Global Product Compliance Laboratory
600-700 Mountain Avenue
Room 5B-108
Murray Hill, New Jersey 07974-0636 USA

TESTING
NVLAP LAB CODE: 100275-0

RF Transmitter Certification Test Report
(FCC ID: 2AD8UAZRBRH1)

Regulation

FCC CFR 47 Part 15 Subpart E, Section 15.407

Client

Nokia Solutions and Networks Oy

Product Evaluated

AZRB AirScale Micro RRH Band 46 LAA UNII 2 (Non-DFS)

GPCL Report Number
TR2018-0233 FCC RF Non-DFS

GPCL Project Number
2018-0233

Date Issued
December 20, 2018

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Date	Revision	Section	Change

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The test results documented in this report refer exclusively to the test model/sample specified, under the conditions and modes of operation as described herein.

Prepared By:

Signed: _____ 12/20/2018
Q. Yu — Date
GPCL Compliance Engineer

Reviewed By:

Signed: _____ 12/20/2018
R.J. Johnson — Date
GPCL Technical Manager
NVLAP Approved Signatory

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1 ATTESTATION OF TEST RESULTS

Company Name (Manufacturer)	Nokia Solutions and Networks Oy 2000 W. Lucent Lane Naperville, IL 60563
FCC ID	2AD8UAZRBRH1
Product Name	AZRB AirScale Micro RRH Band 46 LAA
Model Name	AZRB
Serial Number(s)	1M181320011 (Radiated), 1M181319962 (Conducted)
Test Requirement(s)	47 CFR FCC Part 15 Subpart E, Section 15.407 (Non-DFS)
Test Procedures/Methods	• ANSI C63.10-2013 • FCC KDB 789033 D02, v02r01, December 2017 • FCC KDB 662911 D01, v02r01, October 2013 • FCC KDB 353028 D01, v01, April 2017
Frequency Band	5250-5350 MHz (UNII-2a); 5470-5725 MHz (UNII-2c) E-UTRAN Band 46
Operation Mode	Master Device
FCC Part 15 Subpart B Sections 15.107 and 15.109 Class B	Passed
Date Tested	October 12 – December 20, 2018
Type of Application	C2PC
Test Laboratory	Nokia Global Product Compliance Laboratory 600-700 Mountain Avenue Murray Hill, New Jersey 07974-0636 USA FCC Registration No/Designation No: 896745/US5302
Test Engineers	M. Soli, N. Patel, G. Manuel and J. Yadav

The above product has been evaluated and found to be in compliance with the Commission's Rules and Regulations set forth in the above standards.

FCC Section 2.911(e) Certification of Technical Test Data

The technical test data presented in this report are accurate.

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2 SUMMARY OF THE TEST RESULTS

Applied Standards: 47 CFR FCC Part Subpart E Section 15.407 UNII-2 (Non-DFS)				
Section	**FCC Rules**	**Description of Tests**	**Test Condition**	**Results In Compliance**
4.4	15.403 (i) & 15.407(a)(2) & 15.215(c)	Emission Bandwidth (26dB Bandwidth)	Conducted	Yes
4.5	15.407 (a)(2)(4)	Maximum Power Output		Yes
4.6	15.407 (h)(1)	Transmit Power Control		Yes
4.7	15.407 (a)(2)(5)	Peak Power Spectrum Density		Yes
4.8	15.407 (b)(2)(3)(5)(8)	Unwanted Out-of-Band Emissions	Conducted /Radiated	Yes
4.9	15.407 (b)(2)(3)(5-8)	Unwanted Spurious Emissions		Yes
	15.407 (g)	Frequency Stability*	Conducted	Yes

* KDB 789033 D02 Section II.A.3: the grantee is responsible for ensuring that the EUT meets 15.407(g) requirements; however, the applications for equipment certification are not required to include test reports with explicit demonstration of compliance.

2.1 Measurement Uncertainties for EMC Conducted and Radiated Emissions

The results of the calculations to estimate uncertainties for the several test methods and standards are shown in the Table below. These are the worst-case values.

Worst-Case Estimated Measurement Uncertainties

Standard, Method or Procedure	Condition	Frequency MHz	Expanded Uncertainty (k=2)
a. EMC Emissions, (*e.g.*, ANSI C63.4, CISPR 11, 14, 22, *etc.*, using ESHS 30, EMC-60, LISNs/AMNs and antennas)	Conducted Emissions	0.009 - 30	± 2.0 dB
	Radiated Emissions (AR-8 Semi-Anechoic Chambers)	30 – 200 200 – 1000	±5.1 ~ ±5.4 dB ±4.3 ~ ±4.7 dB
	Radiated Emissions (OATS)	1000 – 18,000	±3.3 dB

2.2 Measurement Uncertainties for Antenna Port Conducted Testing

Worst-Case Estimated Measurement Uncertainties

Standard, Method or Procedure	Expanded Uncertainty (k=2)
RF Power	± 1.4 dB
Occupied Bandwidth	± 2.2 dB
Conducted Spurious Emissions	± 2.8 dB

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3 GENERAL INFORMATION

3.1 Product Descriptions

Table 3.1.1 Product Specifications

Specification Items	Description
Product Type	LAA LTE RRH
Radio Type	Intentional Transceiver
Power Type	DC: -38V to -57V AC: 80V to 276V (via external AC/DC Converter)
FCC Rules	15.407
Operation Mode	Master Device, Point to Multipoint
Modulation	OFDM (QPSK, 16QAM, 64QAM, 256QAM)
Technology	LAA LTE-TDD
Frequency Range	E-UTRAN Band 46 5250-5350 MHz (UNII-2a); 5470-5725 MHz (UNII-2c)
Carrier Operating Frequency	5260-5320 MHz (UNII-2a); 5500-5720 MHz (UNII-2c)
Bandwidth(s)	20/40/60MHz
Max Rated Conducted RF Power	Antennas with Max Gain ≤ 6 dBi: 1x20MHz: 19.5dBm per port and 22.5dBm total 2x20MHz: 21dBm per port and 24dBm total 3x20MHz: 21dBm per port and 24dBm total Antennas with Max Gain =7.5 dBi: 1x20MHz: 18dBm per port and 21dBm total 2x20MHz: 19.5dBm per port and 23.5dBm total 3x20MHz: 19.5dBm per port and 23.5dBm total Antennas with Max Gain =9.5 dBi: 1x20MHz: 16dBm per port and 19dBm total 2x20MHz: 17.5dBm per port and 20.5dBm total 3x20MHz: 17.5dBm per port and 20.5dBm total
Max Rated EIRP Power	1x20MHz: 28.5dBm 2x20MHz: 30dBm 3x20MHz: 30dBm
TPC Function	Yes
Software Version (Master)	FL18A
Hardware Version (Master)	474510A.101
Antennas	Refer to Section 3.5. No beamforming

3.2 Accessories

A Nokia BBU, ASMi, was used for all testing. ASMi consists of an ASIA system module circuit pack and an ABIA baseband sub-module circuit pack. The ASMi was connected to the AZRB through fiber connection. The above accessory device is unmodified and is commercially available per FCC requirement given in 2.1033(b)(8).

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3.3 Description of Antenna(s)

Currently, there are seven available antennas of two types to be equipped for this low power Band 46 LAA RRH AZRB. The demonstration of meeting the FCC Section 15.203 and KDB 353028 D01 requirements on these antennas has been presented in previous filings, where it stated that unique (non-standard) antenna connectors were designed with the product and professional installation was used. There are provisions for special connectors to be used for any external antennas.

Table 3.3.1 UNII-2 Antenna Data from Manufacturers

Ant No	Model Name	Antenna Type/ Size (mm)	Frequency (MHz)	Tx/Rx Port	Max Gain (dBi)	
					Port 1	Port 2
1	AARC	Directional 295(L) × 270(W) × 30(D)	5150 ~ 5850	Tx/Rx 1/2	4.91	4.91
2	FA2RC	Directional 160(L) × 110(W) × 44(D)	5150 ~ 5850	Tx/Rx 1/2	6.0	6.0
3	VVSSP-360S-F	Omni-Directional 600(L) × 100(R)	5150 ~ 5925	Tx/Rx 1/2	5.1	5.1
4	GQ2410-06645	Omni-Directional 634(L) × 127.5(R)	5150 ~ 5925	Tx/Rx 1/2	5.9	5.9
5	2205	Directional 198(W) × 24.5(D) × 198(H)	5150 ~ 5925	Tx/Rx 1/2	9.5	9.5
6	GO4806-06664	Omni-Directional, 1219(L) × 52(D)	5150 ~ 5925	Tx/Rx 1/2	6.0	6.0
7	FA2RA	Omni-Directional , 235(L) × 51(D)	5150 ~ 5850	Tx/Rx 1/2	7.5	7.5

Table 3.3.2 UNII-1/3 Antennas Tested (with the Highest Gain of Each Type)

Antenna No	Model Name	Antenna Type	Frequency (MHz)	Max Gain (dBi)	
				Port 1	Port 2
5	2205	Directional	5150 ~ 5925	9.5	9.5
6	GO4806-06664	Omni-Directional	5150 ~ 5925	6.0	6.0
7	FA2RA	Omni-Directional	5150 ~ 5850	7.5	7.5

The compliance of the EUT with the omni-directional antennas #6 which has the maximum power setting, the omni-directional antenna #7 and the directional antenna #5 which have the highest antenna gain among the same type, was evaluated, respectively.

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4 REQUIRED MEASUREMENTS AND RESULTS

4.1 Regulatory Requirements

FCC 2.1041(a) stated that for equipment operating under parts 15 and 18, the measurement procedures are specified in the rules governing the particular device for which certification is requested.

The tests in this report were performed for Unlicensed-National Information Infrastructure (UNII) Devices Operating in the 5250-5350 MHz and 5470-5725 MHz Bands in accordance with the non-DFS requirements of FCC CFR 47 Part 15 Subpart E.

The requirements are provided in the following:

(1) Emission Bandwidth (FCC 15.403 (i), 15.407(a)(2), 15.215(c))

The emission bandwidth shall be determined by the 26dB bandwidth. 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.

In the case of intentional radiators operating under the provisions of Subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that subpart. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage.

(2) Output Power and Power Spectrum Density Limits (FCC 15.407 (a)(2)(4)(5))

For the 5.25-5.35 GHz and 5.47-5.725 GHz bands, the maximum conducted output power shall not exceed the lesser of 250 mW or 11 dBm + 10 log B, where B is the 26 dB emission bandwidth in megahertz. In addition, 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.

The maximum conducted output power must be measured with *rms* detector. Measurements of the maximum power spectral density in the 5.25-5.35 GHz and 5.47-5.725 GHz are made over a bandwidth of 1 MHz or the 26dB emission bandwidth of the device, whichever is less. A narrower resolution bandwidth can be used, provided that the measured power is integrated over the full reference bandwidth.

(3) Unwanted Emission Limits (FCC 15.407 (b)(2)(3)(5-8)), 15.209 and 15.205 (a, b, c).

The peak emissions outside of the frequency bands of operation shall be attenuated in accordance with the following limits:

i. For transmitters operating in the 5.25-5.35 GHz band: all emissions outside of the 5.15-5.35 GHz band shall not exceed an EIRP of -27 dBm/MHz.

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ii. For transmitters operating in the 5.47-5.725 GHz band: all emissions outside of the 5.47-5.725 GHz shall not exceed an EIRP of −27 dBm/MHz.

iii. The emission measurements shall be performed using a minimum resolution bandwidth of 1 MHz. A lower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 1 MHz.

iv. Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in Section 15.209. Further, any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in Section 15.207.

v. The provisions of Section 15.205 apply to UNII intentional radiators, where the field strength of emissions appearing *within Section 15.205 restricted frequency bands* shall not exceed the limits shown in Section 15.209. At frequencies equal to or less than 1GHz, compliance with the limits in Section 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1GHz, compliance with the emission limits in Section 15.209 shall be demonstrated based on the *average* value of the measured emissions. The provisions in Section 15.35 apply to these measurements.

vi. When measuring the emission limits, the nominal carrier frequency shall be adjusted as close to the upper and lower frequency band edges as the design of the equipment permits.

Therefore,

1) the emissions from the UNII transmitter in the frequency spectrum up to the 10th harmonics are subject to the following requirements:
   a. For emissions outside the restricted bands, per 15.407(b)(6-7), KDB789033 D02 II.G.2.a-c,
      (i) f < 1GHz, the limits specified in 15.209 need to be met by QPK or PK;
      (ii) f > 1GHz, the limits specified in 15.407 (b)(1-4) for UNII-1/2/3 need to be met by PK;
   b. For emissions in the restricted bands, per 15.407(b)(6-7), 15.205 (b), KDB 789033 D02 II.G.1.a-c,
      (i) f < 1GHz, the limits specified in 15.209 need to be met by QPK or PK;
      (ii) f > 1GHz, the limits specified in 15.209 need to be met by AVE and the limits specified in 15.407 (b)(1-4) for UNII-1/2/3 need to be met by PK

2) the emissions from the digital circuits of the EUT in the frequency spectrum up to the 5th harmonics are subject to the 15.109 limit.

3) the emissions from AC power lines in the frequency range of 150kHz and 30MHz are subject to the 15.107 and 15.207 limits.

Either radiated measurement with antenna in place or antenna-port conducted measurement plus cabinet emissions test with antenna terminated can be used.

The emissions of AC power lines have been evaluated in the original filing with EUT transmitting at the maximum power in UNII-3 band which has higher output power than that of UNII-2 carriers. The emissions were in compliance with the FCC 15.207 and 15.107 Class B requirements with over 4dB margin. Therefore, the evaluation of AC power lines emissions for UNII-2 band is waived.

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Table 4.1.1 FCC Part 15.205 (a) Restricted Bands of Operation

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

(4) Frequency Stability (FCC 15.407 (g), 15.215(c), KDB 789033 D02 Section II.A.3).

Section 15.407(g) stated that manufacturers of UNII 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.

Section 15.215(c) stated that in the case of intentional radiators operating under the provisions of Subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that subpart. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage.

KDB 789033 D02 Section II.A.3 stated that the grantee is responsible for ensuring that the EUT meets Section 15.407(g) requirements; however, the applications for equipment certification are *not* required to include test reports with explicit demonstration of compliance.

(5) Antennas to Be Tested (15.203, 15.204, KDB 353028 D01)

Section 15.204(c)(2) requires that compliance testing use the *actual* antennas to be certified with the part 15 intentional radiator. All devices (*e.g.*, radio card, module) must be tested with the antennas connected to the device.

Section 15.204(b) states that an approved "transmission system" must always be marketed as a complete system, *i.e.,* including the antenna.

KDB 353028 D01 Section III.A stated that when submitting test data for part 15 transmitters to be used with multiple antennas, the non-DFS testing for the highest gain of each type of antenna (*e.g.,* highest gain for

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each patch, yagi, grid, dish, monopole, etc.) was required. For systems that can operate at different power levels, test data with the highest output power must be submitted.

(6) Transmit Power Control (TPC) (15.407(h)(1))

U-NII devices operating in the 5.25-5.35 GHz band and the 5.47-5.725 GHz band shall employ a TPC mechanism. The U-NII device is required to have the capability to operate at least 6 dB below the mean EIRP value of 30 dBm. A TPC mechanism is not required for systems with an EIRP of less than 500 mW.

4.2 UNII-2a/2c Band Carrier Frequencies

The channel 144 is a straddle channel. The power and PSD requirement in UNII-3 are less strigent than in UNII-2c. Therefore, the requirements in UNII-2 need to be used.

Table 4.2.1 5GHz UNII-2 (5250-5350MHz, 5470-5725MHz) Frequency Channel Plan

Bands	Channel No (Nch)	Freq (MHz)	Channel Bandwidth	Frequency Bands
UNII-2a (B46b)	52	5260	20MHz	5250-5350
	56	5280		
	60	5300		
	64	5320		
UNII-2c (B46c)	100	5500	20MHz	5470-5725
	104	5520		
	108	5540		
	112	5560		
	116	5580		
	120	5600		
	124	5620		
	128	5640		
	132	5660		
	136	5680		
	140	5700		
	144	5720		
UNII-2a (B46b)	52, 56	5260, 5280	40MHz	5250-5350
	60, 64	5300, 5320		
UNII-2c (B46c)	100, 104	5500, 5520	40MHz	5470-5725
	108, 112	5540, 5560		
	116, 120	5580, 5600		
	124, 128	5620, 5640		
	132, 136	5660, 5680		
	140, 144	5700, 5720		
UNII-2a (B46b)	52, 56, 60	5260, 5280, 5300	60MHz	5250-5350
UNII-2c (B46c)	100, 104, 108	5500, 5520, 5540	60MHz	5470-5725
	112, 116, 120	5560, 5580, 5600		
	124, 128, 132	5620, 5640, 5660		
	136, 140, 144	5680, 5700, 5720		

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Table 4.2.2(a) 5GHz UNII-2a (5250 -5350MHz) Frequency Channels Used for Testing

Channel No.	Freq (MHz)	Bandwidth
52	5260	20MHz
60	5300	
64	5320	
52, 56	5260, 5280	40MHz
60, 64	5300, 5320	
52, 56, 60	5260, 5280, 5300	60MHz

Table 4.2.2(b) 5GHz UNII-2c (5470 -5725MHz) Channels Used for Testing

Channel No.	Freq (MHz)	Bandwidth
100	5500	20MHz
116	5580	
140	5700	
144	5720	
100, 104	5500, 5520	40MHz
116, 120	5580, 5600	
132, 136	5660, 5680	
140, 144	5700, 5720	
100, 104, 108	5500, 5520, 5540	60MHz
112, 116, 120	5560, 5580, 5600	
124, 128, 132	5620, 5640, 5660	
136, 140, 144	5680, 5700, 5720	

4.3 Test Configurations and Setup

All measurements were performed with the EUT transmitting at 100% duty cycle (at least 98% if required by the EUT for amplitude control purposes) at the following power control level.

Table 4.3.1 Power Levels Tested for UNII-2a/2c

Total Per Port Power Setting for Antennas #1-#4, #6 ($G^{max} \leq 6$ dBi)	Total Per Port Power Setting for Antenna #5 ($G^{max} = 9.5$ dBi)	Total Per Port Power Setting for Antenna #7 ($G^{max} = 7.5$ dBi)
1x20MHz: 19.5 dBm; 2x20MHz: 21.0 dBm; 3x20MHz: 21.0 dBm	1x20MHz: 16.0 dBm; 2x20MHz: 17.5 dBm; 3x20MHz: 17.5 dBm	1x20MHz: 18.0 dBm; 2x20MHz: 19.5 dBm; 3x20MHz: 19.5 dBm

Various modulation types (Q/16QAM, 64QAM and 256QAM) and bandwidth modes (20MHz, 40MHz and 60MHz) were (pre-)evaluated for the conducted and radiated tests, incluing RF power output, peak power spectrum density, emissions bandwidth and unwanted emissions.

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The test setup diagrams are given below.

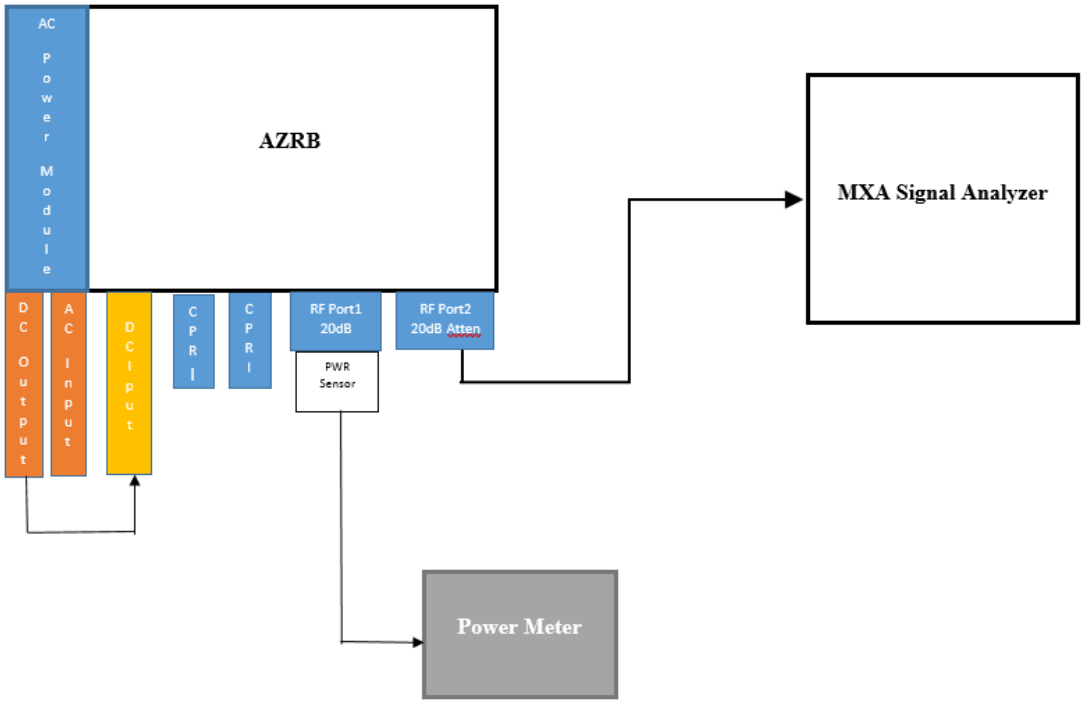

Figure 4.3.1 Setup Diagram of Conducted Test

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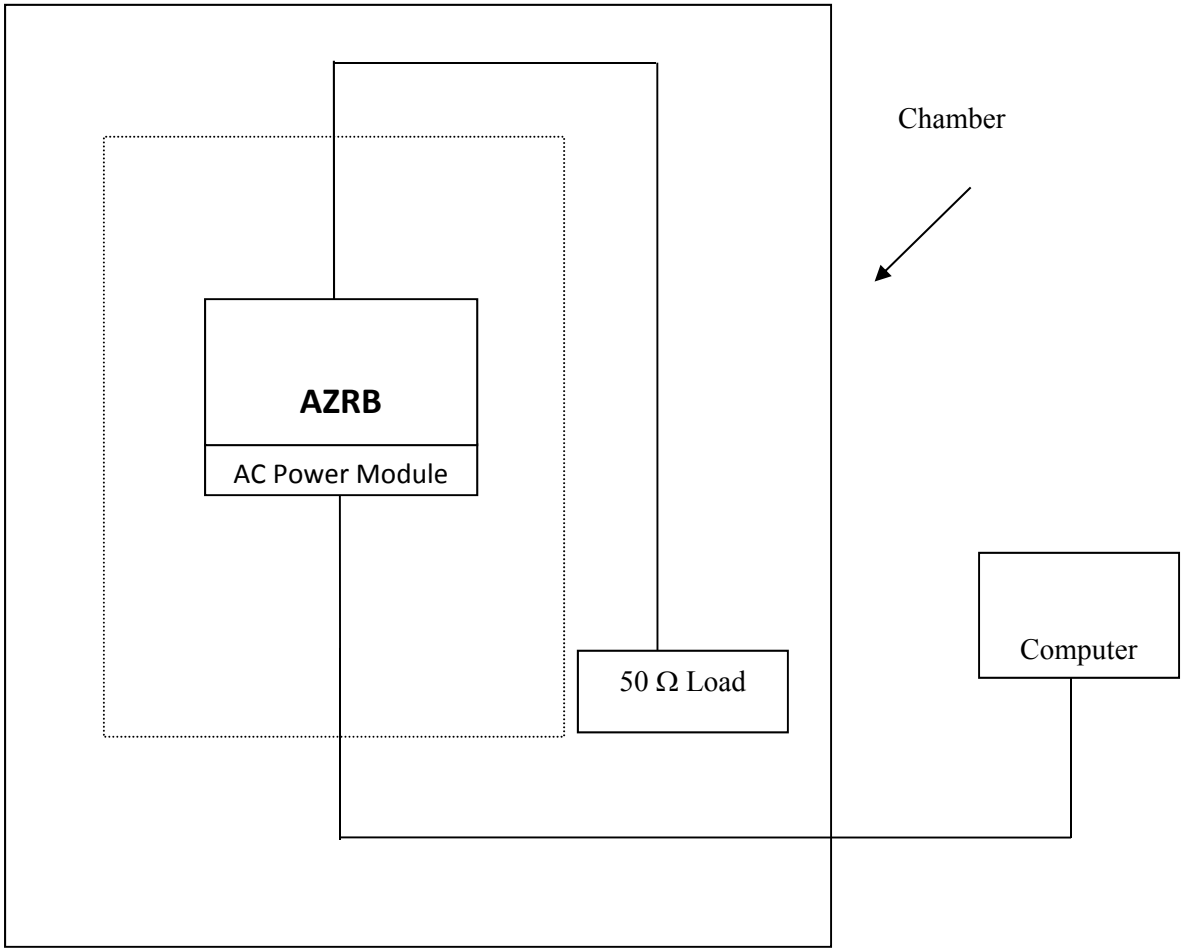

Figure 4.3.2 Setup Diagram of Radiated Test

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4.4 MEASUREMENT REQUIRED: EMISSION BANDWIDTH (26 dB BANDWIDTH) – FCC SECTIONS 15.403 (i) & 15.407(a)(2) & 15.215(c)

The measurement requirements of the emission bandwidth were provided in Section 4.1

The 26dB emission bandwidth was measured at both antenna ports for the channels listed in Table 4.2.2. The measurement follows the procedures given in KDB 789033 D02. The automatic bandwidth measurement function of the spectrum analyzer was utilized where the resolution bandwidth (RBW) is initially set to 1% of the bandwidth and the video bandwidth (VBW), that is 200kHz for 20MHz, 400kHz for 40MHz and 600kHz for 60MHz, the video bandwidth was set to 1MHz, and the peak detector with maximum hold and auto sweep was used. Then the maximum width of the emission that is 26 dB down from the maximum of the emission was measured and compared with the RBW setting of the analyzer. The RBW might be readjusted as needed until the RBW/EBW ration is approximately 1%.

The maximum allowable conducted power levels at 21dBm/port were used for this measurement. The measured results are tabluated below. Three plots which have the widest emission bandwidth are provided below.

Table 4.4.1(a) 26dB Emissions Bandwidth for One-20MHz Carrier UNII-2

Bands (GHz)	Ch No	Carrier Freq (MHz)	Modulation	Port 1 (MHz)	Port 2 (MHz)
5.25-5.35	52	5260	Q/16QAM	19.46	19.57
	60	5300	Q/16QAM	19.31	19.45
			256QAM	18.91	19.02
	64	5320	Q/16QAM	19.29	19.57
5.47-5.725	100	5500	Q/16QAM	19.36	19.45
	116	5580	Q/16QAM	19.47	19.52
			256QAM	19.06	18.88
	140	5700	Q/16QAM	19.23	19.43

Table 4.4.1(b) 26dB Emissions Bandwidth for Two-20MHz Carriers UNII-2

Bands (GHz)	Ch No	Carrier Freq (MHz)	Modulation	Port 1 (MHz)	Port 2 (MHz)
5.25-5.35	52, 56	5260, 5280	Q/16QAM	39.2	39.25
	60, 64	5300, 5320	Q/16QAM	39.05	38.94
			256QAM	38.86	39.06
5.47-5.725	100, 104	5500, 5520	Q/16QAM	39.0	39.28
	116, 120	5580, 5600	Q/16QAM	39.28	39.09
			256QAM	38.91	39.00
	136, 140	5680, 5700	Q/16QAM	39.08	39.22

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Table 4.4.1(c) 26dB Emissions Bandwidth for Three-20 MHz Carriers UNII-2

Bands (GHz)	Ch No	Carrier Freq (MHz)	Modulation	Port 1 (MHz)	Port 2 (MHz)
5.25-5.35	52, 56, 60	5260, 5280, 5300	Q/16QAM	59.61	59.60
			256QAM	59.06	58.98
5.47-5.725	100, 104, 108	5500, 5520, 5540	Q/16QAM	59.62	59.63
	112, 116, 120	5560, 5580, 5600	Q/16QAM	59.56	59.67
			256QAM	59.65	59.03
	124, 128, 132	5620, 5640, 5660	Q/16QAM	59.74	59.71

The maximum 26dB emissions bandwidths of the EUT measured at its antenna transmitting terminals across the UNII-2 bands for various modulations are tabulated below.

Table 4.4.2 Maximum 26dB Emissions Bandwidth (EBW) Measured

Bands (GHz)	Bandwidth (MHz)	Max 26dB EBW (MHz)	Test Limit	Test Results
UNII-2a (5.25-5.35)	1 x 20MHz	19.57	26dB EBW is within the Band	Pass
	2 x 20MHz	39.25		Pass
	3 x 20MHz	59.61		Pass
UNII-2c (5.470- 5.725)	1 x 20MHz	19.52	26dB EBW is within the Band	Pass
	2 x 20MHz	39.28		Pass
	3 x 20MHz	59.74		Pass

The maximum 26dB bandwidths measured are all less their nominal bandwidths. Therefore, any transmission that does not intentionally extend into the other bands, like straddle channels, is down 26 dB and met the requirements. The results and measurements are in full compliance with the Rules of the Commission.

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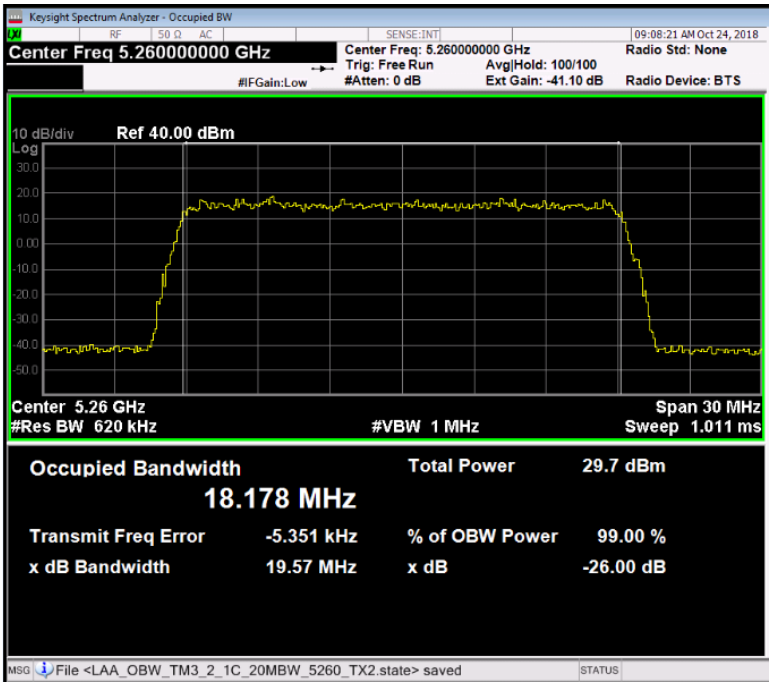

Figure 4.4.1(a) The Maximum 26dB Emission Bandwidth Measured (19.57MHz) for UNII-2a 20 MHz Carrier at Ch 52/5320MHz, 21dBm/pt, QPSK/16QAM, Port 2.

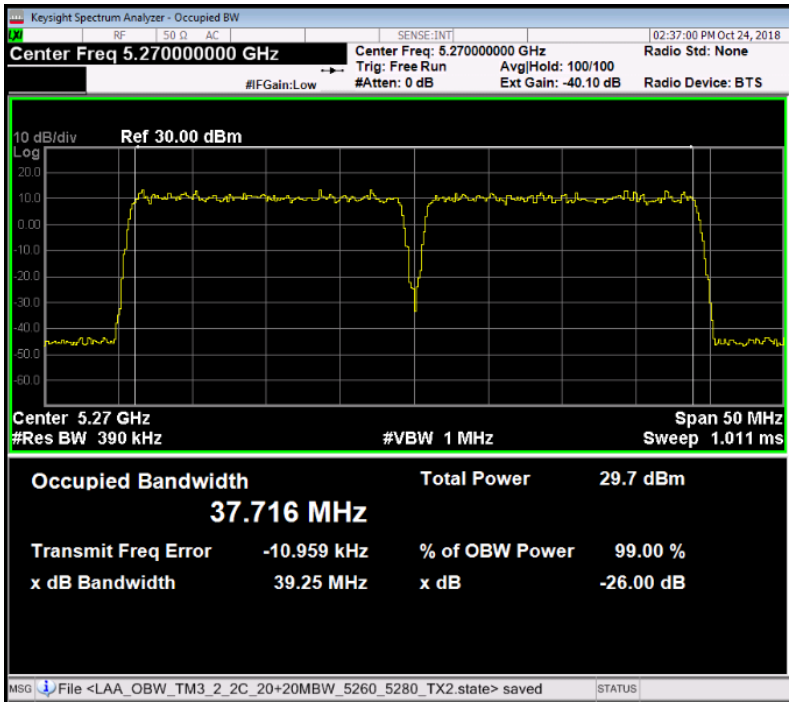

Figure 4.4.1(b) The Maximum 26dB Emission Bandwidth Measured (39.25MHz) for UNII-2a Two 20 MHz Carrier at Ch 52, 56/5260, 5280MHz, 21dBm, QPSK/16QAM, Port 2.

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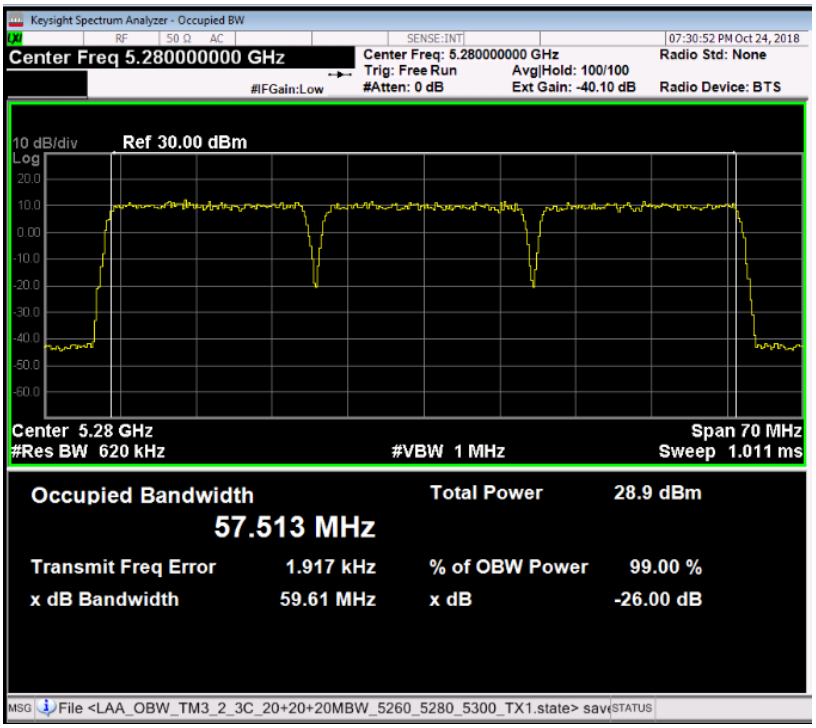

Figure 4.4.1(c) The Maximum 26dB Emission Bandwidth Measured (59.61MHz) for UNII-2a Three 20MHz Carrier at Ch 52, 56, 60/5260, 5280, 5300MHz, 21dBm/pt, QPSK/16QAM, Port 1.

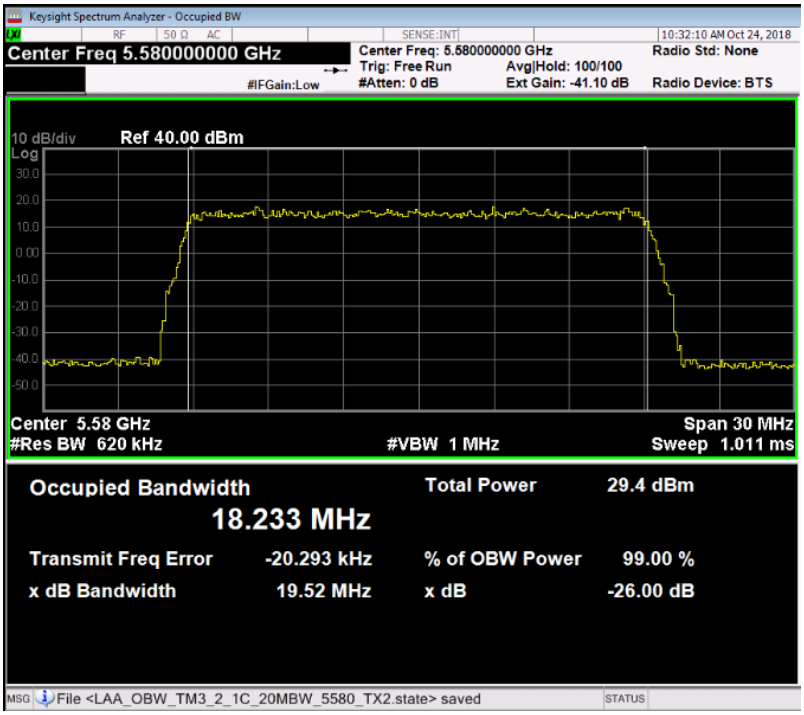

Figure 4.4.2(a) The Maximum 26dB Emission Bandwidth Measured (19.52MHz) for UNII-2c 20 MHz Carrier at Ch 116/5580MHz, 21dBm/pt, QPSK/16QAM, Port 2.

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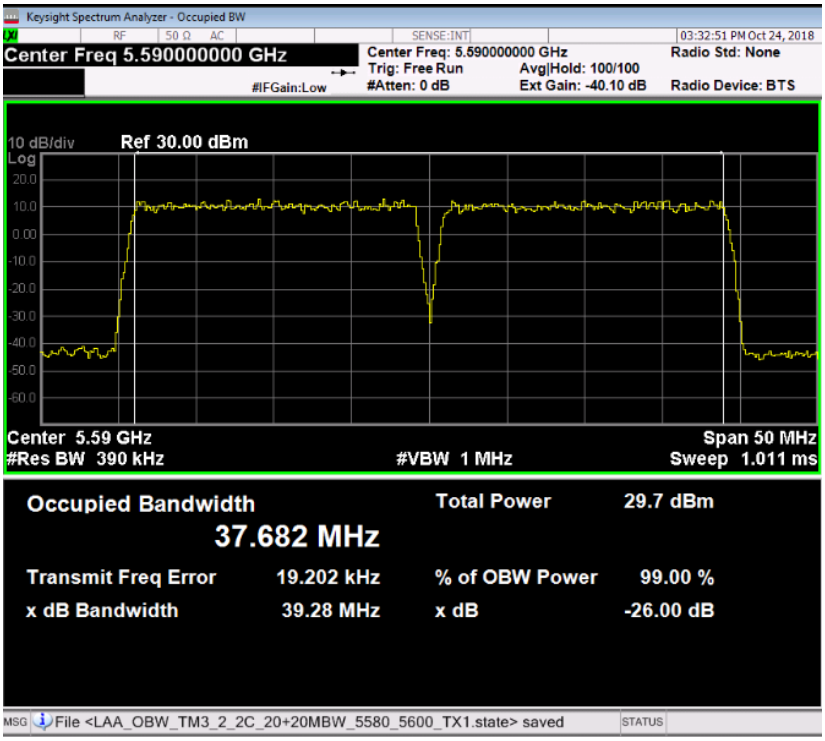

Figure 4.4.2(b) The Maximum 26dB Emission Bandwidth Measured (39.28MHz) for UNII-2c Two 20 MHz Carrier at Ch 116, 120/5580, 5600MHz, 21dBm, QPSK/16QAM, Port 1.

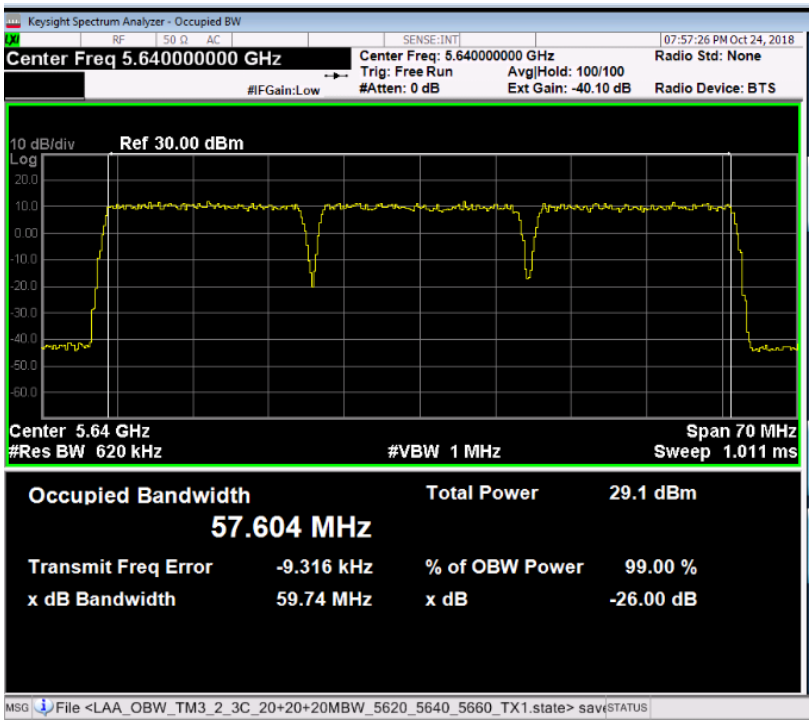

Figure 4.4.2(c) The Maximum 26dB Emission Bandwidth Measured (59.74MHz) for UNII-2c Three 20 MHz Carrier at Ch 124, 128, 132/5620, 5640, 5660 MHz, 21dBm/pt, QPSK/16QAM, Port 1.

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4.5 MEASUREMENT REQUIRED: MAXIMUM POWER OUTPUT – FCC SECTION 15.407 (a)(2)(4)

The maximum ouput power was measured at the both antenna ports for all channels listed in Table 4.2.2 for QPSK/16QAM. The measurement follows the procedures given in KDB 789033 D02.

The limit is Min {250mW (24dBm), 11dBm+10Log B}, where B is 26 dB emission bandwidth. The maximum conducted output power shall be reduced by the amount in dB that the antenna gain exceeds 6 dBi. The minimum 26dB emission bandwidth measured for 20MHz, 40MHz and 60MHz carriers are 18.88MHz, 38.86MHz and 58.96MHz, respectively. Therefore, the power limits for the antenna gain below 6dBi are 23.8dBm, 24dBm and 24dBm for 20MHz, 40MHz and 60MHz carriers, respectively.

For multiple antennas with equal transmit power but unequal gains, per KDB 662911 D01, the directional antenna gain of uncorrelated signals is equal to

$$\text{Directional Gain} = 10\log\left[\frac{10^{G_1/10}+10^{G_2/10}+\ldots\ldots+10^{G_N/10}}{N_{ANT}}\right]dBi, \quad \text{and}$$

the directional antenna gain of correlated signals is equal to

$$\text{Directional Gain} = 10\log\left[\frac{\left(10^{G_1/20}+10^{G_2/20}+\ldots\ldots+10^{G_N/20}\right)^2}{N_{ANT}}\right]dBi,$$

where G_1, G_2 ..., G_N are antenna gains.

For the spatial multiplexing (SM) transmissions, like 802.11n MCS8-15, the EUT operates with two uncorrelated spatial data streams on two transmitting ports. Per KDB 662911 D01 (Section (F)(2)(e)), the directional antenna gain may be calculated by using either of the following methods:

i. Directional Gain = Max{G_1, G_2 ..., G_N} + Array Gain = Max{ G_1, G_2 ..., G_N}, where Array Gain =10 *log* (N_{ANT}/N_{SS}) = 0
ii. Calculate the directional gain by using the formula for uncorrelated signals provided above if each antenna is only fed by its own data stream.

For Cyclic Delay Diversity (CDD) transmissions, per KDB 662911 D01 (Section (F)(2)(f)), the directional antenna gain may be calculated by using either of the following methods:

i. Directional Gain = Max{ G_1, G_2 ..., G_N} + Array Gain
   a. For power measurements, Array Gain = 0 if $N_{ANT} \leq 4$;
   b. For power spectrum density (PSD) measurement, Array Gain = 10 *log* (N_{ANT}/N_{SS}) dB, where N_{ss} is number of spatial streams and N_{ss} = 1 was suggested by the FCC for calculating the worst directional gain.
ii. Calculate the directional gain by using the formula for correlated signals provided above.

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The EUT does not have beamforming function and two signals are not correlated. Hence, for the power and PSD limits, the directional antenna gain was calculated by using the equation above for uncorrelated signals. The limits for the combined maximum transmitting power and PSD are calculated and tabulated below.

Table 4.5.1. Transmitter Power and PSD Limits at Antenna Ports

Band	Antenna	Max Direc Gain for Spectral Density (dBi)	Max Direc Gain for Total Power (dBi)	Maxi Total PSD Limit (dBm/MHz)	Maxi Total Power Limit (dBm)
UNII-2	#1-#4, #6	6.0	6.0	11.0	23.8 for 20MHz and 24 for 40/60MHz
	#5	9.5	9.5	7.5	22.3 for 20MHz and 22.5 for 40/60MHz
	#7	7.5	7.5	9.5	20.3 for 20MHz and 20.5 for 40/60MHz

The output power of the EUT was first verified by a power meter and then measured by a spectrum analyzer. The RBW and VBW were set to 1MHz and 3MHz, respectively. The RMS detector and trace average (≥ 100) were used. The output power was calculated by integrating the spectrum across the EBW of the carrier using the SA's band power measurement function with band limits set equal to the EBW band edges. The total combined output power was calculated by summing the measured output power in mW at the various antenna ports.

Table 4.5.2(a) Maximum Mean Combined RF Power Output at Antenna Ports for 5GHz 1x20MHz Carrier at 19.5dBm/pt in UNII-2 for Antennas with Maxi Gain ≤ 6dBi

Bands (GHz)	Ch No/ Freq (MHz)	Modulation	Port 1 (dBm)	Port 2 (dBm)	Total Power (dBm)	Power Limit (dBm)	Test Results
UNII-2a (5.25- 5.35)	52/5260	Q/16QAM	19.43	19.35	22.40	23.8	Pass
	60/5300	Q/16QAM	19.39	19.50	22.46	23.8	Pass
	64/5320	Q/16QAM	19.62	19.46	22.55	23.8	Pass
UNII-2c (5.47-5.725)	100/5500	Q/16QAM	19.90	19.76	22.84	23.8	Pass
	116/5580	Q/16QAM	19.54	19.53	22.55	23.8	Pass
	140/5720	Q/16QAM	19.39	19.44	22.43*	23.8	Pass

*The power within UNII-2c band is less.

Table 4.5.2(b) Maximum Mean Combined RF Power Output at Antenna Ports for 5GHz 2x20MHz Carriers at 21dBm/pt in UNII-2 with for Antennas with Maxi Gain ≤ 6dBi

Bands (GHz)	Ch No/ Freq (MHz)	Modulation	Port 1 (dBm)	Port 2 (dBm)	Total Power (dBm)	Power Limit (dBm)	Test Results
UNII-2a (5.25-5.35)	52, 56/5260, 5280	Q/16QAM	20.86	20.93	23.91	24	Pass
	60, 64/5300, 5320	Q/16QAM	20.77	20.83	23.81	24	Pass
UNII-2c (5.47-5.725)	100, 104/5500, 5520	Q/16QAM	20.85	20.65	23.76	24	Pass
	116, 120/5580, 5600	Q/16QAM	20.88	20.82	23.86	24	Pass
	136, 140/5680, 5700	Q/16QAM	20.82	20.91	23.88	24	Pass

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Table 4.5.2(c) Maximum Mean Combined RF Power Output at Antenna Ports for 5GHz 3x20MHz Carriers at 21dBm/pt in UNII-2 for Antennas with Maxi Gain ≤ 6dBi

Bands (GHz)	Ch No/ Freq (MHz)	Modulation	Port 1 (dBm)	Port 2 (dBm)	Total Pwr (dBm)	Pwr Limit (dBm)	Test Results
UNII-2a (5.25-5.35)	52, 56, 60/ 5260, 5280, 5300	Q/16QAM	20.83	20.82	23.84	24	Pass
UNII-2c (5.47-5.725)	100, 104, 108/ 5500, 5520, 5540	Q/16QAM	20.98	20.97	23.99	24	Pass
	112, 116, 120/ 5560, 5580, 5600	Q/16QAM	20.97	20.91	23.95	24	Pass
	124, 128, 132 5620, 5640, 5660	Q/16QAM	20.92	20.80	23.87	24	Pass

Table 4.5.3(a) Maximum Mean Combined RF Power Output at Antenna Ports for 5GHz 1x20MHz Carrier at 16dBm/pt in UNII-2 for Antenna #5 with Maxi Gain = 9.5dBi

Bands (GHz)	Ch No/ Freq (MHz)	Modulation	Port 1 (dBm)	Port 2 (dBm)	Total Pwr (dBm)	Pwr Limit (dBm)	Test Results
UNII-2a (5.25- 5.35)	52/5260	Q/16QAM	15.94	15.89	18.93	20.3	Pass
	64/5320	Q/16QAM	15.99	15.87	18.94	20.3	Pass
UNII-2c (5.47-5.725)	100/5500	Q/16QAM	15.83	15.99	18.92	20.3	Pass
	136/5700	Q/16QAM	15.86	15.92	18.90	20.3	Pass
	140/5720	Q/16QAM	15.96	15.91	18.95*	20.3	Pass

*The power within UNII-2c band is less.

Table 4.5.3(b) Maximum Mean Combined RF Power Output at Antenna Ports for 5GHz 2x20MHz Carriers at 17.5dBm/pt in UNII-2 with for Antenna #5 with Maxi Gain = 9.5dBi

Bands (GHz)	Ch No/ Freq (MHz)	Modulation	Port 1 (dBm)	Port 2 (dBm)	Total Pwr (dBm)	Pwr Limit (dBm)	Test Results
UNII-2a (5.25-5.35)	52, 56/5260, 5280	Q/16QAM	17.30	17.50	20.41	20.5	Pass
	60, 64/5300, 5320	Q/16QAM	17.45	17.33	20.40	20.5	Pass
UNII-2c (5.47-5.725)	100, 104/5500, 5520	Q/16QAM	17.42	17.46	20.45	20.5	Pass
	132, 136/5660+5680	Q/16QAM	17.49	17.37	20.44	20.5	Pass
	136, 140/5680, 5700	Q/16QAM	17.38	17.44	20.42	20.5	Pass

Table 4.5.3(c) Maximum Mean Combined RF Power Output at Antenna Ports for 5GHz 3x20MHz Carriers at 17.5dBm/pt in UNII-2 with for Antenna #5 with Maxi Gain = 9.5dBi

Bands (GHz)	Ch No/ Freq (MHz)	Modulation	Port 1 (dBm)	Port 2 (dBm)	Total Pwr (dBm)	Pwr Limit (dBm)	Test Results
UNII-2a (5.25-5.35)	52, 56, 60/ 5260, 5280, 5300	Q/16QAM	17.33	17.33	20.34	20.5	Pass
UNII-2c (5.47-5.725)	100, 104, 108/ 5500, 5520, 5540	Q/16QAM	17.43	17.47	20.46	20.5	Pass
	112, 116, 120/ 5560, 5580, 5600	Q/16QAM	17.48	17.47	20.49	20.5	Pass
	124, 128, 132 5620, 5640, 5660	Q/16QAM	17.42	17.42	20.43	20.5	Pass

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The conducted output power for antennas #5 (9.5dBi) and #6 (6dBi) measured at antenna ports is within ±0.5dB of the output power set for the EUT. Therefore, the maximum power was verified for #7 antenna at both ports for 1x20MHz carriers only.

Table 4.5.4(a) Maximum Mean Combined RF Power Output at Antenna Ports for 5GHz 1x20MHz Carrier at 18dBm/pt in UNII-2 for Antenna #7 with Maxi Gain = 7.5dBi

Bands (GHz)	Ch No/ Freq (MHz)	Modulation	Port 1 (dBm)	Port 2 (dBm)	Total Power (dBm)	Power Limit (dBm)	Test Results
UNII-2a (5.25- 5.35)	52/5260	Q/16QAM	17.82	17.84	20.84	22.3	Pass
	64/5320	Q/16QAM	17.89	17.87	20.89	22.3	Pass
UNII-2c (5.47-5.725)	100/5500	Q/16QAM	17.90	17.92	20.92	22.3	Pass
	136/5700	Q/16QAM	17.97	17.88	20.94	22.3	Pass
	140/5720	Q/16QAM	17.87	17.93	20.91*	22.3	Pass

*The power within UNII-2c band is less.

Table 4.5.4(b) Maximum Mean Combined RF Power Output at Antenna Ports for 5GHz 2x20MHz Carriers at 19.5dBm/pt in UNII-2 with for Antenna #7 with Maxi Gain = 7.5dBi

Bands (GHz)	Ch No/ Freq (MHz)	Modulation	Port 1 (dBm)	Port 2 (dBm)	Total Pwr (dBm)	Pwr Limit (dBm)	Test Results
UNII-2a (5.25-5.35)	52, 56/5260, 5280	Q/16QAM	19.31	19.32	22.33	22.5	Pass
	60, 64/5300, 5320	Q/16QAM	19.45	19.46	22.47	22.5	Pass
UNII-2c (5.47-5.725)	100, 104/5500, 5520	Q/16QAM	19.36	19.45	22.42	22.5	Pass
	132, 136/5660+5680	Q/16QAM	19.40	19.33	22.38	22.5	Pass
	136, 140/5680, 5700	Q/16QAM	19.47	19.32	22.41	22.5	Pass
	140, 144/5700, 5720	Q/16QAM	19.43	19.42	22.44*	22.5	Pass

*The power within UNII-2c band is less.

Table 4.5.4(c) Maximum Mean Combined RF Power Output at Antenna Ports for 5GHz 3x20MHz Carriers at 19.5dBm/pt in UNII-2 with for Antenna #7 with Maxi Gain = 7.5dBi

Bands (GHz)	Ch No/ Freq (MHz)	Modulation	Port 1 (dBm)	Port 2 (dBm)	Total Pwr (dBm)	Pwr Limit (dBm)	Test Results
UNII-2a (5.25-5.35)	52, 56, 60/ 5260, 5280, 5300	Q/16QAM	19.45	19.46	22.47	22.5	Pass
UNII-2c (5.47-5.725)	100, 104, 108/ 5500, 5520, 5540	Q/16QAM	19.49	19.46	22.49	22.5	Pass
	112, 116, 120/ 5560, 5580, 5600	Q/16QAM	19.44	19.27	22.37	22.5	Pass
	124, 128, 132 5620, 5640, 5660	Q/16QAM	19.49	19.46	22.49	22.5	Pass

As a result, the maximum total mean output powers at antenna ports measured are:

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Table 4.5.5(a) Maximum Total Mean Output Power Measured at Antenna Ports for Antennas with Maxi Gain ≤ 6dBi

Bands	Power (dBm) 1x20MHz Carriers	Power (dBm) 2x20MHz Carriers	Power (dBm) 3x20MHz Carriers
UNII-2a (5.25-5.35 GHz)	22.6	23.9	23.8
UNII-2c (5.47-5.725 GHz)	22.8	23.9	24.0

Table 4.5.5(b) Maximum Total Mean Output Power Measured at Antenna Ports for Antenna #5 with Maxi Gain = 9.5dBi

Bands	Power (dBm) 1x20MHz Carriers	Power (dBm) 2x20MHz Carriers	Power (dBm) 3x20MHz Carriers
UNII-2a (5.25-5.35 GHz)	18.94	20.47	20.24
UNII-2c (5.47-5.725 GHz)	18.92	20.42	20.49

Table 4.5.5(c) Maximum Total Mean Output Power Measured at Antenna Ports for Antenna #7 with Maxi Gain = 7.5dBi

Bands	Power (dBm) 1x20MHz Carriers	Power (dBm) 2x20MHz Carriers	Power (dBm) 3x20MHz Carriers
UNII-2a (5.25-5.35 GHz)	20.89	20.41	20.49
UNII-2c (5.47-5.725 GHz)	20.94	20.45	20.49

For UNII-2a and UNII-2c bands, the maximum total output power measured for the EUT equipped with the antennas #5, #6 and #7 are all below the FCC required limits and are in full compliance with the Rules of the Commission.

The measurement results for the conducted output power at both ports and the plots which show the maximum output power are provided below.

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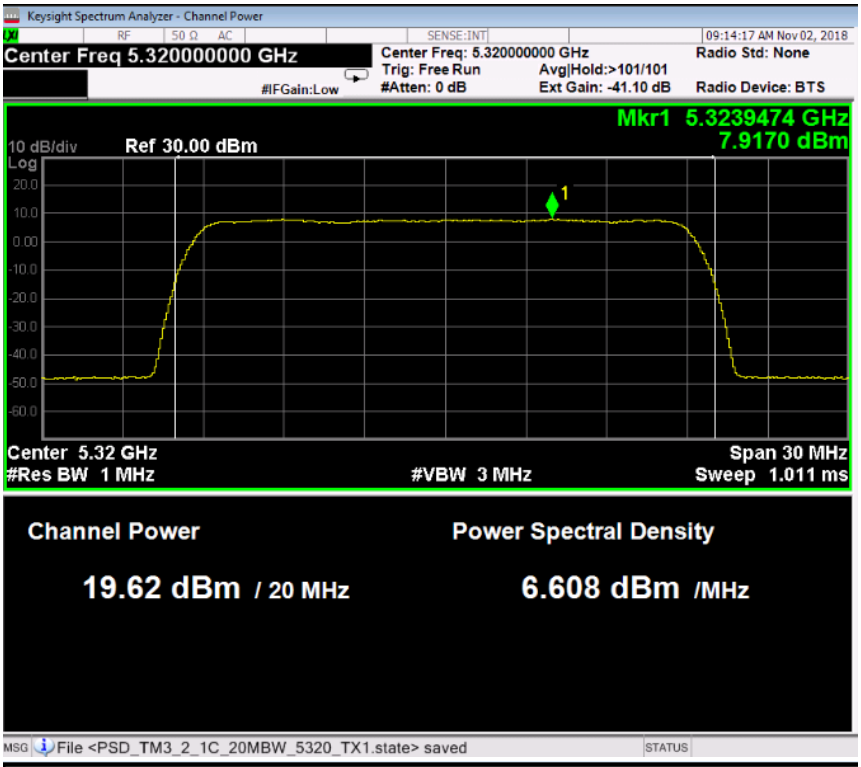

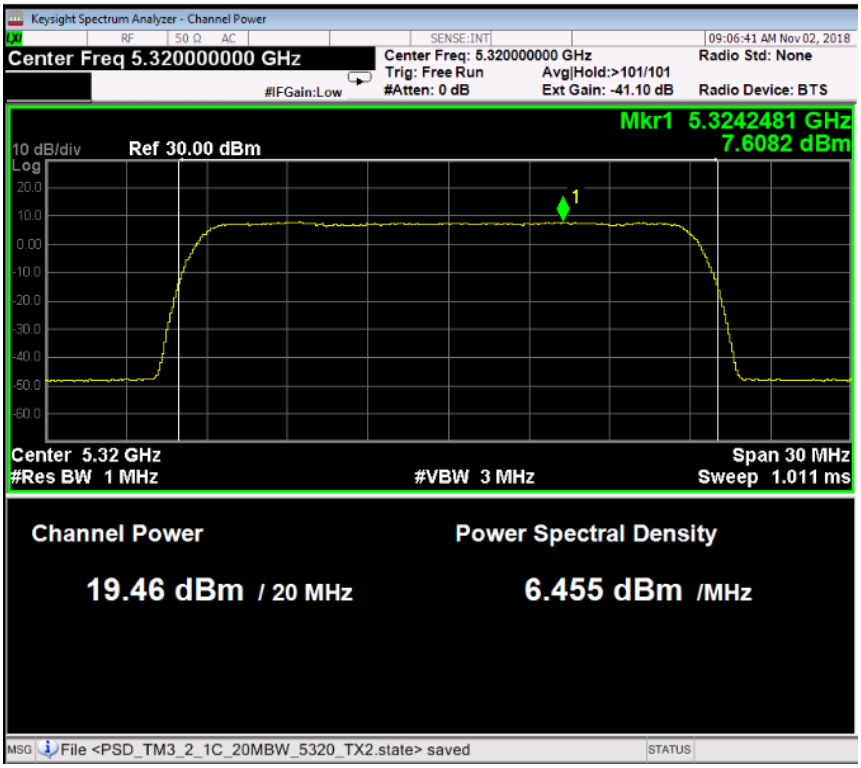

Figure 4.5.1(a) The Mean Output Power and PSD Measured for UNII-2a Q/16QAM 1x20MHz Carrier at Channel 64/5320MHz, 19.5dBm/pt, Port 1 and Port 2, for EUT with Antennas Maximum Gain ≤ 6dBi (Combined Output Power 22.6 dBm).

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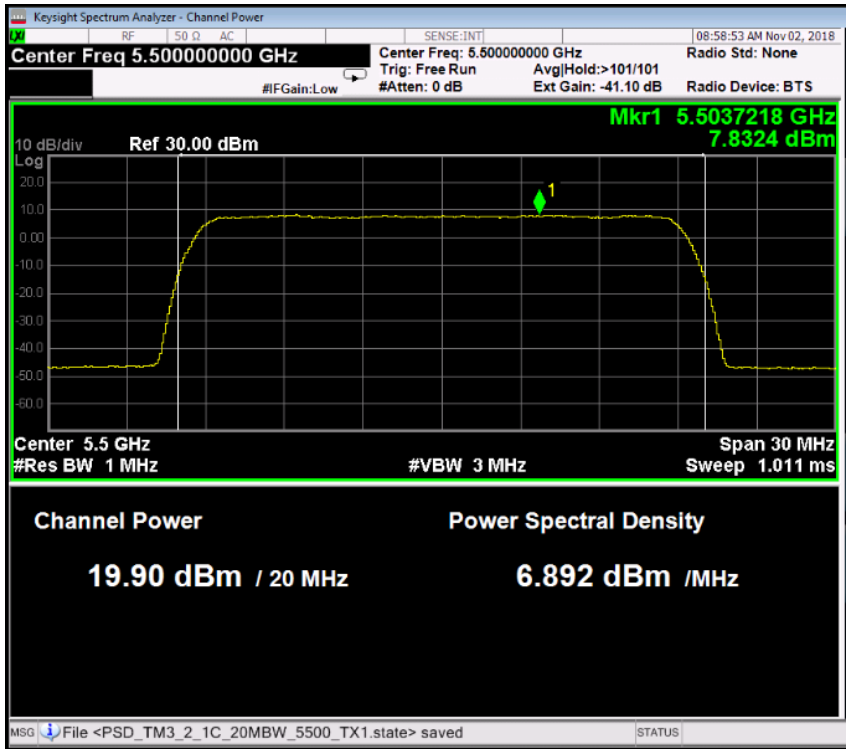

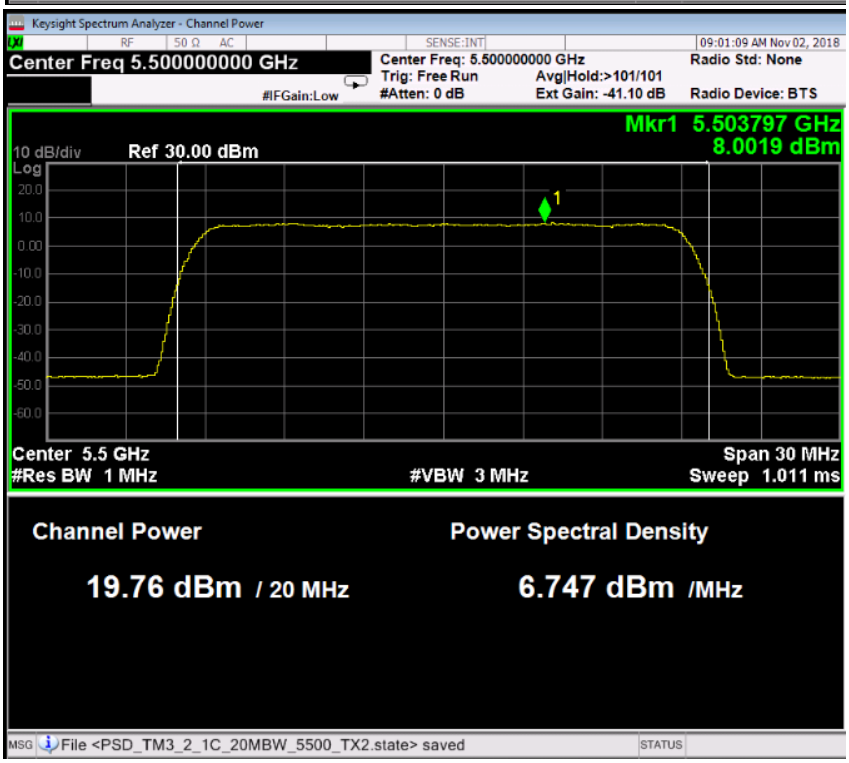

Figure 4.5.1(b) The Mean Output Power and PSD Measured for UNII-2c Q/16QAM 1x20MHz Carrier at Channel 100/5500MHz, 19.5dBm/pt, Port 1 and Port 2, for EUT with Antennas Maximum Gain ≤ 6dBi (Combined Output Power 22.8 dBm).

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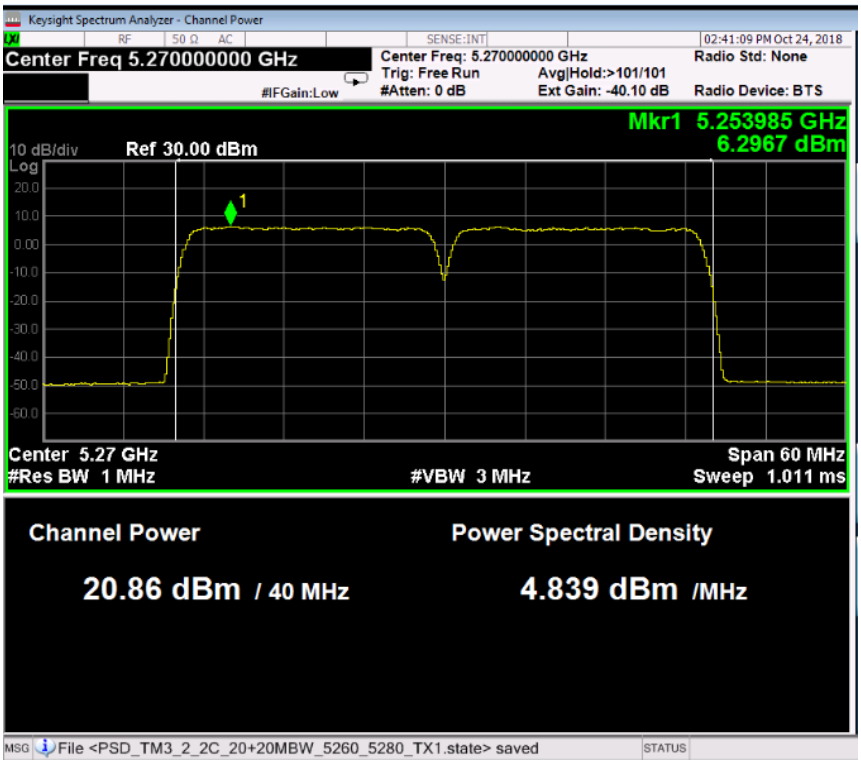

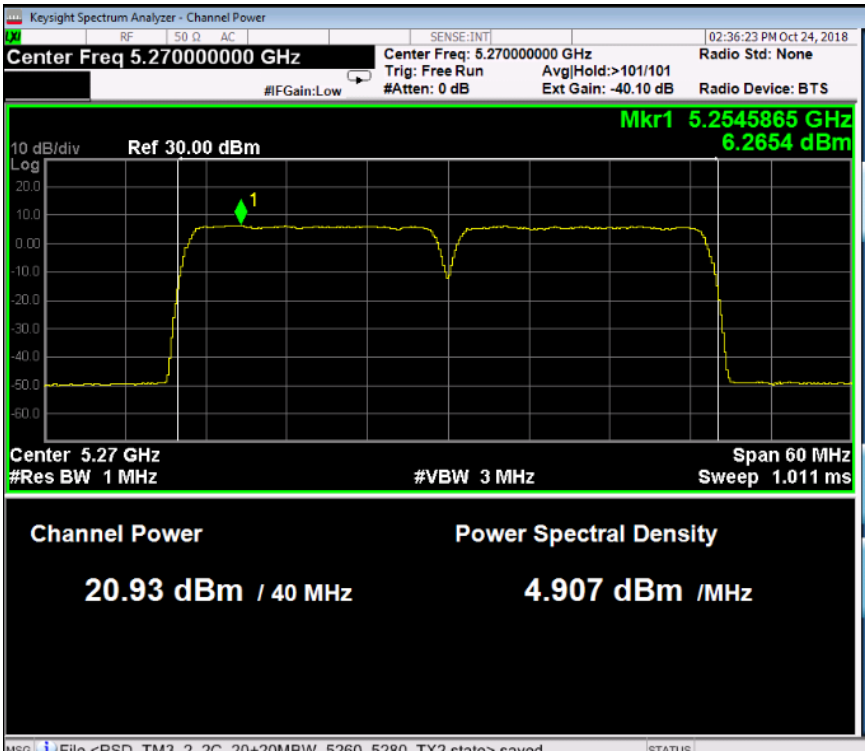

Figure 4.5.2 (a) The Mean Output Power and PSD Measured for UNII-2a Q/16QAM 2x20MHz Carriers at Ch. 52, 56/5260, 5280MHz, 21dBm/pt, Port 1 & Port 2, for EUT with Antennas Maximum Gain ≤ 6dBi (Combined Output Power 23.9 dBm).

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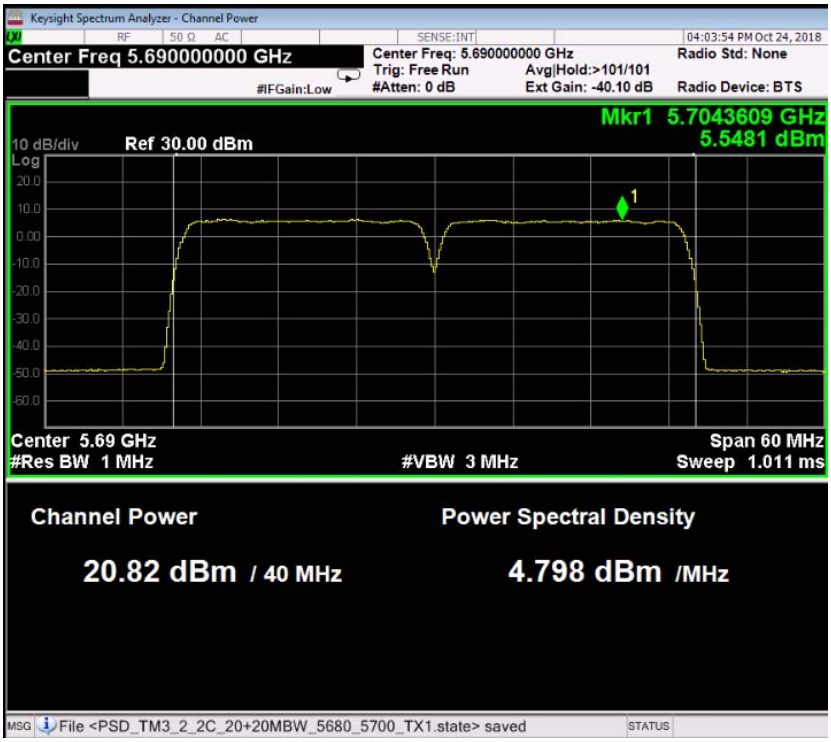

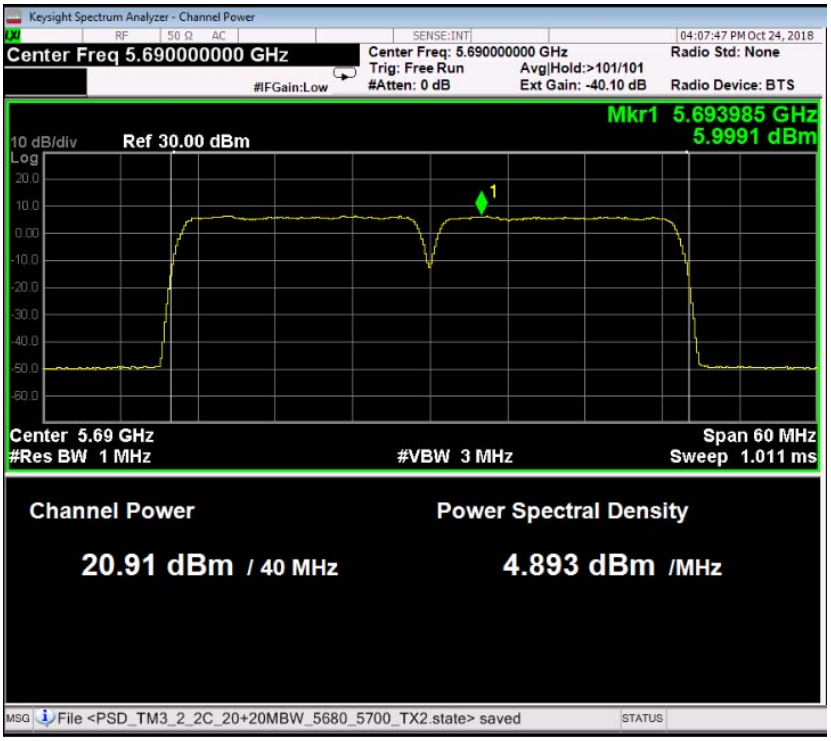

Figure 4.5.2 (b) The Mean Output Power and PSD Measured for UNII-2c Q/16QAM 2x20MHz Carriers at Ch. 136, 140/5680, 5700MHz, 21dBm/pt, Port 1 & Port 2, for EUT with Antennas Maximum Gain ≤ 6dBi (Combined Output Power 23.9 dBm).

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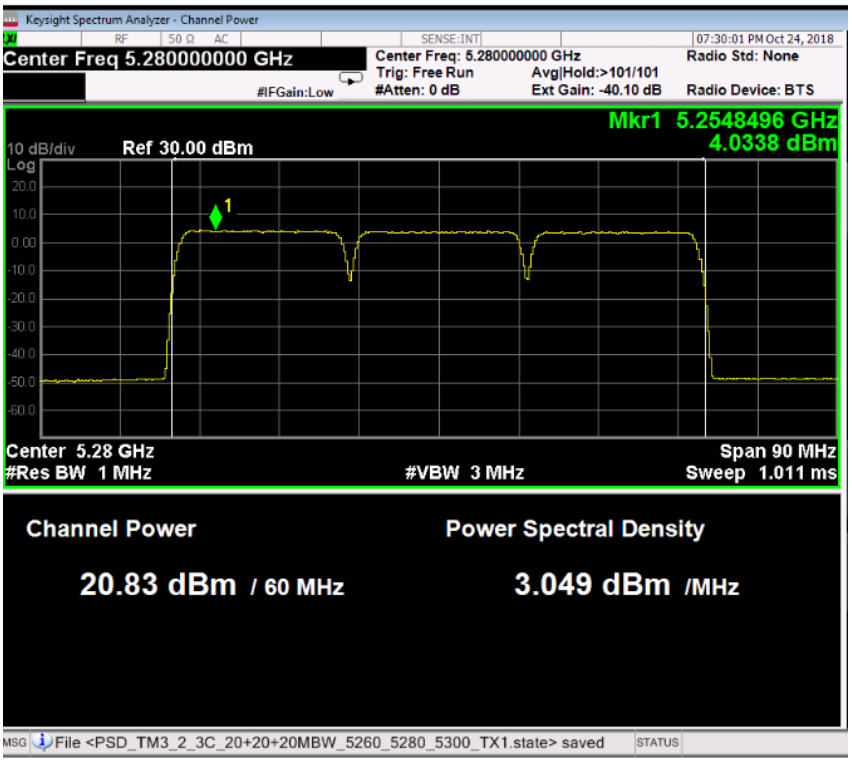

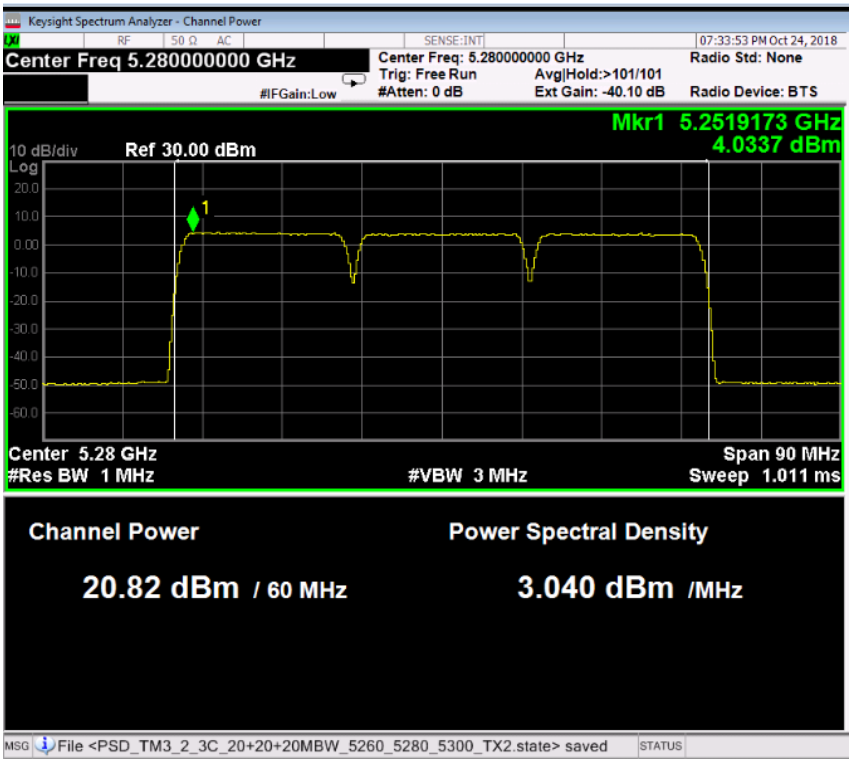

Figure 4.5.3 (a) The Mean Output Power and PSD Measured for UNII-2a Q/16QAM 3x20MHz Carriers at Channel 52, 56, 60/5260, 5280, 5300MHz, 21dBm/pt, Port 1 & Port 2, for EUT with Antennas with Maximum Antenna Gain ≤ 6dBi (Combined Output Power 23.8 dBm).

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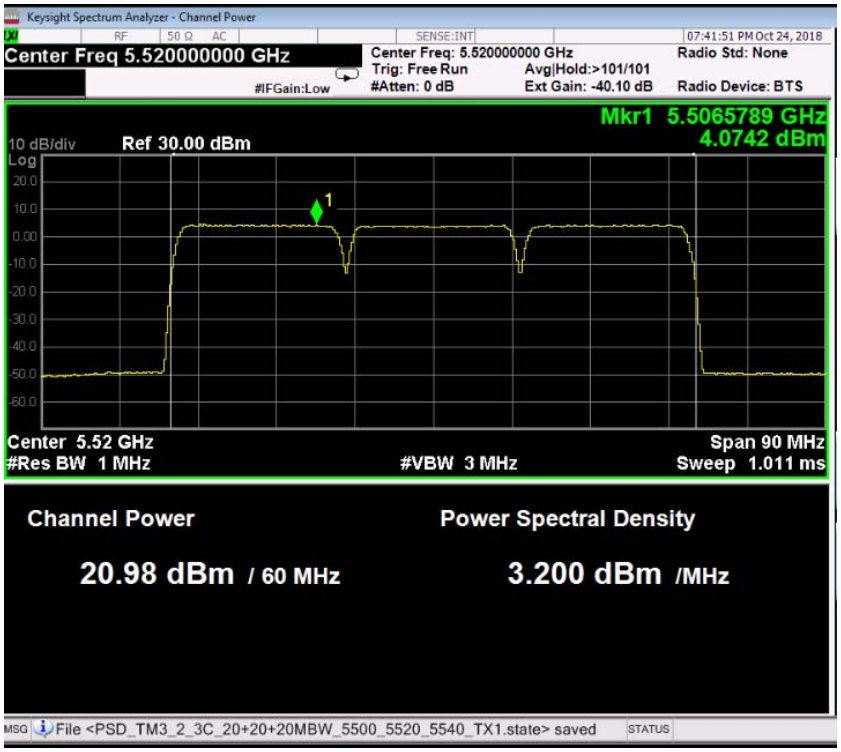

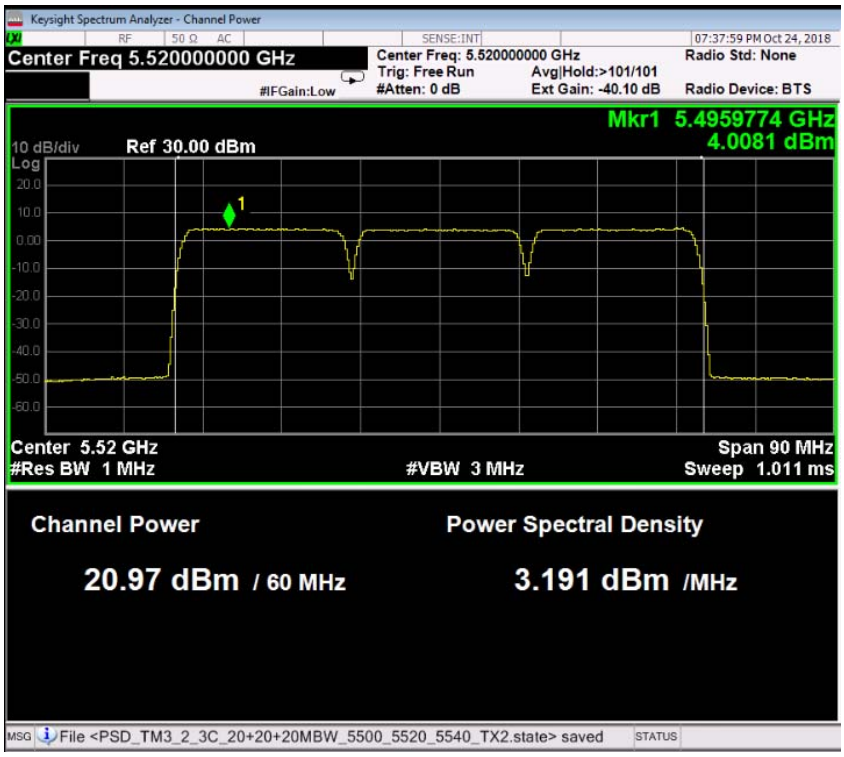

Figure 4.5.3 (b) The Mean Output Power and PSD Measured for UNII-2a Q/16QAM 3x20MHz Carriers at Channel 100, 104, 108/5500, 5520, 5540MHz, 21dBm/pt, Port 1 & Port 2, for EUT with Antennas with Maximum Antenna Gain ≤ 6dBi (Combined Output Power 24.0 dBm).

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4.6 MEASUREMENT REQUIRED: TRANSMIT POWER CONTROL – FCC SECTION 15.407 (h)(1)

U-NII devices operating in the 5.25-5.35 GHz band and the 5.47-5.725 GHz band are required to employ a TPC (transmit power control) mechanism. The U-NII device is required to have the capability to operate at least 6 dB below the mean EIRP value of 30 dBm. This test is to evaluate the TPC capability of the EUT.

The antenna #5 has the highest antenna gain, 9.5dBi. Hence, when the EUT is equipted with antenna #5, the EUT needs to have the capability to operate at an output power below 14.5dBm.

The reduced output power was measured with TPC ON at both antenna ports for the channels listed in Table 4.2.2 for QPSK/16QAM modulation. The measurement follows the procedures given in KDB 789033 D02.

The measurement results are given below. The power levels measured are all below the FCC required limits and are in compliace with the FCC TPC requirement.

Table 4.6.1(a) Reduced Mean Combined Output Power with TPC ON at Antenna Ports for 5GHz 1x20MHz Carrier at 10dBm/pt in UNII-2 for Antenna with Maxi Gain = 9.5 dBi

Bands (GHz)	Ch No/ Freq (MHz)	Modulation	Port 1 (dBm)	Port 2 (dBm)	Total Power (dBm)	Power Limit (dBm)	Test Results
UNII-2a (5.25- 5.35)	52/5260	Q/16QAM	9.73	9.75	12.8	14.5	Pass
	64/5320	Q/16QAM	9.95	9.95	13.0	14.5	Pass
UNII-2c (5.47-5.725)	100/5500	Q/16QAM	9.74	9.71	12.7	14.5	Pass
	140/5720	Q/16QAM	9.76	9.97	12.9	14.5	Pass

Table 4.6.1(b) Reduced Mean Combined Output Power with TPC ON at Antenna Ports for 5GHz 2x20MHz Carrier at 10dBm/pt in UNII-2 for Antenna with Maxi Gain = 9.5 dBi

Bands (GHz)	Ch No/ Freq (MHz)	Modulation	Port 1 (dBm)	Port 2 (dBm)	Total Power (dBm)	Power Limit (dBm)	Test Results
UNII-2a (5.25-5.35)	52, 56/5260, 5280	Q/16QAM	9.79	9.88	12.8	14.5	Pass
	60, 64/5300, 5320	Q/16QAM	9.87	9.91	12.9	14.5	Pass
UNII-2c (5.47-5.725)	100, 104/5500, 5520	Q/16QAM	9.87	9.82	12.9	14.5	Pass
	140, 144/5700, 5720	Q/16QAM	9.86	9.93	12.9	14.5	Pass

Table 4.6.1(c) Reduced Mean Combined Output Power with TPC ON at Antenna Ports for 5GHz 3x20MHz Carrier at 10dBm/pt, in UNII-2 for Antenna with Maxi Gain = 9.5 dBi

Bands (GHz)	Ch No/ Freq (MHz)	Port 1 (dBm)	Port 2 (dBm)	Total Power (dBm)	Power Limit (dBm)	Test Results
UNII-2a (5.25-5.35)	52, 56, 60/ 5260, 5280, 5300	9.64	9.64	12.7	14.5	Pass
UNII-2c (5.47-5.725)	100, 104, 108/5500, 5520, 5540	9.88	9.79	12.8	14.5	Pass
	112, 116, 120/ 5560, 5580, 5600	9.95	9.98	13.0	14.5	Pass
	136, 140, 144/5680, 5700, 5720	9.94	9.96	13.0	14.5	Pass

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4.7 MEASUREMENT REQUIRED: PEAK POWER SPECTRUM DENSITY – FCC SECTION 15.407 (a)(2)(5)

The peak power spectrum density (PPSD) measures the maximum value of the time average of the PSD measured during a period of continuous transmission.

The PPSD was measured at the both antenna ports for the channels listed in Table 4.2.2 for QPSK/16QAM modulation. The measurement follows the procedures given in KDB 789033 D02.

The PPSD limits calculated were provided in Table 4.5.1.

The PSD was measured by a spectrum analyzer. The RBW and VBW were set to 1MHz and 3MHz, respectively. The RMS detector and trace average (≥ 100) were used. The PPSD can be found by using either the peak search function on the instrument to find the peak of the spectrum or the spectrum analyzer's PSD function.

Normally, the total PPSD was calculated by the PPSD measured at the port which usually has higher PPSD based on the measurement for output power plus 3dB for two ports. When the margin is slim, the PPSD measurement was performed at both ports to obtain the combined PPSD value, where the total PPSD was obtained by summing the PPSD measured at both antenna ports. The 2x20MHz and 3x20MHz have the same power levels. Hence, there is no need to measure PPSD of 3x20MHz carriers.

The measurement results are given below. The total PPSD measured are all below the FCC required limits.

Table 4.7.1(a) Maximum Mean Combined PPSD at Antenna Ports for 5GHz 1x20MHz Carrier at 19.5dBm/pt in UNII-2 for Antennas with Maxi Gain ≤ 6dBi

Bands (GHz)	Ch No/ Freq (MHz)	Modulation	Port 1 (dBm)	Port 2 (dBm)	Total PPSD (dBm)	PPSD Limit (dBm)	Test Results
UNII-2a (5.25- 5.35)	52/5260	Q/16QAM	7.6791	7.7250	10.7	11	Pass
	60/5300	Q/16QAM	7.8239	7.7241	10.8	11	Pass
	64/5320	Q/16QAM	7.9170	7.6082	10.8	11	Pass
UNII-2c (5.47-5.725)	100/5500	Q/16QAM	7.8324	8.0019	10.9	11	Pass
	116/5580	Q/16QAM	7.6794	7.8003	10.8	11	Pass
	140/5720	Q/16QAM	7.5869	7.5426	10.6	11	Pass

Table 4.7.1(b) Maximum Mean Combined PPSD at Antenna Ports for 5GHz 2x20MHz Carriers at 21dBm/pt in UNII-2 for Antennas with Maxi Gain ≤ 6dBi

Bands (GHz)	Ch No/ Freq (MHz)	Modulation	Port 1 (dBm)	Port 2 (dBm)	Total Power (dBm)	Power Limit (dBm)	Test Results
UNII-2a (5.25-5.35)	52, 56/5260, 5280	Q/16QAM	6.2967	6.2654	9.3	11	Pass
	60, 64/5300, 5320	Q/16QAM	6.0147	5.9101	9.0	11	Pass
UNII-2c (5.47-5.725)	100, 104/5500, 5520	Q/16QAM	5.9961	6.1097	9.1	11	Pass
	116, 120/5580+5600	Q/16QAM	6.2564	5.8473	9.1	11	Pass
	136, 140/5680, 5700	Q/16QAM	5.5481	5.9991	8.8	11	Pass

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Table 4.7.2(a) Maximum Mean Combined PPSD at Antenna Ports for 5GHz 1x20MHz Carrier at 16dBm/pt in UNII-2 for Antenna #5 with Maxi Gain = 9.5dBi

Bands (GHz)	Ch No/ Freq (MHz)	Modulation	Port 1 (dBm)	Port 2 (dBm)	Total PPSD (dBm)	PPSD Limit (dBm)	Test Results
UNII-2a (5.25- 5.35)	52/5260	Q/16QAM	4.4691	4.4456	7.5	7.5	Pass
	64/5320	Q/16QAM	4.5184	4.4738	7.5	7.5	Pass
UNII-2c (5.47-5.725)	100/5500	Q/16QAM	4.3564	4.5034	7.4	7.5	Pass
	136/5700	Q/16QAM	4.3636	4.4404	7.4	7.5	Pass
	140/5720	Q/16QAM	4.4988	4.4977	7.5	7.5	Pass

Table 4.7.2(b) Maximum Mean Combined PPSD at Antenna Ports for 5GHz 2x20MHz Carriers at 17.5dBm/pt in UNII-2 with for Antenna #5 with Maxi Gain = 9.5dBi

Bands (GHz)	Ch No/ Freq (MHz)	Modulation	Port 1 (dBm)	Port 2 (dBm)	Total Power (dBm)	Power Limit (dBm)	Test Results
UNII-2a (5.25-5.35)	52, 56/5260, 5280	Q/16QAM	2.5938	3.3252	6.0	7.5	Pass
	60, 64/5300, 5320	Q/16QAM	2.9863	2.8328	5.9	7.5	Pass
UNII-2c (5.47-5.725)	100, 104/5500, 5520	Q/16QAM	1.9536	3.0271	5.5	7.5	Pass
	132, 136/5660+5680	Q/16QAM	3.0717	2.5806	5.8	7.5	Pass
	136, 140/5680, 5700	Q/16QAM	2.4456	2.6386	5.6	7.5	Pass

From the above PPSD data measured at the antenna ports for antenna #6 and #5, the PPSD for 1x20MHz carriers has less margin, though the output power level for 2x20MHz is 1.5dB higher. Therefore, for antenna #7, only PPSD for 1x20MHz was measured.

Table 4.7.3 Maximum Mean Combined PPSD at Antenna Ports for 5GHz 1x20MHz Carrier at 18dBm/pt in UNII-2 for Antenna #7 with Maxi Gain = 7.5dBi

Bands (GHz)	Ch No/ Freq (MHz)	Modulation	Port 1 (dBm)	Port 2 (dBm)	Total PPSD (dBm)	PPSD Limit (dBm)	Test Results
UNII-2a (5.25- 5.35)	52/5260	Q/16QAM	6.3052	6.4942	9.4	9.5	Pass
	64/5320	Q/16QAM	6.3820	6.4099	9.4	9.5	Pass
UNII-2c (5.47-5.725)	100/5500	Q/16QAM	6.3559	6.4780	9.4	9.5	Pass
	136/5700	Q/16QAM	6.4185	6.3500	9.4	9.5	Pass
	140/5720	Q/16QAM	6.4402	6.4400	9.5	9.5	Pass

As a result, the maximum total PPSD at antenna ports measured are:

Table 4.5.5(a) Maximum Total PPSD Measured at Antenna Ports for Antennas with Maxi Gain ≤ 6dBi (22.5dBm/unit for 1x20MHz and 24dBm/unit for 2x20MHz)

Bands	PPSD 20MHz (dBm/MHz)	PPSD 2x20MHz (dBm/MHz)
UNII-2a (5.25-5.35 GHz)	10.8	9.3
UNII-2c (5.47-5.725 GHz)	10.9	9.1

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Table 4.5.5(b) Maximum Total PPSD Measured at Antenna Ports for Antenna #5 with Maxi Gain = 9.5dBi (19dBm/unit for 1x20MHz and 20.5dBm/unit for 2x20MHz)

Bands	PPSD 20MHz (dBm/MHz)	PPSD 2x20MHz (dBm/MHz)
UNII-2a (5.25-5.35 GHz)	7.5	6.0
UNII-2c (5.47-5.725 GHz)	7.5	5.8

Table 4.5.5(c) Maximum Total PPSD Measured at Antenna Ports for Antenna #7 with Maxi Gain = 7.5dBi (21dBm/unit for 1x20MHz)

Bands	PPSD 20MHz (dBm/MHz)
UNII-2a (5.25-5.35 GHz)	9.4
UNII-2c (5.47-5.725 GHz)	9.5

The PPSD plots which have the smallest margin for 1x20MHz carriers with 19.5dBm/port and for 2x20MHz carriers with 21dBm/port are provided in Figures 4.5.1(b) and 4.5.2(a), respectively.

The combined PPSD of the EUT at its antenna transmitting terminals across the UNII-2a and UNII-2c bands are all below FCC required limits and are in full compliance with the Rules of the Commission.

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4.8 MEASUREMENT REQUIRED: UNWANTED OUT-OF-BAND EMISSIONS – FCC SECTION 15.407 (b)(2)(3)(5)(8)

The out-of-band emissions provided in this section are the unwanted emissions outside the band, but near the band edges. The unwanted emissions at the frequencies away from the band edges were provided in the next section.

The requirements of the out-of-band emissions are provided in Section 4.1. Per KDB 789033 D02 guidance II.G.3.b, "The unwanted emission limits in both the restricted and non-restricted bands are based on radiated measurements; however, as an alternative, antenna-port conducted measurements in conjunction with cabinet emissions tests will be permitted to demonstrate compliance."

The out-of-band conducted emissions were evaluated per KDB 789033 D02 measurement guidance for the EUT equipped with the omni-directional antenna #6 which allows the EUT to transmit at the highest conducted power. The carrier with Q/16QAM modulation was found to have similar out-of-band emissions compared with that of 64QAM and 256QAM modulations. The out-of-band conducted emissions with peak detector have much smaller margins than that with average detector. Therefore, the out-of-band conducted emissions were evaluated for the low, middle (1x20MHz only) and high channels listed in Table 4.2.2 with peak detector and QPSK/16QAM modulation, where the margin variation for various channels evaluated are less than 2dB. The out-of-band conducted emissions with the lowest margin among 1x20MHz, 2x20MHz and 3x20MHz carriers are given in Figure 4.8.1.

Table 4.8.1 FCC 15.407E UNII-2 Out-of-Band Conducted Emission limits for Antennas $G^{Max} \leq$ 6dBi without Beamforming

Band (GHz)	Freq Investigated (GHz)	Emission Limits		Detector	RBW (MHz)
		Freq Range (GHz)	Limit (dBm/MHz)		
5.25-5.35	5.10-5.40	5.10 - 5.15 & 5.35 - 5.40	-47.2/-33	ave/pk	1
5.47-5.725	5.40-5.8 (w/o Ch 144)	5.40 - 5.46	-47.2/-33	ave/pk	1
		5.46 - 5.47 & 5.725 - 5.8	-33	pk	
	5.40-5.90 (with Ch 144)	5.40 - 5.46	-47.2/-33	ave/pk	
		5.46-5.47 & 5.85-5.9	-33	pk	

The out-of-band radiated emissions were evaluated per KDB 789033 D02 measurement guidance for the EUT equipped with the omni-directional antenna #6 which allows the maximum output power, and the omni-directional antenna #7 which has the highest antenna gain among all omni-directional antennas and the directional antenna #5 which has the highest gain among all directional antennas, respectively. For the EUT with the omni-directional antennas #6, six low and high channels for 1x20MHz, 2x20MHz and 3x20MHz were evaluated with Q/16QAM modulation. For the EUT with the directional antennas #5 and the omni-directional antennas #7, three low and high channels were evaluated for 1x20MHz, 2x20MHz and 3x20MHz with Q/16QAM modulation and 256QAM modulations, respectively.

Per KDB 789033 D02, for the radiated measurement, the field strength limit is obtained from the EIRP limit by

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$$EIRP = \frac{\sqrt{\mathrm{E\ x\ d}}}{30},$$

where

- E is the field strength in V/m;
- d is the measurement distance in m;
- EIRP is the equivalent isotropically radiated power in W.

Therefore, with E in,

$$E\ (\mathrm{dB\mu V/m}) = EIRP(dBm) - 20 * \log(d) + 104.77.$$

At 3m with EIRP = - 27dBm, E = 68.2 dBμV/m.

Table 4.8.2 FCC 15.407E UNII-2 Out-of-Band Radiated Emission limits

Band (GHz)	Freq Investigated (GHz)	Emission Limits		Detector	RBW (MHz)
		Freq Range (GHz)	Limit (dBm/MHz)		
5.25-5.35	5.10-5.40	5.10 - 5.15 & 5.35 - 5.40	54/68.2	ave/pk	1
5.47-5.725	5.40-5.8 (w/o Ch 144)	5.40 - 5.46	54/68.2	ave/pk	1
		5.46 - 5.47 & 5.725 - 5.8	68.2	pk	
	5.40-5.90 (with Ch 144)	5.40 - 5.46	54/68.2	ave/pk	
		5.46-5.47 & 5.85-5.9	68.2	pk	

The recommendations of ANSI C63.10 were followed for the EUT testing setup and cabling. The test setup diagram was given in Section 4.3. The emissions were maximized by rotating the turntable 360° and moving the receiving antenna height to scan and capture the emissions from the EUT.

The out-of-band emissions measured for the EUT equipped with both omni-directional antennas #6 and #7 and directional antenna #5 are all below the FCC average and/or peak limits required in both the restricted and non-restricted bands (see Table 4.8.2). The restricted bands are provided in Table 4.1.1.

The out-of-band emissions plots which give the minimum emission margin evaluated for each antenna (#5, #6 and #7) equipped for 1x20MHz, 2x20MHz and 3x20MHz carriers were shown below in Figure 4.8.2, respectively.

The unwanted radiated out-of-band emissions measured with the EUT transmitting in the UNII-2a and UNII-2c bands for all operation bandwidths are all below FCC required limits for the EUT equipped either omni-directional antenna or directional antenna, respectively, and are in full compliance with the Rules of the Commission.

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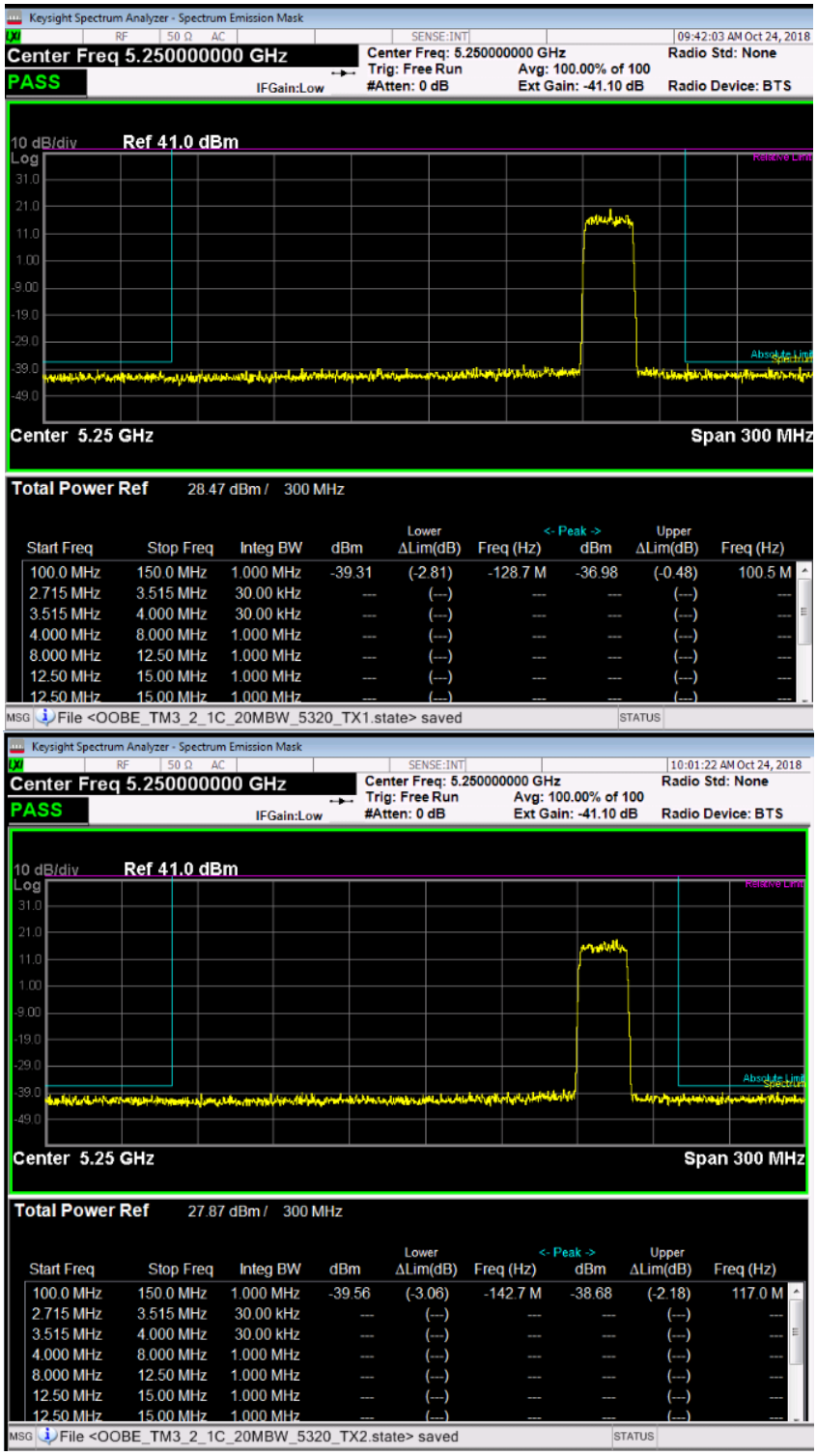

Figure 4.8.1(a) The Conducted Out-of-Band Emissions with Minimum Margin Evaluated for 1x20MHz Carriers at UNII-2 Channel 64 (5320MHz), QPSK/16QAM, 21dBm/pt, at Port 1 (-36.98dBm/MHz) and Port 2 (-38.68dBm/MHz) (total -34.7dBm/MHz, for Antennas with Maxi Gain ≤ 6dBi.

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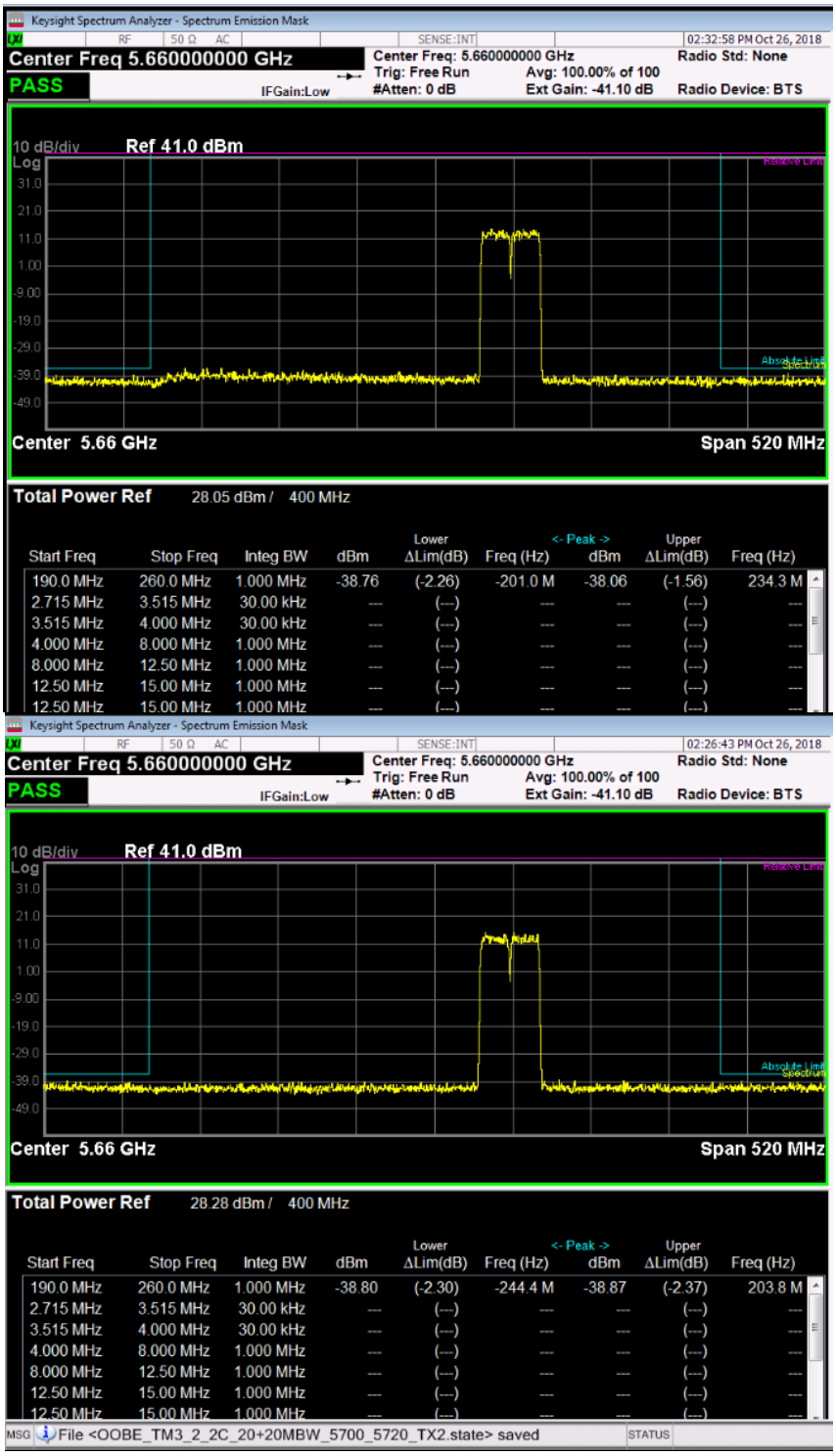

Figure 4.8.1(b) The Conducted Out-of-Band Emissions with Minimum Margin Evaluated for 2x20MHz Carriers at UNII-2 Channel 140, 144/5700, 5720MHz, QPSK/16QAM, 21dBm/pt, at Port 1 (-38.06dBm/MHz) and Port 2 (-38.87dBm/MHz) (total -35.4dBm/MHz, for Antennas with Maxi Gain ≤ 6dBi.

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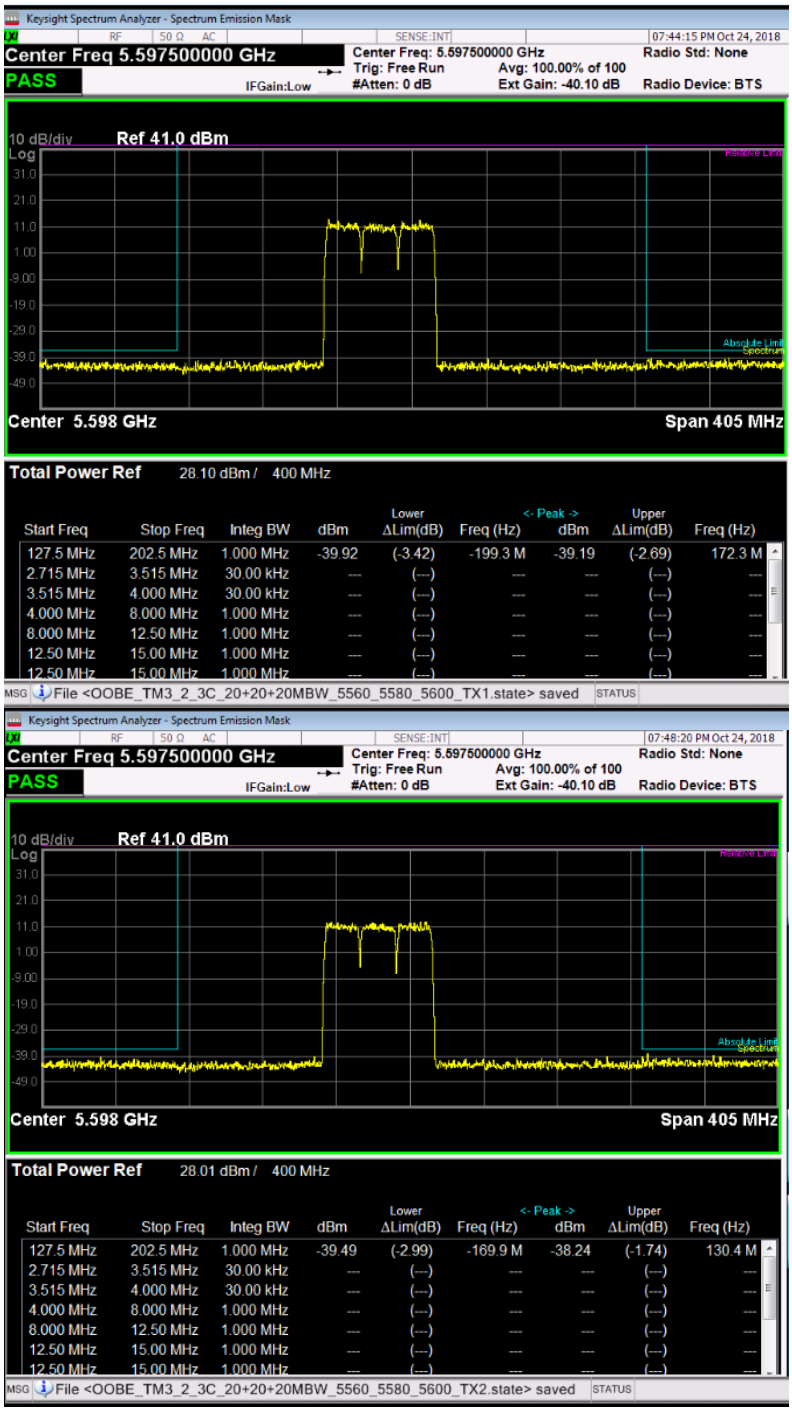

Figure 4.8.1(c) The Conducted Out-of-Band Emissions with Minimum Margin Evaluated for 3x20MHz Carriers at UNII-2 Channel 112, 116, 120/5560, 5580, 5600MHz, QPSK/16QAM, 21dBm/pt, at Port 1 (-39.19dBm/MHz) and Port 2 (-38.24dBm/MHz) (total -35.7dBm/MHz, for Antennas with Maxi Gain ≤ 6dBi.

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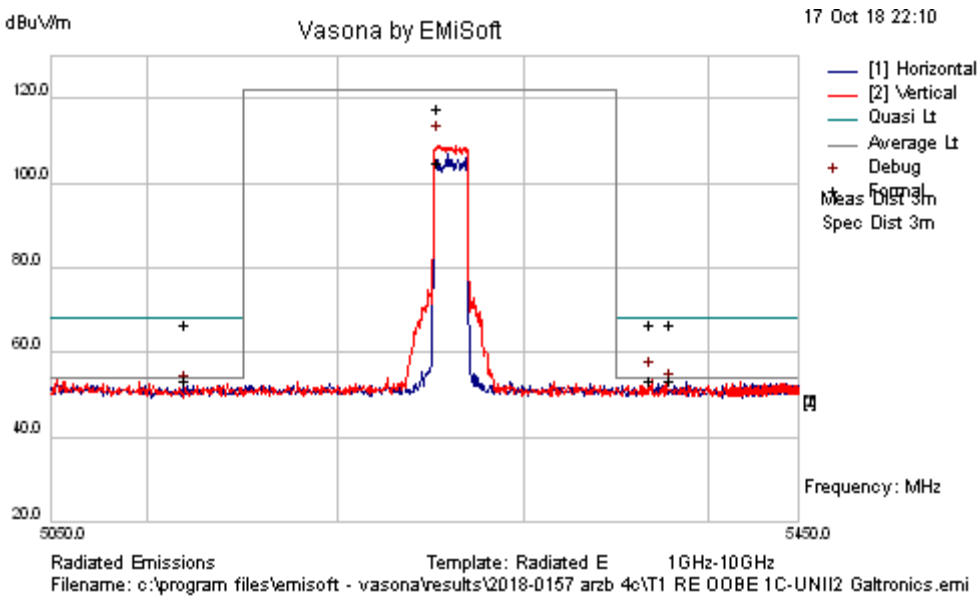

FORMAL DATA

Freq. (MHz)	Raw (dBuV)	Cable (dB)	Factor (dB)	Level (dBuV/m)	Emission Type	Pol (H/V)	Ht (cm)	Az (deg)	Limit (dBuV/m)	Margin (dB)	Pass /Fail	Comments
5368.87	30.22	22.21	-3.58	48.85	Average	V	311	286	54	-5.15	Pass	
5379.22	30.1	22.22	-3.57	48.74	Average	H	327	133	54	-5.26	Pass	
5119.57	30.11	22.2	-3.78	48.52	Average	V	372	199	54	-5.48	Pass	
5368.87	43.41	22.21	-3.58	62.04	Peak	V	311	286	68.2	-6.16	Pass	
5379.22	43.24	22.22	-3.57	61.88	Peak	H	327	133	68.2	-6.32	Pass	
5119.57	43.32	22.2	-3.78	61.74	Peak	V	372	199	68.2	-6.46	Pass	
5253.5	94.41	22.21	-3.67	112.94	Peak	V	361	284	122.2	-9.26	Pass	NA
5253.5	81.87	22.21	-3.67	100.4	Average	V	361	284	122	-21.6	Pass	NA

Figure 4.8.2(a) The Radiated Out-of-Band Emissions with the Minimum Margin Evaluated for the EUT with Omni-Directional Antenna #6 at 21dBm/pt, 1x20MHz at UNII-2a Channel 52 (5260MHz), Q/16QAM, (Preview RBW: 100k and Formal RBW: 1MHz).

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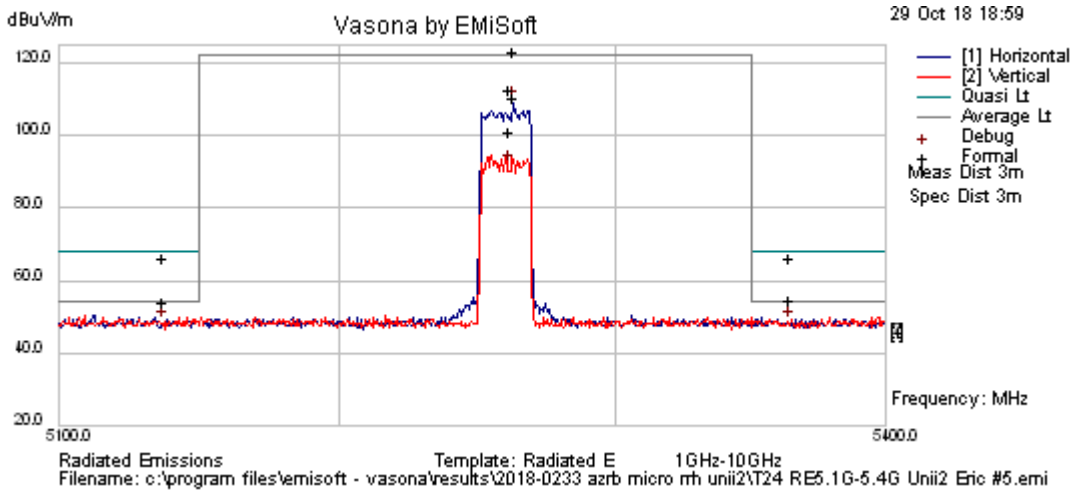

FORMAL DATA												
Freq. (MHz)	Raw (dBuV)	Cable (dB)	Factor (dB)	Level (dBuV/m)	Emission Type	Pol (H/V)	Ht (cm)	Az (deg)	Limit (dBuV/m)	Margin (dB)	Pass /Fail	Comments
5262.98	100.79	22.21	-3.67	119.33	Peak	H	167	1	122	-2.67	Pass	
5365.08	32.05	22.21	-3.59	50.68	Average	V	218	32	54	-3.32	Pass	
5137.6	31.91	22.2	-3.77	50.34	Average	V	163	349	54	-3.66	Pass	
5365.08	43.89	22.21	-3.59	62.52	Peak	V	218	32	68.2	-5.68	Pass	
5137.6	43.75	22.2	-3.77	62.18	Peak	V	163	349	68.2	-6.02	Pass	
5262.12	90.28	22.21	-3.67	108.82	Peak	V	146	9	122	-13.18	Pass	
5262.98	88.14	22.21	-3.67	106.68	Average	H	167	1	122	-15.32	Pass	NA
5262.12	78.88	22.21	-3.67	97.42	Average	V	146	9	122	-24.58	Pass	NA

Figure 4.8.2(b) The Radiated Out-of-Band Emissions with the Minimum Margin Evaluated for the EUT with Directional Antenna #5 at 17.5dBm/pt, 1x20MHz at UNII-2a Channel 52 (5260MHz), Q/16QAM, (Preview RBW: 30k and Formal RBW: 1MHz).

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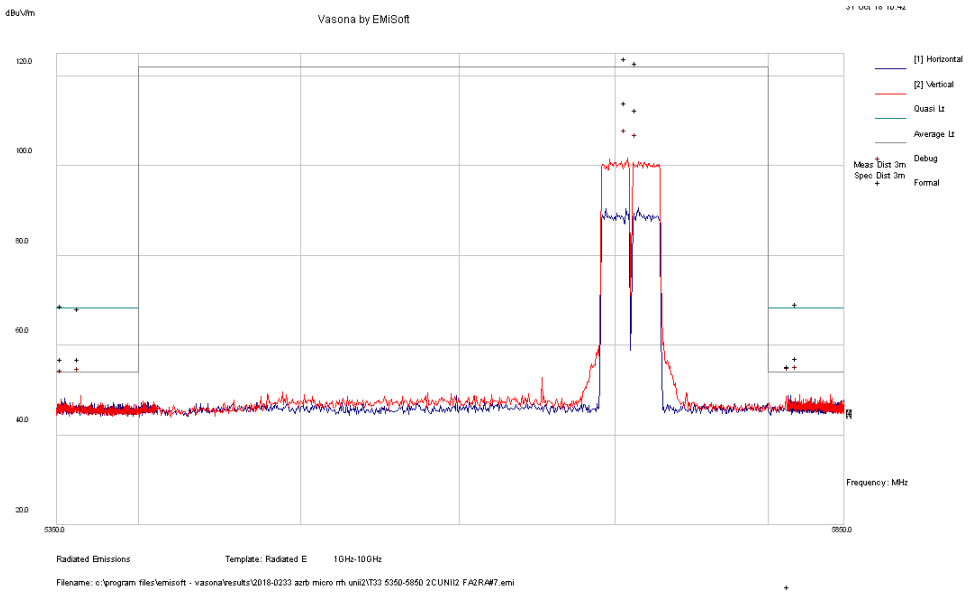

FORMAL DATA

Freq. (MHz)	Raw (dBuV)	Cable (dB)	Factor (dB)	Level (dBuV/m)	Emission Type	Pol (H/V)	Ht (cm)	Az (deg)	Limit (dBuV/m)	Margin (dB)	Pass /Fail	Comments
5820.46	31.93	22.25	-3.23	50.95	AvgMax	V	230	112	54	-3.05	Pass	NA
5364.75	32.01	22.21	-3.59	50.64	AvgMax	V	271	163	54	-3.36	Pass	
5354.65	32	22.21	-3.59	50.62	AvgMax	H	107	319	54	-3.38	Pass	
5708.07	98.69	22.24	-3.32	117.61	Quasi Max	V	157	346	122	-4.39	Pass	
5814.81	30.09	22.25	-3.24	49.1	AvgMax	H	273	312	54	-4.9	Pass	NA
5820.46	43.97	22.25	-3.23	62.98	Quasi Max	V	230	112	68.2	-5.22	Pass	
5715.14	97.69	22.24	-3.31	116.62	Quasi Max	V	115	327	122	-5.38	Pass	
5814.81	43.75	22.25	-3.24	62.76	Quasi Peak	V	273	312	68.2	-5.44	Pass	
5354.65	43.92	22.21	-3.59	62.54	Quasi Max	H	107	319	68.2	-5.66	Pass	
5364.75	43.42	22.21	-3.59	62.05	Quasi Max	V	271	163	68.2	-6.15	Pass	
5708.07	88.84	22.24	-3.32	107.76	AvgMax	V	157	346	122	-14.24	Pass	NA
5715.14	87.3	22.24	-3.31	106.22	AvgMax	V	115	327	122	-15.78	Pass	NA

Figure 4.8.2(c) The Radiated Out-of-Band Emissions with the Minimum Margin Evaluated for the EUT with Omni-Directional Antenna #7 at 19.5dBm/pt, 2x20MHz at UNII-2c, 140, 144/5700, 5720MHz, 256QAM, (Preview RBW: 30k and Formal RBW: 1MHz, File No T33).

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4.9 MEASUREMENT REQUIRED: UNWANTED SPURIOUS EMISSIONS – FCC SECTION 15.407 (b)(2)(3)(5-8), 15.209 & 15.205

The requirements of the unwanted emissions are provided in Section 4.1. Per KDB 789033 D02 guidance II.G.3.b, "The unwanted emission limits in both the restricted and non-restricted bands are based on radiated measurements; however, as an alternative, antenna-port conducted measurements in conjunction with cabinet emissions tests will be permitted to demonstrate compliance."

The Limits of FCC 15.109 Class B, 15.209 and 15.407 were given in Tables 4.9.1 and 4.9.2, where the conversion between the EIRP and electrical field strength was given in Section 4.8. The restricted bands of operation specified in FCC 15.205(a) were provided in Section 4.1. The FCC 15.109 Class B limits are identical to the 15.209 limits between 30MHz and 30GHz for the EUT operating in UNII bands.

Table 4.9.1. FCC 15.109 Class B and 15.209 Radiated Emissions Limits

Frequency (MHz)	Field Stength at 3m (dB uV/m)		RBW (kHz)	Detector
	FCC 15.109 Class B	FCC 15.209		
10 - 30		49.5	9	QP
30 - 88	40	40	120	QP
88 - 216	43.5	43.5		
216 - 230	46	46		
230 - 960	46	46		
960 - 1000	54	54		
1000 - 3000	54	54	1000	Ave.
	74	74		Peak
> 3000 - 5 f_c	54	54	1000	Ave.
	74	74		Peak
5 f_c - 10 f_c / 40GHz		54	1000	Ave.
		74		Peak

Table 4.9.2. Combined Worst Radiated Emission Limits per 15.407 UNII-1/2/3, 15.209 and 15.109 at 3m

Frequency (MHz)	E (dBuV/m)*	RBW (kHz)	Detector
30 - 88	40/63.7	120kHz	QP/Peak
88 - 216	43.5/63.7		
216 - 960	46/63.7		
960 - 1000	54/63.7		
1G - 40G in Restricted Bands	54/68.2	1000	Ave/Peak
1G - 40G in Non-Restricted Bands	68.2	1000	Peak

*Per KDB 789033 D02, the ground reflection 4.7dB was included for frequencies below 1GHz.

The emissions were investigated from 30MHz to 40GHz. The emissions near the band edges were provided in Section 4.8.

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The conducted spurious emissions in 30MHz-40GHz were evaluated per KDB 789033 D02 measurement guidance for the EUT equipped with the omni-directional antenna #6 which allows the EUT to transmit at the highest conducted power at 21dBm/port.

Table 4.9.3. Derived Combined Worst Conducted Spurious Limits per FCC 15.407, 15.209, 15.109 for Emissions Outside UNII-2

Freq (MHz)	P^{Lim} **G = 6dBi** (dBm)	Detector/RBW
30-88	-66/-42.2	qpk/pk 120kHz
88-216	-62.4/-42.2	
216-960	-60/-42.2	
960-1000	-52/-42.2	
1G - 40G in Restricted Bands	-47.2/-33	ave/pk/1MHz
1G - 40G in Non-Restricted Bands	-33	pk/1MHz

The carrier with Q/16QAM modulation was found to have similar spurious emissions compared with that of 64QAM and 256QAM modulations. Therefore, the conducted spurious emissions were evaluated by using peak and average detectors transmitting at the maximum output power at the low, middle (1x20MHz only) and high channels listed in Table 4.2.2 with QPSK/16QAM modulation, respectively. The emissions are all below the required limits. There are no significant emission differences observed in the frequency range of below 1GHz and above 10GHz for various carrier configurations.

The radiated spurious emissions were also evaluated for the EUT equipped with the omni-directional antenna #6 which has the maximum output power, the omni-directional antenna #7 which has the highest antenna gain among all omni-directional antennas and the directional antenna #5 which has the highest gain among all directional antennas, respectively. The carriers transmitted at the maximum power levels. The radiated spurious emissions of the EUT with the omni-directional antennas #6 in the frequency range of 30MHz-40GHz (mainly in 1-10GHz) was evaluated for 1x20MHz, 2x20MHz and 3x20MHz configurations at four selected low and/or high channels given in Table 4.2.2, respectively.

For the EUT with the directional antennas #5 and the omni-directional antennas #7, the radiated spurious emissions in the frequency range of 1-10GHz were evaluated for 1x20MHz, 2x20MHz and 3x20MHz carriers at three low and high channels, respectively.

The recommendations of ANSI C63.10 were followed for EUT testing setup and cabling. The measurement guidance given in KDB 789033 D02 was followed. The test setup diagram was given in Section 4.3. The emissions were maximized by rotating the turntable 360° and moving the receiving antenna height to scan and capture the emissions from the EUT.

The unwanted radiated spurious emissions measured in the frequency range of 30MHz-40GHz for the EUT, which operated in UNII-2a/2c bands and was equipped with the omni-directional antennas #6 and #7 and the directional antenna #5, respectively, met the FCC 15.407 and 15.209 requirements for intentional radiators and the FCC 15.109 Class B requirements for unintentional radiators. The plots with the minimum margins in each frequency range evaluated for each antenna were provided in Figures 4.9.1-4.9.3, respectively.

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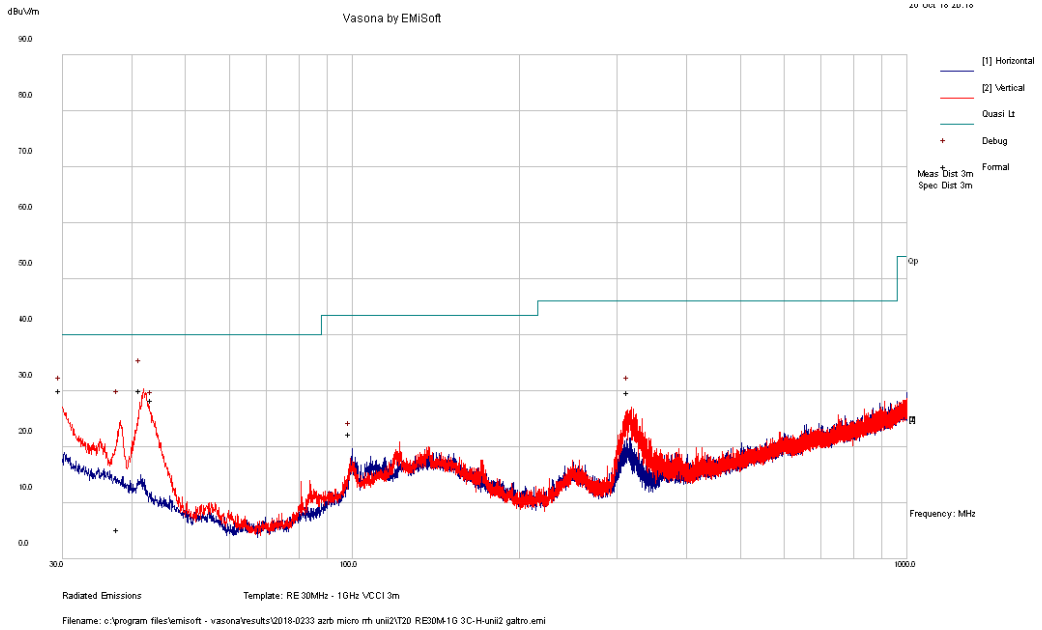

FORMAL DATA

Freq. (MHz)	Raw (dBuV)	Cable (dB)	Factor (dB)	Level (dBuV/m)	Emission Type	Pol (H/V)	Ht (cm)	Az (deg)	Limit (dBuV/m)	Margin (dB)	Pass /Fail	Comments
42	40.06	0.37	-15.6	24.81	Quasi Max	V	138	42	40	-15.19	Pass	
30.001	33.6	0.3	-9.19	24.71	Quasi Max	V	126	209	40	-15.29	Pass	
44	39.18	0.38	-16.5	23.04	Quasi Max	V	99	353	40	-16.96	Pass	
38.155	35.1	0.35	-13.7	21.73	Quasi Peak	V	156	208	40	-18.27	Pass	
317.923	37.32	1.03	-13.9	24.46	Quasi Max	V	172	72	46	-21.54	Pass	
100.066	30.53	0.6	-14.2	16.93	Quasi Max	H	281	115	43.5	-26.57	Pass	

PREVIEW DATA

Freq. (MHz)	Raw (dBuV)	Cable (dB)	Factor (dB)	Level (dBuV/m)	Emission Type	Pol (H/V)	Ht (cm)	Az (deg)	Limit (dBuV/m)	Margin (dB)	Pass /Fail	Comments
42	45.55	0.37	-15.6	30.3	Preview	V	100	45	40	-9.7	Pass	
30	35.98	0.3	-9.19	27.1	Preview	V	100	180	40	-12.9	Pass	
38.1538	38.12	0.35	-13.7	24.75	Preview	V	180	180	40	-15.25	Pass	
44	40.68	0.38	-16.5	24.54	Preview	V	100	45	40	-15.46	Pass	
317.923	40	1.03	-13.9	27.14	Preview	V	180	45	46	-18.86	Pass	
100.066	32.7	0.6	-14.2	19.1	Debug	H	99	315	43.5	-24.4	Pass	

Note: Preview data was measured using a peak detector to identify frequencies of interest for formal measurement. Formal data consist of all frequencies in the preview list within 6 dB of specification limit or the top six frequencies. Failure in preview data does not necessarily constitute failure in formal data.

Figure 4.9.1(a) The Radiated Unwanted Emissions in 30MHz-1GHzMHz for the EUT with Omni-Directional Antenna #6 (6dBi) in UNII-2a, 1x20MHz Carrier at Channel 52 (5260MHz), Q/16QAM, maximum power, against FCC Part 15.209 and 15.109 Class B Limits at 3m (T21) (Preview 10k RBW Peak, Formal 120kHz RBW QPK).

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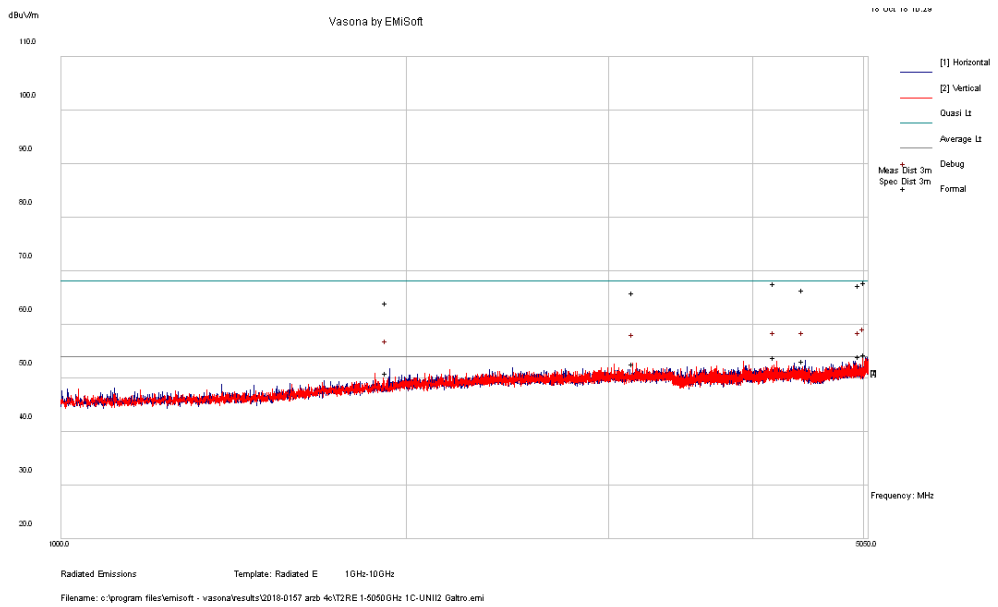

FORMAL DATA

Freq. (MHz)	Raw (dBuV)	Cable (dB)	Factor (dB)	Level (dBuV/m)	Emission Type	Pol (H/V)	Ht (cm)	Az (deg)	Limit (dBuV/m)	Margin (dB)	Pass /Fail	Comments
5043.39	44.24	22.18	-3.84	62.57	Peak	H	281	209	68.2	-5.63	Pass	
4450.89	43.64	21.76	-4.3	61.1	Peak	H	213	97	68.2	-7.1	Pass	
4989.35	43.76	22.14	-3.89	62.01	Peak	V	363	156	68.2	-6.19	Pass	
4201.47	45.15	21.57	-4.46	62.27	Peak	V	157	157	68.2	-5.93	Pass	
3167.97	45.6	20.88	-5.87	60.61	Peak	V	129	268	68.2	-7.59	Pass	
1931.97	46.38	20.34	-8.04	58.68	Peak	H	295	224	68.2	-9.52	Pass	
5043.39	30.66	22.18	-3.84	48.99	AvgMax	H	281	209	54	-5.01	Pass	
4450.89	30.43	21.76	-4.3	47.89	AvgMax	H	213	97	54	-6.11	Pass	NA
4989.35	30.47	22.14	-3.89	48.72	AvgMax	V	363	156	54	-5.28	Pass	
4201.47	31.5	21.57	-4.46	48.62	AvgMax	V	157	157	54	-5.38	Pass	
3167.97	32.35	20.88	-5.87	47.36	AvgMax	V	129	268	54	-6.64	Pass	NA
1931.97	33.29	20.34	-8.04	45.59	AvgMax	H	295	224	54	-8.41	Pass	NA

Figure 4.9.1(b) The Radiated Unwanted Emissions in 1-5.05GHzMHz for the EUT with Omni-Directional Antenna #6 (6dBi) in UNII-2a, 1x20MHz Carrier at Channel 52 (5260MHz), Q/16QAM, maximum power, against FCC Part 15.407 and 15.209 Limits at 3m (T2) (Preview 100k RBW Peak, Formal 1MHz RBW PK/AVE).

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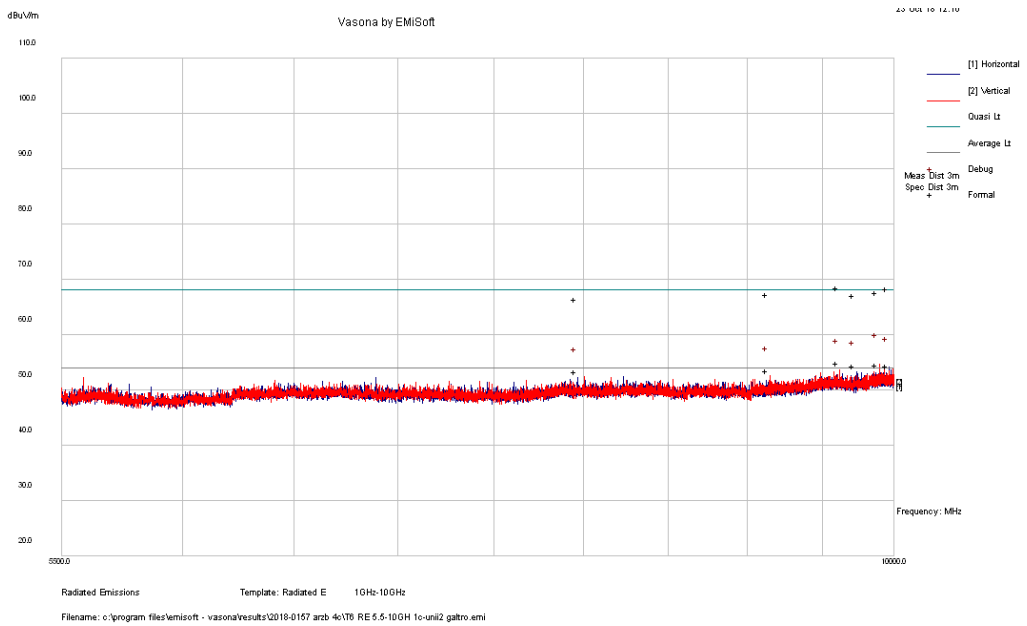

FORMAL DATA

Freq. (MHz)	Raw (dBuV)	Cable (dB)	Factor (dB)	Level (dBuV/m)	Emission Type	Pol (H/V)	Ht (cm)	Az (deg)	Limit (dBuV/m)	Margin (dB)	Pass /Fail	Comments
9615.29	31.06	20.79	-2.25	49.6	AvgMax	V	100	30	54	-4.4	Pass	NA
9893.95	30.32	20.91	-1.95	49.28	AvgMax	V	255	64	54	-4.72	Pass	NA
9965.52	30.02	20.94	-1.88	49.09	AvgMax	H	139	80	54	-4.91	Pass	NA
9732.91	30.3	20.84	-2.12	49.02	AvgMax	H	214	344	54	-4.98	Pass	NA
9615.29	44.6	20.79	-2.25	63.14	Peak	V	100	30	68.2	-5.06	Pass	
9965.52	43.93	20.94	-1.88	62.99	Peak	H	139	80	68.2	-5.21	Pass	
9144.85	30.08	20.57	-2.51	48.14	AvgMax	V	185	264	54	-5.86	Pass	
9893.95	43.3	20.91	-1.95	62.26	Peak	V	255	64	68.2	-5.94	Pass	
7967.95	30.63	20.06	-2.75	47.95	AvgMax	H	269	193	54	-6.05	Pass	NA
9144.85	43.89	20.57	-2.51	61.95	Peak	V	185	264	68.2	-6.25	Pass	
9732.91	43.12	20.84	-2.12	61.84	Peak	H	214	344	68.2	-6.36	Pass	
7967.95	43.79	20.06	-2.75	61.1	Peak	H	269	193	68.2	-7.1	Pass	

Figure 4.9.1(c) The Radiated Unwanted Emissions in 5.5-10GHzMHz for the EUT with Omni-Directional Antenna #6 (6dBi) in UNII-2a, 1x20MHz Carrier at Channel 52 (5260MHz), Q/16QAM, maximum power, against FCC Part 15.407 and 15.209 Limits at 3m (T6) (Preview 100k RBW Peak, Formal 1MHz RBW PK/AVE).

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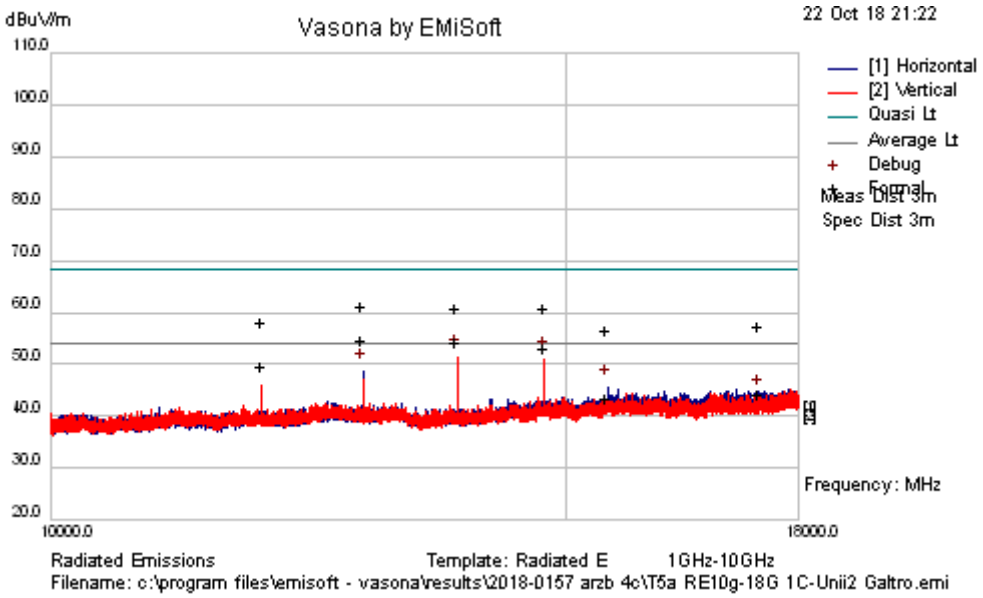

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Freq. (MHz)	Raw (dBuV)	Cable (dB)	Factor (dB)	Level (dBuV/m)	Emission Type	Pol (H/V)	Ht (cm)	Az (deg)	Limit (dBuV/m)	Margin (dB)	Pass /Fail	Comments
12779.5	40.78	8.39	1.7	50.87	Average	H	101	333	54	-3.13	Pass	NA
13762.5	39.5	8.8	2.1	50.39	Average	V	104	335	54	-3.61	Pass	NA
14745.6	37.46	9.68	2.29	49.42	Average	V	110	10	54	-4.58	Pass	NA
11796.5	37.75	8.01	-0.02	45.74	Average	V	99	302	54	-8.26	Pass	
12779.5	47.35	8.39	1.7	57.45	Peak	H	101	333	68.2	-10.75	Pass	
14745.6	45.11	9.68	2.29	57.08	Peak	V	110	10	68.2	-11.12	Pass	
13762.5	45.98	8.8	2.1	56.87	Peak	V	104	335	68.2	-11.33	Pass	
17447.9	25.18	10.58	4.49	40.25	Average	V	266	78	54	-13.75	Pass	NA
11796.5	46.35	8.01	-0.02	54.33	Peak	V	99	302	68.2	-13.87	Pass	
15490.6	27.38	10.18	2.26	39.82	Average	H	163	306	54	-14.18	Pass	
17447.9	38.61	10.58	4.49	53.68	Peak	V	266	78	68.2	-14.52	Pass	

Figure 4.9.1(d) The Radiated Unwanted Emissions in 10-18GHzMHz for the EUT with Omni-Directional Antenna #6 (6dBi) in UNII-2a, 1x20MHz Carrier at Channel 52 (5260MHz), Q/16QAM, maximum power, against FCC Part 15.407 and 15.209 Limits at 3m (T5a) (Preview 100k RBW Peak, Formal 1MHz RBW PK/AVE).

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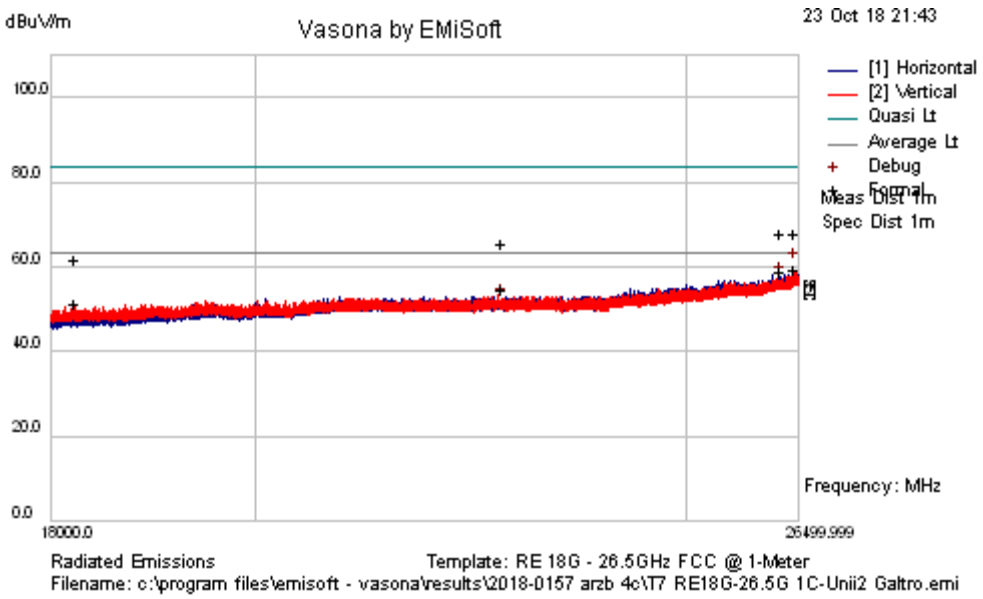

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Freq. (MHz)	Raw (dBuV)	Cable (dB)	Factor (dB)	Level (dBuV/m)	Emission Type	Pol (H/V)	Ht (cm)	Az (deg)	Limit (dBuV/m)	Margin (dB)	Pass /Fail	Comments
26467.8	31.93	10.28	12.26	54.48	Average	H	230	136	63.5	-9.02	Pass	NA
26275.5	32.27	10.04	11.73	54.04	Average	V	237	329	63.5	-9.46	Pass	NA
22723.6	31.56	8.98	9.23	49.76	Average	V	209	173	63.5	-13.74	Pass	
18217.1	30.8	8.28	7.64	46.72	Average	V	119	179	63.5	-16.78	Pass	
26275.5	41.67	10.04	11.73	63.44	Peak	V	237	329	83.5*	-20.06	Pass	
26467.8	40.75	10.28	12.26	63.29	Peak	H	230	136	83.5	-20.21	Pass	
22723.6	42.5	8.98	9.23	60.71	Peak	V	209	173	83.5	-22.79	Pass	
18217.1	41.24	8.28	7.64	57.16	Peak	V	119	179	83.5	-26.34	Pass	

- This limit is for FCC Par t15 Class B. For 15.407, the limit is 77.7.

Figure 4.9.1(e) The Radiated Unwanted Emissions in 18-26.5GHzMHz for the EUT with Omni-Directional Antenna #6 (6dBi) in UNII-2a, 1x20MHz Carrier at Channel 52 (5260MHz), Q/16QAM, maximum power, against FCC Part 15.407 and 15.209 Limits at 1m (T7) (Preview 100k RBW Peak, Formal 1MHz RBW PK/AVE).

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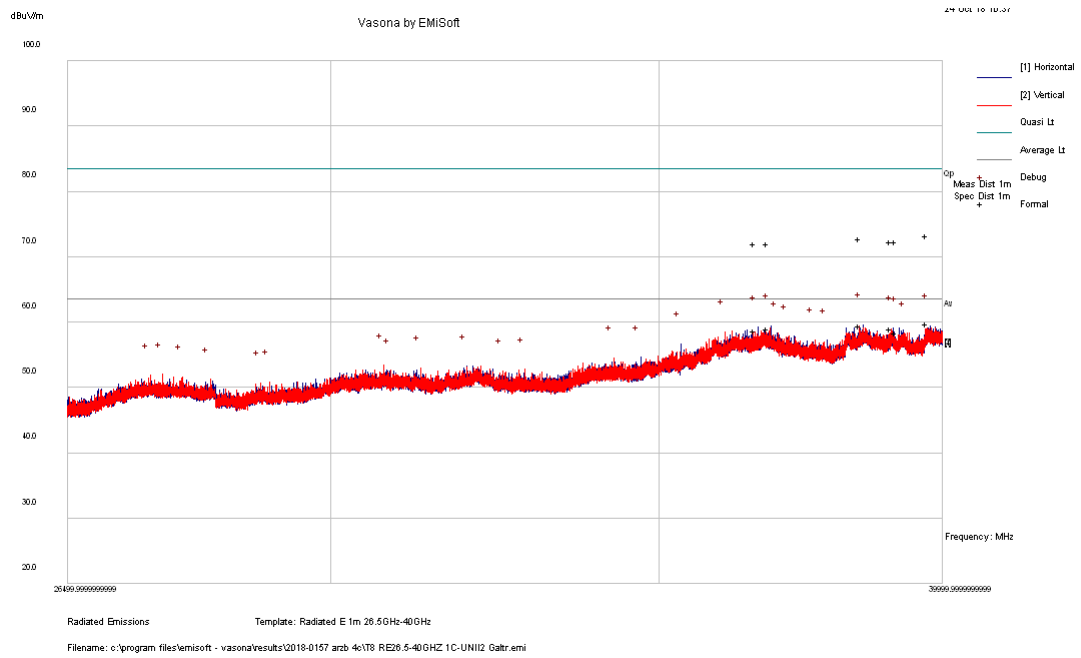

FORMAL DATA

Freq. (MHz)	Raw (dBuV)	Cable (dB)	Factor (dB)	Level (dBuV/m)	Emission Type	Pol (H/V)	Ht (cm)	Az (deg)	Limit (dBuV/m)	Margin (dB)	Pass /Fail	Comments
39760.5	25.91	0	29.11	55.03	AvgMax	H	121	116	63.5	-8.47	Pass	
38527.7	25.77	0	28.91	54.68	AvgMax	H	178	305	63.5	-8.82	Pass	
39082.3	25.51	0	28.81	54.31	AvgMax	H	109	220	63.5	-9.19	Pass	
36891.9	24.45	0	29.8	54.25	AvgMax	H	109	326	63.5	-9.25	Pass	NA
36666.3	24.3	0	29.65	53.95	AvgMax	H	190	99	63.5	-9.55	Pass	NA
39185.8	24.96	0	28.71	53.67	AvgMax	H	104	198	63.5	-9.83	Pass	
39760.5	39.34	0	29.11	68.45	Peak	H	121	116	83.5*	-15.05	Pass	
38527.7	39.21	0	28.91	68.12	Peak	H	178	305	83.5	-15.38	Pass	
39082.3	38.77	0	28.81	67.58	Peak	H	109	220	83.5	-15.92	Pass	
39185.8	38.82	0	28.71	67.53	Peak	H	104	198	83.5	-15.97	Pass	
36666.3	37.72	0	29.65	67.37	Peak	H	190	99	83.5	-16.13	Pass	
36891.9	37.44	0	29.8	67.24	Peak	H	109	326	83.5	-16.26	Pass	

- The 83.5 limit is for Part 15 class B. The 77.7 limit is for 15.407.

Figure 4.9.1(f) The Radiated Unwanted Emissions in 26.5-40GHzMHz for the EUT with Omni-Directional Antenna #6 (6dBi) in UNII-2a, 1x20MHz Carrier at Channel 52 (5260MHz), Q/16QAM, maximum power, against FCC Part 15.407 and 15.209 Limits at 1m (T8) (Preview 100k RBW Peak, Formal 1MHz RBW PK/AVE).

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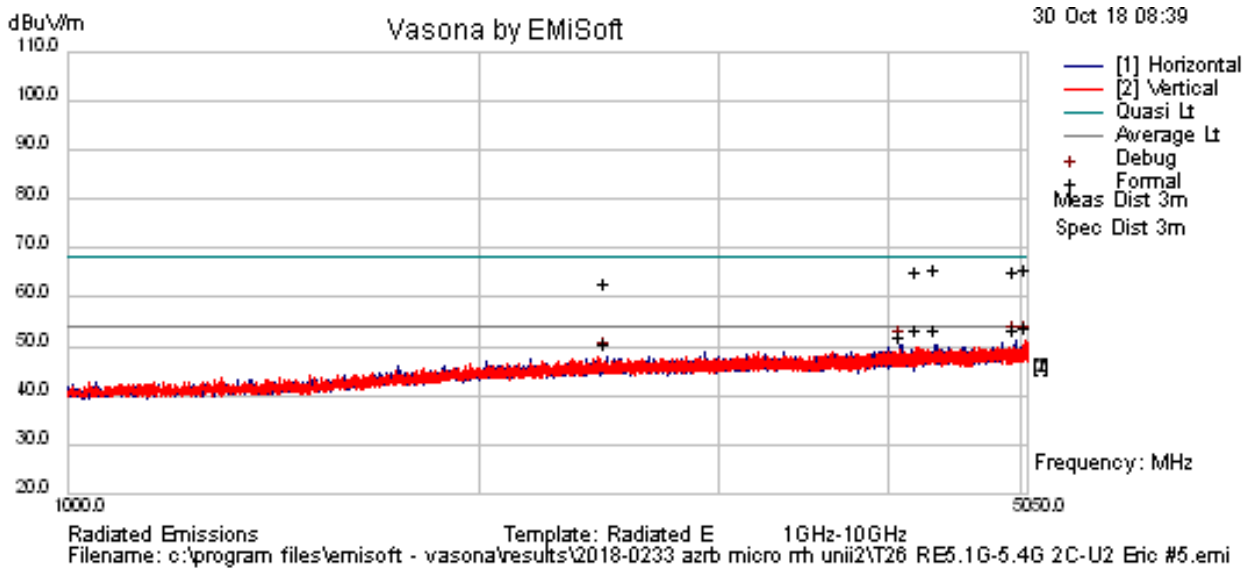

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Freq. (MHz)	Raw (dBuV)	Cable (dB)	Factor (dB)	Level (dBuV/m)	Emission Type	Pol (H/V)	Ht (cm)	Az (deg)	Limit (dBuV/m)	Margin (dB)	Pass /Fail	Comments
5046.21	32.33	22.18	-3.84	50.66	Average	V	256	289	54	-3.34	Pass	
4948.36	32.13	22.11	-3.92	50.33	Average	H	155	227	54	-3.67	Pass	
4335.2	32.72	21.67	-4.37	50.02	Average	H	109	74	54	-3.98	Pass	
4198.93	32.84	21.57	-4.46	49.95	Average	V	114	60	54	-4.05	Pass	
4085.14	31.6	21.48	-4.53	48.54	Average	H	248	280	54	-5.46	Pass	
5046.21	44.32	22.18	-3.84	62.66	Peak	V	256	289	68.2	-5.54	Pass	
4335.2	44.98	21.67	-4.37	62.28	Peak	H	109	74	68.2	-5.92	Pass	
4198.93	45.07	21.57	-4.46	62.18	Peak	V	114	60	68.2	-6.02	Pass	
4948.36	43.83	22.11	-3.92	62.02	Peak	H	155	227	68.2	-6.18	Pass	
2484.74	32.97	20.57	-6.23	47.3	Average	V	170	285	54	-6.7	Pass	
2484.74	45.33	20.57	-6.23	59.67	Peak	V	170	285	68.2	-8.53	Pass	

Figure 4.9.2(a) The Radiated Unwanted Emissions in 1-5.05GHzMHz for the EUT with Directional Antenna #5 (9.5dBi) in UNII-2c, 2x20MHz Carrier at Channels 100, 104/5500MHz, 5520MHz, Q/16QAM, 17.5dBm/pt, against FCC Part 15.407 and 15.209 Limits at 3m (T26) (Preview 100k RBW Peak, Formal 1MHz RBW PK/AVE).

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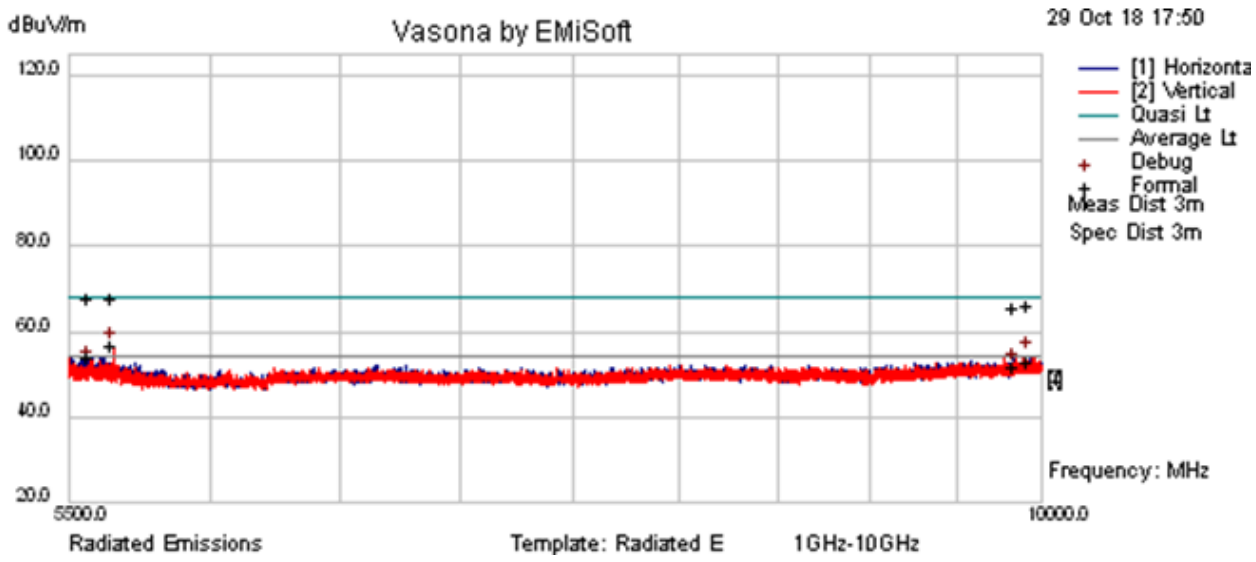

FORMAL DATA												
Freq. (MHz)	Raw (dBuV)	Cable (dB)	Factor (dB)	Level (dBuV/m)	Emission Type	Pol (H/V)	Ht (cm)	Az (deg)	Limit (dBuV/m)	Margin (dB)	Pass /Fail	Comments
5652.41	36.87	19.24	-3.36	52.74	Average	V	136	14	54	-1.26	Pass	NA
5571.15	34.37	19.23	-3.43	50.17	Average	V	118	15	54	-3.83	Pass	NA
5571.15	48.03	19.23	-3.43	63.84	Peak	V	118	15	68.2	-4.36	Pass	
5652.41	47.93	19.24	-3.36	63.8	Peak	V	136	14	68.2	-4.4	Pass	
9923.93	30.18	20.92	-1.92	49.18	Average	H	249	65	54	-4.82	Pass	NA
9839.88	29.32	20.89	-2.01	48.2	Average	V	133	336	54	-5.8	Pass	NA
9923.93	43.28	20.92	-1.92	62.28	Peak	H	249	65	68.2	-5.92	Pass	
9839.88	42.72	20.89	-2.01	61.59	Peak	V	133	336	68.2	-6.61	Pass	

Figure 4.9.2(b) The Radiated Unwanted Emissions in 5.5-10GHzMHz for the EUT with Directional Antenna #5 (9.5dBi) in UNII-2a, 1x20MHz Carrier at Channel 52/5260MHz, Q/16QAM, 17.5dBm/pt, against FCC Part 15.407 and 15.209 Limits at 3m (T23) (Preview 100k RBW Peak, Formal 1MHz RBW PK/AVE).

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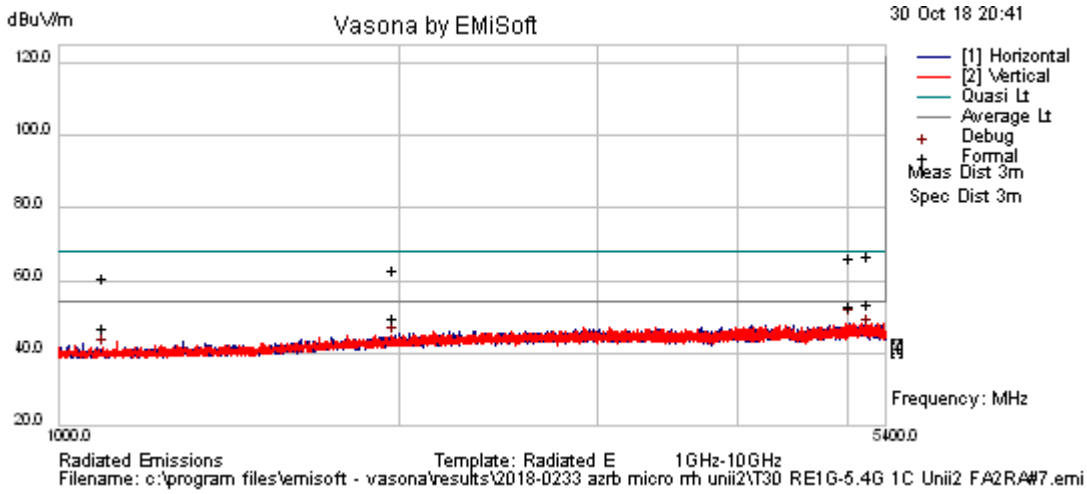

FORMAL DATA												
Freq. (MHz)	Raw (dBuV)	Cable (dB)	Factor (dB)	Level (dBuV/m)	Emission Type	Pol (H/V)	Ht (cm)	Az (deg)	Limit (dBuV/m)	Margin (dB)	Pass /Fail	Comments
5212.11	31	22.2	-3.71	49.5	Average	V	163	355	54	-4.5	Pass	NA
5026.92	30.77	22.17	-3.86	49.08	Average	H	127	178	54	-4.92	Pass	NA
5212.11	44.3	22.2	-3.71	62.79	Peak	V	163	355	68.2	-5.41	Pass	
5026.92	43.82	22.17	-3.86	62.12	Peak	H	127	178	68.2	-6.08	Pass	
1979.79	33.33	20.35	-7.75	45.93	Average	V	107	97	54	-8.07	Pass	NA
1979.79	46.39	20.35	-7.75	58.99	Peak	V	107	97	68.2	-9.21	Pass	
1099.04	35.58	19.64	-12.3	42.97	Average	V	220	194	54	-11.03	Pass	
1099.04	49.31	19.64	-12.3	56.71	Peak	V	220	194	68.2	-11.49	Pass	

Figure 4.9.3(a) The Radiated Unwanted Emissions in 1-5.4GHzMHz for the EUT with Omni-Directional Antenna #7 (7.5dBi) in UNII-2c, 1x20MHz Carrier at Channel 100/5500MHz, Q/16QAM, 19.5dBm/pt, against FCC Part 15.407 and 15.209 Limits at 3m (Preview 30k RBW Peak, Formal 1MHz RBW PK/AVE).

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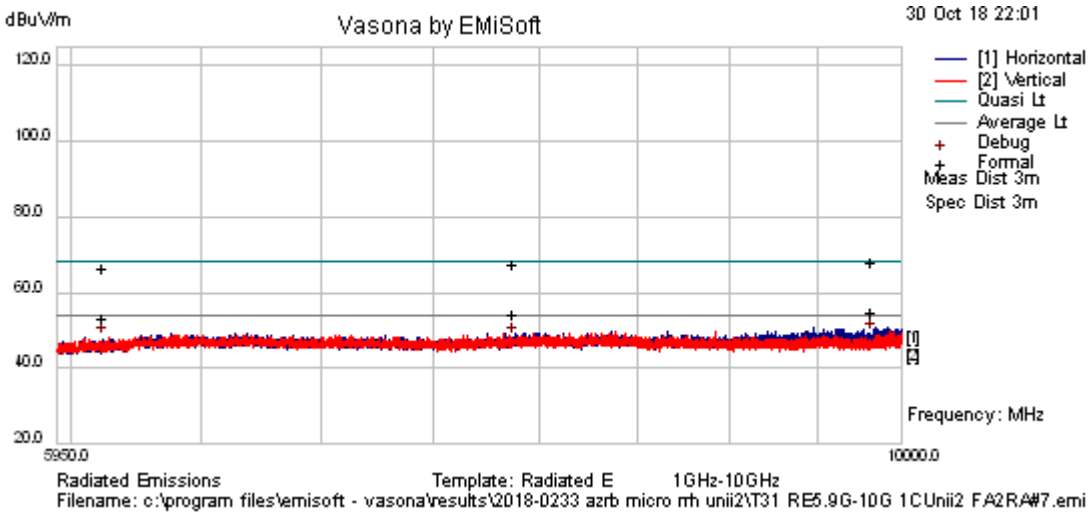

FORMAL DATA												
Freq. (MHz)	Raw (dBuV)	Cable (dB)	Factor (dB)	Level (dBuV/m)	Emission Type	Pol (H/V)	Ht (cm)	Az (deg)	Limit (dBuV/m)	Margin (dB)	Pass /Fail	Comments
10000	30.03	23.96	-1.84	52.15	Average	H	262	143	54	-1.85	Pass	NA
10000	43.68	23.96	-1.84	65.8	Peak	H	262	143	68.2	-2.4	Pass	
9827.57	28.99	23.88	-2.02	50.85	Average	V	220	136	54	-3.15	Pass	NA
7877.54	29.89	23.02	-2.74	50.18	Average	V	134	267	54	-3.82	Pass	NA
9827.57	42.35	23.88	-2.02	64.21	Peak	V	220	136	68.2	-3.99	Pass	
7877.54	43.24	23.02	-2.74	63.52	Peak	V	134	267	68.2	-4.68	Pass	
6125.53	29.92	22.29	-2.99	49.22	Average	V	213	191	54	-4.78	Pass	NA
6125.53	43.3	22.29	-2.99	62.6	Peak	V	213	191	68.2	-5.6	Pass	

Figure 4.9.3(b) The Radiated Unwanted Emissions in 5.95-10GHzMHz for the EUT with Omni-Directional Antenna #7 (7.5dBi) in UNII-2c, 1x20MHz Carrier at Channel 100/5500MHz, Q/16QAM, 19.5dBm/pt, against FCC Part 15.407 and 15.209 Limits at 3m (T31) (Preview 30k RBW Peak, Formal 1MHz RBW PK/AVE).

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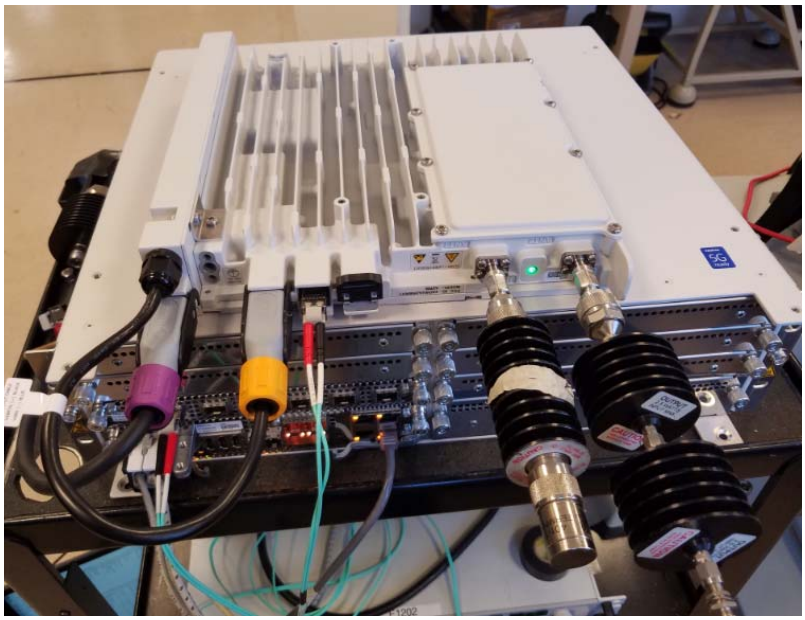
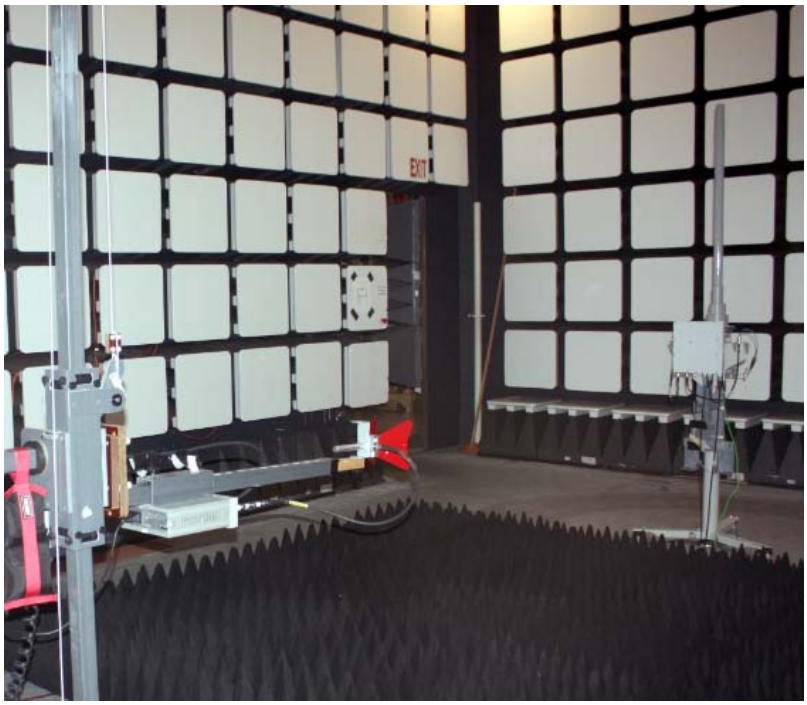
5 PHOTOGRAPHS OF EUT SETUP

The setup photos of the conducted and radiated emissions tests were provided below.





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6 LIST OF TEST EQUIPMENT

Table 6.1 List of Test Equipment Used

Equipment	Manufacturer	Model	Serial #	Last Cal Date	Cal Due Date
MXA Signal Analyzer (20Hz-26.5GHz)	Agilent	N9020A	MY48011791	2018-02-15	2020-02-15
EMI Test Receiver (20Hz to 40 GHz)	Rohde & Schwarz	ESU40	100246	2016-12-05	2018-12-05
10 dB Attenuator (0.05 – 26 GHz, 25W)	Weinschel	74-10-12	1068	N/A	N/A
10 dB Attenuator (0.05 – 26 GHz, 25W)	Weinschel	74-10-12	1069	N/A	N/A
EMC Receiver / SA (20Hz to 40 GHz)	Rohde & Schwarz	ESIB-40	100119	2017-11-06	2019-11-06
30 dB Attenuator (0.05 – 26 GHz, 25W)	Weinschel	74-30-12	1065	N/A	N/A
High Pass Filter 10-30 GHz	RLC Electronics	F-19414	1444001	N/A	N/A
6 dB Attenuator	Weinschel	2-6	CD2518	2017-05-01	2019-05-01
6 dB Attenuator	Weinschel	2-6	CD2534	2017-05-23	2019-05-23
6 dB Attenuator	Weinschel	2-6	CD2545	2017-03-03	2019-03-03
Preamplifier (1-26.5 GHz, 30dB)	Hewlett Packard	8449B	3008A01384	2018-04-10	2020-04-10
Preamplifier (9kHz-1 GHz)	Sonoma Instrument Co.	310N	185785	2018-01-09	2020-01-09
Double-Ridged Horn (1-18 GHz)	ETS Lindgren	3117	00135198	2017-06-09	2019-06-09
Double-Ridged Horn (18-40 GHz)	EMC Test Systems	3116	2539	2017-06-16	2019-06-16
Standard Horn (26.5-40GHz)	A.H. Systems	SAS-200/573	137	2017-10-04	2019-10-04
Bilogical Antenna (25-2000MHz)	A.H. Systems	SAS-521-2	408	2017-07-11	2019-07-11
High Pass Filter (10-30GHz)	RLC Electronics Inc	F-19414	1444002	N/A	N/A
Multi-Device Controller	ETS Lindgren	2090	0004-1507	N/A	N/A

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7 TEST FACILITIES

All measurement facilities used to collect the measurement data under normal condition are located at 600-700 Mountain Avenue, Murray Hill, New Jersey 07974-0636 USA. The field strength measurements of radiated spurious emissions are made in a FCC and IC registered semi-anechoic chamber AR9 (FCC Site Registration Number: 896745, IC Filing Number: 6933F-9). The sites were constructed and are continuously in conformance with the requirements of ANSI C63.4 and CISPR Publication 32.

Nokia Global Product Compliance Laboratory is accredited with the US Department of Commerce National Institute of Standards and Technology's National Voluntary Laboratory Accreditation Program (NVLAP) for satisfactory compliance with criteria established in Title 15, Part 7 Code of Federal Regulations for offering test services for selected test methods in Electromagnetic Compatibility; Voluntary Control Council for Interference (VCCI), Japan; Australian Communications and Media Authority (ACMA). The laboratory is ISO 9001:2008 Certified.

United States Department of Commerce
National Institute of Standards and Technology

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2018-09-05 through 2019-09-30
Effective Dates

For the National Voluntary Laboratory Accreditation Program

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8 REFERENCES

[1]. Title 47 Code of Federal Regulations (CFR) Parts 2 and 15.

[2]. ANSI C63.10, American Nation Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices, 2013.

[3]. FCC KDB 789033 D02, Guidelines for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices (Part 15, Subpart E), December 2017, v02r01.

[4]. FCC KDB 662911D01, Emissions Testing of Transmitters with Multiple Outputs in the Same Band, October 2013, v02r01.

[5]. FCC KDB 353028 D01, Basic Equipment Authorization Guidance for Antennas Used with Part 15 Intentional Radiators, April 2017, v01.

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