(1)(iv)	Transmitter Maximum Power Spectral Density	P	
RSS-247 6.2.1.1	Transmitter EIRP Spectral Density	P	
FCC 15.407 (b)(1)(6) / RSS-247 6.2.1.2	Transmitter Out of Band Radiated Emissions	P	
FCC 15.407 (b)(1) / RSS-247 6.2.1.2	Transmitter Band Edge Radiated Emissions	P	
FCC 15.407 (h)(1) / RSS-247 6.2.1.1	Transmitter Power Control	P	
Supplementary information and remarks: None.			

C. U-NII-3 Band: 5.725 - 5.85 GHz

FCC PART 15 PARAGRAPH / RSS-247			
Requirement – Test case		Verdict	Remark
FCC 15.407 (a)(3) / RSS-247 6.2.4.1	Transmitter Maximum conducted Output Power	P	
FCC 15.407 (e) / RSS-247 6.2.4.1	6 dB bandwidth.	P	
FCC 15.407 (a)(3) / RSS-247 6.2.4.1	Transmitter Maximum Power Spectral Density	P	
FCC 15.407 (b)(4) / RSS-247 6.2.4.2	Transmitter Band Edge Radiated Emissions	P	
FCC 15.407 (b)(4)(6) / RSS-247 6.2.4.2	Transmitter Out of Band Radiated Emissions	P	
FCC 15.40 (h)(1) / RSS-247 6.2.4.1	Transmitter Power Control	N/A	
Supplementary information and remarks: None			

Appendix A: Test Common requirements for all bands

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15.35 (c) / RSS-Gen 8.2 Transmitter Duty Cycle

SPECIFICATION:

Unless otherwise specified, e.g. §15.255(b) and §15.256(l)(5), when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value.

RESULTS:

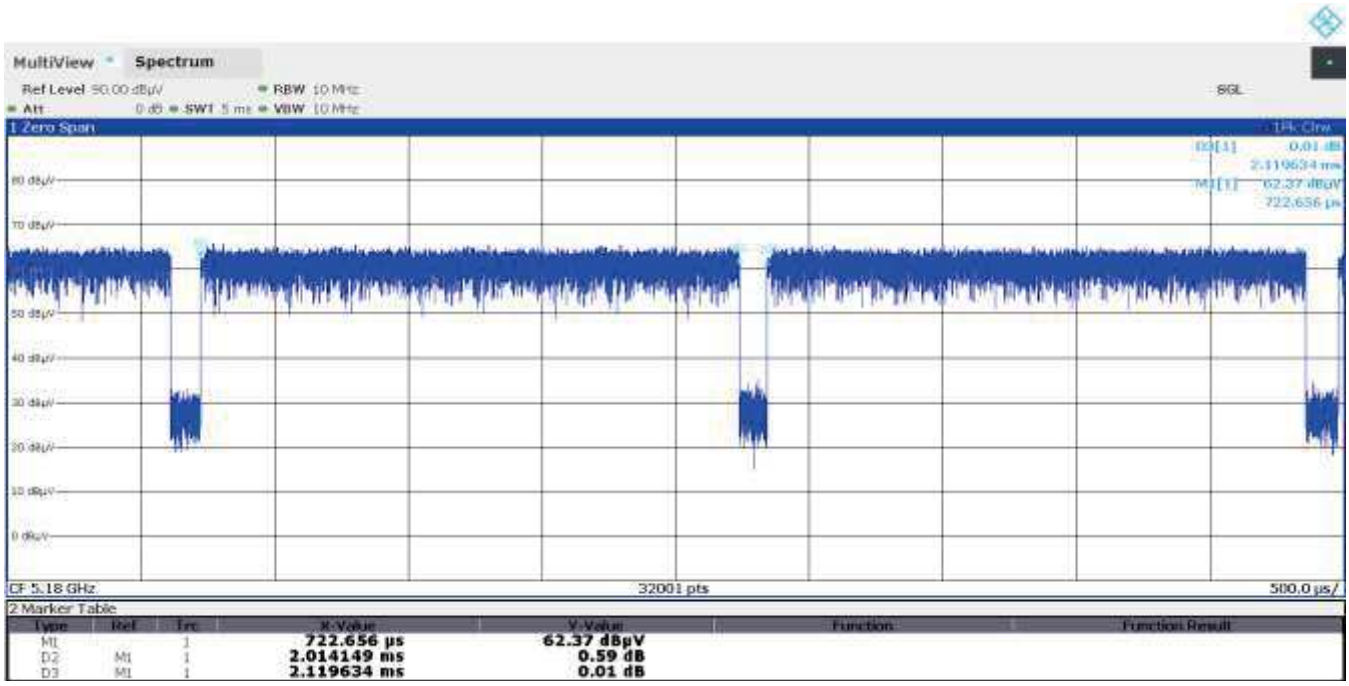
The results below are for data rates with a duty cycle less than 98%. The results for all rest of modes having a value > 98%.

Mode	Sub-band U-NII-1		
	Pulse Duration (ms)	Period (ms)	Duty Cycle Correction (dB)
802.11a20	2.014149	2.119634	0.22169282
802.11n20	1.878541	1.975059	0.21759395
802.11ac40	0.923339	1.084595	0.69906418
802.11ac80	0.452853	0.549310	0.83860256

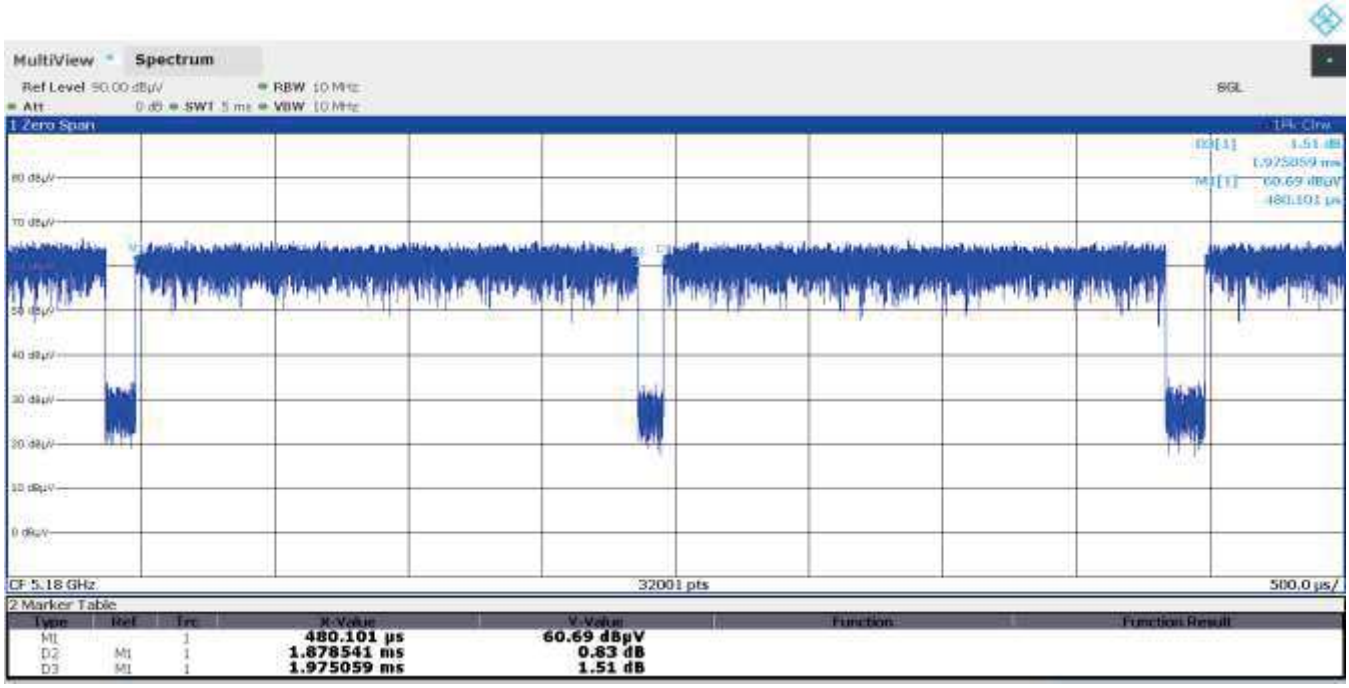
Mode	Sub-band U-NII-3		
	Pulse Duration (ms)	Period (ms)	Duty Cycle Correction (dB)
802.11a20	2.014459	2.189214	0.3612978
802.11n20	1.878721	2.026972	0.3298546
802.11n40	0.925058	1.029628	0.4651138
802.11ac80	0.453418	0.583266	1.0936790

Sub-band U-NII-1

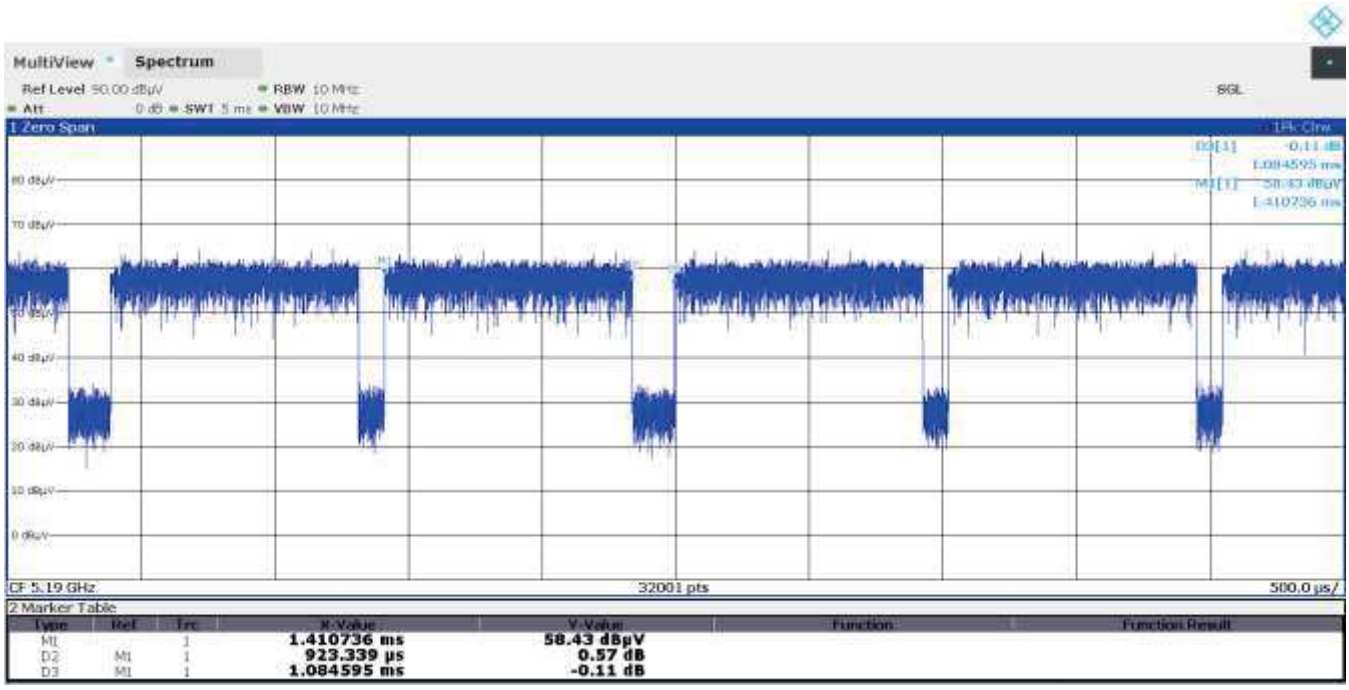
802.11a20



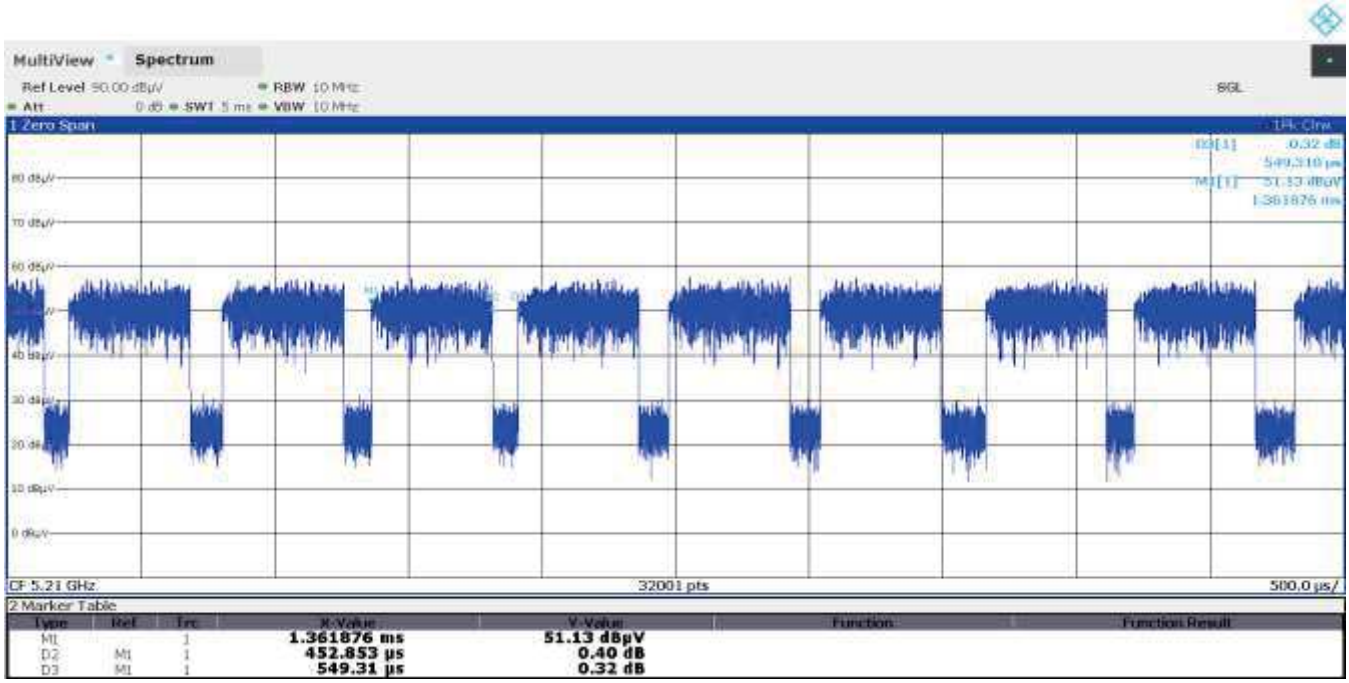
802.11n20



802.11ac40



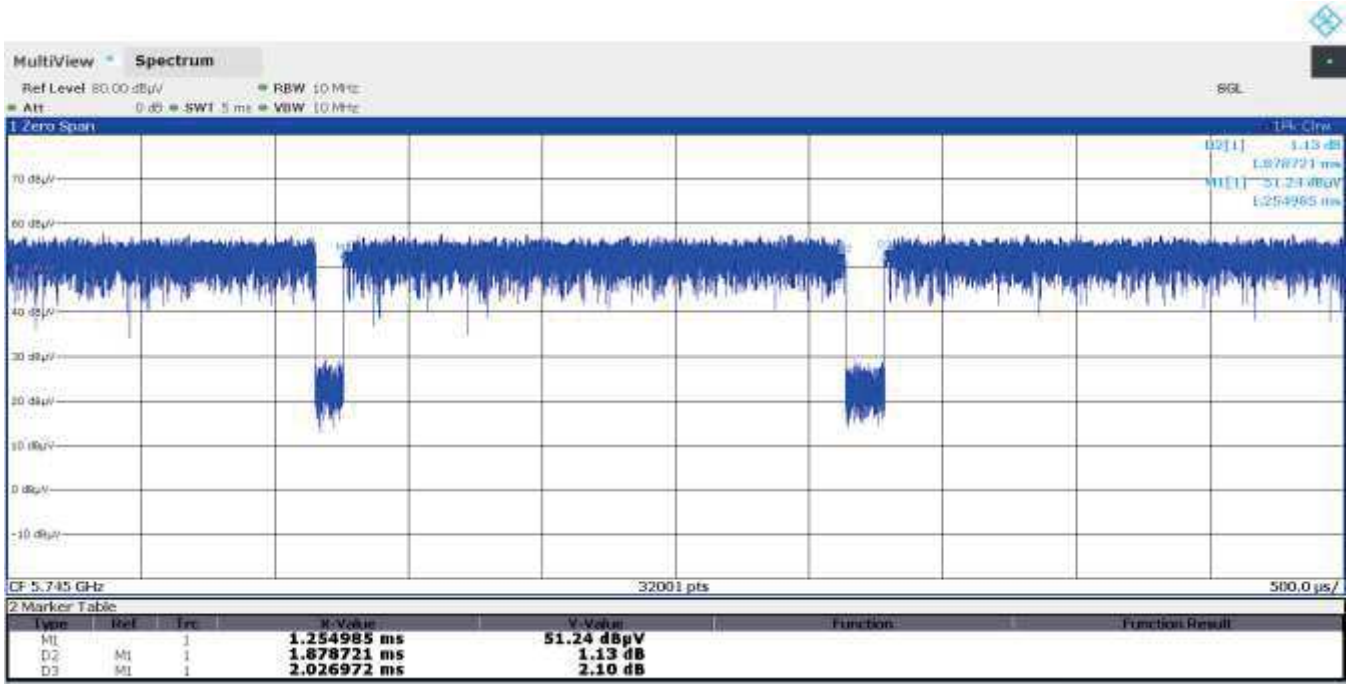
802.11ac80



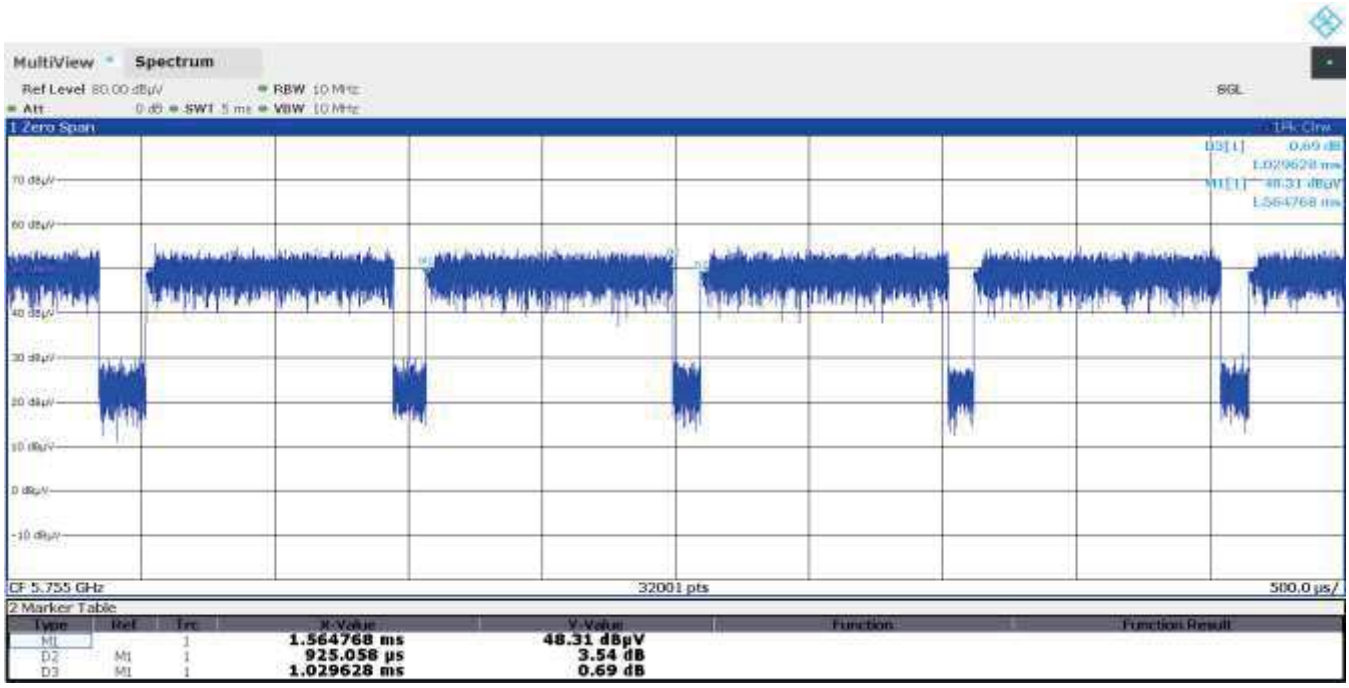
Sub-band U-NII-3

802.11a20

802.11n20



802.11n40



802.11ac80

RSS-Gen 6.7 / RSS-247 6.2 Transmitter 99% Occupied Bandwidth

SPECIFICATION:

The occupied bandwidth or the “99% emission bandwidth” is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

In some cases, the “x dB bandwidth” is required, which is defined as the frequency range between two points, one at the lowest frequency below and one at the highest frequency above the carrier frequency, at which the maximum power level of the transmitted emission is attenuated x dB below the maximum in-band power level of the modulated signal, where the two points are on the outskirts of the in-band emission.

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

The client supplied U.FL RF cables with the EUT in order to perform conducted measurements. The measured additional path loss was included in any path loss calculations.

Measurements were performed on the SISO modes for testing:

U-NII-1 (5150-5250 MHz)

- 802.11a: 6 Mbit/s / SISO
- 802.11n HT20: MCS0 / SISO
- 802.11ac VHT40: MCS0 / SISO
- 802.11ac VHT80: MCS0x1 / SISO

U-NII-3 (5725-5850 MHz)

- 802.11a: 6 Mbit/s / SISO
- 802.11n HT20: MCS0 / SISO
- 802.11n HT40: MCS0 / SISO
- 802.11ac VHT80: MCS0x1 / SISO

Mode 802.11 a20:

U-NII-1 (5150-5250 MHz)

Channels	Low Channel 36 (5180 MHz)	Middle Channel 40 (5200 MHz)	High Channel 48 (5240 MHz)
99% Occupied Bandwidth (MHz)	16.304	16.288	16.300
Measurement uncertainty (kHz)	<±36.95		

U-NII-3 (5725-5850 MHz)

Channels	Low Channel 149 (5745 MHz)	Middle Channel 157 (5785 MHz)	High Channel 165 (5825 MHz)
99% Occupied Bandwidth (MHz)	16.300	16.300	16.300
Measurement uncertainty (%)	<±1.13		

Mode 802.11 n20 (HT20):

U-NII-1 (5150-5250 MHz)

Channels	Low Channel 36 (5180 MHz)	Middle Channel 40 (5200 MHz)	High Channel 48 (5240 MHz)
99% Occupied Bandwidth (MHz)	17.396	17.404	17.400
Measurement uncertainty (kHz)	<±36.95		

U-NII-3 (5725-5850 MHz)

Channels	Low Channel 149 (5745 MHz)	Middle Channel 157 (5785 MHz)	High Channel 165 (5825 MHz)
99% Occupied Bandwidth (MHz)	17.400	17.300	17.400
Measurement uncertainty (%)	<±1.13		

Mode 802.11 ac40 (VHT40):

U-NII-1 (5150-5250 MHz)

Channels	Low Channel 38 (5190 MHz)	High Channel 46 (5230 MHz)
99% Occupied Bandwidth (MHz)	35.896	35.936
Measurement uncertainty (kHz)	<±62.36	

Mode 802.11 n40 (HT40):

U-NII-3 (5725-5850 MHz)

Channels	Low Channel 151 (5755 MHz)	High Channel 159 (5795 MHz)
99% Occupied Bandwidth (MHz)	36.000	36.000
Measurement uncertainty (%)	<±1.13	

Mode 802.11 ac80 (VHT80):

U-NII-1 (5150-5250 MHz)

Channel	Single Channel 42 (5210 MHz)
99% Occupied Bandwidth (MHz)	74.928
Measurement uncertainty (kHz)	<±124.71

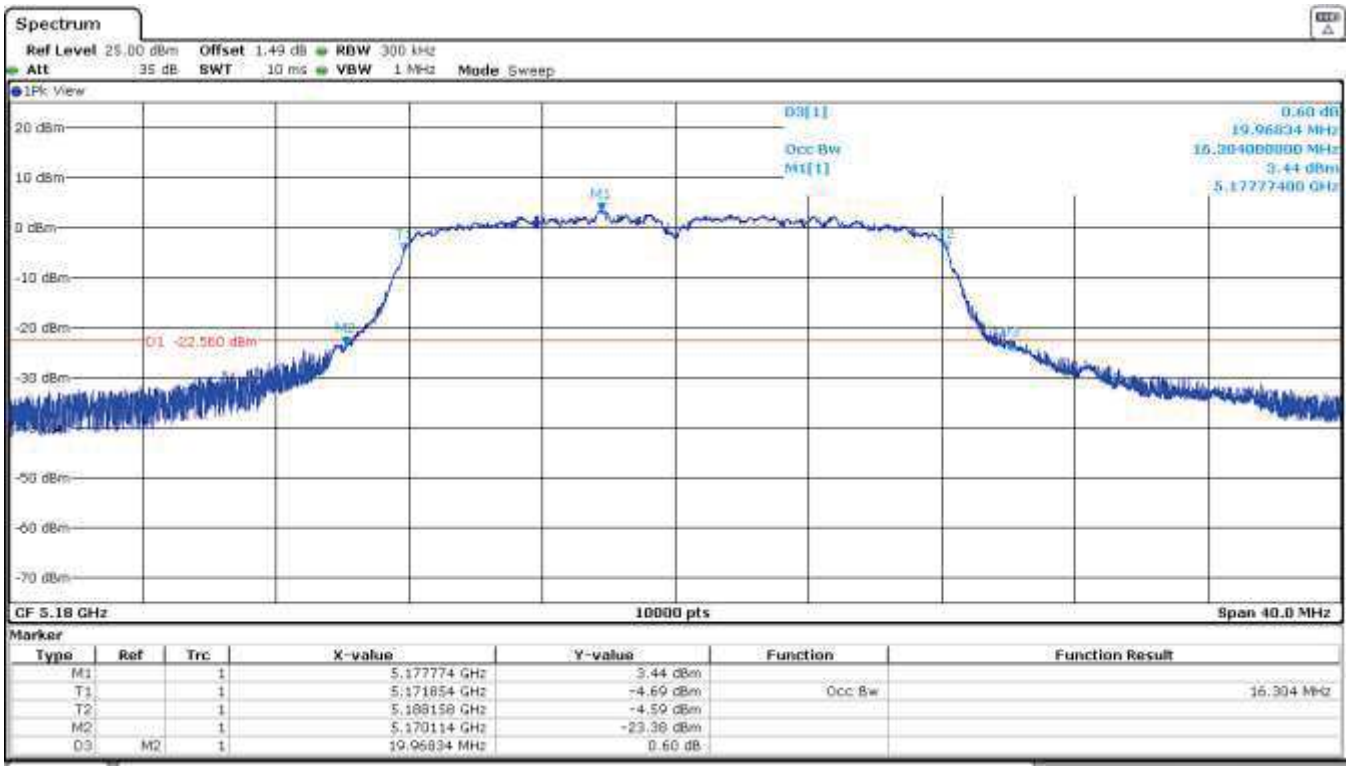
U-NII-3 (5725-5850 MHz)

Channels	Single Channel 155 (5775 MHz)
99% Occupied Bandwidth (MHz)	75.000
Measurement uncertainty (%)	<±1.13

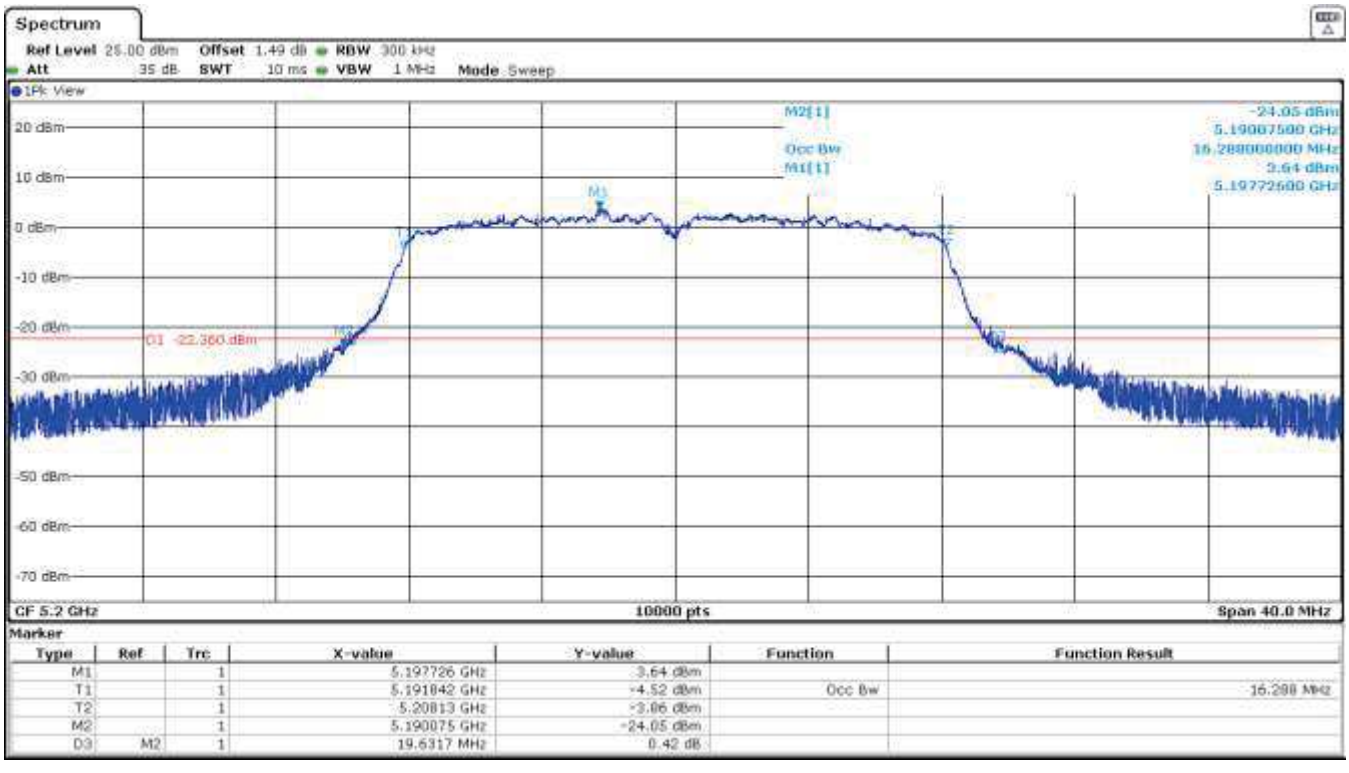
U-NII-1 (5150-5250 MHz)

Mode 802.11 a20:

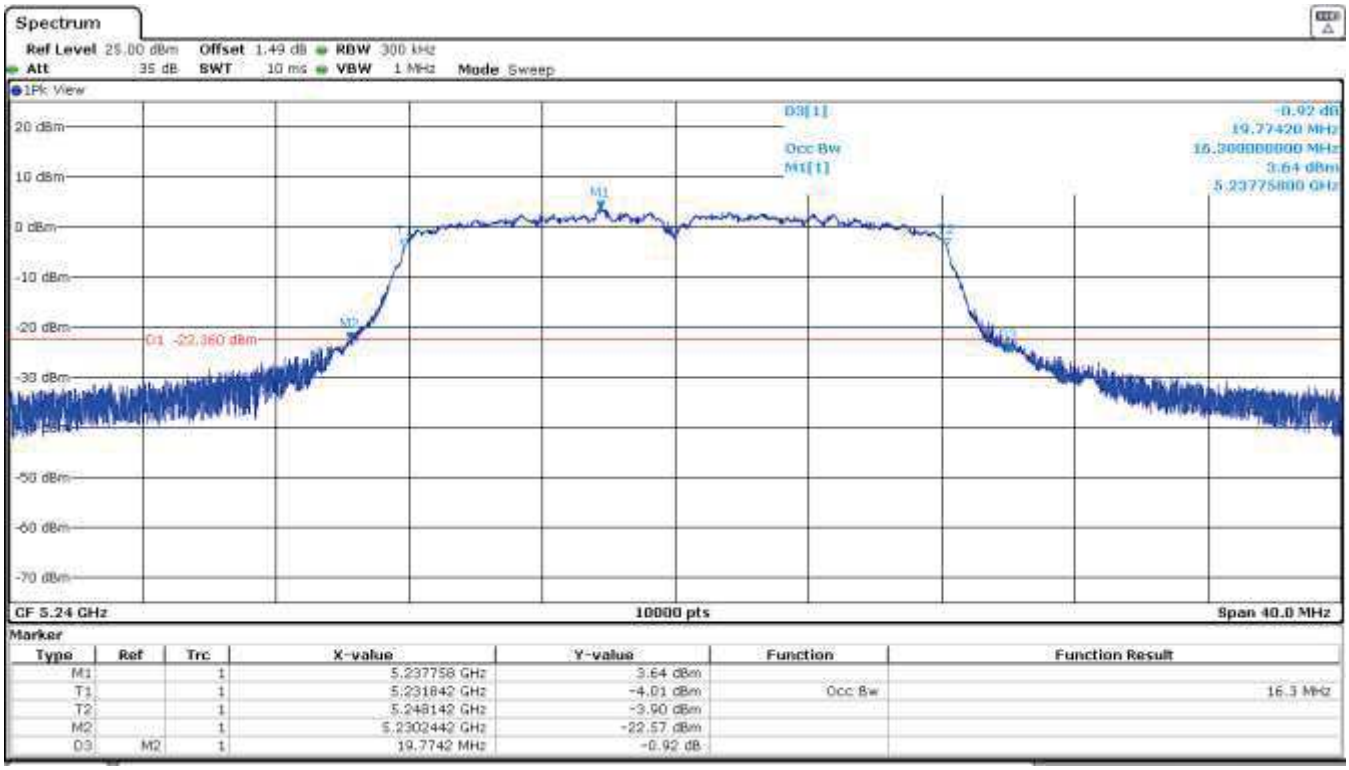
Low Channel 36



Middle Channel 40

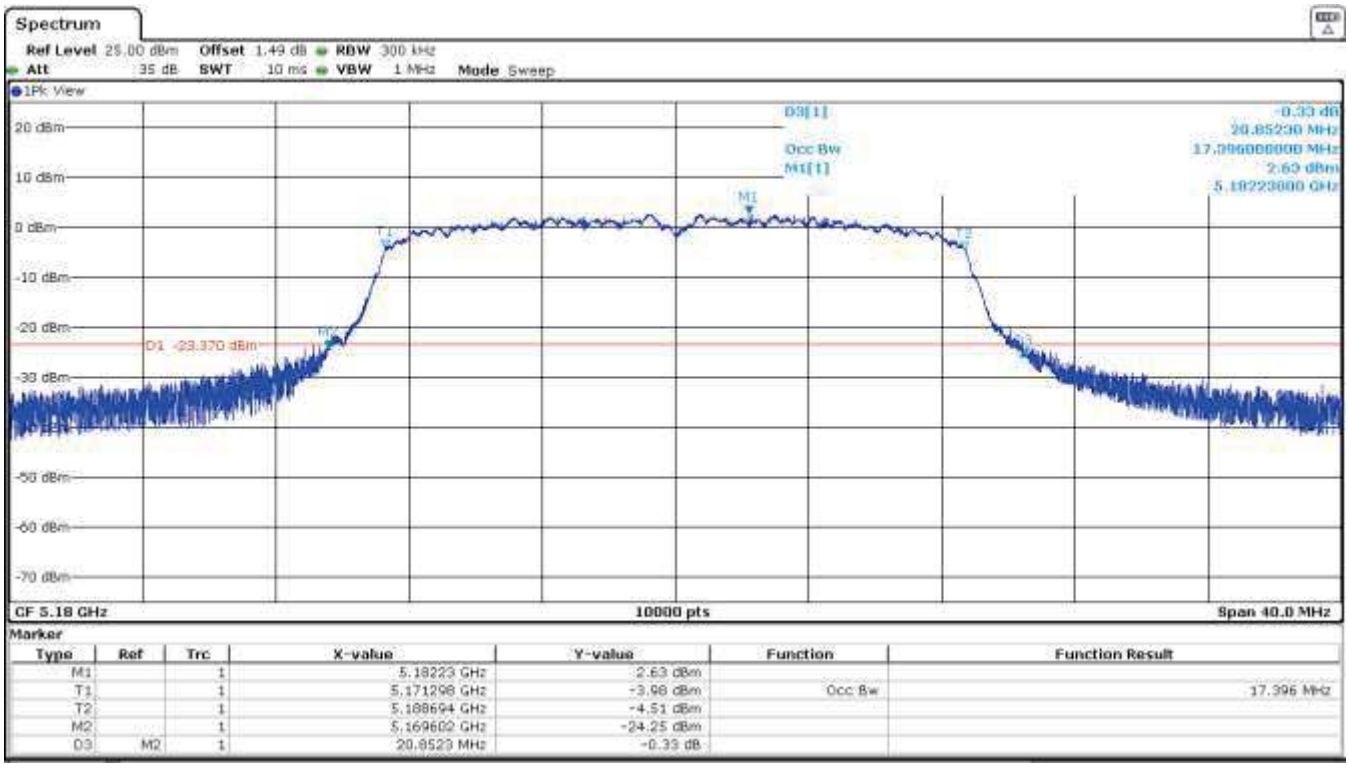


High Channel 48

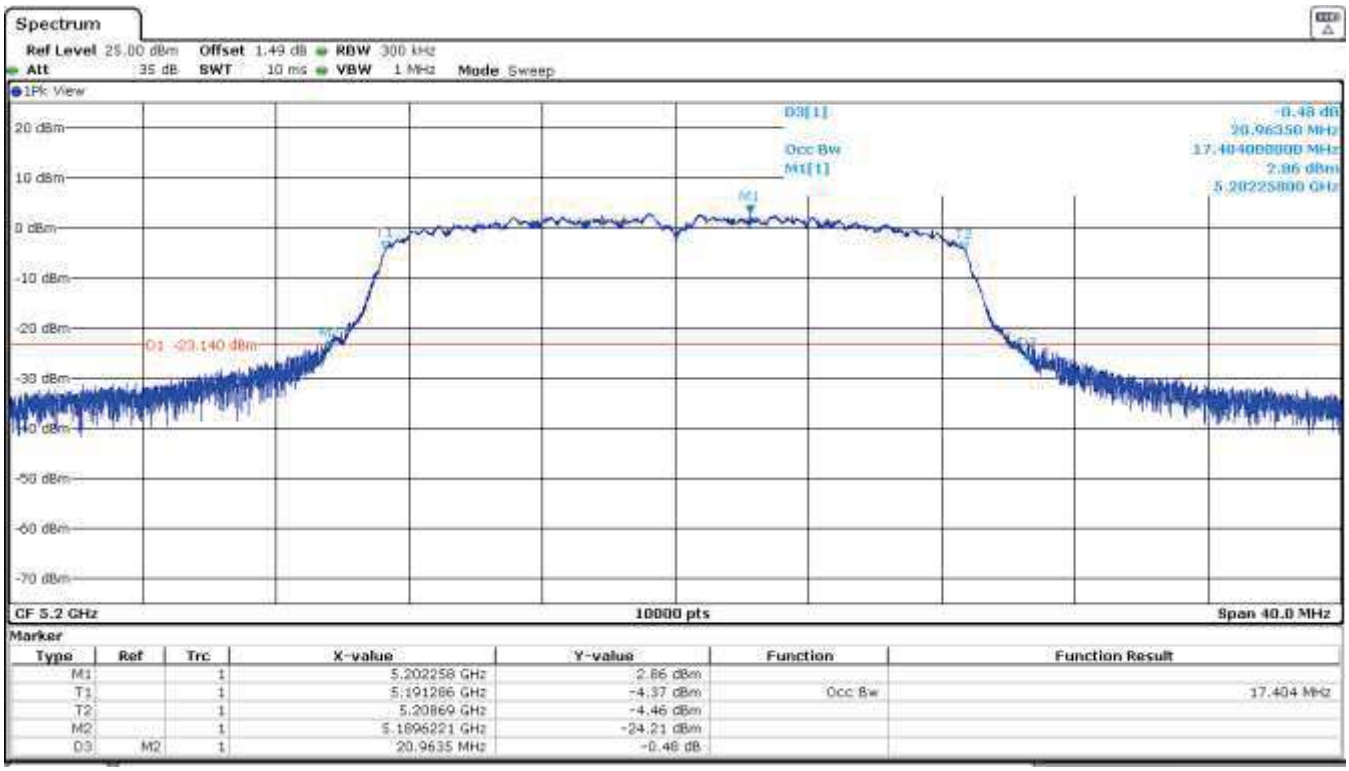


Mode 802.11 n20 (HT20):

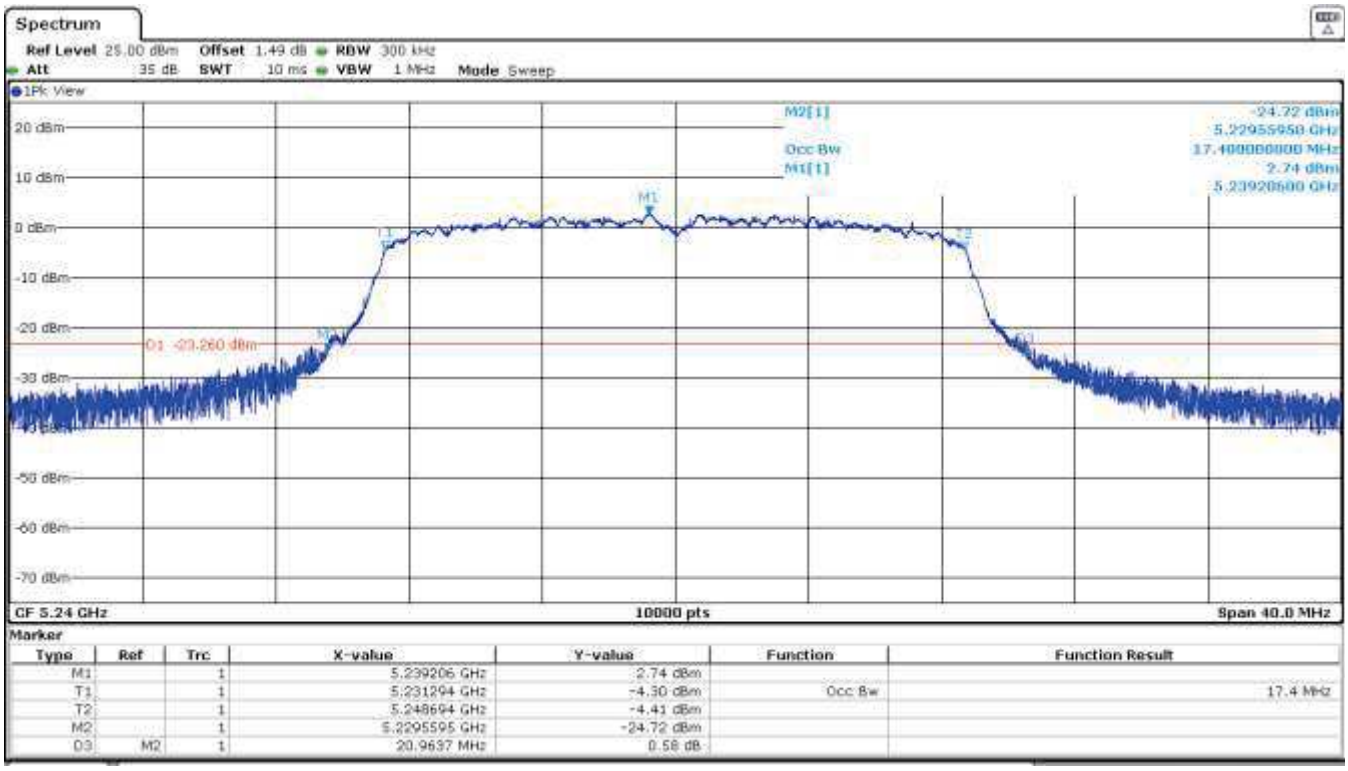
Low Channel 36



Middle Channel 40

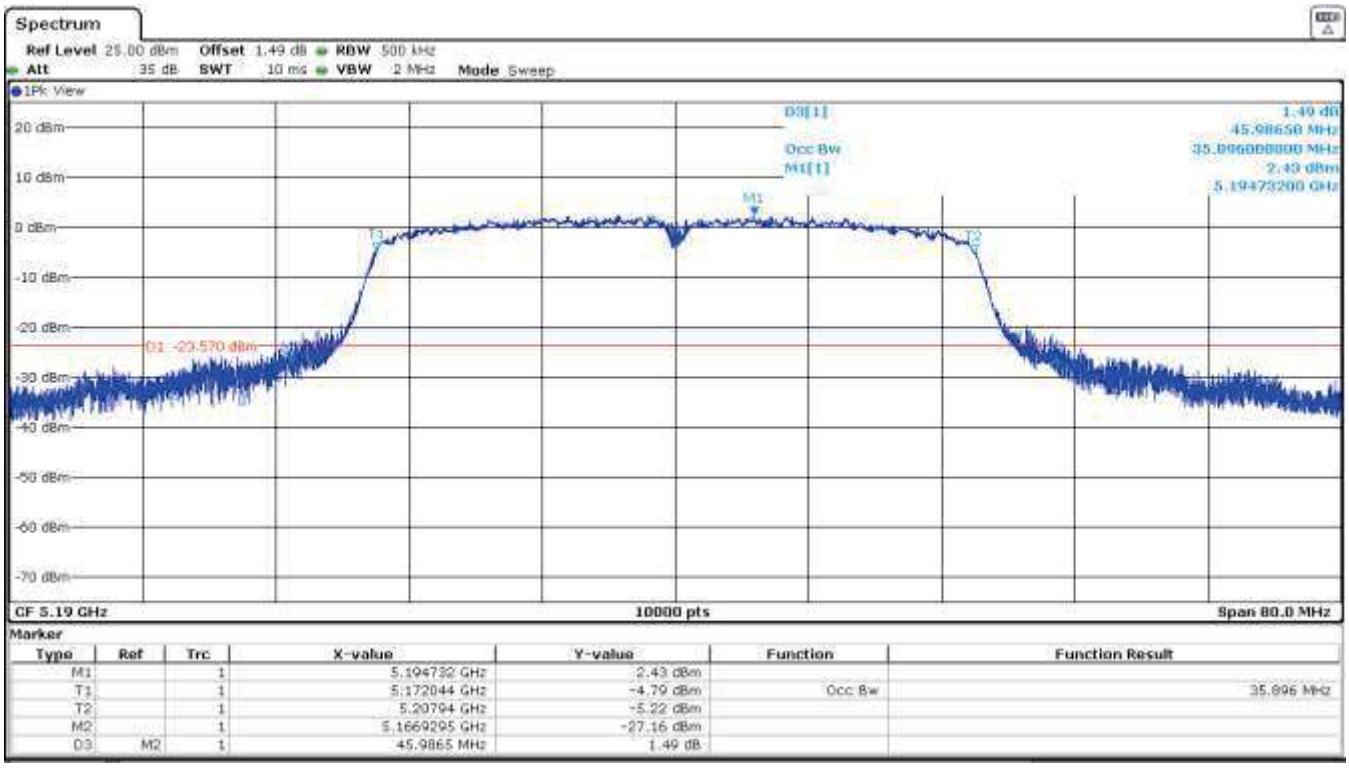


High Channel 48

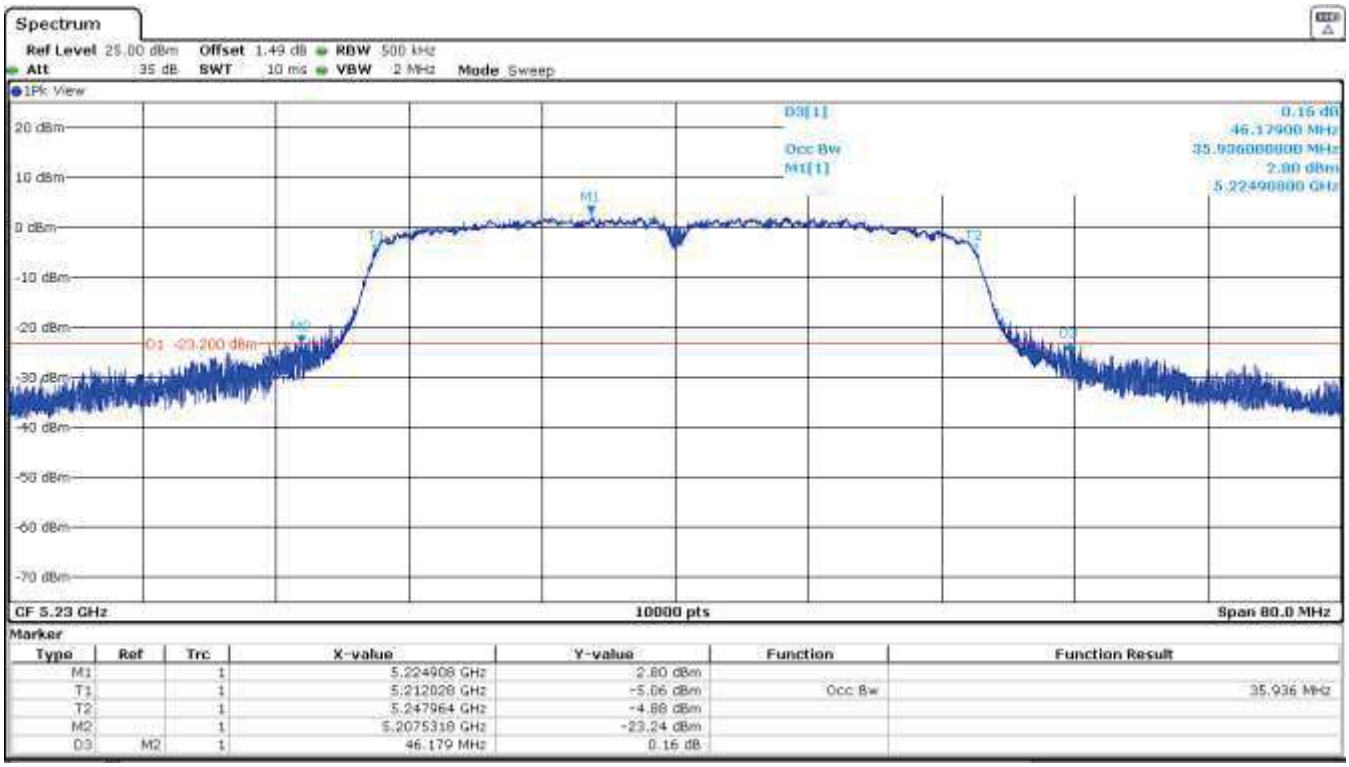


Mode 802.11 ac40 (VHT40):

Low Channel 38

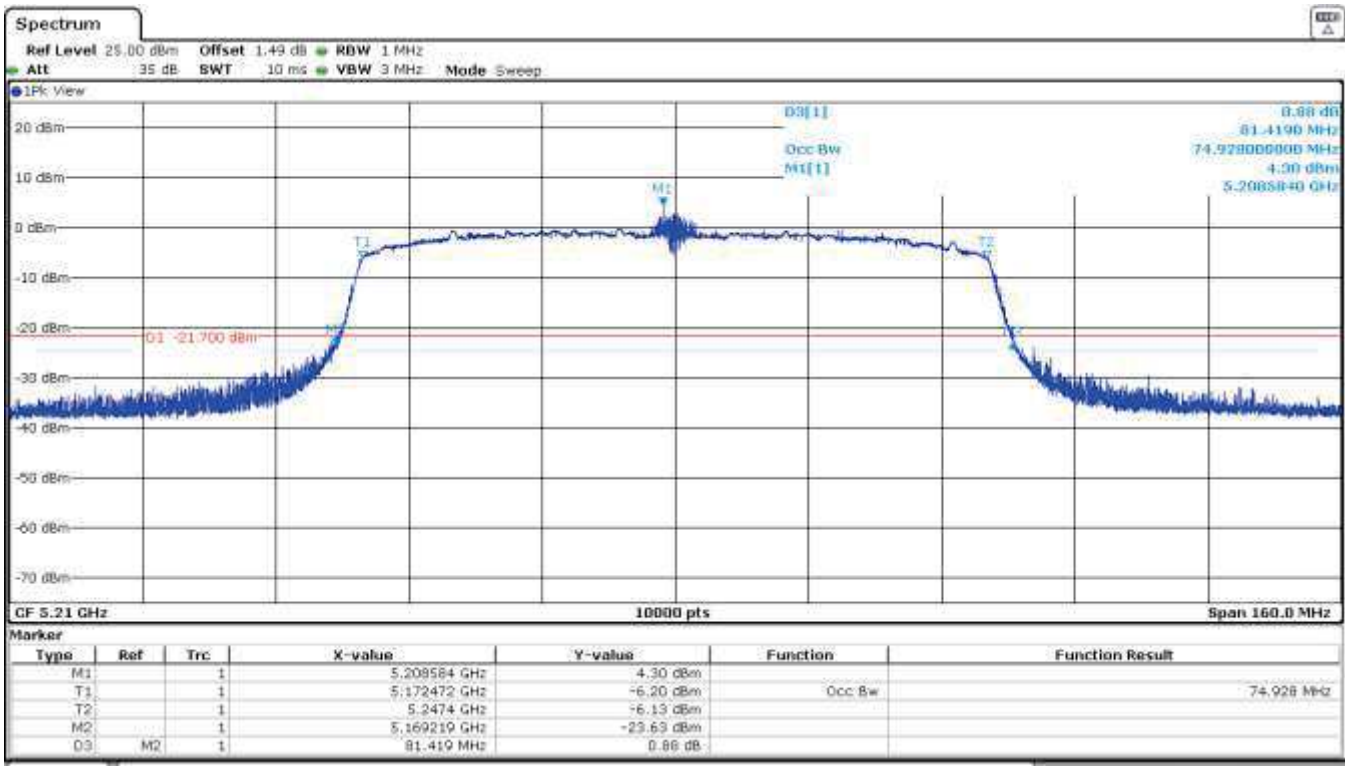


High Channel 46



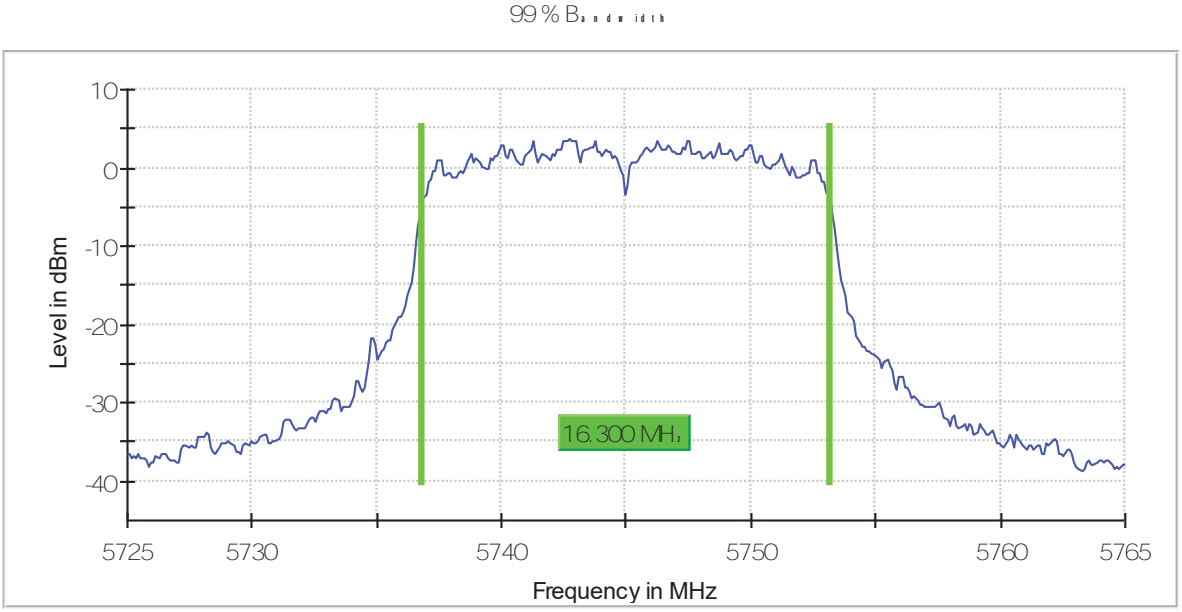
Mode 802.11 ac80 (VHT80):

Middle Channel 42

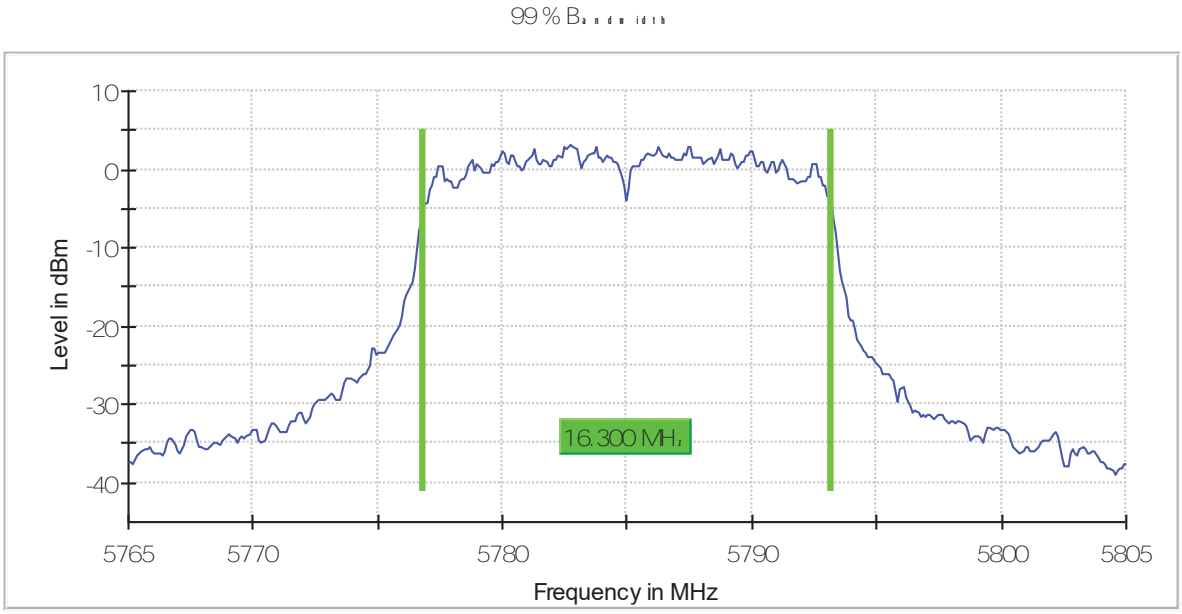


U-NII-3 (5725-5850 MHz)

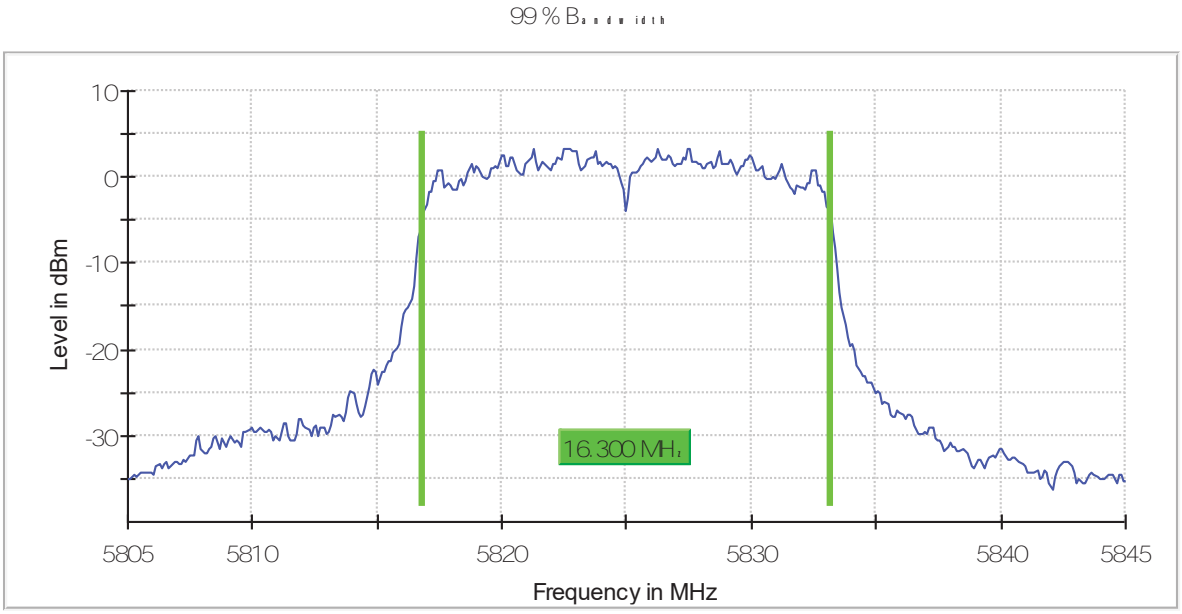
Mode 802.11 a20:
Low Channel 36



Middle Channel 40

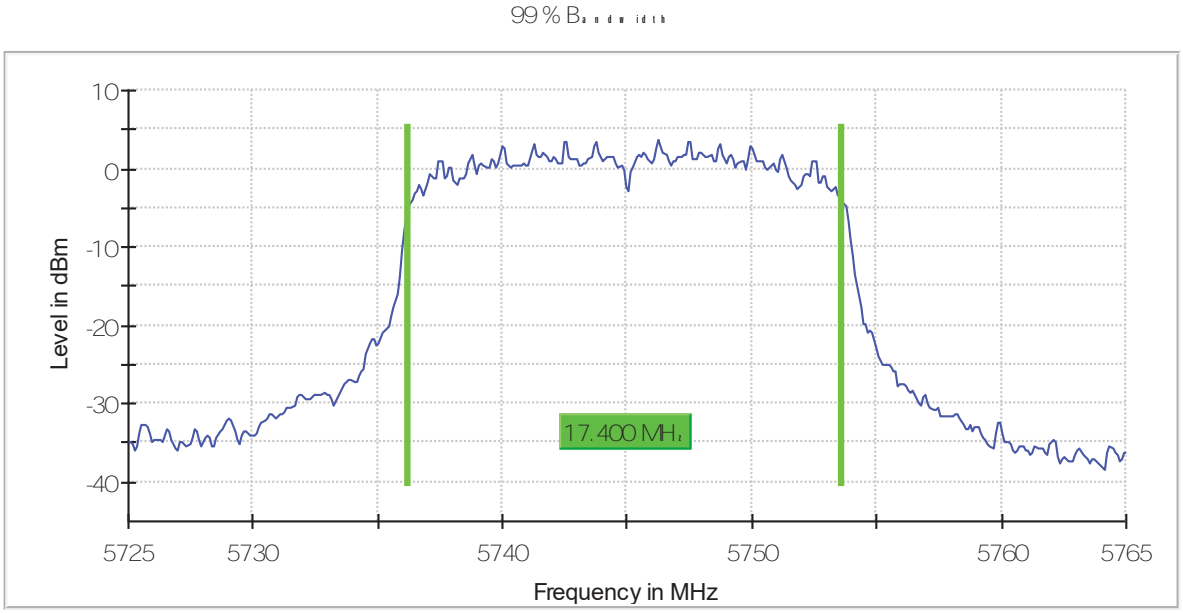


High Channel 48

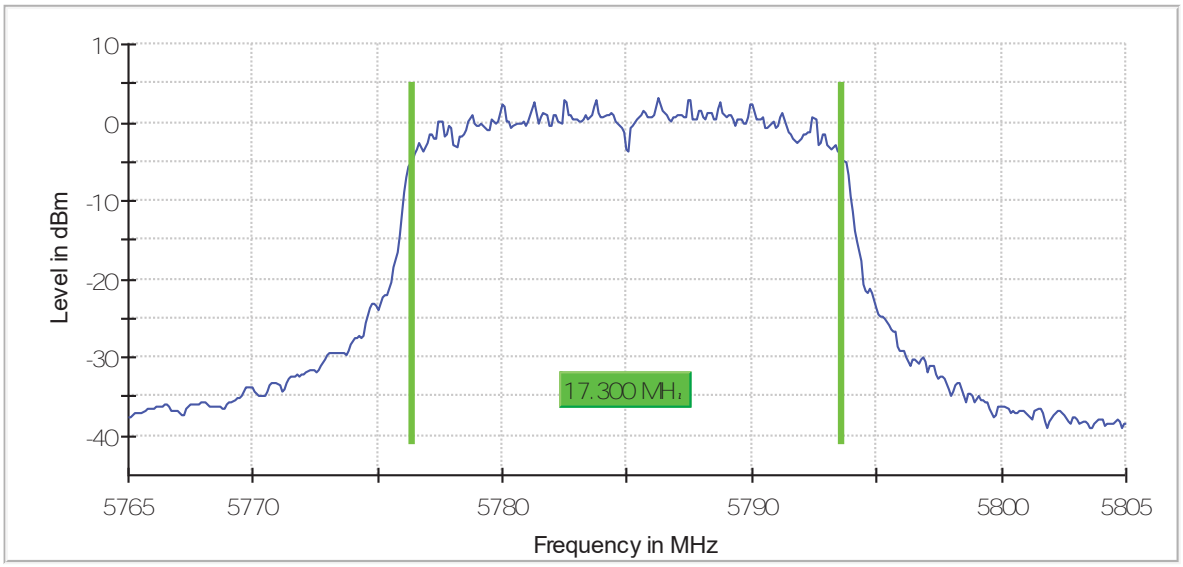


Mode 802.11 n20 (HT20):

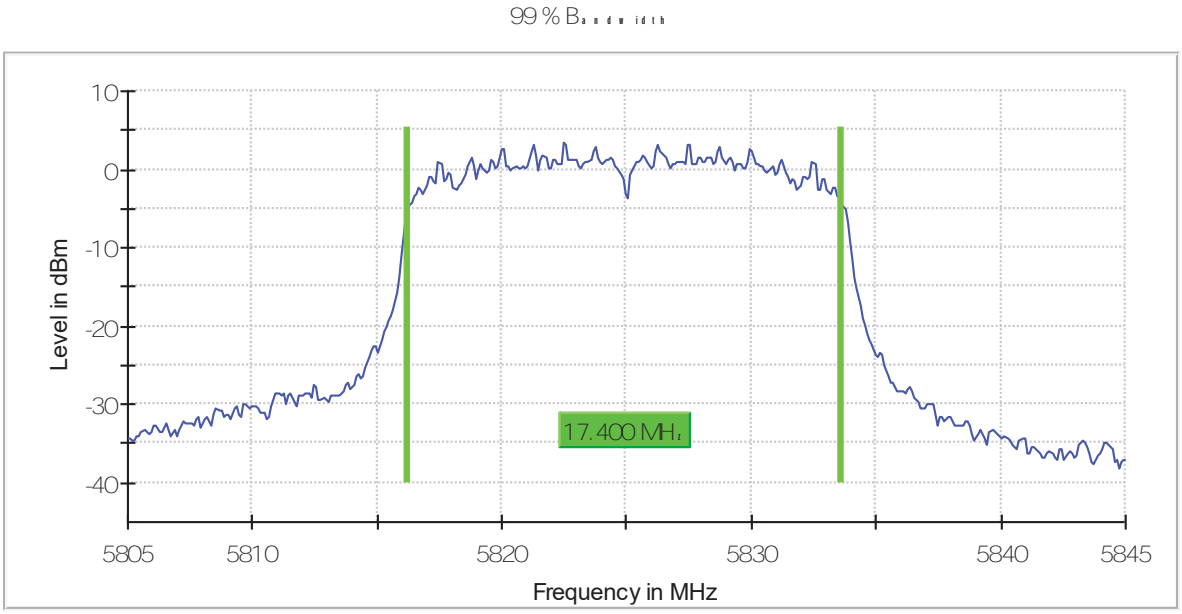
Low Channel 36



Middle Channel 40

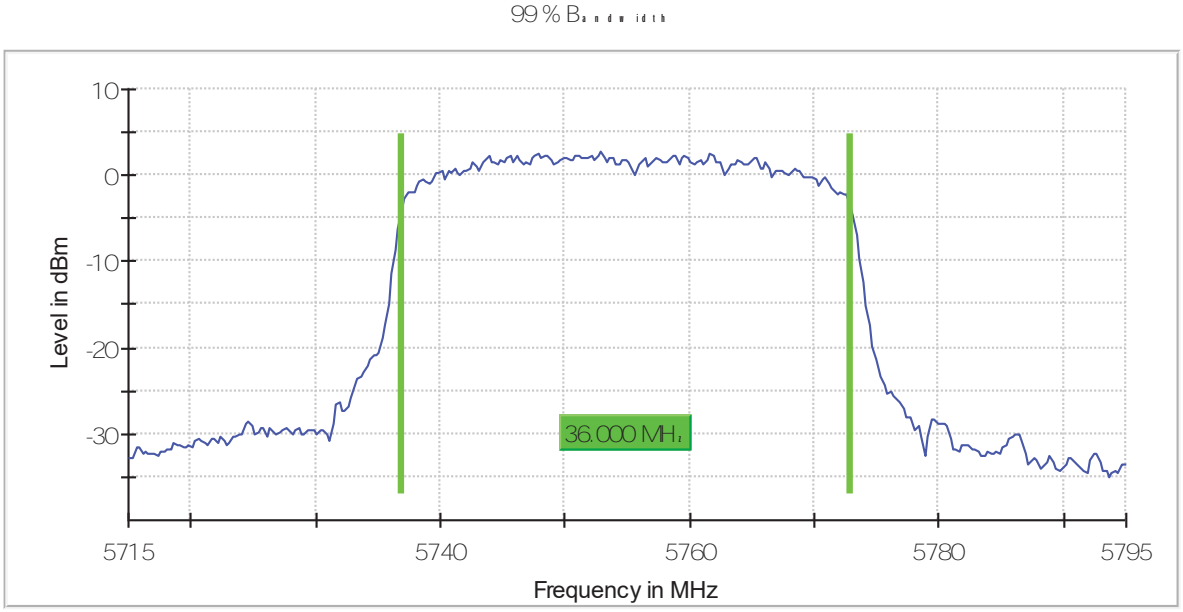


High Channel 48

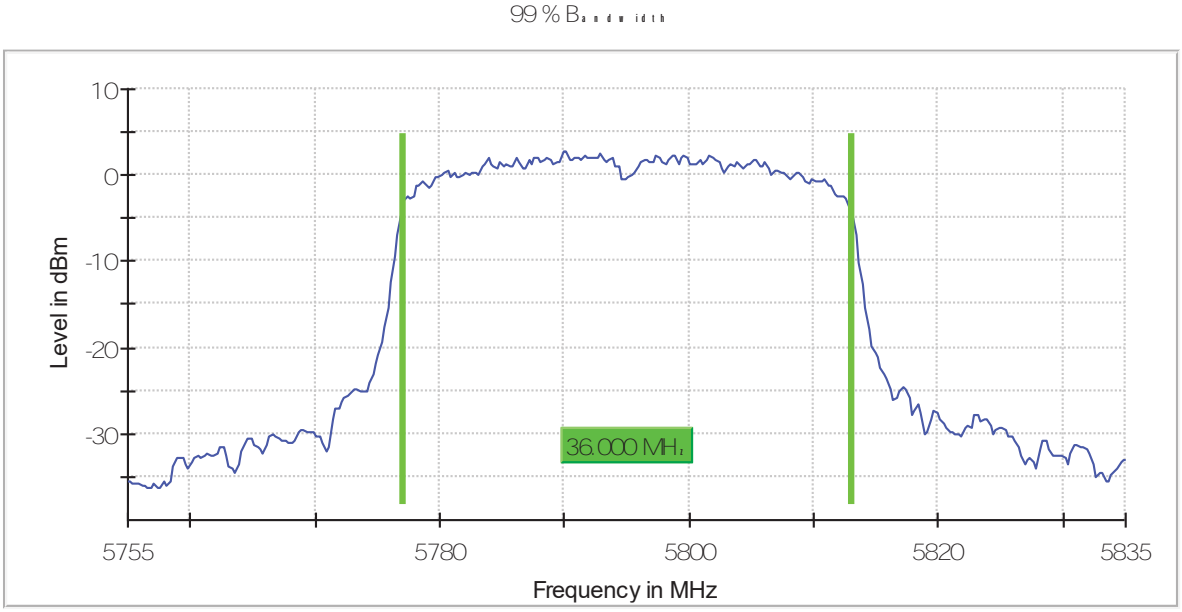


Mode 802.11 n40 (HT40):

Low Channel 38

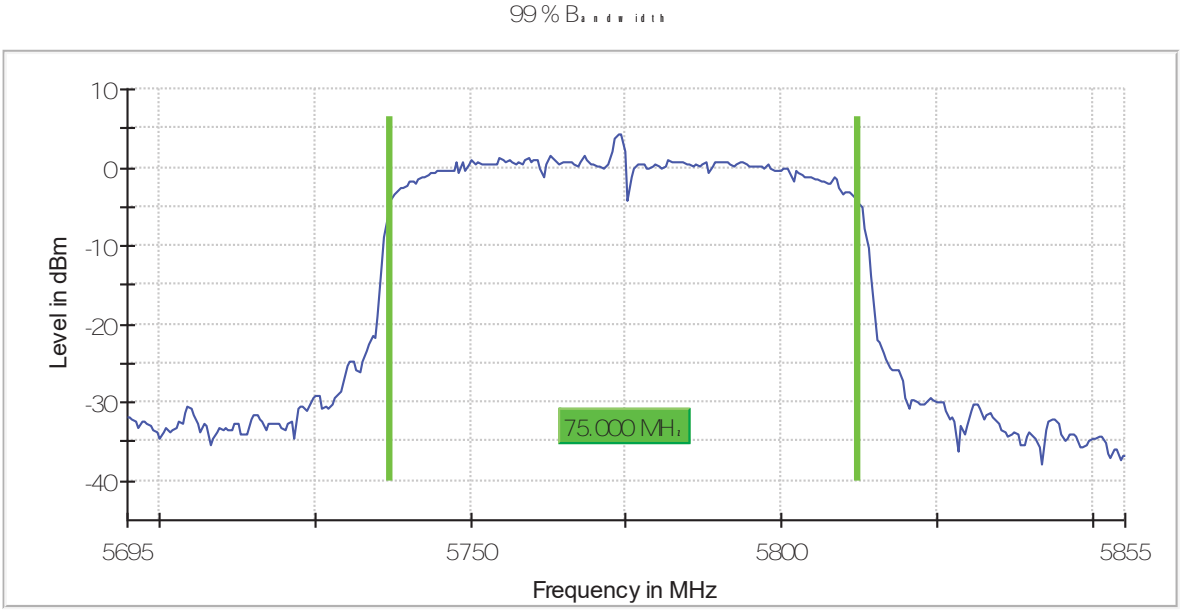


High Channel 46



Mode 802.11 ac80 (VHT80):

Middle Channel 42



15.403(i) Transmitter 26 dB Emission Bandwidth (EBW)

SPECIFICATION:

For purposes of this subpart the emission bandwidth shall be determined by measuring the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, that are 26 dB down relative to the maximum level of the modulated carrier. Determination of the emissions bandwidth is based on the use of measurement instrumentation employing a peak detector function with an instrument resolution bandwidth approximately equal to 1.0 percent of the emission bandwidth of the device under measurement.

RESULTS:

The 26 dB Emission Bandwidth was measured using the method according to point C) 1) of 789033 D02 General UNII Test Procedures New Rules v02r01.

Mode 802.11 a20:

U-NII-1 (5150-5250 MHz)

Channels	Low Channel 36 (5180 MHz)	Middle Channel 40 (5200 MHz)	High Channel 48 (5240 MHz)
26 dB Emission Bandwidth (MHz)	19.968	19.632	19.774
Measurement uncertainty (kHz)	<±36.95		

Mode 802.11 n20 (HT20):

U-NII-1 (5150-5250 MHz)

Channels	Low Channel 36 (5180 MHz)	Middle Channel 40 (5200 MHz)	High Channel 48 (5240 MHz)
26 dB Emission Bandwidth (MHz)	20.852	20.964	20.964
Measurement uncertainty (kHz)	<±36.95		

Mode 802.11 ac40 (VHT40):

U-NII-1 (5150-5250 MHz)

Channels	Low Channel 38 (5190 MHz)	High Channel 46 (5230 MHz)
26 dB Emission Bandwidth (MHz)	45.987	46.179
Measurement uncertainty (kHz)	<±62.36	

Mode 802.11 ac80 (VHT80):

U-NII-1 (5150-5250 MHz)

Channel	Single Channel 42 (5210 MHz)
26 dB Emission Bandwidth (MHz)	81.4190
Measurement uncertainty (kHz)	<±124.71

The 26 dB Emission Bandwidth plot for each mode can be seen in the plots of the previous test case “RSS-Gen 6.6 / RSS-247 6.2. Transmitter 99% Occupied Bandwidth”.

Appendix B: Tests results for the U-NII-1 Band 5.15 – 5.25 GHz

INDEX

TEST CONDITIONS

POWER SUPPLY (V):

V nonimal: 12 Vdc.

Type of Power Supply: External power supply (Car Battery).

ANTENNA:

Type of Antenna: Indoor the vehicle.
Outdoor the vehicle.

Max. Declared Gain: Indoor: +2.2 dBi
Outdoor: +0.6 dBi

TEST FREQUENCIES:

Technology Tested:	WLAN (IEEE 802.11 a,n,ac) / U-NII-1	
Modes:	802.11a20: 6, 9, 12, 18, 24, 36, 48 & 54 Mbps	
	802.11n HT20: MCS0 to MCS7	
	802.11n HT40: MCS0 to MCS7	
	802.11ac VHT20: MCS0 to MCS9	
	802.11ac VHT40: MCS0 to MCS9	
	802.11ac VHT80: MCS0 to MCS9	
Setting of cores / ports:	One port.	
Beamforming:	No.	
Frequency Range:	5150 MHz to 5250 MHz	
Channel Spacing:	20 MHz	
Transmit Channels	Channel	Channel Frequency (MHz)
	Lowest: 36	5180
	Middle: 40	5200
	Highest: 48	5240
Channel Spacing:	40 MHz	
Transmit Channels	Channel	Channel Frequency (MHz)
	Lowest: 38	5190
	Highest: 46	5230
Channel Spacing:	80 MHz	
Transmit Channels	Middle: 42	5210

802.11 a: Adjustment of Maximum RF Output Power: +9 dBm

802.11 n20/ac20: Adjustment of Maximum RF Output Power: +9 dBm

802.11 n40/ac40: Adjustment of Maximum RF Output Power: +8 dBm

802.11 ac80: Adjustment of Maximum RF Output Power: +9 dBm

The test set-up was made in accordance to the general provisions of FCC Unlicensed National Information Infrastructure (U-NII) Devices 789033 D02 General U-NII Test Procedures New Rules v02r01 dated Dec 14, 2017.

The EUT was tested in the following operating mode:

- Continuously transmitting with a modulated carrier at maximum power in all required channels using the supported data rates/modulations types.

The field strength at the band edges was evaluated for each mode on the lowest and highest channels at the rated power for the channel under test.

For all modes, the EUT was configured in test mode using a software application. The application was used to enable a continuous transmission and to select the test channels as required. The client supplied instructions to configure the EUT. The customer supplied a document containing the setup instructions.

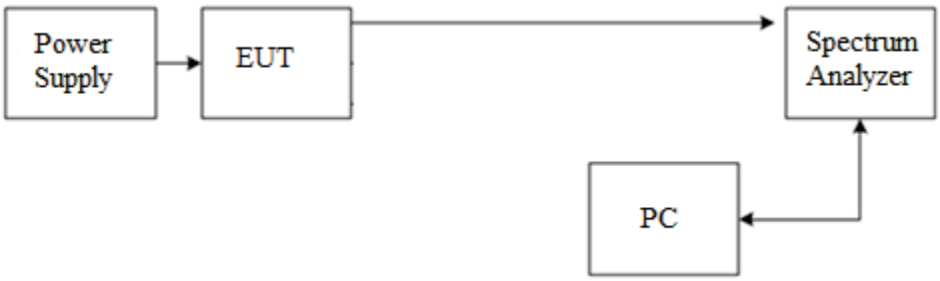
The worst cases for testing were identified for output power and spurious levels at the band edges which were selected based on preliminary testing that correspond to next data rates:

- 802.11a20: 6 Mbits
- 802.11n HT20: MCS0
- 802.11ac HT20: MCS0
- 802.11n HT40: MCS0
- 802.11ac HT40: MCS0
- 802.11ac VHT80: MCS0

CONDUCTED MEASUREMENTS

The equipment under test was set up in a shielded room and connected to the spectrum analyzer using a low loss RF cable. The reading in the spectrum analyzer is corrected taking into account the internal and external RF cable loss.

For all modes:



The DC supply voltage is applied using an external power supply.

RADIATED MEASUREMENTS

All radiated tests were performed in a semi-anechoic chamber. The measurement antenna (Bilog antenna for the range between 30 MHz to 1000 MHz) and 1 GHz-18 GHz Double ridge horn antenna is situated at a distance of 3 m and a distance of 1 m for the frequency range 17 GHz-40 GHz (18 GHz-40 GHz horn antenna).

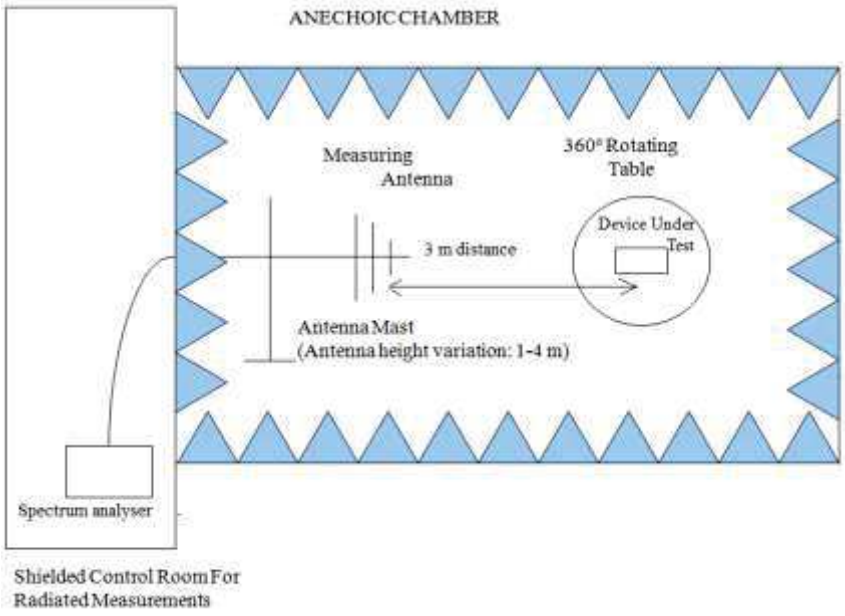
For radiated emissions in the range 17 GHz-40 GHz that is performed at a distance closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

The equipment under test was set up on a non-conductive platform above the ground plane and the situation and orientation was varied to find the maximum radiated emission. It was also rotated 360º and the antenna height (Bilog antenna and Double ridge horn antenna) was varied from 1 to 4 meters to find the maximum radiated emission.

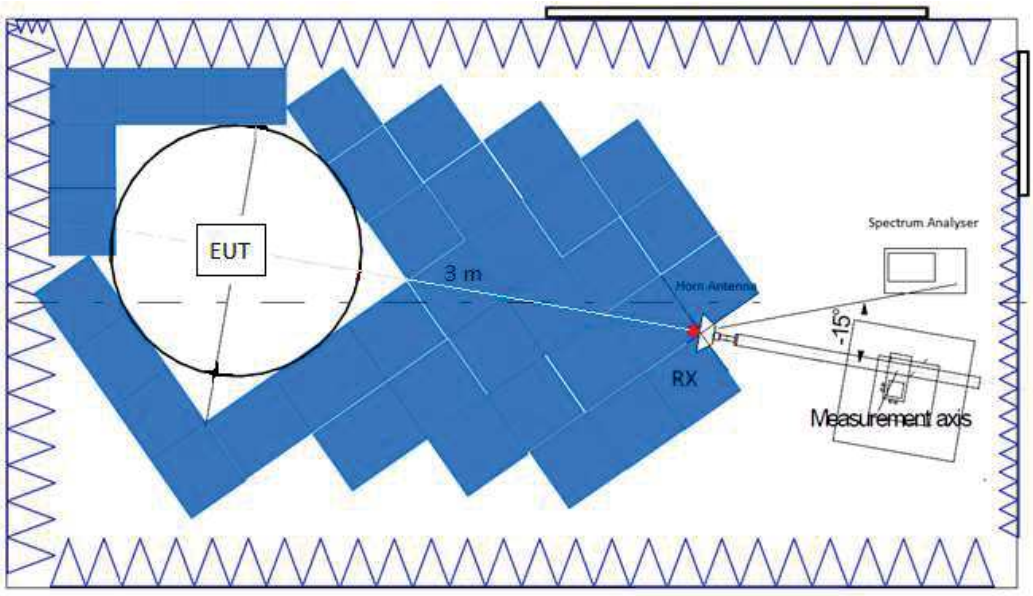
Measurements were made in both horizontal and vertical planes of polarization.

The final measured value, for the given emission, in the tables below incorporates the calibrated antenna factor and cable loss.

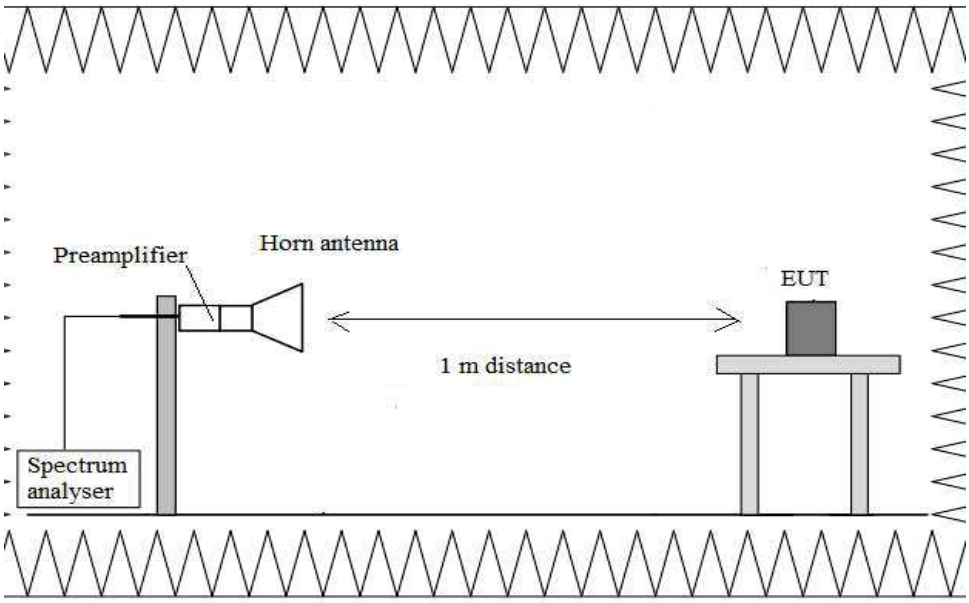
Radiated measurements setup f < 1 GHz.



Radiated measurements setup from 1 GHz to 17 GHz:



Radiated measurements setup f > 17 GHz up to 40 GHz:



FCC 15.407 (a)(1)(iv) Transmitter Maximum Conducted Output Power / RSS-247 6.2.1.1 Transmitter Maximum Equivalent Isotropically Radiated Power

SPECIFICATION:

FCC 15.407: For client devices in the band 5.15-5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 250 mW (24 dBm) provided the maximum antenna gain does not exceed 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

RSS-247: For OEM devices installed in vehicles, the maximum e.i.r.p shall not exceed 30mW or 1.76 + $10\log_{10}B$, dBm, whichever is less. Devices shall implement transmitter power control (TPC) in order to have the capability to operate at least 3 dB below the maximum permitted e.i.r.p of 30mW.

RESULTS:

The maximum conducted output power was measured using the channel power integration method according to point E) 2) b) (Method SA-1) of 789033 D02 General UNII Test Procedures New Rules v02r01 when the duty cycle is >98% and the channel power integration method according to point E) 2) d) (Method SA-2) of 789033 D02 General UNII Test Procedures New Rules v02r01 when the duty cycle is <98%.

For data rates where the EUT was transmitting at <98% duty cycle, the duty calculated in Appendix A was added to the measured power in order to calculate the total average power during the actual transmission time.

The e.i.r.p. levels are calculated by adding the declared maximum antenna gain (dBi).

For all modes of operation, the antenna gain is less than 6 dBi.

INDOOR ANTENNA: Maximum Declared Assembly Antenna Gain: +2.2 dBi

Mode 802.11 a20

	Low Channel 36 (5180 MHz)	Middle Channel 40 (5200 MHz)	High Channel 48 (5240 MHz)
Max. Conducted Power (dBm)	8.43	8.58	8.59
Duty Cycle Correction Factor (dB)	0.3686		
Max. Conducted Power Corrected (dBm)	8.799	8.949	8.959
Max. EIRP power Corrected (dBm)	10.999	11.149	11.159
Measurement uncertainty (dB)	<±1.20		

Mode 802.11 n20 (HT20)

	Low Channel 36 (5180 MHz)	Middle Channel 40 (5200 MHz)	High Channel 48 (5240 MHz)
Max. Conducted Power (dBm)	8.30	8.36	8.41
Duty Cycle Correction Factor (dB)	0.28790155		
Max. Conducted Power Corrected (dBm)	8.588	8.648	8.698
Max. EIRP power Corrected (dBm)	10.788	10.848	10.898
Measurement uncertainty (dB)	<±1.20		

Mode 802.11 ac40 (VHT40)

	Low Channel 38 (5190 MHz)	High Channel 46 (5230 MHz)
Max. Conducted Power (dBm)	8.43	8.36
Duty Cycle Correction Factor (dB)	0.609261398	
Max. Conducted Power Corrected (dBm)	9.039	8.969
Max. EIRP power Corrected (dBm)	11.239	11.760
Measurement uncertainty (dB)	<±1.20	

Mode 802.11 ac80 (VHT80)

	Single Channel 42 (5210 MHz)
Max. Conducted Power (dBm)	7.88
Duty Cycle Correction Factor (dB)	0.82575511
Max. Conducted Power Corrected (dBm)	8.706
Max. EIRP power Corrected (dBm)	11.280
Measurement uncertainty (dB)	<±1.20

Verdict: PASS

RSS-247 6.2.2.1 Transmitter Power Control

SPECIFICATION:

For OEM devices installed in vehicles, the maximum e.i.r.p shall not exceed 30mW or 1.76 + 10log$_{10}$B, dBm, whichever is less. Devices shall implement transmitter power control (TPC) in order to have the capability to operate at least 3 dB below the maximum permitted e.i.r.p of 30mW.

RESULTS:

The maximum conducted output power was measured using the channel power integration method according to point E) 2) b) (Method SA-1) of 789033 D02 General UNII Test Procedures New Rules v02r01 when the duty cycle is >98% and the channel power integration method according to point E) 2) d) (Method SA-2) of 789033 D02 General UNII Test Procedures New Rules v02r01 when the duty cycle is <98%.

For data rates where the EUT was transmitting at <98% duty cycle, the duty calculated in Appendix A was added to the measured power in order to calculate the total average power during the actual transmission time.

The e.i.r.p. levels are calculated by adding the declared maximum antenna gain (dBi).

For all modes of operation, the antenna gain is less than 6 dBi.

INDOOR ANTENNA: Maximum Declared Assembly Antenna Gain: +2.2 dBi

TPC ACTIVATED:

Mode 802.11 a20

	Low Channel 36 (5180 MHz)	Middle Channel 40 (5200 MHz)	High Channel 48 (5240 MHz)
Max. Conducted Power (dBm)	5.25	5.38	5.40
Duty Cycle Correction Factor (dB)	0.3686		
Max. Conducted Power Corrected (dBm)	5.619	5.749	5.769
Max. EIRP power Corrected (dBm)	7.819	7.949	7.969
Measurement uncertainty (dB)	<±1.20		

Mode 802.11 n20 (HT20)

	Low Channel 36 (5180 MHz)	Middle Channel 40 (5200 MHz)	High Channel 48 (5240 MHz)
Max. Conducted Power (dBm)	5.09	5.22	5.21
Duty Cycle Correction Factor (dB)	0.28790155		
Max. Conducted Power Corrected (dBm)	5.378	5.508	5.498
Max. EIRP power Corrected (dBm)	7.578	7.708	7.698
Measurement uncertainty (dB)	<±1.20		

Mode 802.11 ac40 (VHT40)

	Low Channel 38 (5190 MHz)	High Channel 46 (5230 MHz)
Max. Conducted Power (dBm)	5.48	5.69
Duty Cycle Correction Factor (dB)	0.609261398	
Max. Conducted Power Corrected (dBm)	6.089	6.299
Max. EIRP power Corrected (dBm)	7.680	7.890
Measurement uncertainty (dB)	<±1.20	

Mode 802.11 ac80 (VHT80)

	Single Channel 42 (5210 MHz)
Max. Conducted Power (dBm)	4.69
Duty Cycle Correction Factor (dB)	0.82575511
Max. Conducted Power Corrected (dBm)	5.516
Max. EIRP power Corrected (dBm)	7.716
Measurement uncertainty (dB)	<±1.20

Verdict: PASS

FCC 15.407 (a)(1)(iv) Transmitter Maximum Power Spectral Density / RSS-247 6.2.1.1 Transmitter EIRP Spectral Density

SPECIFICATION:

FCC 15.407: The maximum power spectral density shall not exceed 11 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

RSS-247: The e.i.r.p. spectral density shall not exceed 10 dBm in any 1.0 MHz band.

RESULTS:

The maximum power spectral density (PSD) was measured using the method according to point F) referencing E.2.b) (Method SA-1) and E.2.b) (Method SA-2) of Guidance 789033 D02 General UNII Test Procedures New Rules v02r01.

The PSD test uses the same setup as the transmitter maximum conducted output power test. The result of the Peak PSD was measured by colocation a maker on the peak of the signal and the results are in the tables below.

The e.i.r.p. levels are calculated by adding the declared maximum antenna gain (dBi).

For all modes of operation, the antenna gain is less than 6 dBi.

INDOOR ANTENNA: Maximum Declared Assembly Antenna Gain: +2.2 dBi. Results below take account 1.2dB due to the loss of SMA cable.

Mode 802.11 a20

	Low Channel 36 (5180 MHz)	Middle Channel 40 (5200 MHz)	High Channel 48 (5240 MHz)
Maximum Average PSD (dBm/MHz)	-1.90	-2.00	-1.93
Duty Cycle Correction Factor (dB)	0.3686		
Maximum Average PSD Corrected (dBm/MHz)	-1.531	-1.631	-1.561
Maximum EIRP PSD Corrected (dBm/MHz)	0.669	0.569	0.639
Measurement uncertainty (dB)	<±1.20		

Mode 802.11 n20 (HT20)

	Low Channel 36 (5180 MHz)	Middle Channel 40 (5200 MHz)	High Channel 48 (5240 MHz)
Maximum Average PSD (dBm/MHz)	-2.24	-1.99	-2.22
Duty Cycle Correction Factor (dB)	0.28790155		
Maximum Average PSD Corrected (dBm/MHz)	-1.952	-1.702	-1.932
Maximum EIRP PSD Corrected (dBm/MHz)	0.248	0.498	0.268
Measurement uncertainty (dB)	<±1.20		

Mode 802.11 ac40 (VHT40)

	Low Channel 38 (5190 MHz)	High Channel 46 (5230 MHz)
Maximum Average PSD (dBm/MHz)	-5.10	-5.59
Duty Cycle Correction Factor (dB)	0.6092614	
Maximum Average PSD Corrected (dBm/MHz)	-4.491	-4.981
Maximum EIRP PSD Corrected (dBm/MHz)	-2.291	-2.781
Measurement uncertainty (dB)	<±1.20	

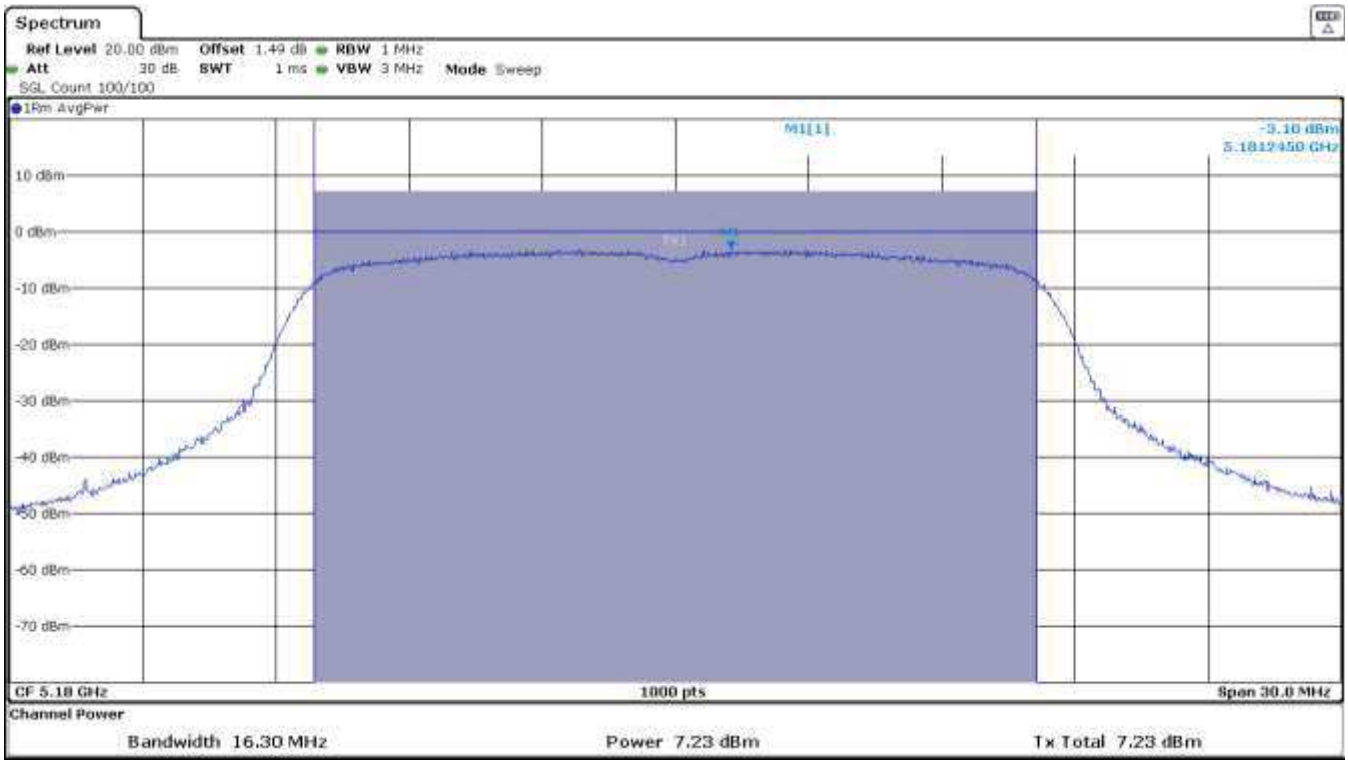
Mode 802.11 ac80 (VHT80)

	Middle Channel 42 (5210 MHz)
Maximum Average PSD (dBm/MHz)	-8.73
Duty Cycle Correction Factor (dB)	0.82575511
Maximum Average PSD Corrected (dBm/MHz)	-7.904
Maximum EIRP PSD Corrected (dBm/MHz)	-5.704
Measurement uncertainty (dB)	<±1.20

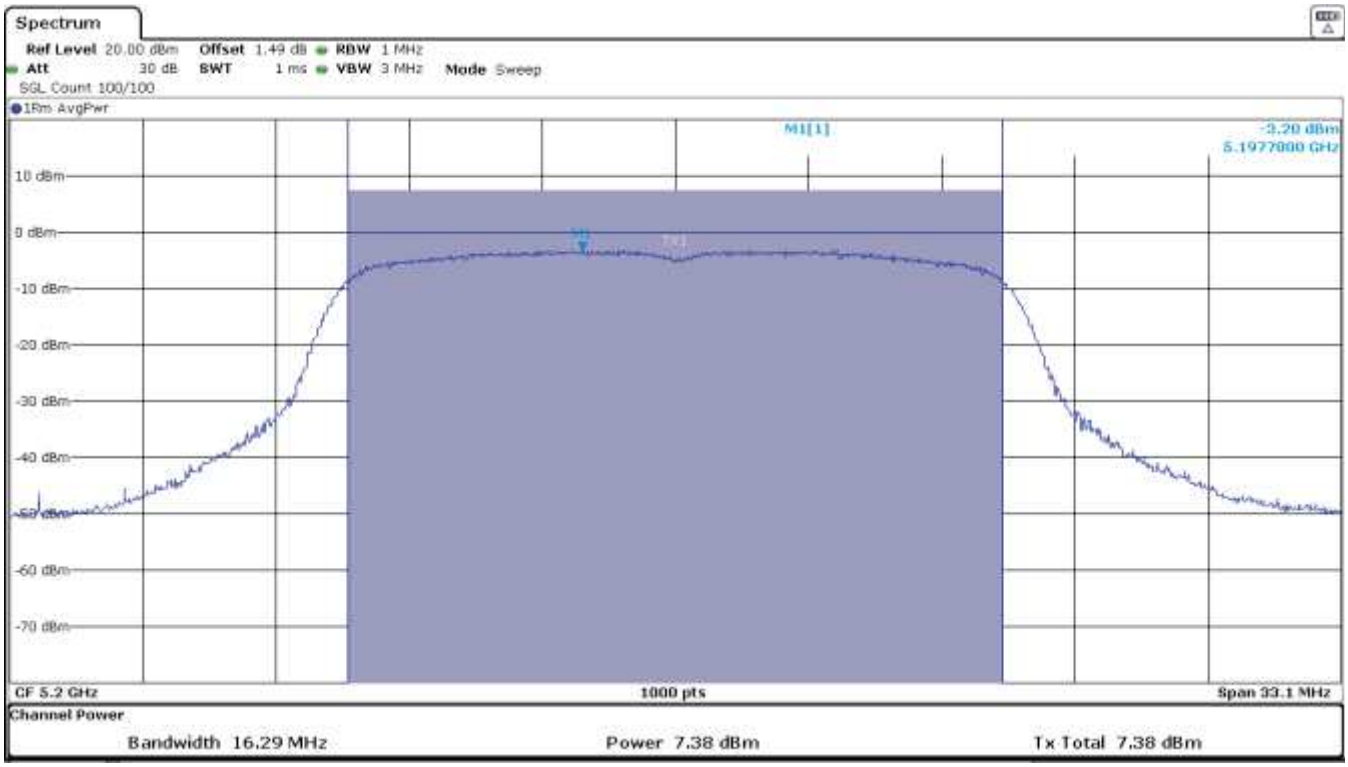
Verdict: PASS

Mode 802.11 a20

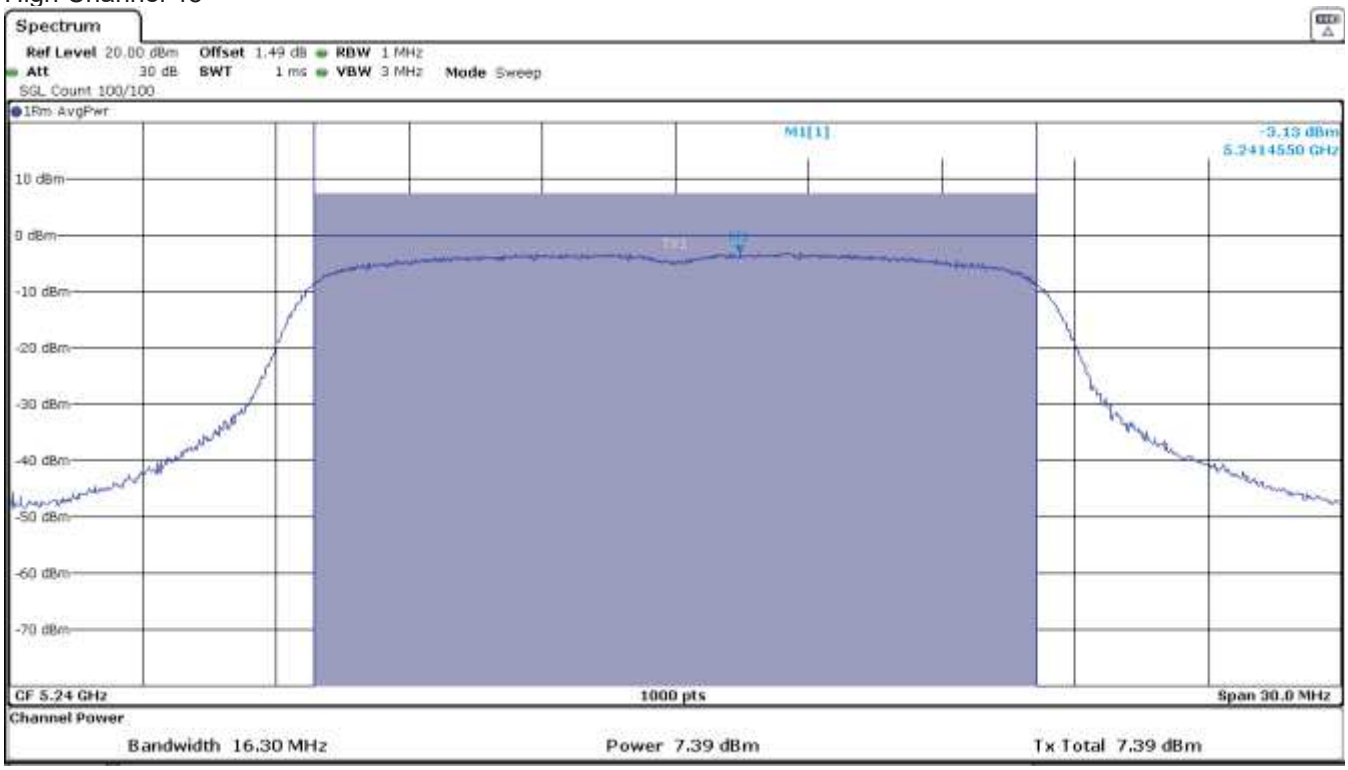
Low Channel 36



Middle Channel 40

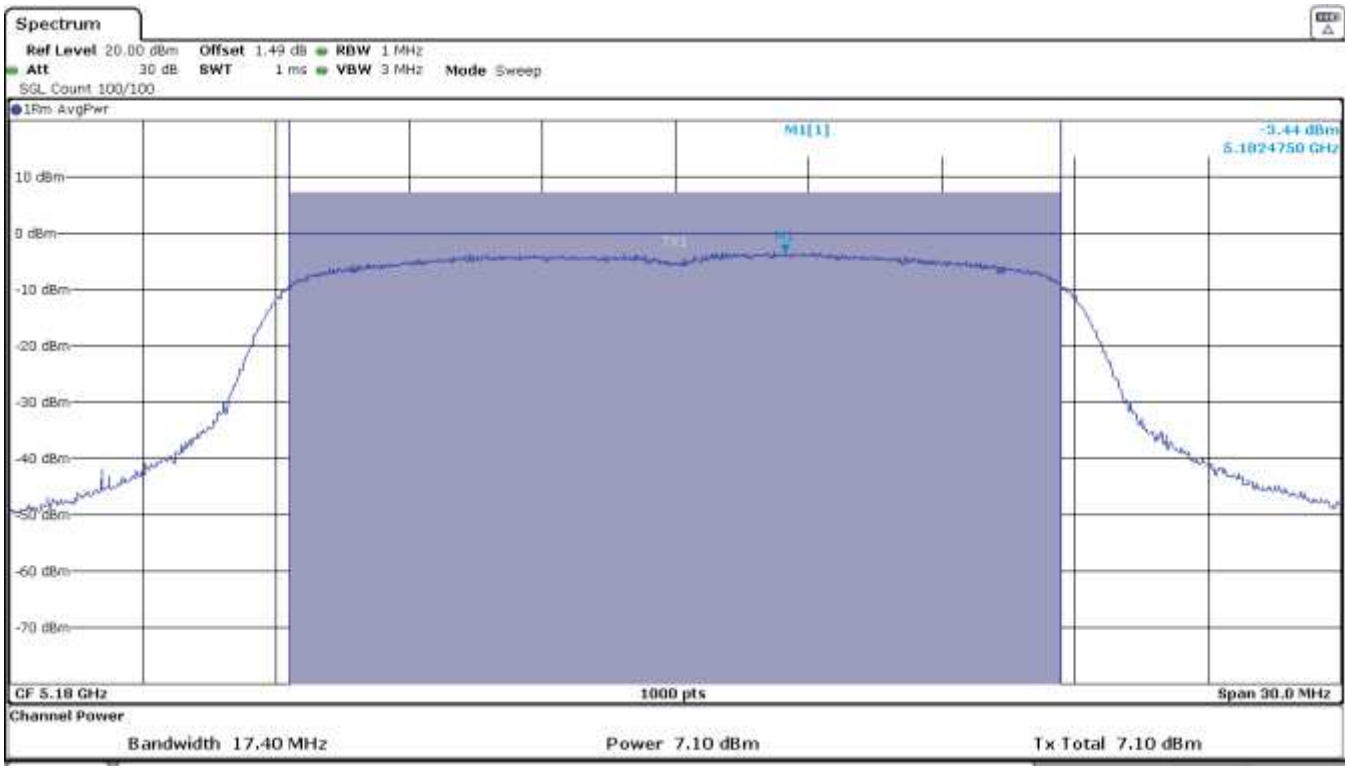


High Channel 48

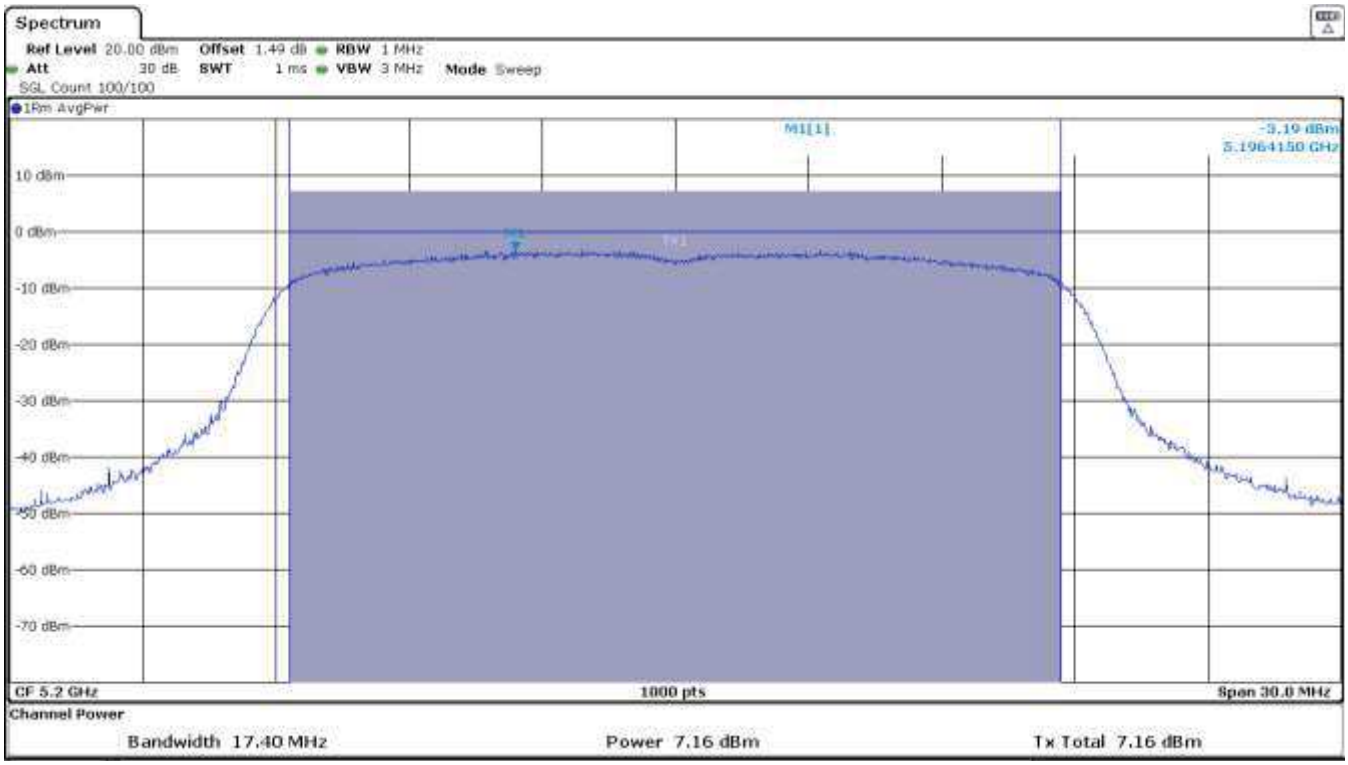


Mode 802.11 n20 (HT20)

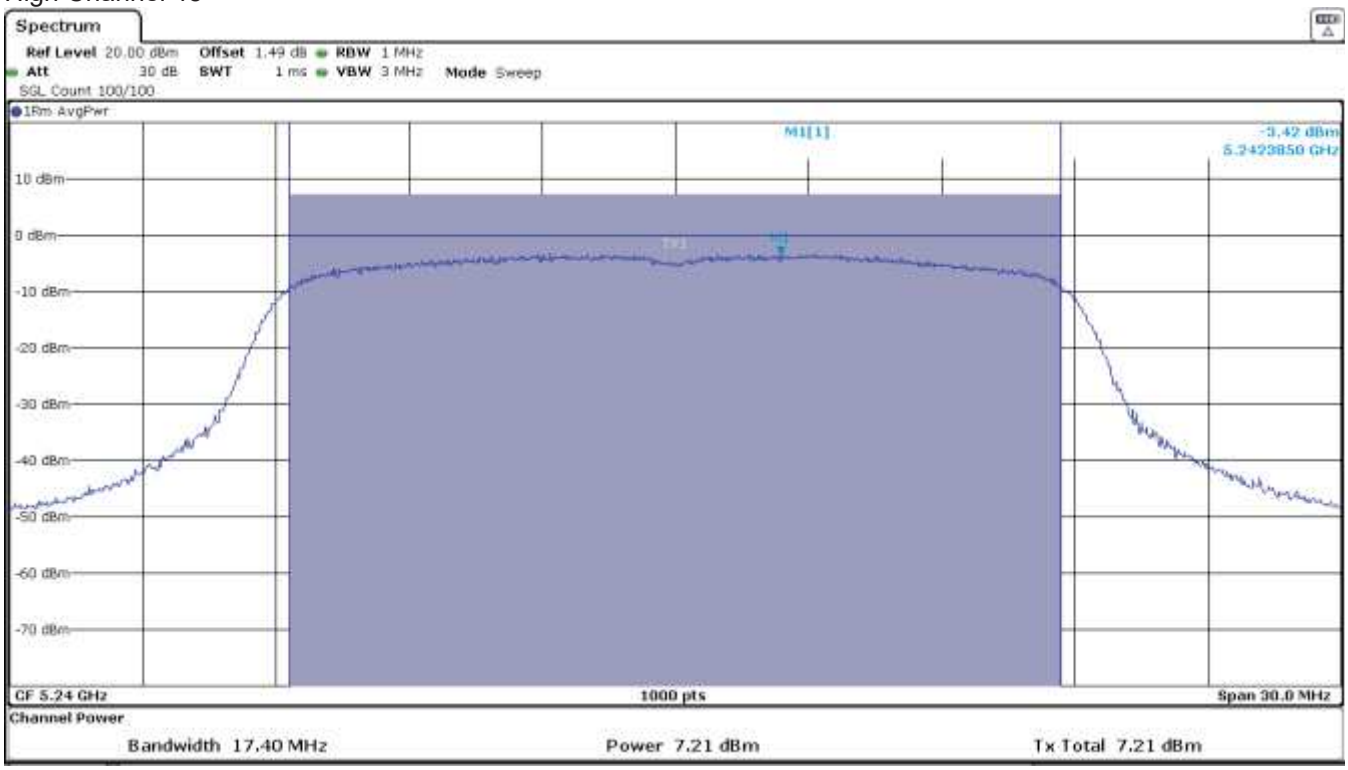
Low Channel 36



Middle Channel 40

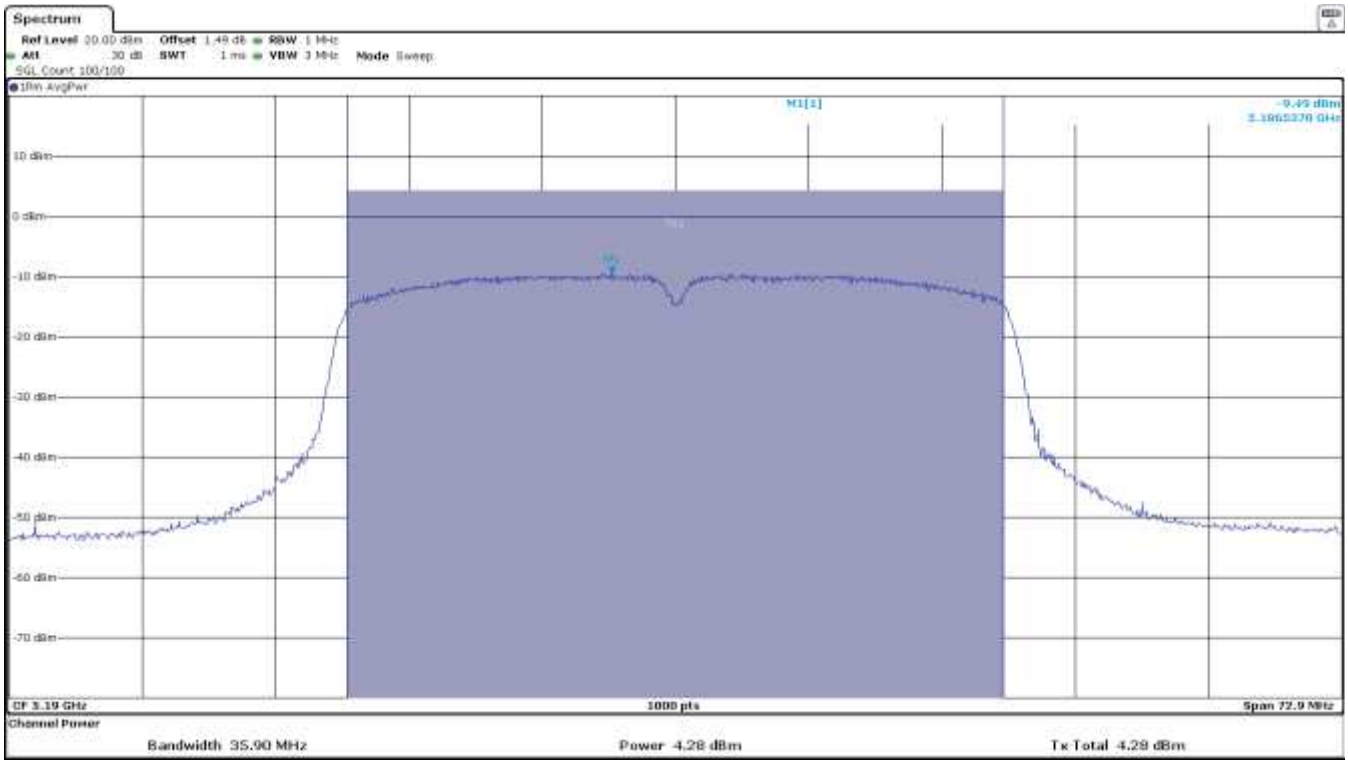


High Channel 48

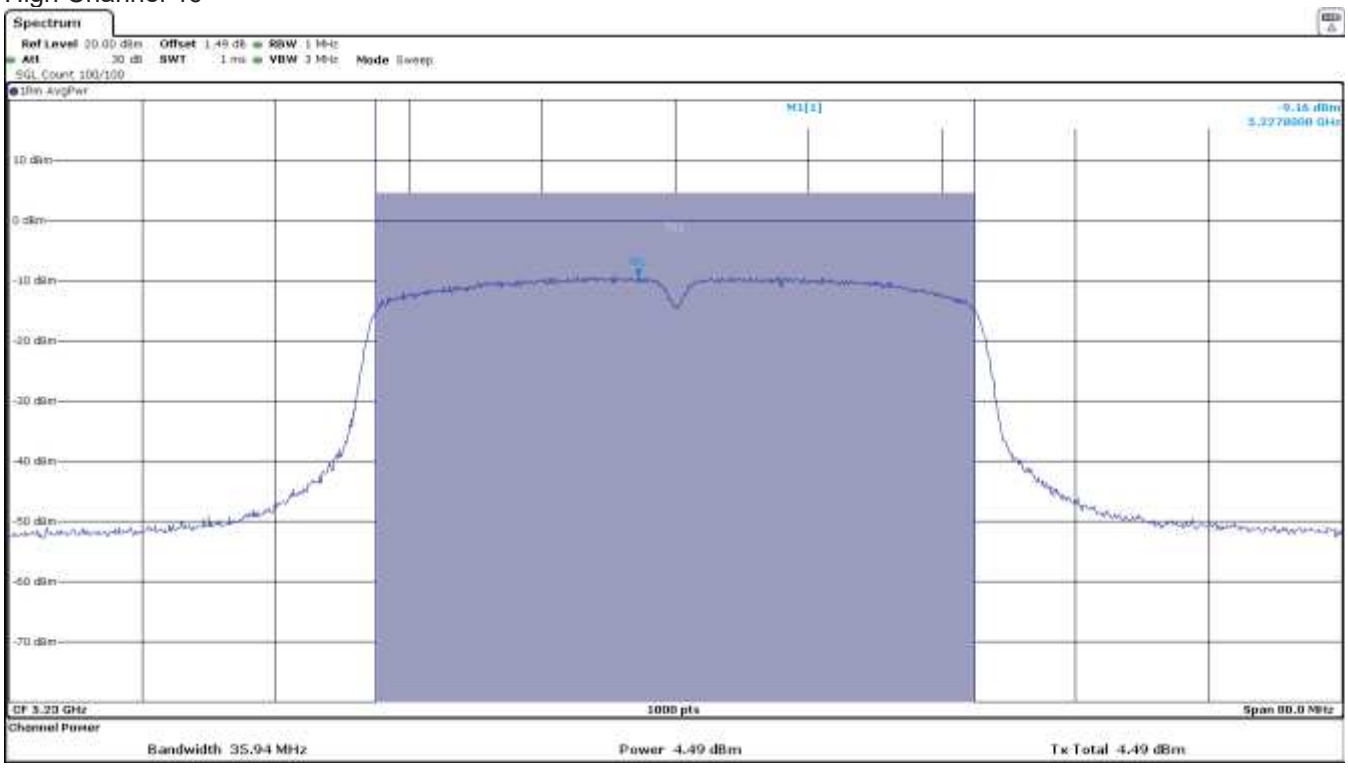


Mode 802.11 ac40 (VHT40)

Low Channel 38

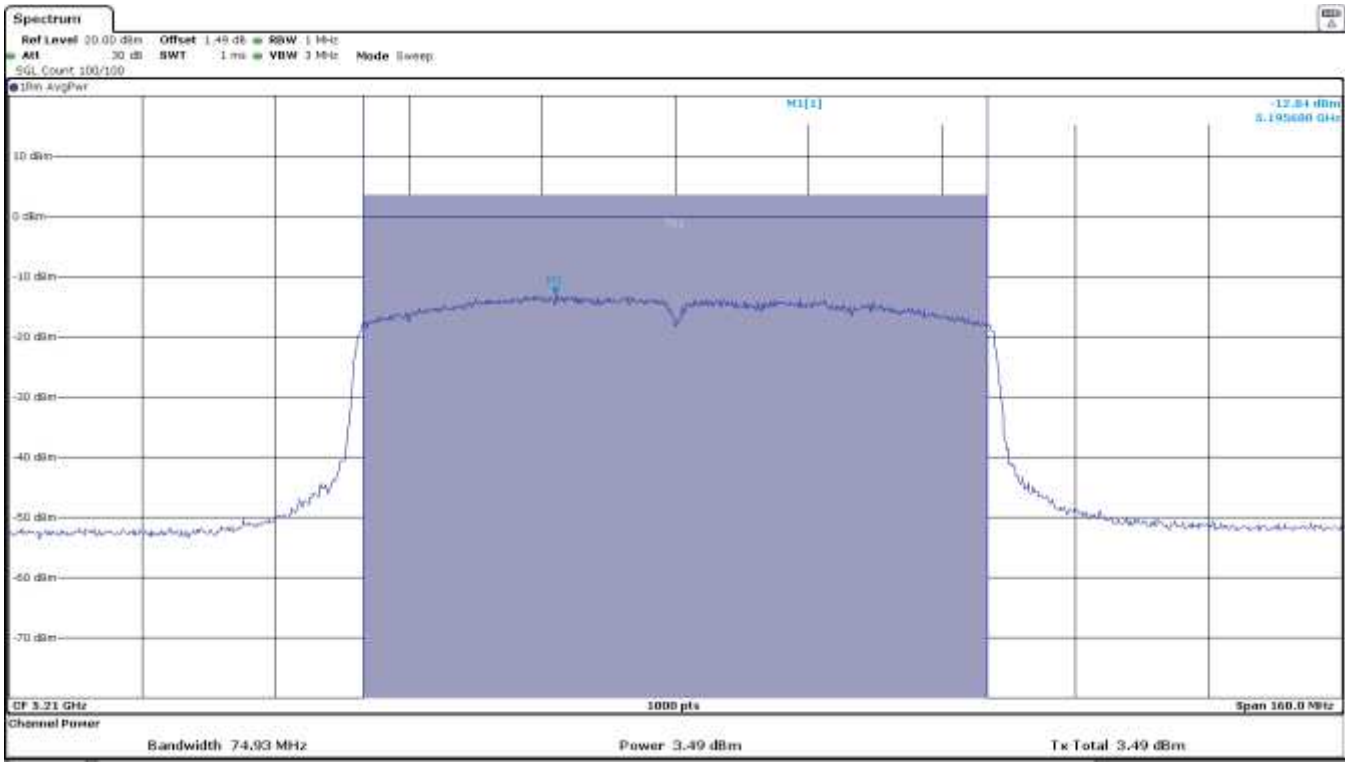


High Channel 46



Mode 802.11 ac80 (VHT80)

Middle Channel 42



FCC 15.407 (b)(1)(6) / RSS-247 6.2.1.2 Transmitter Out of Band Radiated Emissions

SPECIFICATION:

For transmitters operating in the 5.15–5.25 GHz band: all emissions outside of the 5.15–5.35 GHz band shall not exceed an EIRP of –27 dBm/MHz (68.23 dBµV/m at 3 m distance).

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)):

Frequency Range (MHz)	Field strength (µV/m)	Field strength (dBµV/m)	Measurement distance (m)
0.009-0.490	2400/F(kHz)	-	300
0.490-1.705	24000/F(kHz)	-	300
1.705 - 30.0	30	-	30
30 - 88	100	40	3
88 - 216	150	43.5	3
216 - 960	200	46	3
960 - 40000	500	54	3

The emission limits shown in the above table are based on measurements employing CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.
For average radiated emission measurements above 1000 MHz, there is also a limit corresponding to 20 dB above the indicated values in the table is specified when measuring with peak detector function.

RESULTS:

The situation and orientation was varied to find the maximum radiated emission. It was also rotated 360º and the antenna height was varied from 1 to 4 meters to find the maximum radiated emission.

Measurements were made in both horizontal and vertical planes of polarization.

All tests were performed in a semi-anechoic chamber at a distance of 3m for the frequency range 30 MHz-17 GHz and a distance of 1m for frequency range 17 GHz-40 GHz.

The field strength is calculated by adding correction factor to the measured level from the spectrum analyzer. This correction factor includes antenna factor, cable loss and pre-amplifiers gain.

Test performed on the following worst case:
- 802.11a20: 6Mbps. For outdoor Antenna
- 802.11n20: MCS0. For indoor Antenna

The worst case was determined by measuring the eirp density (radiated).

INDOOR ANTENNA: Maximum Declared Assembly Antenna Gain: +2.2 dBi

Frequency range 30 MHz - 1 GHz

The spurious emissions below 1 GHz do not depend on either the operating channel or the modulation mode selected in the EUT.

No spurious frequencies detected at less than 20 dB below the limit.

Measurement Uncertainty (dB) <±4.99

Frequency range 1 - 40 GHz

The results in the next tables show the maximum measured levels in the 1-40 GHz frequency range.

The Low, Middle and High Channels were measured for out-of-band emissions for the worst mode.

Spurious frequencies in the restricted bands with peak levels above the average limit (54 dBµV/m at 3 m) are measured with an average detector for checking compliance with the average limit.

- **Mode 802.11 n20** (worst case)

  - LOW CHANNEL. Spurious frequencies detected at less than 20 dB below the limit:

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector
10.3590	52.41	V	Peak

  - MIDDLE CHANNEL. Spurious frequencies detected at less than 20 dB below the limit:

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector
10.4000	49.01	H	Peak

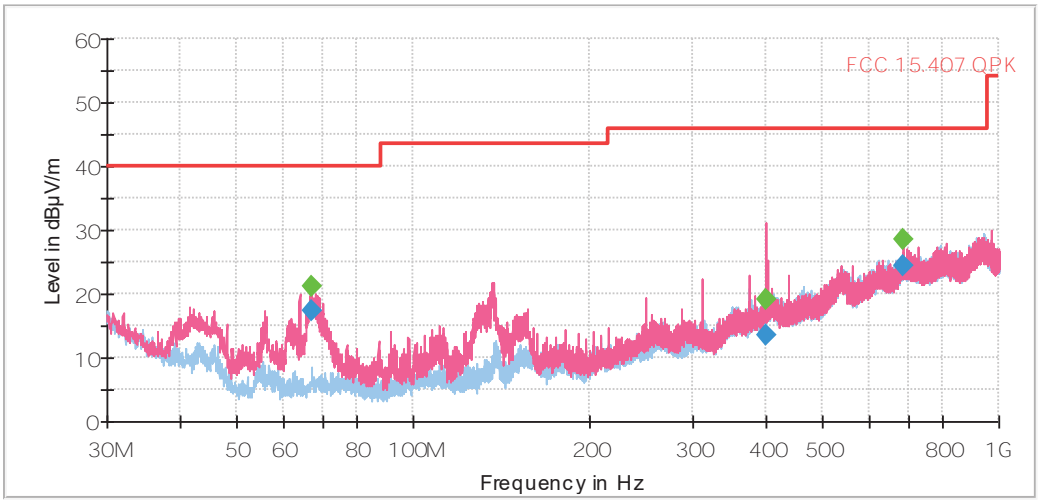
  - HIGH CHANNEL. Spurious frequencies detected at less than 20 dB below the limit:

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector
10.4780	51.50	H	Peak

Measurement Uncertainty (dB) 1GHz to 17GHz <±4.98
17GHz to 26GHz <±5.08
26GHz to 40GHz <±5.13

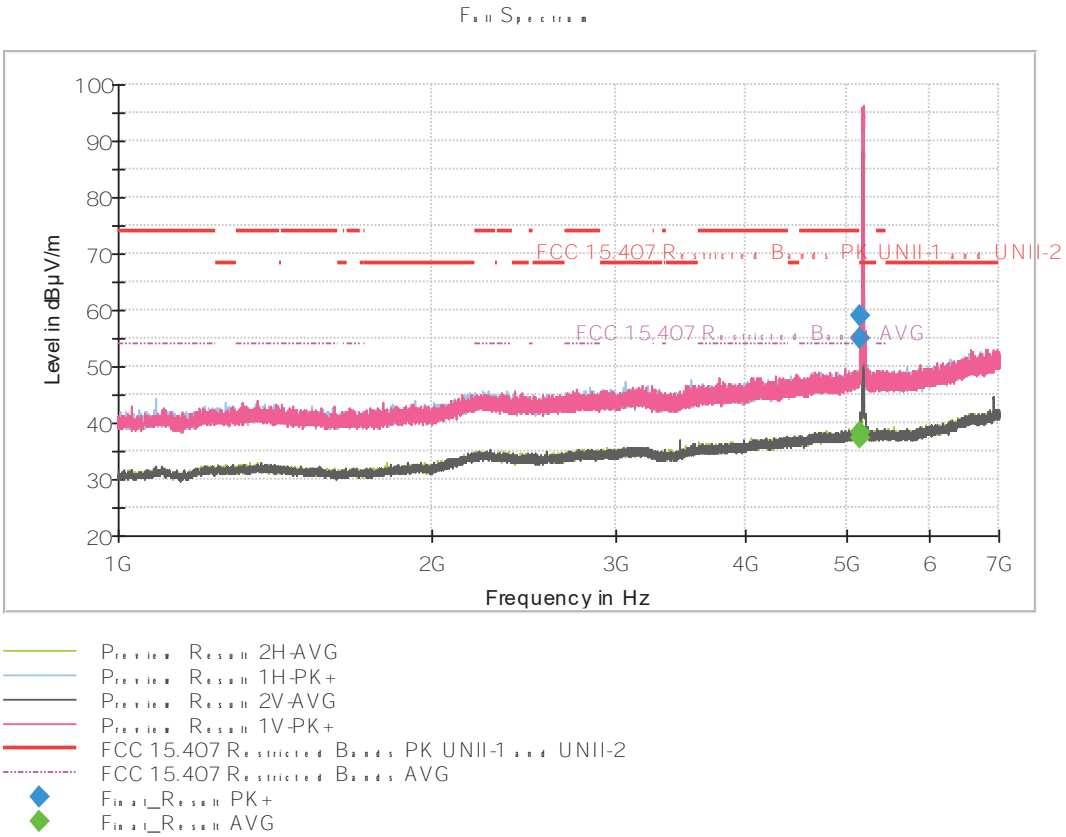
Verdict: PASS

Frequency range 30 MHz - 1 GHz
This plot is valid for all channels

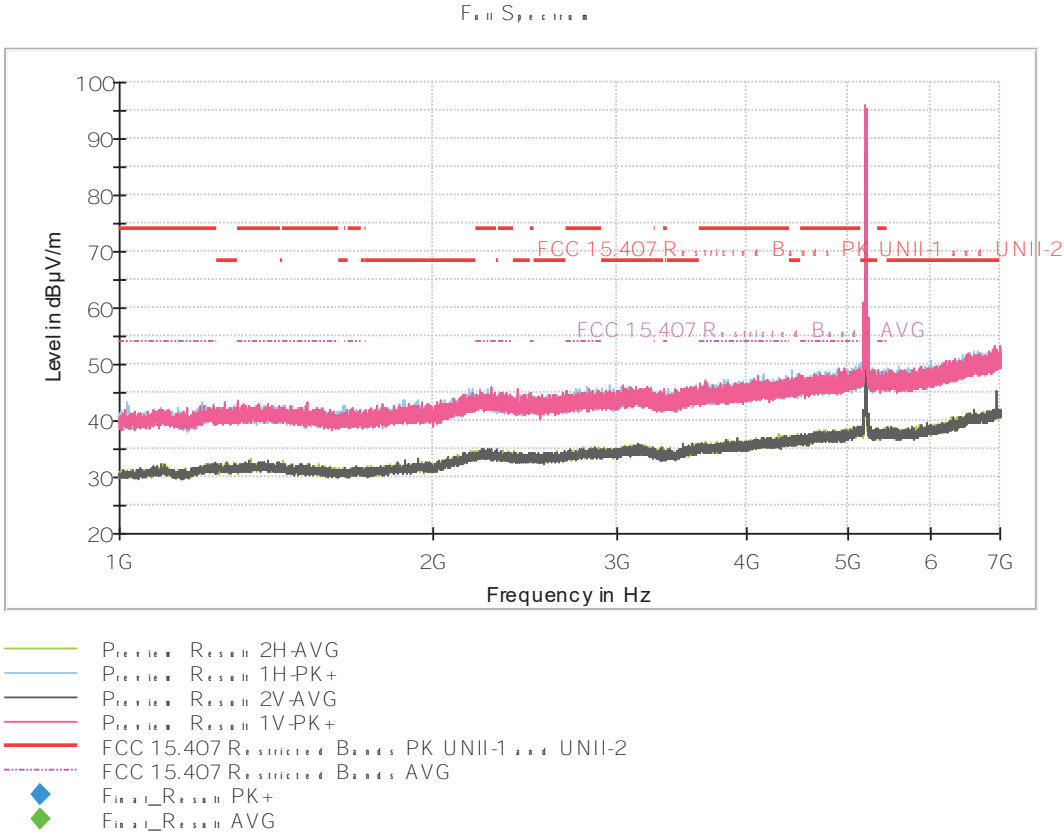


Frequency range 1 - 7 GHz

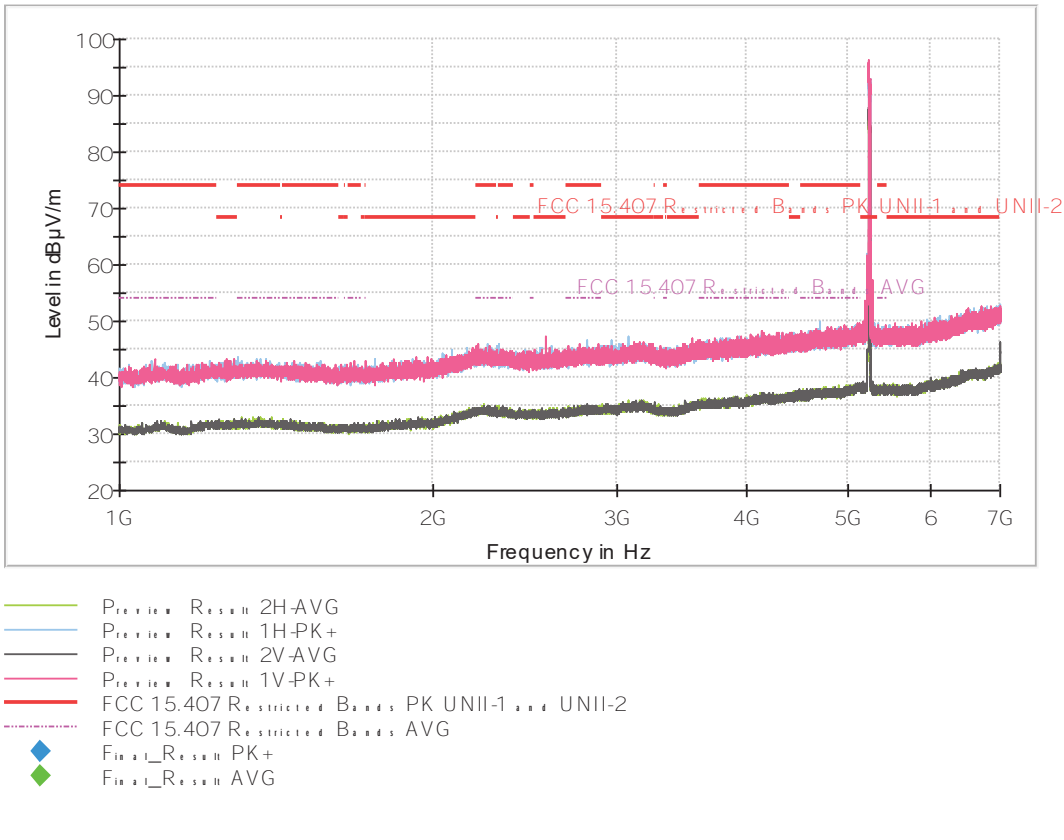
LOW CHANNEL



MIDDLE CHANNEL

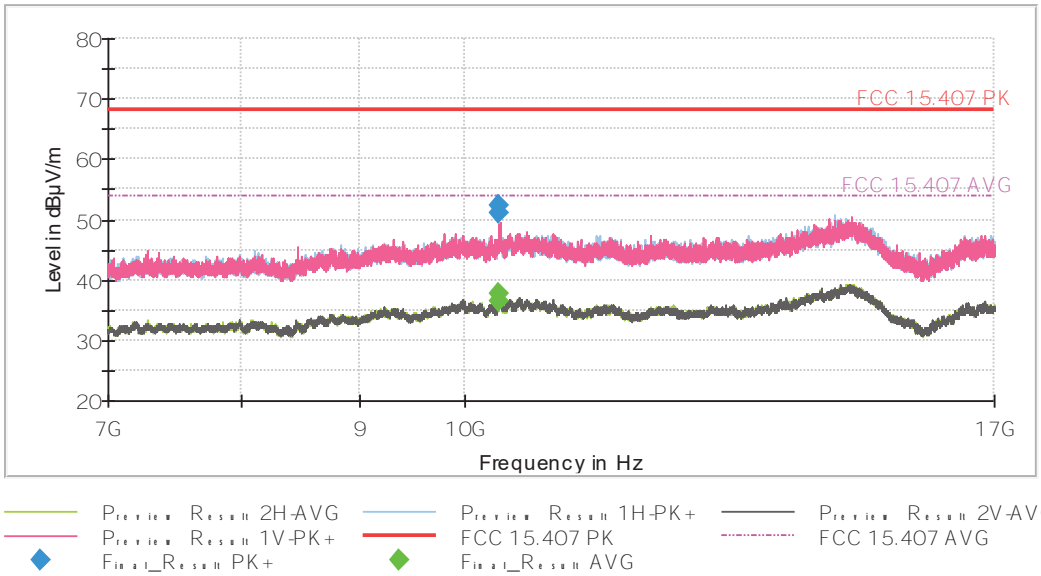


HIGH CHANNEL

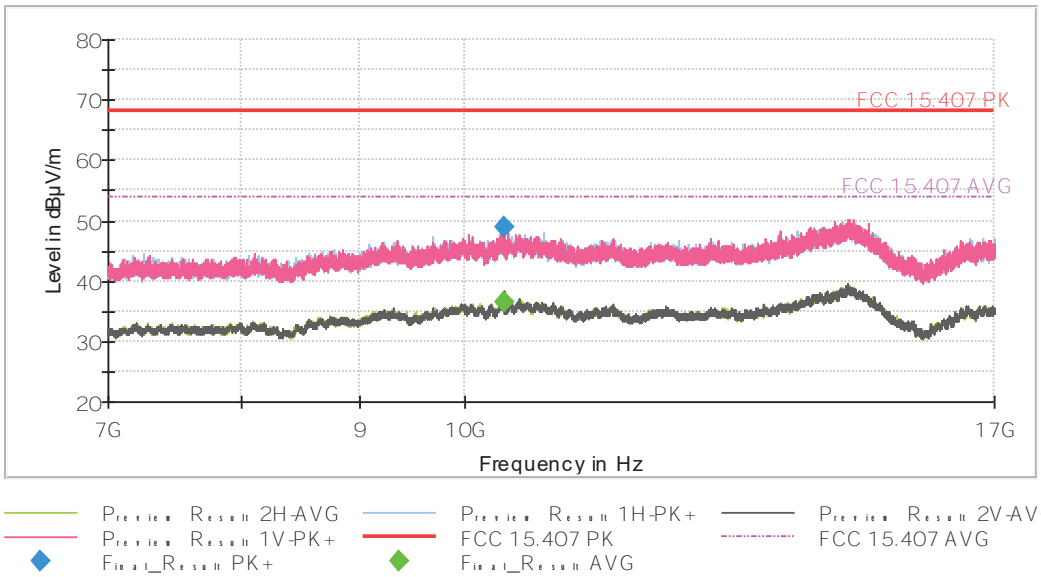


Frequency range 7 - 17 GHz

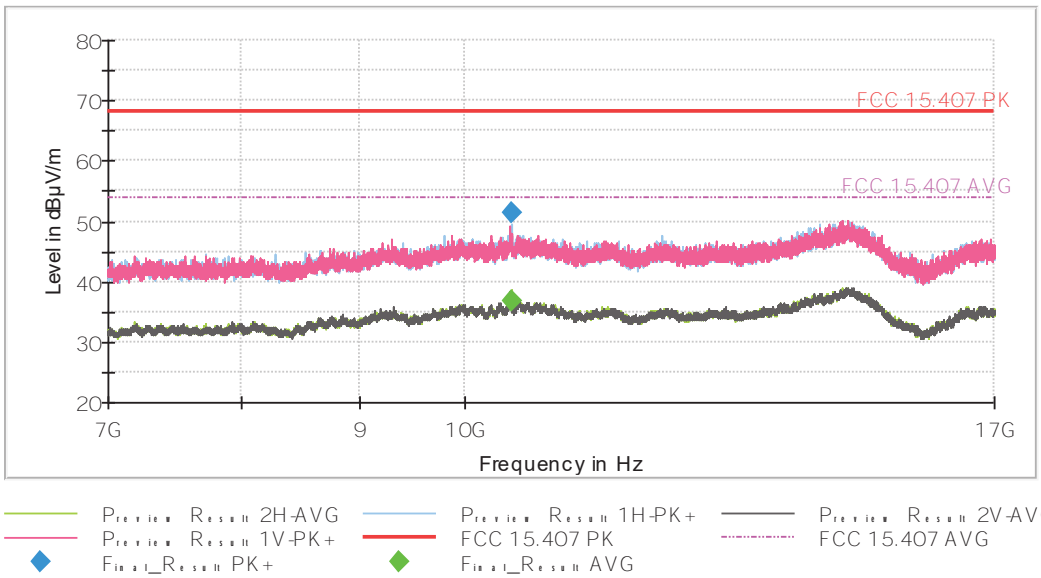
LOW CHANNEL



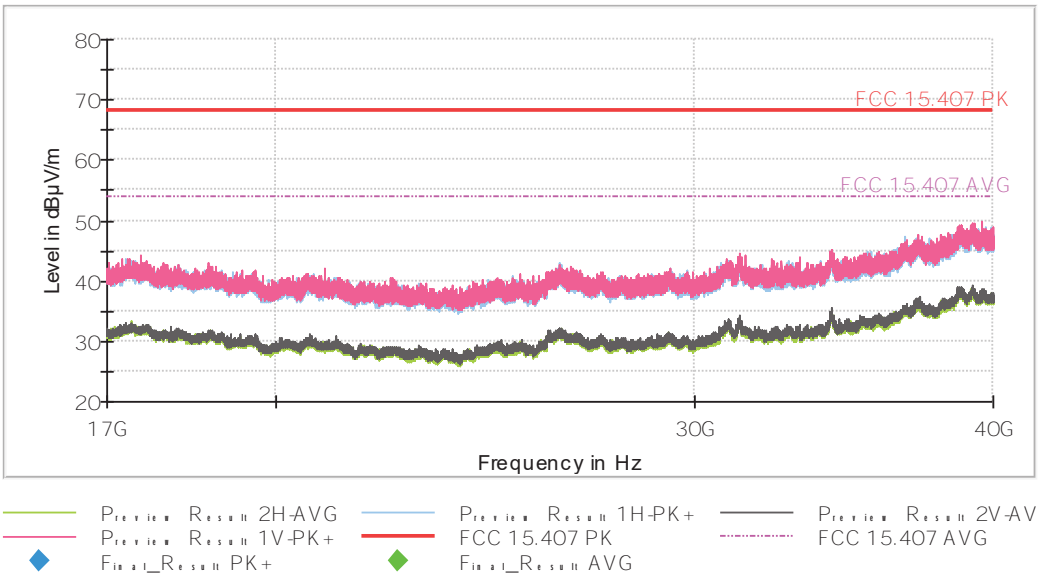
MIDDLE CHANNEL



HIGH CHANNEL



Frequency range 17 - 40 GHz
This plot is valid for all channels



OUTDOOR ANTENNA: Maximum Declared Assembly Antenna Gain: +0.6 dBi

Frequency range 30 MHz - 1 GHz

- LOW CHANNEL. No spurious frequencies detected at less than 20 dB below the limit.

- MIDDLE CHANNEL. No spurious frequencies detected at less than 20 dB below the limit.

- HIGH CHANNEL. No spurious frequencies detected at less than 20 dB below the limit.

Measurement Uncertainty (dB) <±4.99

Frequency range 1 - 40 GHz

The results in the next tables show the maximum measured levels in the 1-40 GHz frequency range.

The Low, Middle and High Channels were measured for out-of-band emissions for the worst mode.

Spurious frequencies in the restricted bands with peak levels above the average limit (54 dBµV/m at 3 m) are measured with an average detector for checking compliance with the average limit.

- **Mode 802.11 a20** (worst case)

- LOW CHANNEL. Spurious frequencies detected at less than 20 dB below the limit:

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector
10.0365	52.27	V	Peak

- MIDDLE CHANNEL. No spurious frequencies detected at less than 20 dB below the limit.

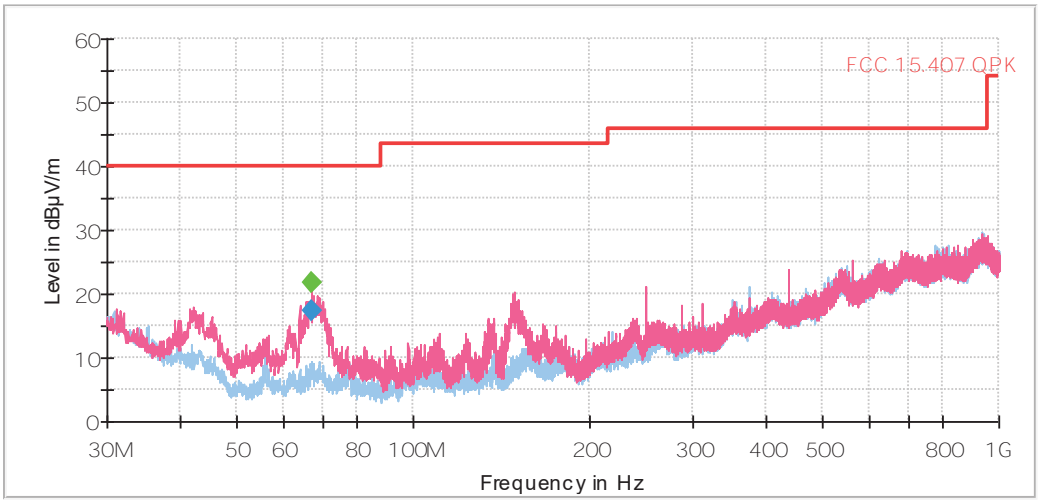
- HIGH CHANNEL. Spurious frequencies detected at less than 20 dB below the limit:

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector
10.4400	51.36	V	Peak

Measurement Uncertainty (dB) 1GHz to 17GHz <±4.98
17GHz to 26GHz <±5.08
26GHz to 40GHz <±5.13

Verdict: PASS

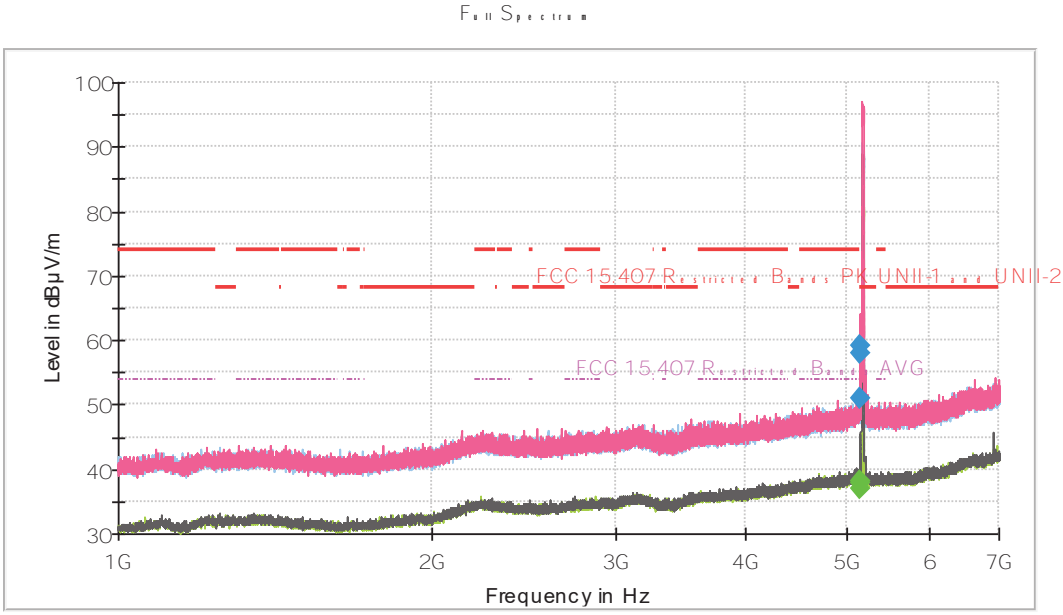
Frequency range 30 MHz - 1 GHz
This plot is valid for all channels



Preview Result 1H-PK+
Preview Result 1V-PK+
FCC 15.407 QPK
Final_Result QPK
Final_Result PK+

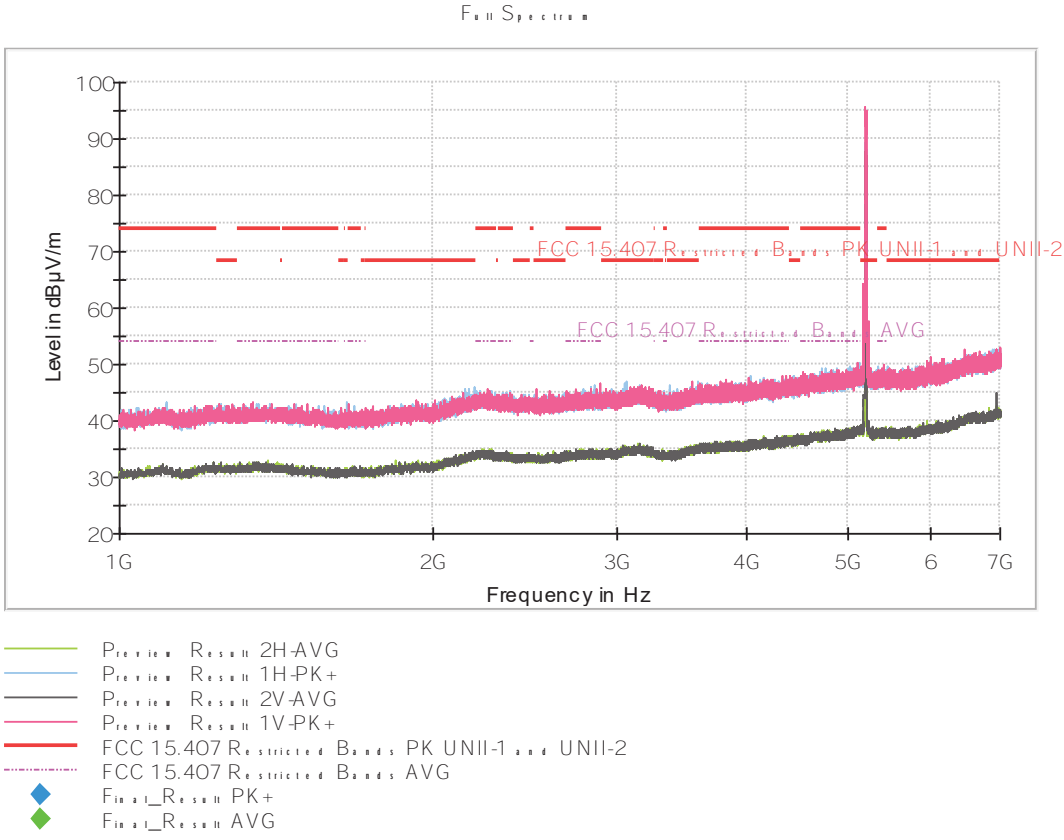
Frequency range 1 - 7 GHz

LOW CHANNEL

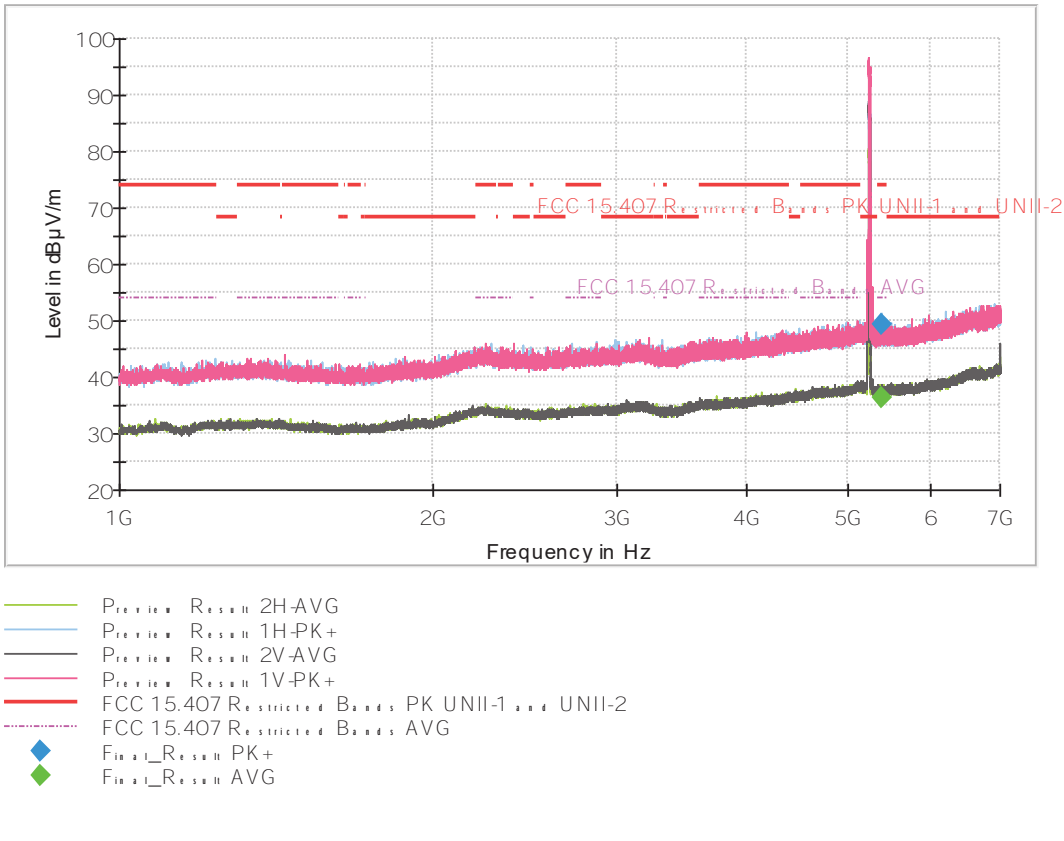


Preview Result 2H-AVG
Preview Result 1H-PK+
Preview Result 2V-AVG
Preview Result 1V-PK+
FCC 15.407 Restricted Bands PK UNII-1 and UNII-2
FCC 15.407 Restricted Bands AVG
Final_Result PK+
Final_Result AVG

MIDDLE CHANNEL

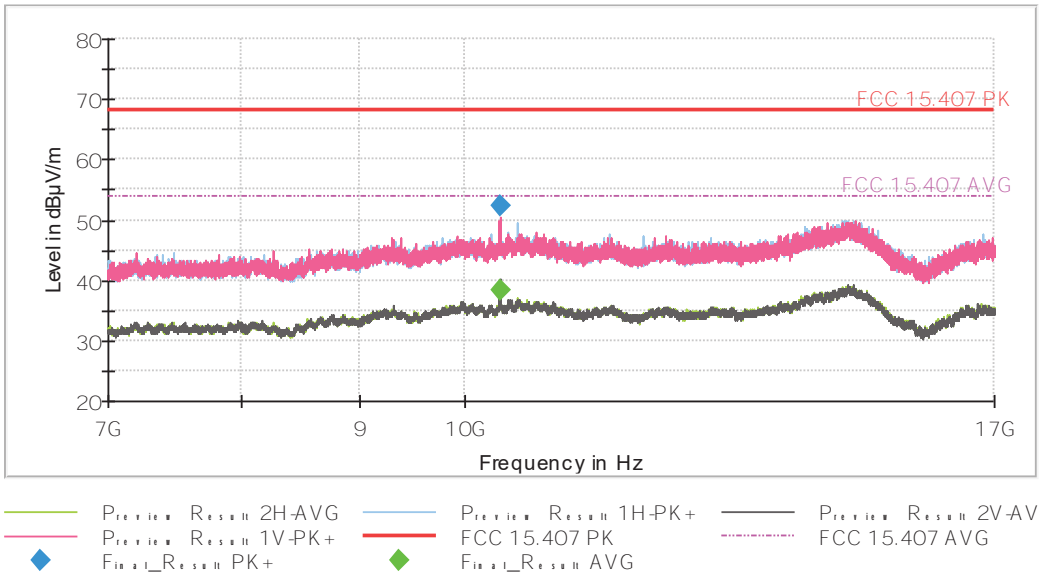


HIGH CHANNEL

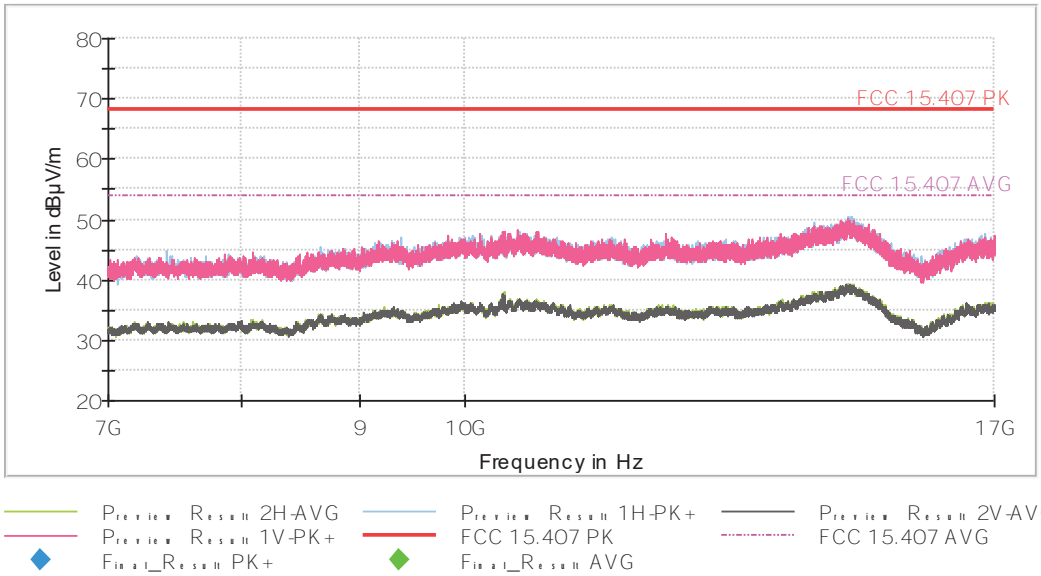


Frequency range 7 - 17 GHz

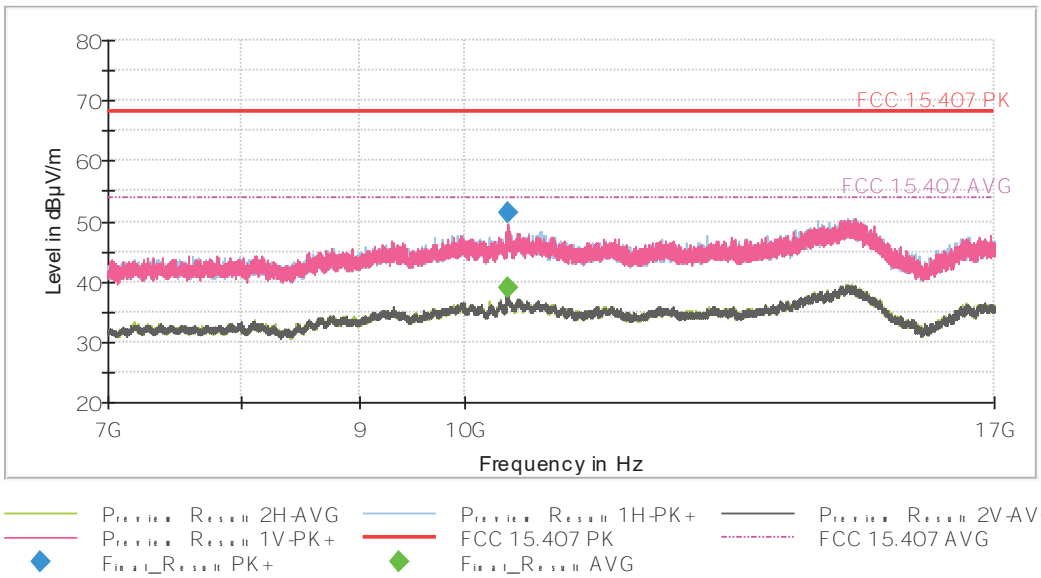
LOW CHANNEL



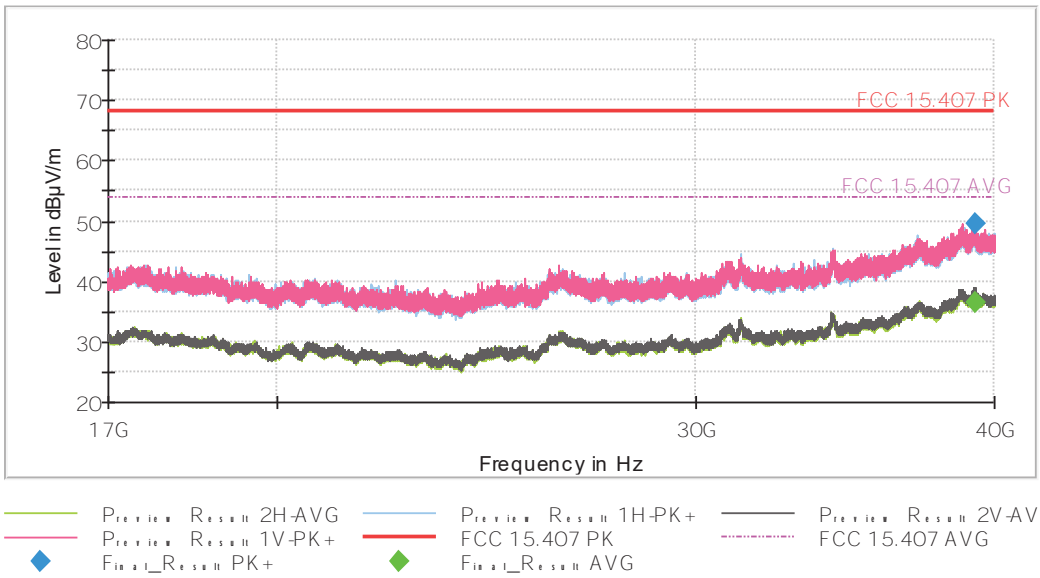
MIDDLE CHANNEL



HIGH CHANNEL



Frequency range 17 - 40 GHz
This plot is valid for all channels



FCC 15.407 (b) (1) / RSS-247 6.2.1.2 Transmitter Band Edge Radiated Emissions

SPECIFICATION:

For transmitters operating in the 5.15–5.25 GHz band: all emissions outside of the 5.15–5.35 GHz band shall not exceed an EIRP of –27 dBm/MHz (68.23 dBµV/m at 3 m distance).

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)):

Frequency Range (MHz)	Field strength (µV/m)	Field strength (dBµV/m)	Measurement distance (m)
0.009-0.490	2400/F(kHz)	-	300
0.490-1.705	24000/F(kHz)	-	300
1.705 - 30.0	30	-	30
30 - 88	100	40	3
88 - 216	150	43.5	3
216 - 960	200	46	3
960 - 40000	500	54	3

The emission limits shown in the above table are based on measurements employing CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

For average radiated emission measurements above 1000 MHz, there is also a limit corresponding to 20 dB above the indicated values in the table is specified when measuring with peak detector function.

RSS 247: Any unwanted emissions that fall into the band 5250-5350 MHz shall be attenuated below the channel power by at least 26 dB, when measured using a resolution bandwidth between 1 and 5% of the occupied bandwidth (i.e. 99% bandwidth), above 5250 MHz.

RESULTS:

The field strength is calculated by adding correction factor to the measured level from the spectrum analyzer. This correction factor includes antenna factor, cable loss and pre-amplifiers gain.

All emissions outside of the 5.15-5.35GHz band shall not exceed an EIRP of -27dBm/MHz. There are restricted bands of operation below band edge at 4.5-5.15 GHz also above the upper band edge at 5.35-5.46GHz therefore the provision of FCC Part 15.205 apply.

Field strength measurements using peak and average detector performed in the restricted bands below 5.15GHz and above 5.35 GHz.

Test performed on the following worst cases modes in all relevant tests channels:

- 802.11a: 6 Mbit/s.
- 802.11n HT20: MCS0.
- 802.11ac VHT20: MCS0.
- 802.11n HT40: MCS0.
- 802.11ac VHT40: MCS0.
- 802.11ac VHT80: MCS0.

INDOOR ANTENNA: Maximum Declared Assembly Antenna Gain: +2.2 dBi

- **Mode 802.11 a20**

- Lower Band Edge Channel 36 (5180 MHz): Inside band spurious emissions in 4.50-5.15 GHz adjacent band.

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
5.1456	55.92	V	Peak	<±3.98
	37.67		Average