NOKIA Bell Labs

Global Product Compliance Laboratory
600-700 Mountain Avenue
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TESTING
NVLAP LAB CODE: 100275-0

FCC Certification Part 30 Test Report

Product Evaluated
Flexi Zone Multiband Outdoor (MBO) Micro BTS
AEUA-01, 4 Carrier
FCC ID: VBNAEUA-01

Customer
Nokia Solutions and Networks US LLC
6000 Connection Drive
Irving, Texas 75039 USA

Test Laboratory
Nokia Bell Labs
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Date: May 17, 2019

Revisions

Date	Revision	Section	Change
4/24/2019	0		Initial Release
4/26/2019	1	1.0	Test Standards issue date
5/17/2019	2	4.3.1.1	Added Channel Aggregation

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Prepared By: W. Steve Majkowski NCE

5/17/2019

Product Certification Filing Lead
Nokia Bell Labs
Nokia, Global Product Compliance Laboratory

Approved By: Ray Johnson

5/17/2019

Technical Manager
Nokia Bell Labs
Nokia, Global Product Compliance Laboratory

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1. ATTESTATION OF TEST RESULTS

Company Name	**Nokia Solutions and Networks** 6000 Connection Drive Irving, Texas 75039 USA
FCC ID	**VBNAEUA-01**
Product Name	**AirScale 28 GHz Radio Unit (AEUA) Band 30** PRI20183530
Model Name	**AEUA**
Part No	474214A.101
Serial Number(s)	DC Model: L1183016394
Test Standard(s)	• 47 CFR FCC Parts 2 • KDB 971168 D01 Power Meas License Digital Systems v03r01 April 9, 2018. • KDB 662911 D01 Multiple Transmitter Output v02r01 Oct 2013 • Procedures on TRP Compliance for Out of Band and Spurious Emissions C63.26 mmWave JTG - Version # 1 July 14th 2018
Reference(s)	• 47 CFR FCC Part 2 and Part 30 • ANSI C63.26 (2015) • ANSI C63.4 (2014) • TR 14-1001, MMW Measurements with Harmonic Mixers (April-4-2014)
Frequency Band	(Tx: 27.5 – 28.35 GHz), NR Band n261
Technology	5G-New Radio, LTE-TDD: 97M5G7W,
Test Frequency Range	10MHz – 100GHz
Operation Mode(s)	2x 57dBm EIRP, 60 dBm EIRP Total. MIMO
Submission Type	Class II Change for 4 carrier operation
FCC Part 15 Subpart B	Compliance with Class B
Test Date	March 25- April 16, 2019
Test Laboratory	Nokia Global Product Compliance Laboratory 600-700 Mountain Avenue, Rm 5B-108 Murray Hill, New Jersey 07974-0636 USA **NVLAP** Lab Code: 100275-0 **FCC Registration Number: 395774**

This is to certify that the above product has been evaluated and found to be in compliance with the Rules and Regulations set forth in the above standard(s). The data and the descriptions about the test setup, procedures and configuration presented in this report are accurate. The results of testing in this report

apply only to the product/system which was tested. Other similar equipment will not necessarily produce the same results due to production tolerance and measurement uncertainties.

Per the requirement of Section 2.911(d) Certification of Technical Test Data, I hereby certify that the technical test data are the results of tests either performed or supervised by me.

W. Steve Majkowski NCE
Member of Technical Staff
Nokia, Global Product Compliance Laboratory

2. SUMMARY OF THE TEST RESULTS

47 CFR FCC Sections	Description of Tests	Compliance Results
2.1046, 30.202 (a)	RF Power Output	Pass
2.1047,	Modulation Characteristics	Pass
2.1049, 30.203	(a) Occupied Bandwidth (b) Edge-of-Band Emissions	Pass
2.1051, 30.203	Spurious Emissions at Antenna Terminals - Radiated	Pass
2.1053, 30.203	Field Strength of Spurious Radiation	Pass
2.1055,	Measurement of Frequency Stability	N/A, Note 1

Note 1: There was no hardware change to the to unit or to the Frequency generating and stabilizing sections of the unit.

2.1 Measurement Uncertainty

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

Worst-Case Estimated Measurement Uncertainties

Standard, Method or Procedure	Condition	Frequency MHz	Expanded Uncertainty (k=2)
a. Classical Emissions, (*e.g.*, ANSI C63.4, CISPR 11, 14, 22, *etc.*, using ESHS 30,	Conducted Emissions	0.009 - 30	±3.5 dB
	Radiated Emissions (AR-8 Semi-Anechoic Chamber)	30 MHz – 200MHz H 30 MHz – 200 MHz V 200 MHz – 1000 MHz H 200 MHz – 1000 MHz V 1 GHz- 18 GHz	±5.4 dB ±5.4 dB ±4.7 dB ±4.7 dB ±3.3 dB

Antenna Port Test	**Signal Bandwidth**	**Frequency Range**	**Expanded Uncertainty (k=2), Amplitude**
Occupied Bandwidth, Edge of Band,	10 Hz 100 Hz 10 kHz to 1 MHz 1MHz to 100 MHz	9 kHz to 20 MHz 20 MHz to 1 GHz 1 GHz to 10 GHz 10 GHz to 40 GHz:	±2.2 dB
Conducted Spurious Emissions	30 kHz to 100 MHz	10 MHz to 40 GHz:	±2.8 dB
RF Power, Channel Power	10 Hz to 100 MHz	10 MHz to 40 GHz	±1.4 dB

3. GENERAL INFORMATION

3.1 Product Descriptions

The equipment under test (EUT) has the following specifications.

Table 3.1.1 Product Specifications

Specification Items	Description
Product Type	Compact Base Station LTE Module (2Tx, 2Rx), 2x2 MIMO
Radio Type	Intentional Transceiver
Power Type	115 VAC
Modulation	5G New Radio LTE-TDD with QPSK, 16QAM, 64QAM & 256QAM
Operating Frequency Range	TDD (Tx/Rx: 27.5-28.35 GHz),
Channel Bandwidth	100 MHz,
Max Radiated Power (EIRP)	57 dBm EIRP per polarizations; based upon 28 dBm Tx output. 60 dBm EIRP Total for the two polarizations.
Antenna Gain	29 dBi
Operating Mode	2x2 MIMO (2 duplex Tx/Rx Ports)
Software Version	FLF17SP
Hardware Version	474214A.101
Antenna(s)	Refer to Section 3.2

The EUT supports the following carrier configurations:

Table 3.1.2 EUT Supported Configurations

Carrier Bandwidth (MHz)	Carriers per Path	MIMO Modes	Signal Type	Modulation
100	1	2x	LTE-TDD	QPSK, 16QAM & 64QAM

The operating band consists of the following channels and spectrum:

Table 3.1.3 NRARFCN per 38.101-2, for n261 with 100 MHz Carriers

NRARFCN	TDD Center Reference Frequency (MHz)	Width of Channel (MHz)
2071675	27,550.56	100
2073341	27,650.52	100
2075007	27,750.48	100
2076673	27,850.44	100
2078339	27,950.40	100
2080005	28,050.36	100
2081671	28,150.32	100
2083337	28,250.20	100

3.2 EIRP/ PSD Compliance and Antenna Information.

The product incorporates integrated antennas. Externally mounted antennas cannot be attached to the unit or mounted remotely. The units integrated antennas are electronically steerable with a maximum gain of 29 dBi. There are two antenna assemblies inside the product. Each antenna assembly is a 16x16 matrix (256 elements). One assembly is vertically polarized and the second is horizontally polarized. The antennas RF drive level is 29 dBm. The 28 dBm RF power and 29 dBi gain results in a 57 dBm EIRP per assembly. The sum of the two 57 dBm EIRP beams results in a maximum EIRP of 60 dBm. Antenna Gain vs frequency is detailed in Exhibit 6 of the original filing package.

3.3 Antenna Far Field Determination Distance

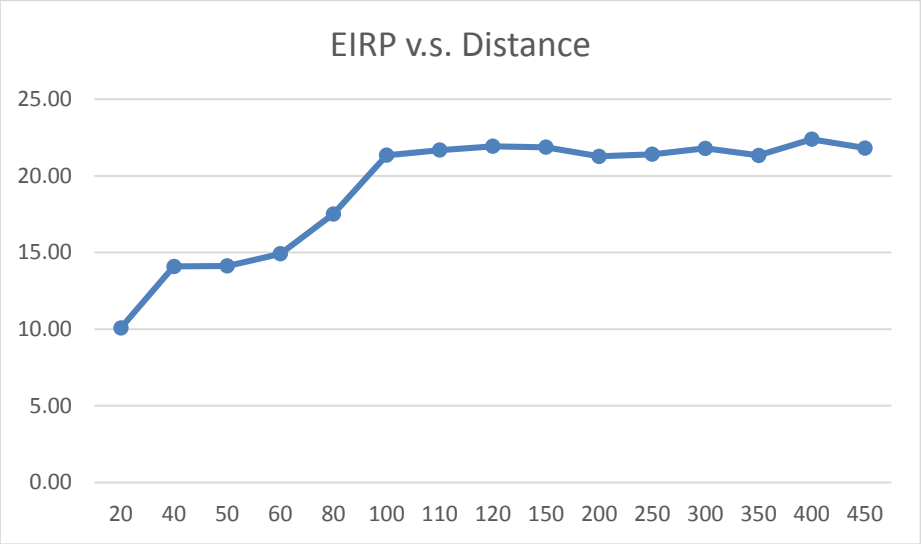
Calculations and low power measurements were performed to determine the far field boundary location for the antenna per the Fraunhofer distance calculated from

$$d_{ff} = 2D^2/\lambda$$

where d_{ff} = Far Field distance in meters,
D is the maximum size of the radiating array λ = wavelength of the operating signal in meters

The antenna patch height is 15 mm and 7.6 mm wide and the patches are 15 .
At 28 GHz the 15 cm dimension results in a far field distance d_{ff} of 4.54 meters.
At 28 GHz the 7.6 cm dimension results in a far field distance d_{ff} of 1.07 meters.

Measurements were performed at low power and using a small horn antenna
In horizontal polarization the determined boundary was 100 cm, which matches the horizontal dimension.
To eliminate any inconsistancy all power measurements were made at 4m.



4. REQUIRED MEASUREMENTS AND RESULTS

Per 47CFR FCC Section 2.1033(c)(14), the following certification tests are required by Section 2.1046 through Section 2.1057. These tests are identified in Table 4.0a below.

Table 4.0a Required Certification Measurements

47 CFR FCC Sections	Description of Tests	Test Required for Class II Authorization
2.1046, 30.202 (a)	**RF Power Output** **(a) Power Limits, EIRP, PSD**	**Yes**
2.1047,	**Modulation Characteristics**	**Yes**
2.1049, 30.203	**(a) Occupied Bandwidth** **(b) Out-of-Band Emissions**	**Yes**
2.1051, 30.203	**Spurious Emissions at Antenna Terminals**	**Yes**
2.1053, 30.203, 30.204, 15.109(a) Class B	**Field Strength of Spurious Radiation**	**Yes**
2.1055,	**Measurement of Frequency Stability**	**N/A**

.

The measurements were conducted in accordance with the procedures set out in Section 2.1041 and as appropriate per the test Standards listed in Table 4.0b below. The comprehensive list of tests performed included measurements at Left, Center and Right side of the Part 30 Band. These tests are presented to demonstrate compliance with FCC requirements.

Table 4.0b Test Standards Used for Radiated Measurements of Radio Performance

Test Standard(s)	• 47 CFR FCC Parts 2 • KDB 971168 D01 Licensed DTS Guidance v02 June 4, 2013 • KDB 662911 D01 Multiple Transmitter Output v02r01 Oct 2013 • Procedures on TRP Compliance for Out of Band and Spurious Emissions C63.26 mmWave JTG - Version # 1 July 14th 2018
Reference(s)	• 47 CFR FCC Part 2 and Part 30 • ANSI C63.26 (2015) • ANSI C63.4 (2014) • TR 14-1001, MMW Measurements with Harmonic Mixers (April-4-2014)

4.1 Section 2.1046 MEASUREMENT REQUIRED: RF POWER OUTPUT

This test is a measurement of the total Radiated Power level transmitted at the antenna-transmitting terminal. The product was configured for test as shown in Figure 4.1.1 below and allowed to warm up and stabilize per KDB 971168 D01 and ANSI C63.26.

The **Nokia AirScale 28 GHz Radio Unit (AEUA), FCC ID: VBNAEUA-01,** is a 5G-NR LTE TDD transceiver specified to provide a maximum power output of 57 dBm EIRP/500 W EIRP per transmit polarization for a sum total of 60 dBm EIRP /1000W EIRP per unit.

The power is under digital control. The product is designed to operate under Part 30 rules for Band n261. Under Part 30 the average power of the sum of all antenna elements is limited to an equivalent isotopically radiated power (EIRP) density of +75dBm/100 MHz.

The product incorporates internal antennas and substitution of antennas is not possible.

4.1.1 RF Power Output Measurement

Power measurements of the 5G New Radio transmit signal were conducted with an FSW Spectrum Analyzers per KDB 971168 D01. Measurements were performed at 4m distance. The path loss, cable loss and measurement antenna gain were offset and displayed on the screen. The transmitted signals were TDD LTE based and had the general modulation characteristics of QPSK, 16 QAM, 64QAM and 256QAM.

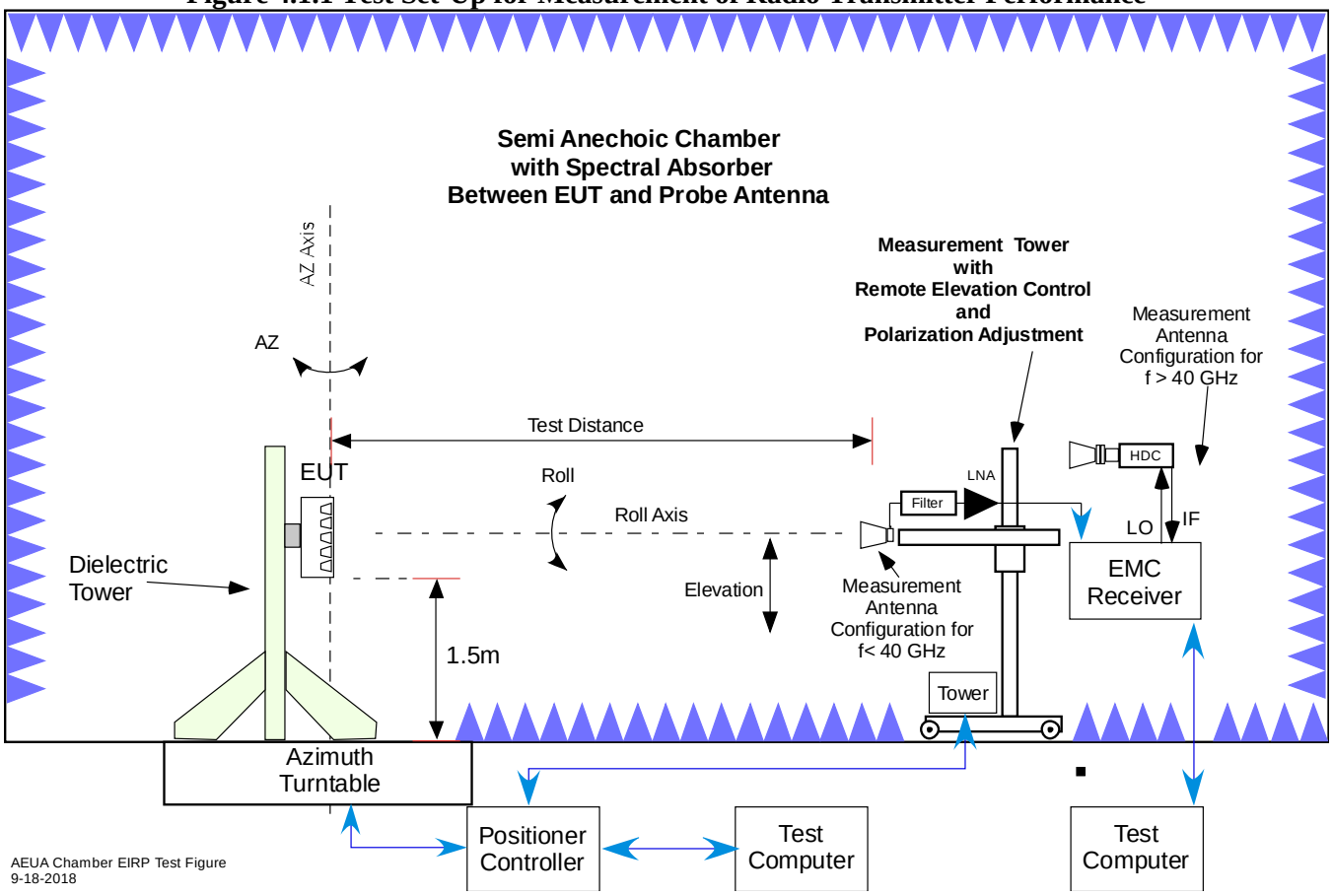
The maximum rated average EIRP at the 4m boundary distance was measured at the Left, Center and Right side of the 27.5-28.35 GHz frequency range for a 100 MHz bandwidth carrier in three different Modulations modes. These were 3GPP standard base station test models for QPSK, 16 QAM, 64QAM and 256QAM modulation. This power level was documented on each data sheet for Channel Power.

4.1.1.1 RF Power Output Results

Power output measurements verified the expected performance of 57 dBm EIRP. The maximum measured level was **57.77 dBm**. This level is well within the maximum Part 30.202a limit of 75 dBm EIRP. Measurements were performed for each modulation.

The measured performance was in full compliance with the Rules of the Commission. The data plots are detailed below.

Figure 4.1.1 Test Set-Up for Measurement of Radio Transmitter Performance



4.1.1.2 RF Power Output Data

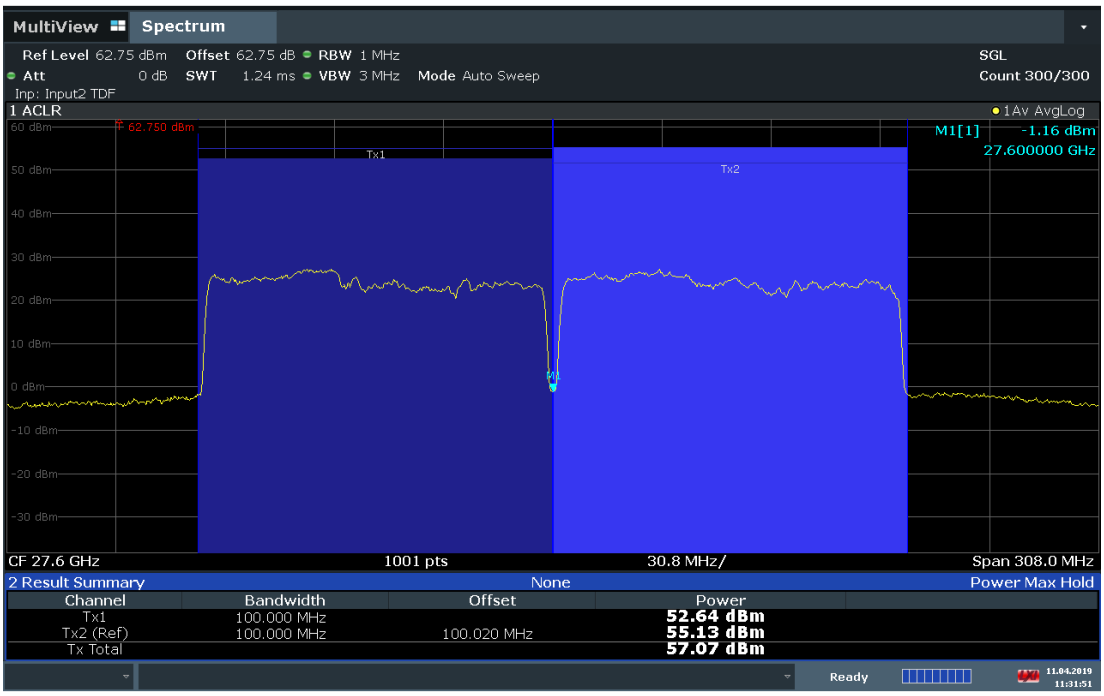
The Table below summarizes the Total Measured EIRP for the different configurations and modulations for 2 carrier, 3 carrier and 4 carrier configurations. The data plots follow.

Total Measured EIRP

	Horiz.	Vert.	Modulation	Compliance
Configuration	**dBm**	**dBm**	**Verified Constellation**	
2c Left	**57.07**	**57.77**	**64QAM**	**Compliant**
3c Right	**57.12**	**57.02**	**64QAM**	**Compliant**
4c Left	**57.19**	**57.06**	**QPSK**	**Compliant**
4c Middle	**57.06**	**57.03**	**64QAM**	**Compliant**
4c Right	**57.09**	**57.01**	**256QAM**	**Compliant**
4c Spread	**57.02**	**57.04**	**QPSK+16QAM**	**Compliant**

4m Channel Power Measurements. 2 Carriers At The Left side of Band - 64QAM Horizontal - 57.07 dBm Total

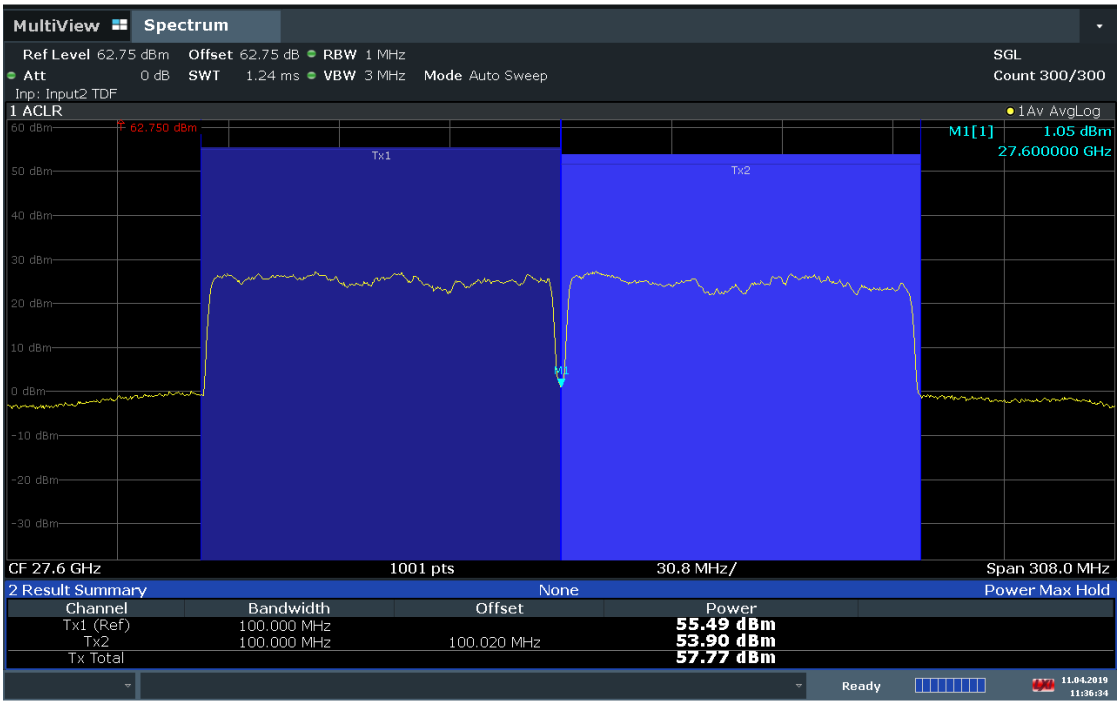
2019-0064 28 GHz AEUA 4C s/n L1183016394



11:31:52 11.04.2019

Vertical - 57.77 dBm Total

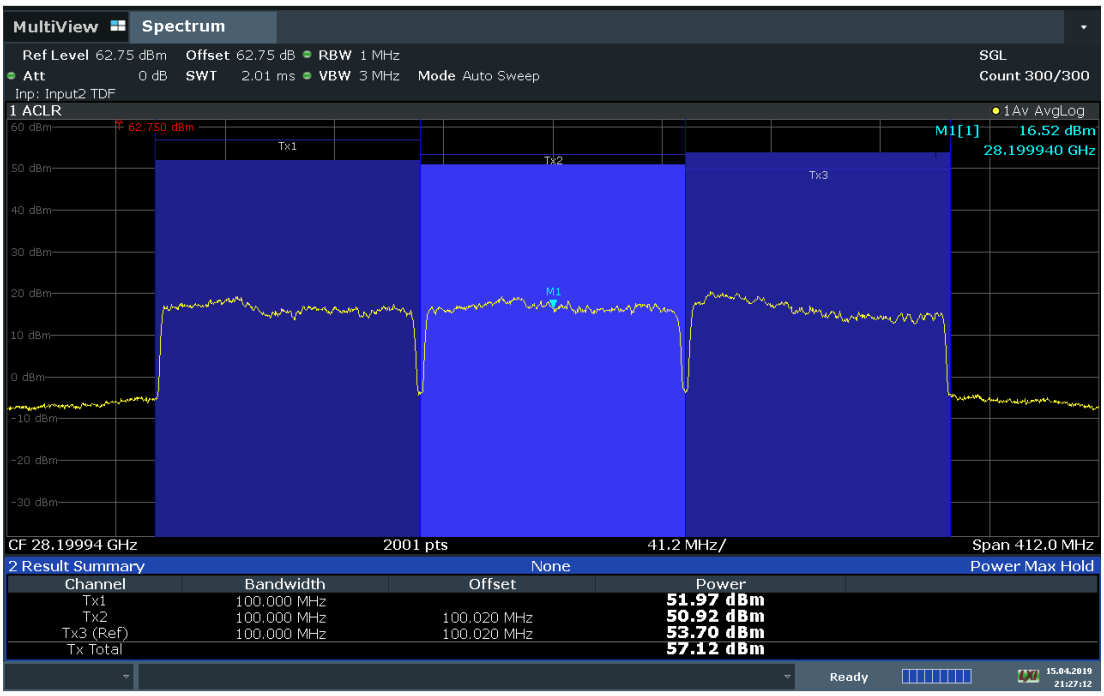
2019-0064 28 GHz AEUA 4C s/n L1183016394



11:36:35 11.04.2019

3 Carriers At The Right Side of The Band – 64QAM
Horizontal - 57.12 dBm Total

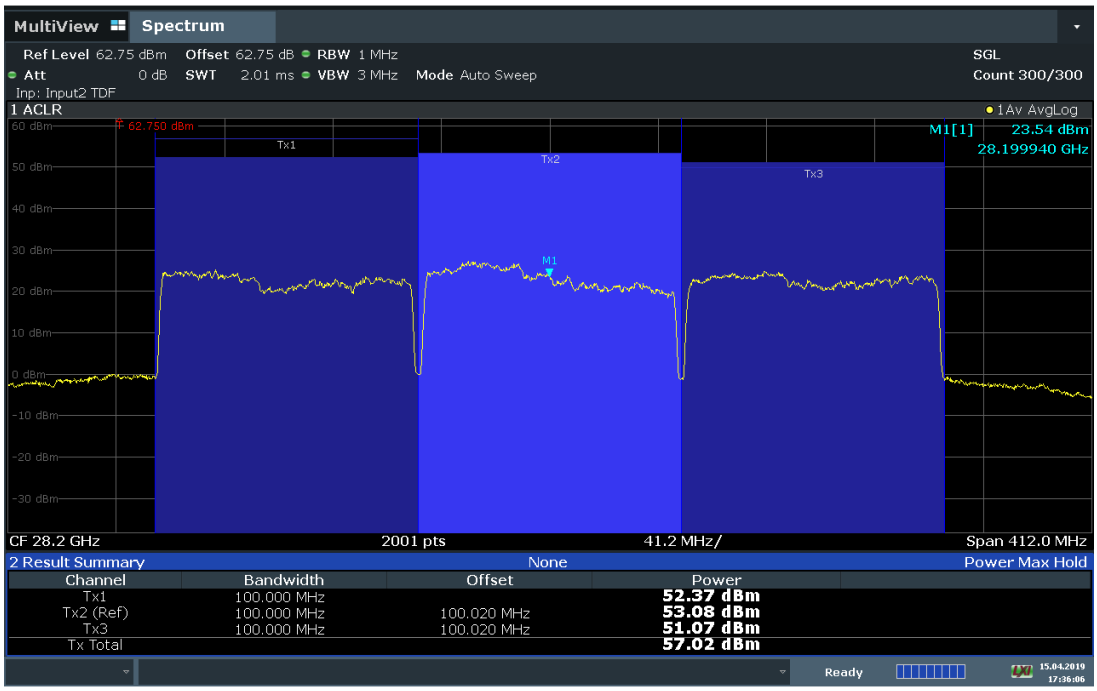
2019-0064 28 GHz AEUA 4C s/n L1183016394



21:27:13 15.04.2019

Vertical - 57.02 dBm Total

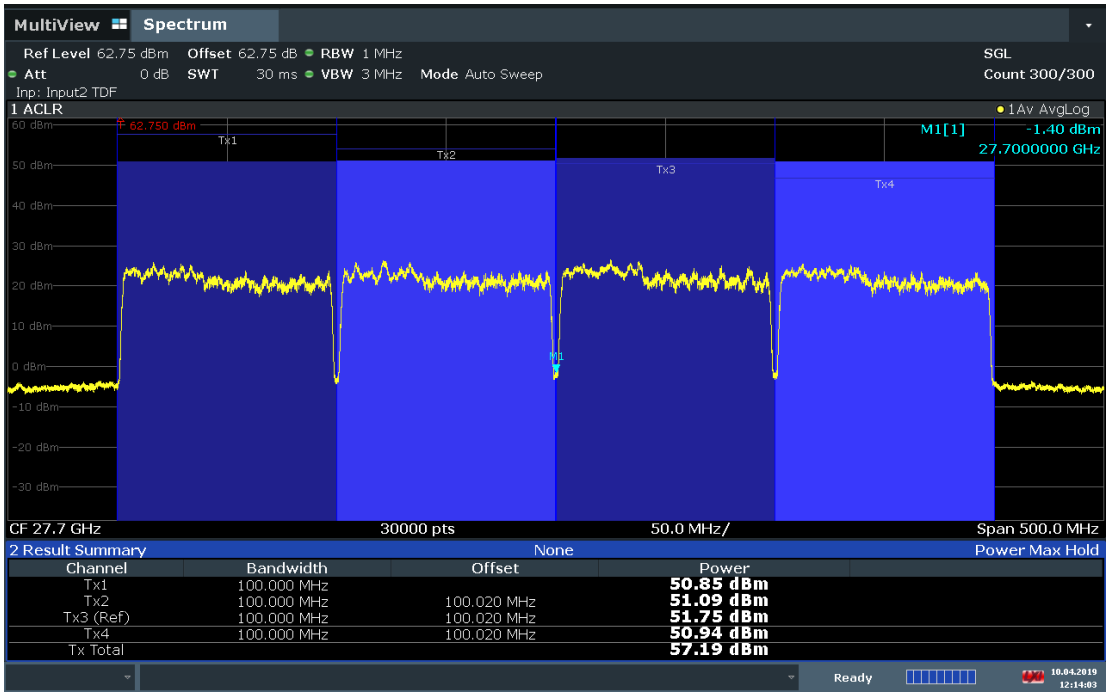
2019-0064 28 GHz AEUA 4C s/n L1183016394



17:36:06 15.04.2019

4 Carriers At The Left Side of The Band - QPSK Horizontal - 57.19 dBm Total

2019-0064 28 GHz AEUA 4C s/n L1183016394



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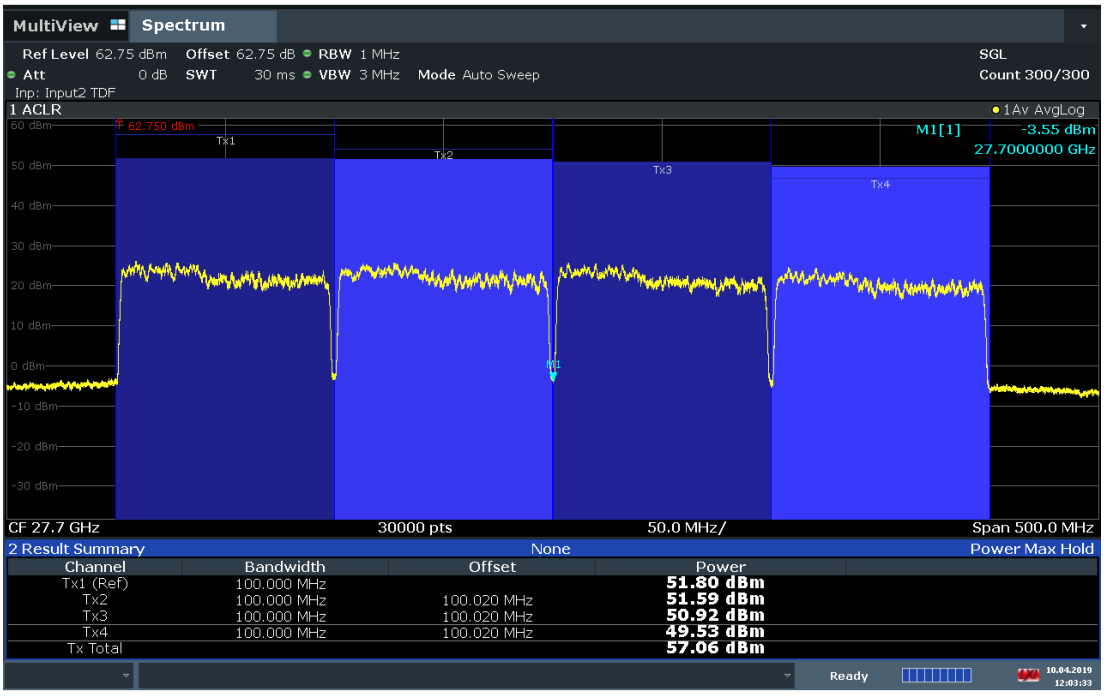
Vertical - dBm 57.06 dBm Total

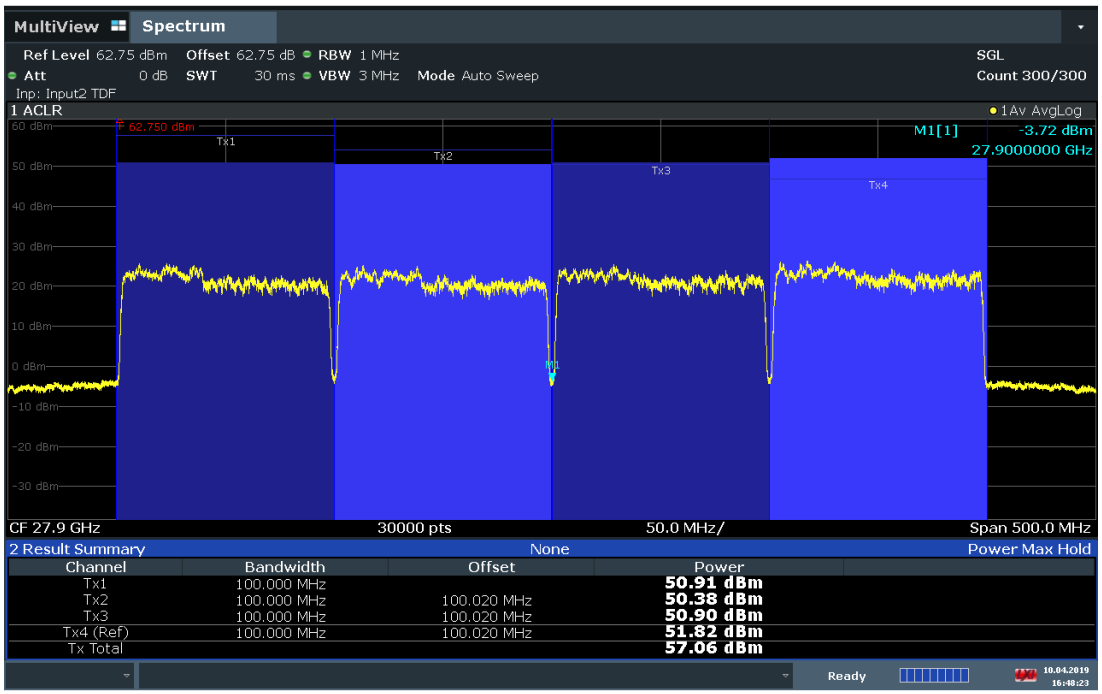
2019-0064 28 GHz AEUA 4C s/n L1183016394



12:03:34 10.04.2019

4 Carriers At The Middle of The Band – 64QAM+ Horizontal - 57.06 dBm Total

2019-0064 28 GHz AEUA 4C s/n L1183016394



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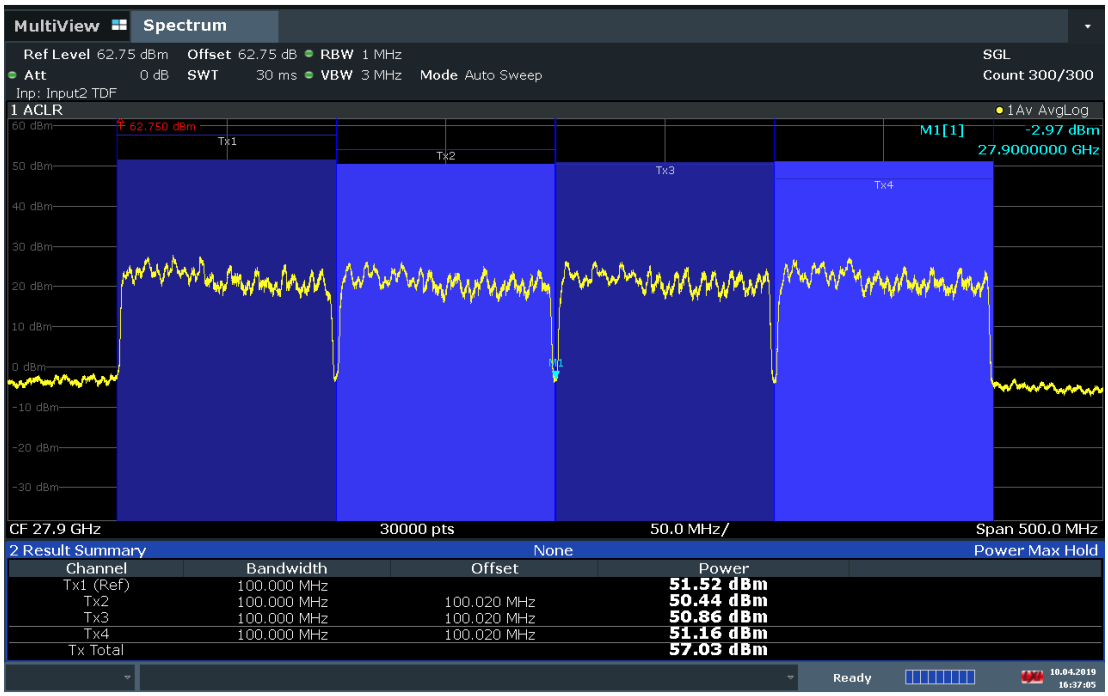
Vertical - dBm 57.03 dBm Total

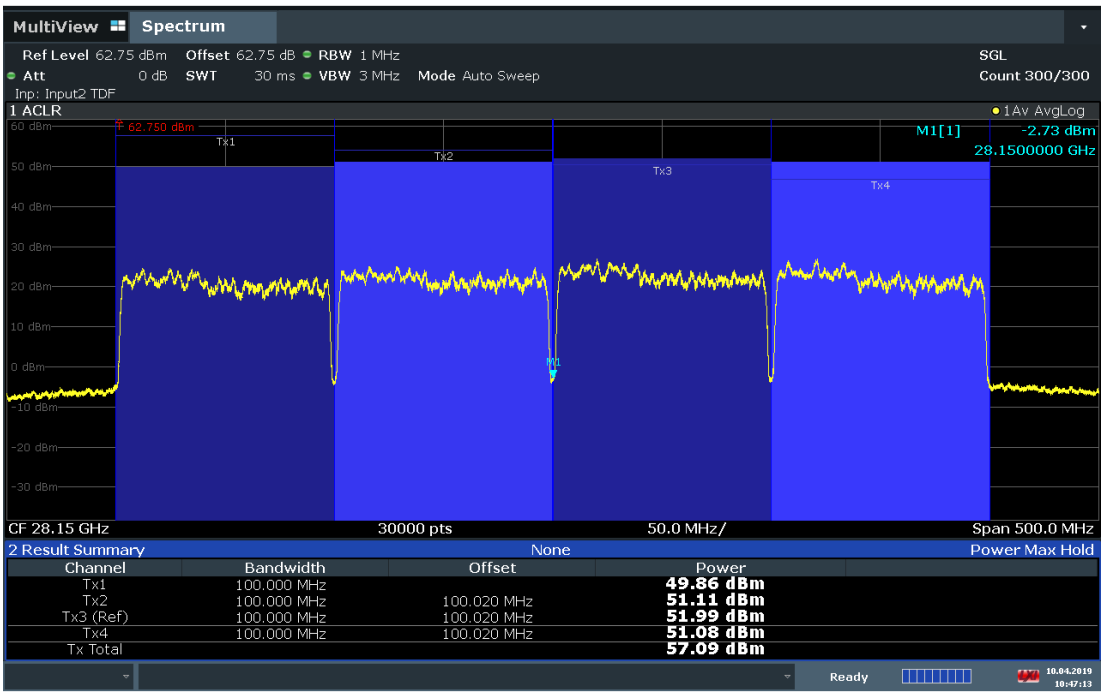
2019-0064 28 GHz AEUA 4C s/n L1183016394



16:37:06 10.04.2019

4 Carriers At The Right Side of The Band – 256QAM
Horizontal - 57.09 dBm Total

2019-0064 28 GHz AEUA 4C s/n L1183016394



10:47:14 10.04.2019

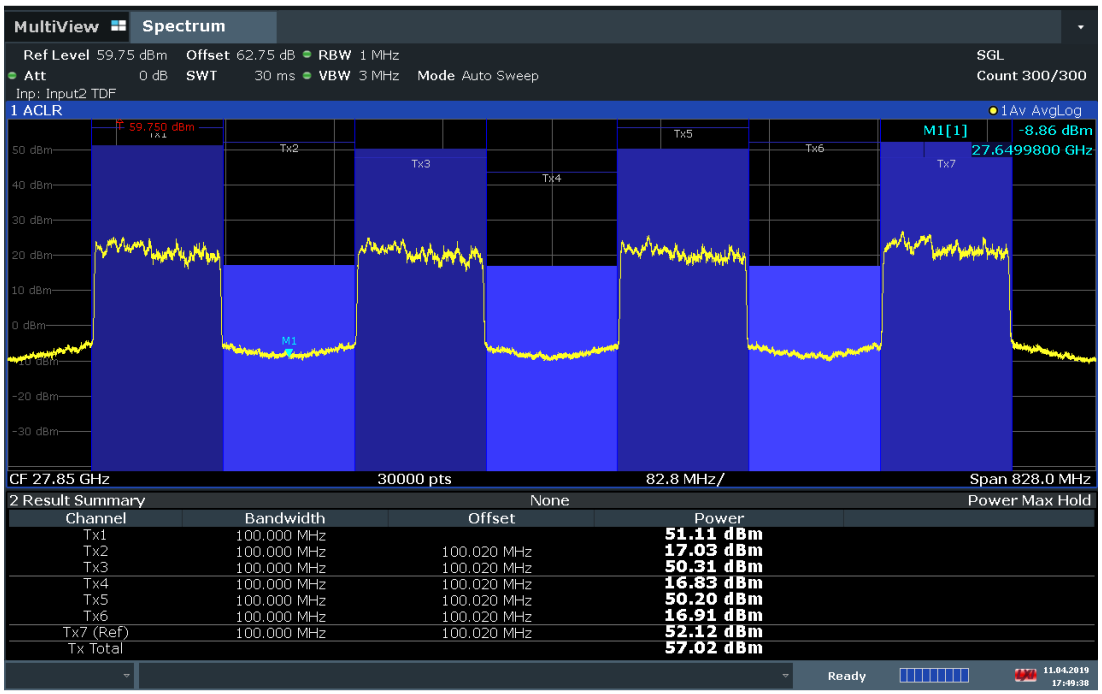
Vertical - dBm 57.01 dBm Total

2019-0064 28 GHz AEUA 4C s/n L1183016394

19:02:36 09.04.2019

4 Carriers Spread Across The Band – QPSK + 16 QAM
Horizontal - 57.02 dBm Total

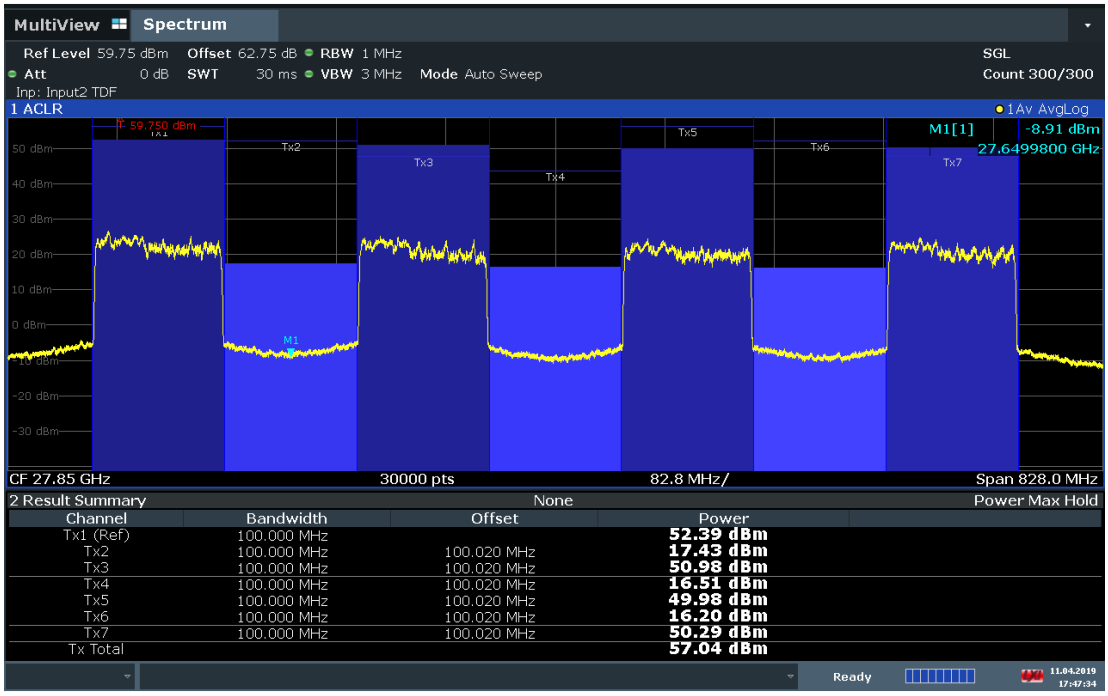
2019-0064 28 GHz AEUA 4C s/n L1183016394



17:49:38 11.04.2019

Vertical - dBm 57.04 dBm Total

2019-0064 28 GHz AEUA 4C s/n L1183016394



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4.2 Section 2.1047 MEASUREMENT REQUIRED: MODULATION CHARACTERISTICS

The **VBNAEUA-01** supports the 5G New Radio Modulation Format based upon LTE TDD technologies. LTE utilizes Orthogonal Frequency Division Multiplexing (OFDM) which splits the carrier frequency bandwidth into many small subcarriers. Each individual subcarrier can be modulated with a combined QPSK + 16QAM and 64QAM digital modulation formats.

In QPSK, there are 4 possible symbol states and each symbol carries 2 bits of information. In 16QAM, there are 16 possible symbol states and each 16-QAM symbol carries 4 bits of information. In 64QAM, there are 64 possible symbol states and each 64-QAM symbol carries 6 bits of information. The higher-order modulations, where the constellations become more dense, are more sensitive to poor channel conditions than the lower-order modulation.

The modulation characteristics measurement of LTE carriers measures the difference between the ideal symbols and the measured symbols after the equalization. The 5G-New Radio format is still in revision in 3GPP and Release 16 was expected Q4 of 2018. For this evolutionary 5G-NR configuration the constellations were recorded to assess that the subcarrier configurations were achieved.

There are no FCC Limits for Modulation and all of the formats above look spectrally the same from a channel edge and regrowth standpoint. It is expected that greater fidelity will be available after test equipment is configurable withfuture formats of 5G-NR.

4.2.1 Modulation Characteristics Measurement

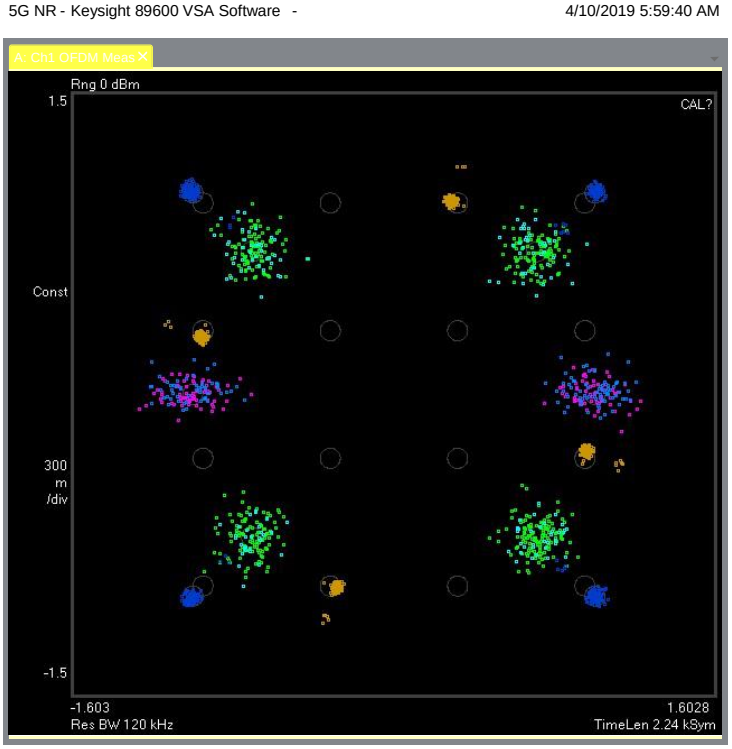
The measurements were performed at a distance of 4 m from the unit utilizing the test configuration in Figure 4.4.1 utilizing a 44 GHz MXA Signal analyzer. Representative screen plots of the modulation measurement are attached below for the various subcarrier configurations and Various Polarizations.

4.2.2 Modulation Measurements Results:

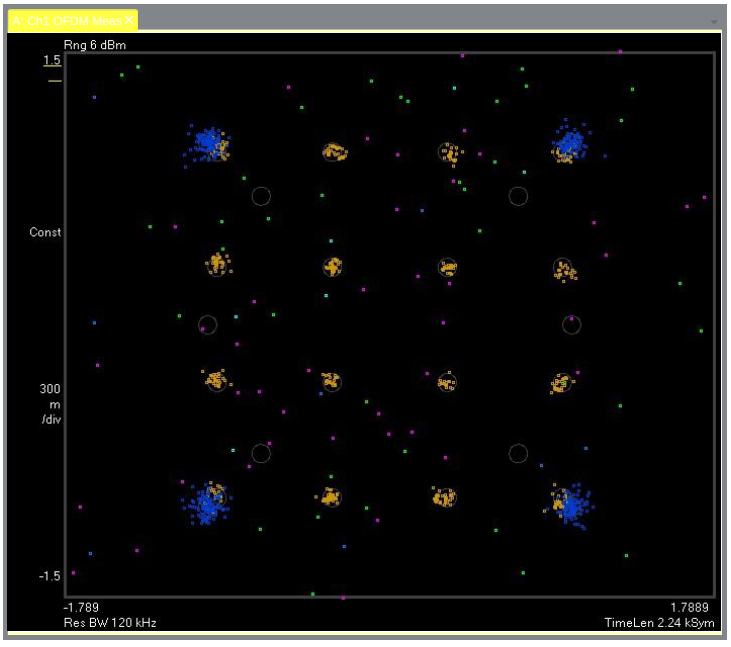
The typical measured modulation characteristics of the EUT are shown below:

Figure 4.2 Modulation Results

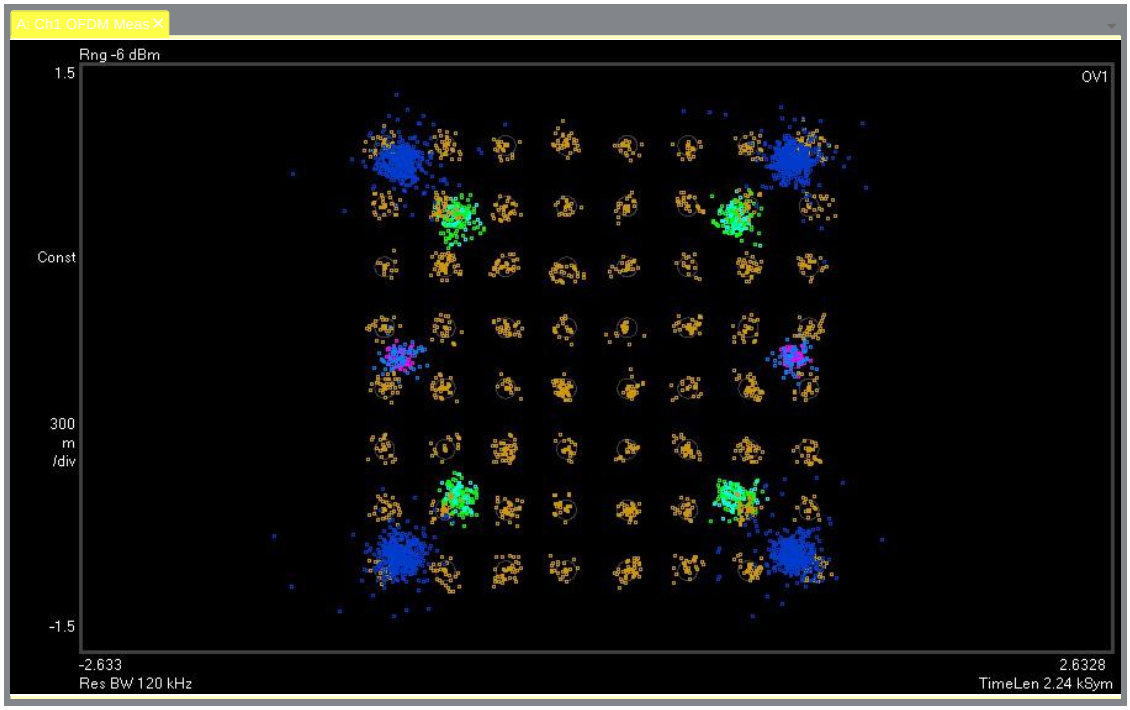
Sample QPSK 27.64980 GHz Vertical Polarization



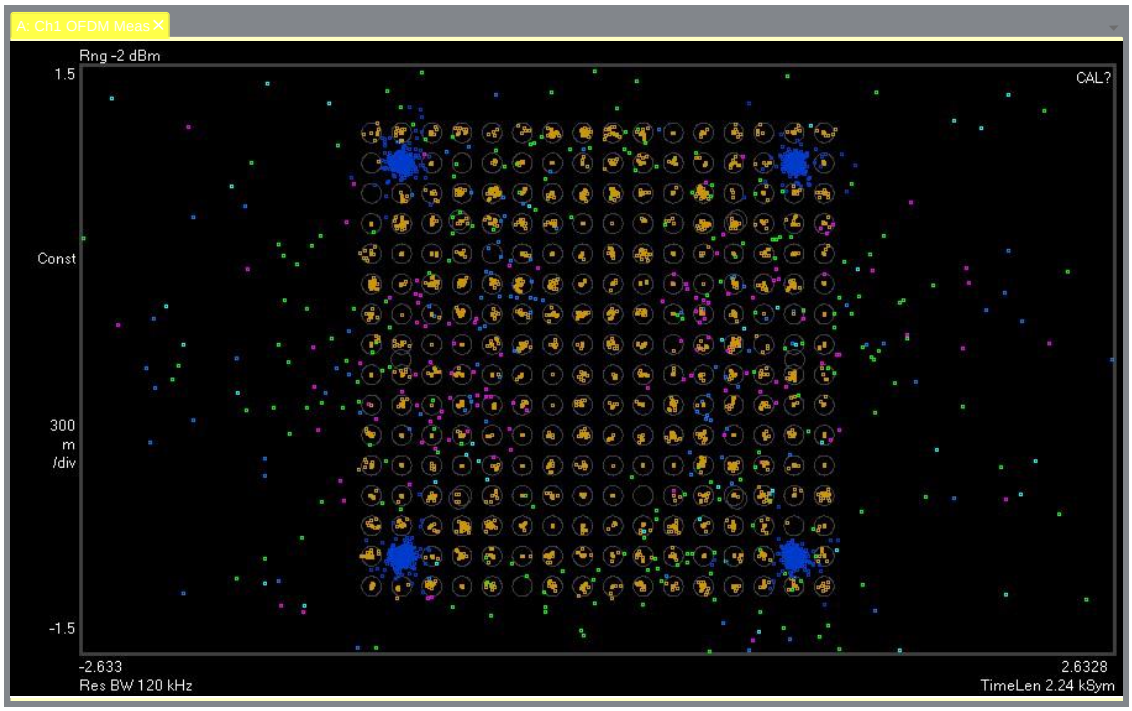
Sample 16QAM 2.099925 GHz Vertical Polarization



Sample 64QAM 27.750 GHz Vertical Polarization



Sample 256QAM 28.29996 GHz Horizontal Polarization



4.3 Section 2.1049 MEASUREMENT REQUIRED: OCCUPIED BANDWIDTH and EDGE of BAND EMISSIONS

This test measures the Occupied Bandwidth of the transmitting carrier and the Edge of-Block Emissions in the frequency spectrum immediately outside and adjacent to the transmitting carrier(s).

The occupied bandwidth (OBW) is usually defined either as the 99% power OBW or a relative OBW. The 99% OBW is the signal bandwidth such that, below its lower and above its upper frequency limits, the mean power radiated or conducted are each equal to 0.5 percent of the total mean power radiated or conducted by a given emission. The relative -26 dB OBW is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated by at least 26 dB below the transmitter power.

Per KDB 971168 D01 v02, the relative OBW must be measured and reported when it is specified in the applicable rule part; otherwise, the 99% OBW shall be measured and reported. The OBW shall be measured when modulated by an input signal such that its amplitude and symbol rate represent the maximum rated conditions under which the equipment is operated.

The ANSI C63.26 Section 5.4.3 Occupied bandwidth-Relative measurement procedure was followed using the functionality of the FSW spectrum Analyzer. Measurements were performed to assess the OBW Signal Bandwidth when measured with as stated the *"nominal RBW shall be in the range of 1% to 5% of the anticipated OBW"*. That given the OBW-Signal bandwidths were measured with RBW's of 1 MHz, 3 MHz and 5 MHz. This was performed for both the Horizontally and Vertically polarized beams and for every nominal 100 MHz carrier.

4.3.1 Results Occupied Bandwidth (Signal Bandwidth)

The measured 99% occupied bandwidth was measured with a Rohde & Schwarz ESU 40 GHz spectrum signal analyzer for the 97M5G7W emission designator. The results are presented below and shows that the measured signals are within the parameters of the 97M5G7W of the emissions designator.

4.3.1.1 Carrier Aggregation

The April 12, 2016 TCBC viewgraph package identified that Carrier Aggregation data need be supplied. This requirement is not yet formalized in a KDB for LTE, 5G-NR or UMFUS. The 4 carrier bandwidth of the AEUA is defined as follows. The individual carriers, 97.5 MHz maximum, are spaced 100.08 MHz apart and do not overlap. The overall signal bandwidth for 4 adjacent carriers is depicted in Figure 4.3.1.1. This documents the assessment that the 4 carrier aggregated bandwidth is 397.74 MHz.

Figure 4.3.1.1 Channel Aggregation.

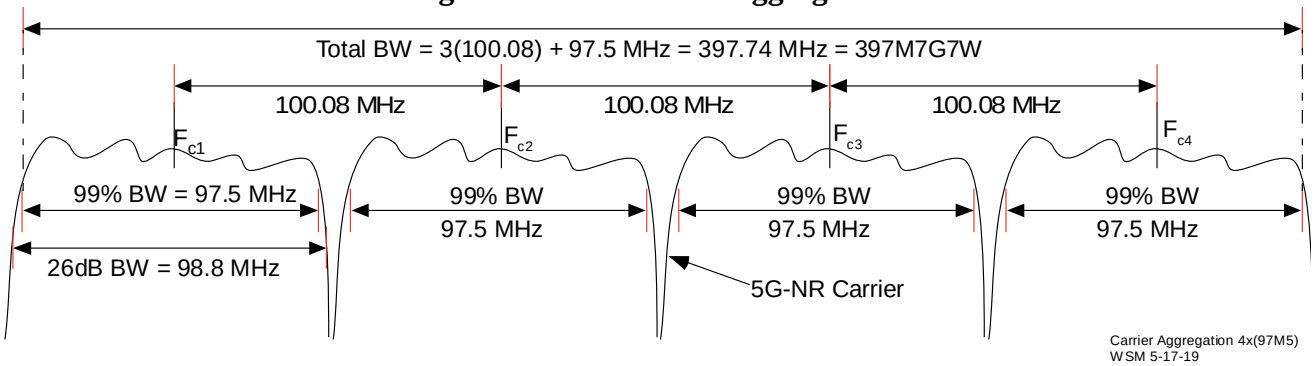
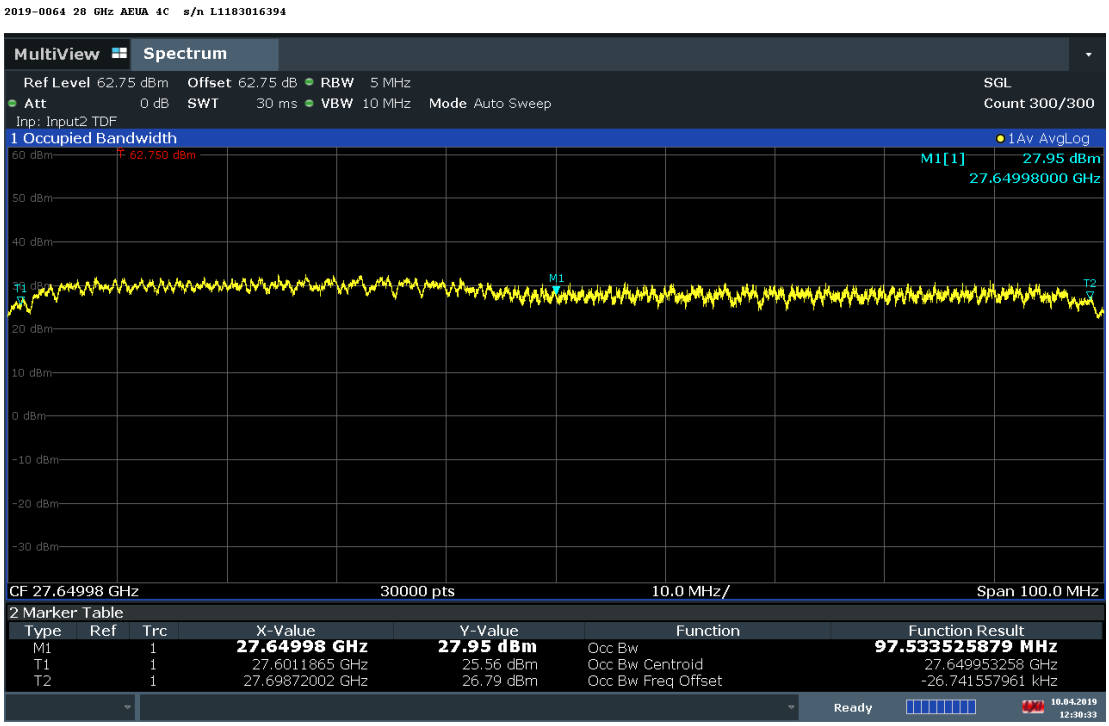
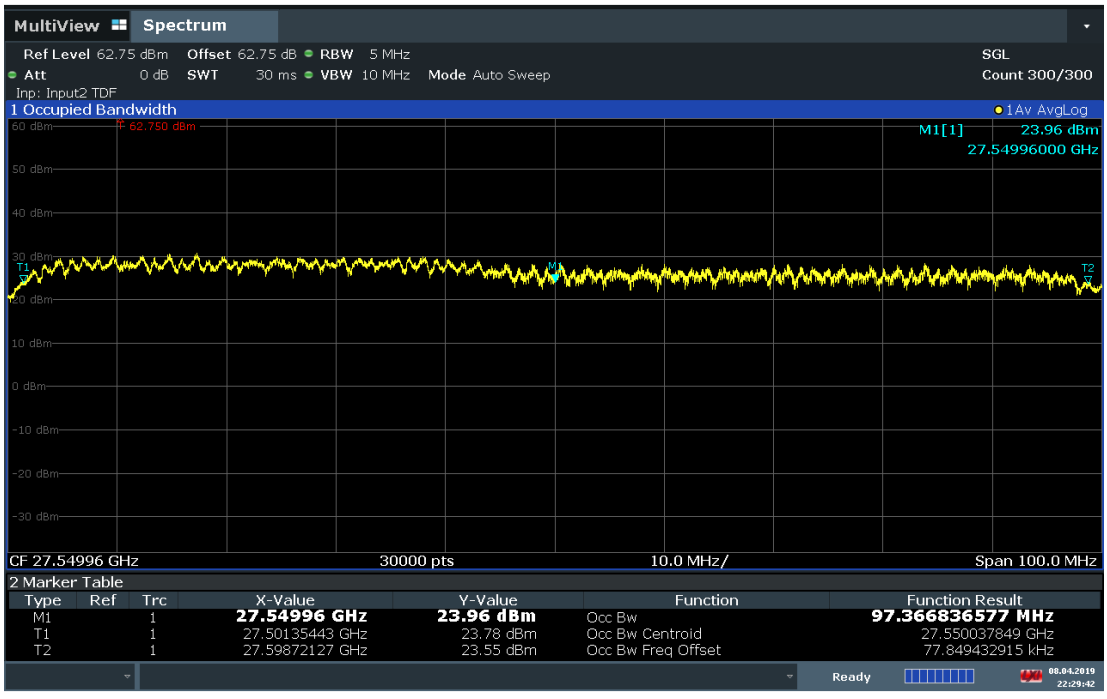


Figure 4.3.1- Occupied Bandwidth - Typical Signal Bandwidth

99% Signal Bandwidth 100 MHz Horizontal - 27.64998 GHz QPSK

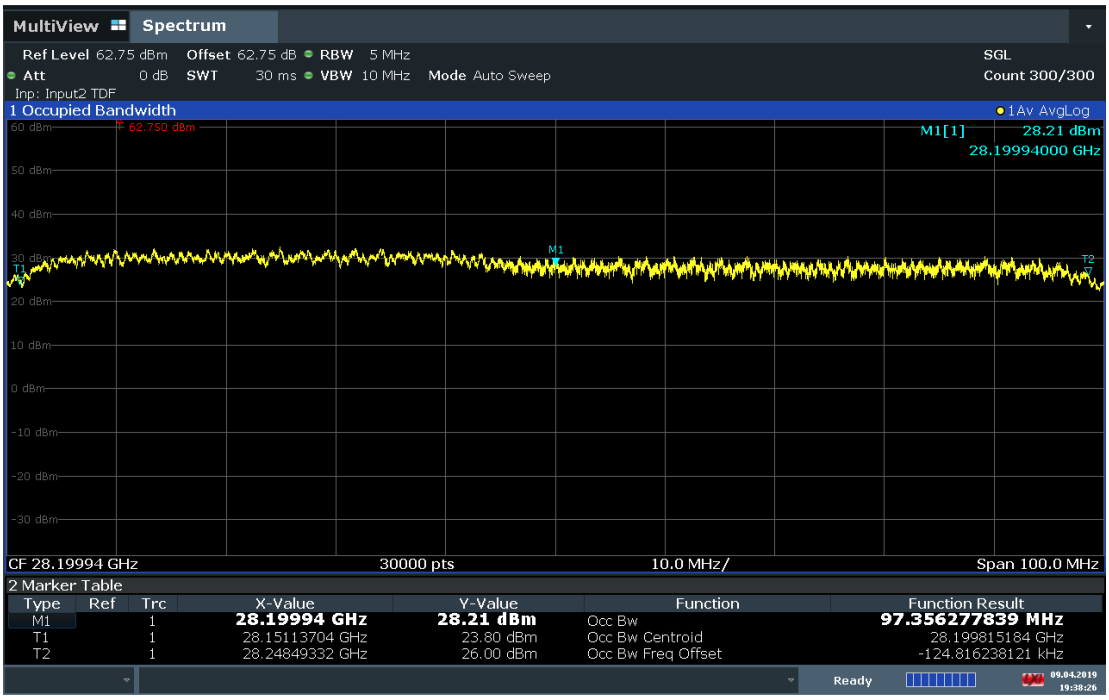


99% Signal Bandwidth 100 MHz Vertical - 27.54996 GHz - 64QAM



99% Signal Bandwidth 100 MHz Horizontal - 28.19994 GHz 256QAM

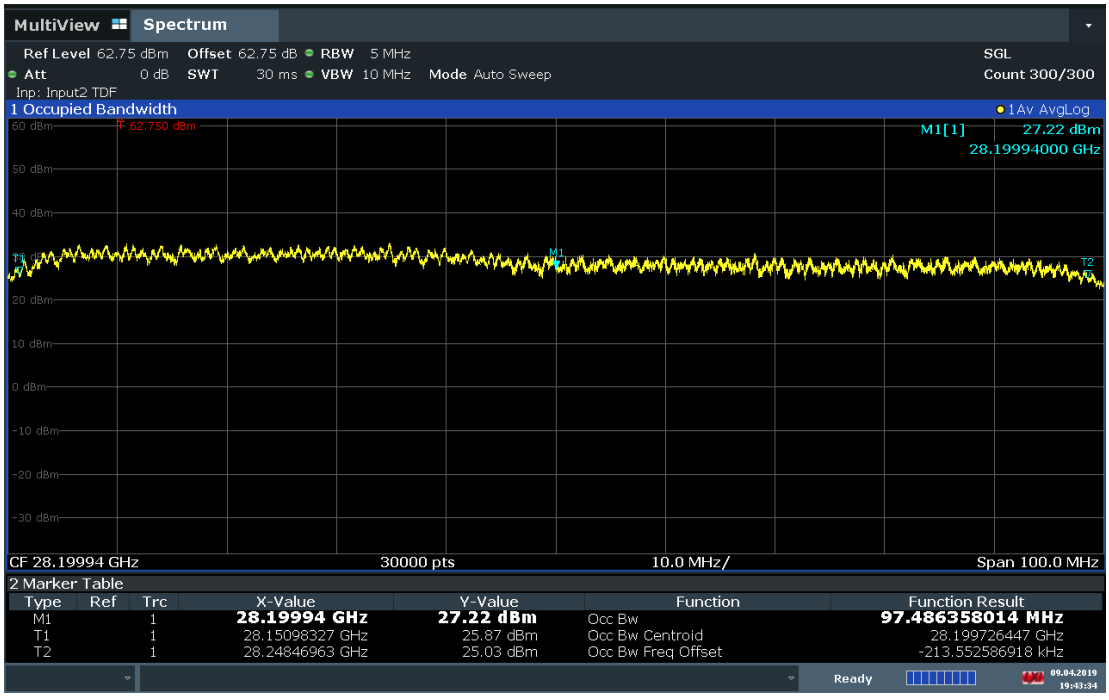
2019-0064 28 GHz AEUA 4C s/n L1183016394



19:38:26 09.04.2019

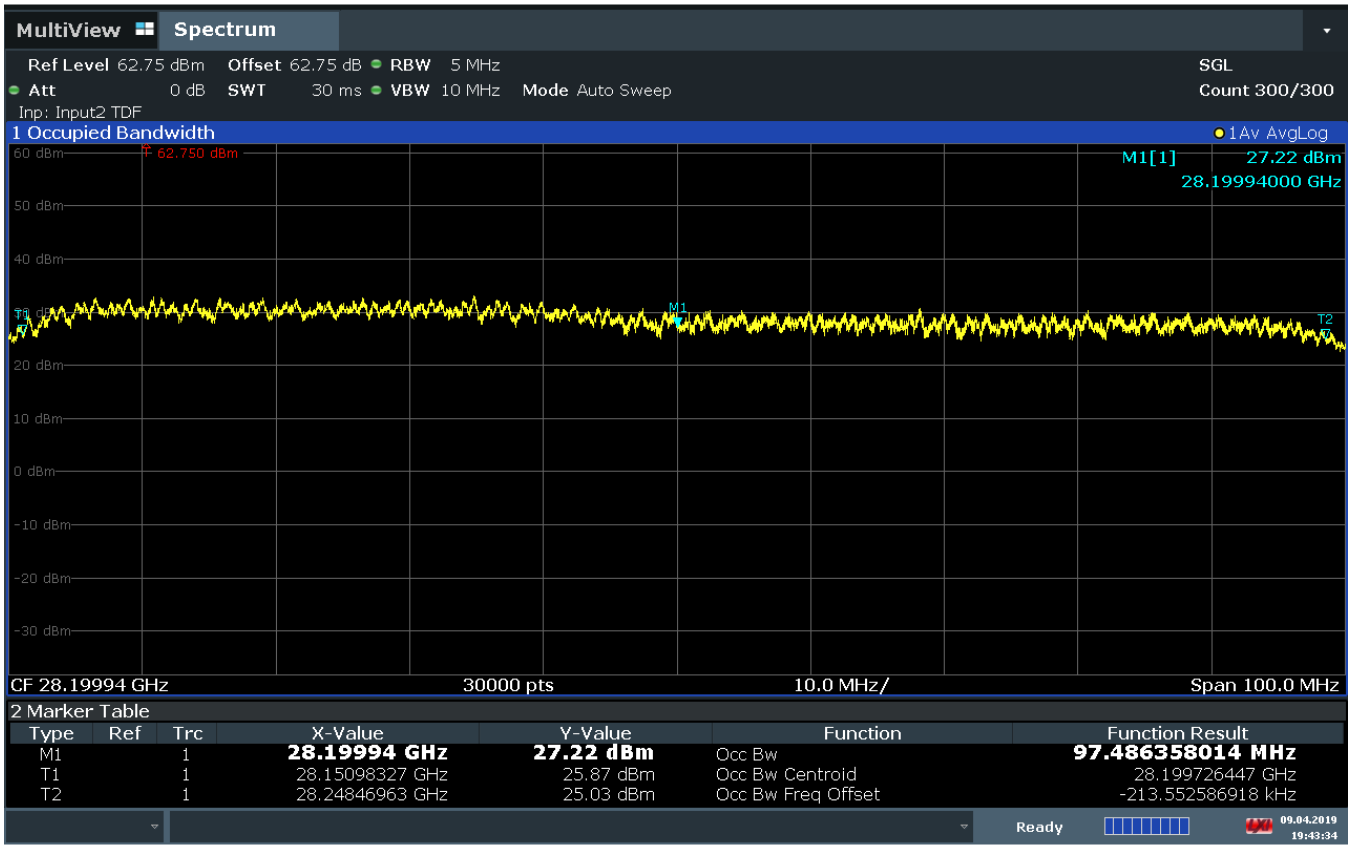
99% Signal Bandwidth 100 MHz Vertical - 28.19994 GHz 256QAM

2019-0064 28 GHz AEUA 4C s/n L1183016394



19:43:34 09.04.2019

2019-0064 28 GHz AEUA 4C s/n L1183016394



19:43:34 09.04.2019

4.3.2 Occupied Bandwidth-Edge of Band Emissions

Classical Occupied Bandwidth – Edge of Block Emissions is an evaluation of the transmit carrier compliance with edge of band requirements and characterizes Out Of Band Emissions (OOBE). This measurement documents the product's ability to maintain compliance with FCC Parts 2 and Part 30.203 limitations on emissions outside the band of operation. Since there are presently no internal blocks measurements are required at the Left side and Right side of band.

The **VBNAEUA-01** 28 GHz Radio Unit presently supports single 5G-New Radio LTE TDD technologies. This evaluation addresses 2x2 MIMO operation with 100 MHz carriers. In each test configuration the carriers were configured at the left side and right side of the Part 30 band as appropriate. All power measurements were performed prior to other measurements. Power was set to the total per polarization maximum. The measurements are described below.

The occupied bandwidth of each of the signals identified in Table 4.3.6.1 was measured using a Rohde & Schwarz FSW Spectrum analyzer, a remote PC based instrumentation controller and the same calibrated RF attenuation path used for channel power. The measurement process meets the requirements of ANSI C63.26 and ISO17025. The test setup was as shown in Figure 4.1.1. Measurements were performed at 4.0 m for both vertical and horizontal polarizations.

Plots are provided using the triggered functionality of the test analyzer and demonstrate compliance with edge of band limits. These sheets contain data for single carrier configurations for "Left Edge of Block", and "Right Edge of Block" across the Part 30 Upper Microwave Flexible Use Service spectrum.

4.3.3 Requirements 28 GHz Emissions Limits

The Limit in 47 CFR 30.203 for Emissions Limits is as follows:

(a) The conductive power or the total radiated power of any emission outside a licensee's frequency block shall be −13 dBm/MHz or lower. However, in the bands immediately outside and adjacent to the licensee's frequency block, having a bandwidth equal to 10 percent of the channel bandwidth, the conductive power or the total radiated power of any emission shall be −5 dBm/MHz or lower.

(b)(1) Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 1 megahertz or greater.

(2) When measuring the emission limits, the nominal carrier frequency shall be adjusted as close to the licensee's frequency block edges as the design permits.

(3) The measurements of emission power can be expressed in peak or average values.

In order to address the limit as imposed for the requirement in 47CFR 30.203 we evaluated emissions per the requirements in ANSI C63.26 and per KDB 940660 D01 Part 30 CBRS Equipment.
The average detector function was used for all MXA measurements and the Peak detector function were used for EMC receiver measurements.

4.3.4 Measurement Offset and MIMO

As this was a radiated EIRP measurement no MIMO adjustment was used.

For the 5G-NR LTE system there is no carrier without modulation. Since the 5G-NR LTE signal is broadband and is 100 MHz wide, all of the measurements performed at the specified 1 MHz resolution bandwidths. The following relationship was used to provide the correct level different resolution bandwidths..

10*log (Resolution Bandwidth/ Transmit Bandwidth) = Signal Offset (1)

4.3.5 Mask Parameters

The mask parameters are in units as stated in Part 30 and are listed in Table 4.3.5

Table 4.3.5 - Mask Parameters Out Of Band / Edge of Band Emissions

Frequency	Part 30 Limit
GHz	dBm
26.50	-13
27.49	-13
27.49	-5
27.50	-5
27.50	57
28.35	57
28.35	-5
28.36	-5
28.36	-13
29.00	-13
40.00	-13

4.3.6 Measurement Path Corrections

The measured power at the spectrum analyzer input was corrected for calculated free space loss, cable loss measurement antenna gain and the product antenna gain over its applicable frequency range as documented in Exhibit 6 of the filing and the table below. This is the same procedure as was previously used in other filings filed under Part 30. This is appropriate for Out Of Band Emissions / Edge of Band emissions only for the frequency range that the transmit antenna has documentable and consistent gain. Since different products have different gain responses vs frequency, the documentable antenna gain of the product applies only for the operational frequency range of the products antenna gain.
This adjustment was not used outside the OOBE/EoB frequency range. Table 4.3.6 below lists the offset correction factors used for the measurement distance of 4m including the AEUA product gain.

Frequency	Free Space Path Loss, PL	Measurement Antenna Gain, G1	Measurement Cable Loss, L1	PL-G1+L1	AEUA Antenna Gain	Total
GHz	dB	dBi	dB	dB	dBi- IEEE	dB
26.50	72.78	23.25	12.57	62.10	28.60	33.50
27.00	72.95	23.40	12.61	62.15	28.70	33.45
27.50	73.11	23.45	12.64	62.30	28.80	33.50
27.55	73.27	23.60	12.77	62.44	28.88	33.56
27.85	73.29	23.60	12.79	62.47	28.89	33.58
28.00	73.38	23.60	12.86	62.64	28.93	33.71
28.25	73.43	23.70	12.90	62.63	28.95	33.68
28.35	73.50	23.78	12.96	62.68	28.97	33.71
28.50	73.53	23.80	12.99	62.72	28.98	33.74
29.00	73.58	23.85	13.03	62.76	29.00	33.76
29.50	73.73	23.95	13.15	62.93	29.05	33.88
30.00	73.88	24.05	13.26	63.09	29.08	34.01
30.50	74.03	24.10	13.36	63.29	29.10	34.19

Sample calculation:

Offset Value = Free Space Path Loss – Measurement Antenna Gain + Cable Loss – Product Gain.

The following sample calculation is the correction for 30 GHz;

Offset Value = 34.01 dB = 73.88 dB -24.05 dBi + 13.26 dB - 29.08 dBi

The measurements were made using a flat offset of 33.9 dB with a transducer factor table used for the delta values of +/- 0.398 dB.

4.3.7 Edge of Band Measurements

The measurements were performed with an FSW spectrum analyzer in compliance with the procedure and requirements of ANSI C63.26. The test set-up diagram in Figure 4.1.1 was used. Testing was performed for the 100 MHz carrier configurations at the left side, and right side of the Part 30 Band.
Mask parameters were as stated in Table 4.3.5. Mask Edge Offsets = ½ the Resolution Bandwidth of the measurement were not used as there was sufficient margin to pass the limit without this accommodation.

4.3.7.1 Results - Occupied Bandwidth-Edge of Block Emissions

The occupied bandwidth plots for operation at the left side, center and the right side of the band for the 100 MHz signal bandwidth are below. The mask accurately depicts the limits for the Part 30 NAR Band to determine compliance with FCC requirements. The mask limits include the appropriate considerations for operation.

From the out-of-band emissions plots attached below, it can be seen that all the emissions are under the required emission masks.

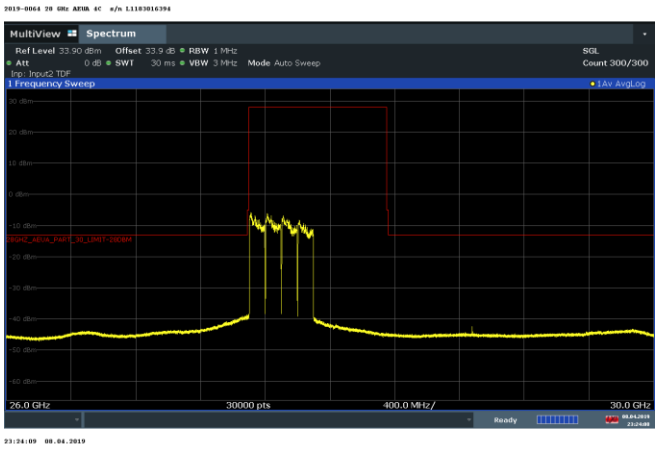
The measurement results of the occupied bandwidth and the out-of-band emissions as documented in the plots and Table 4.3.6.1 demonstrate the full compliance with the Rules of the Commission for the operating band.

4.3.7.2 Occupied Bandwidth - OOBE/EoB Band Charts

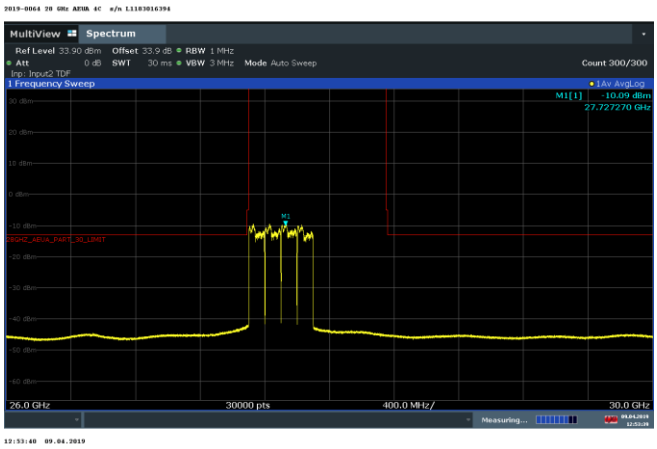
The following Out of Band Emissions / Edge-of-Band emissions measurements were made as a radiated measurement at a distance of 4m

4.3.7.2.1 4 Carrier - Left Side of Band OOBE/EoB Band Charts

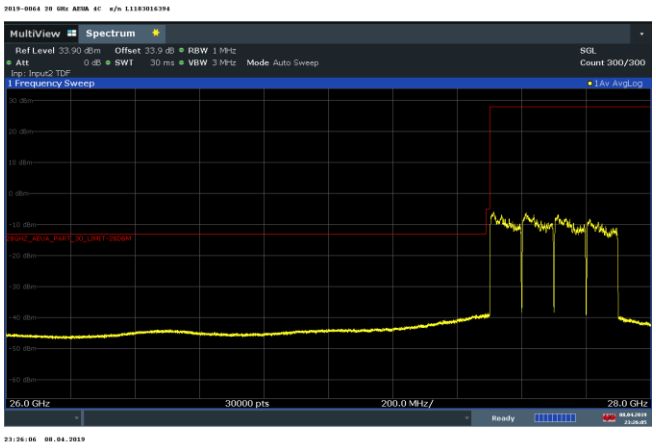
OOBE/EoB - V - 4c Left Side of Band QPSK



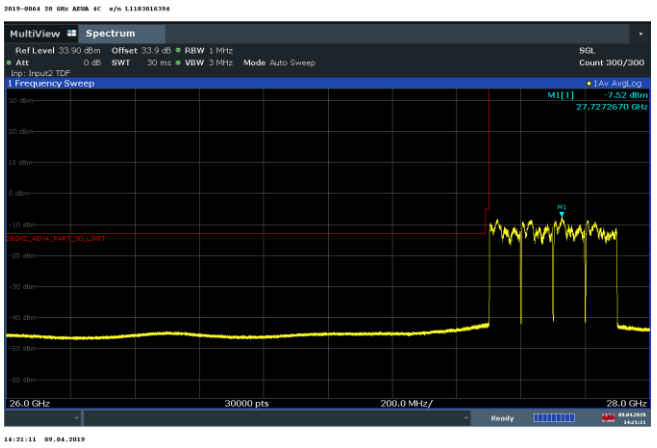
OOBE/EoB - H - 4c Left Side of Band QPSK



OOBE/EoB - V - 4c Left Side of Band QPSK

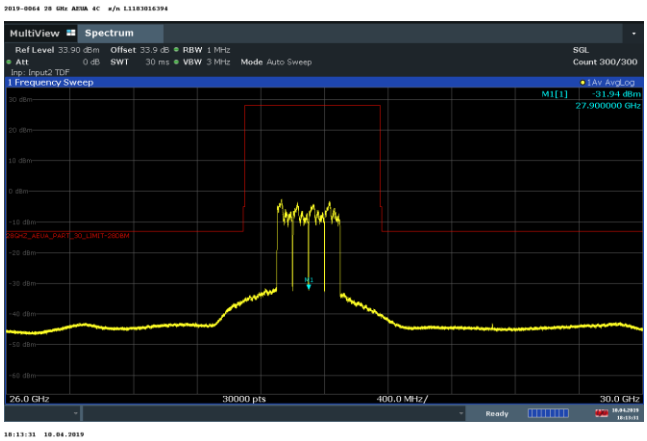


OOBE/EoB - H - 4c Left Side of Band QPSK

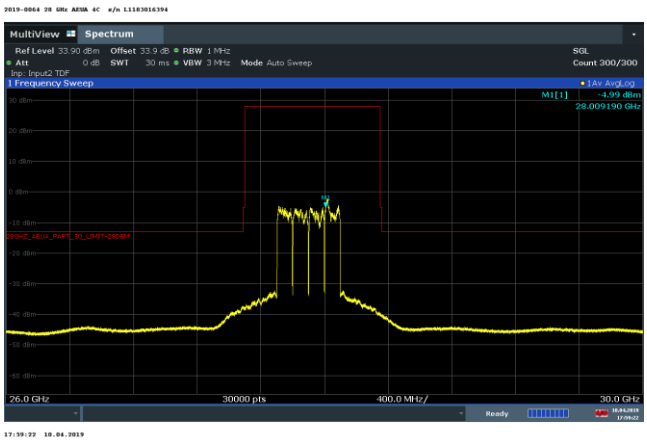


4.3.7.2.2 4 Carrier - Middle of Band OOBE/EoB Band Charts

OOBE - V - 4c Middle of Band 64QAM

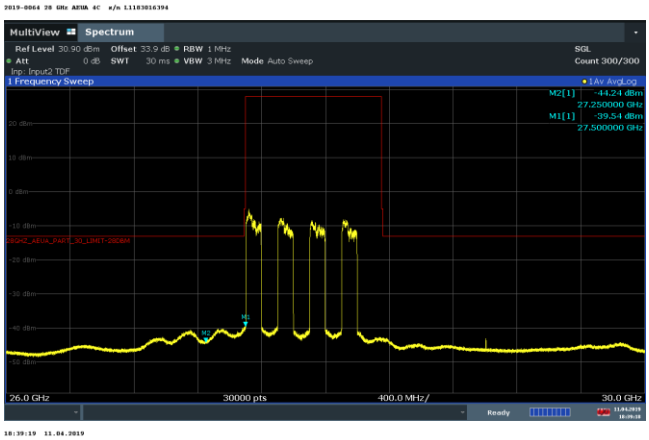


OOBE / - H - 4c Middle of Band 64QAM



4.3.7.2.3 4 Spread Carriers - OOBE/EoB Band Charts

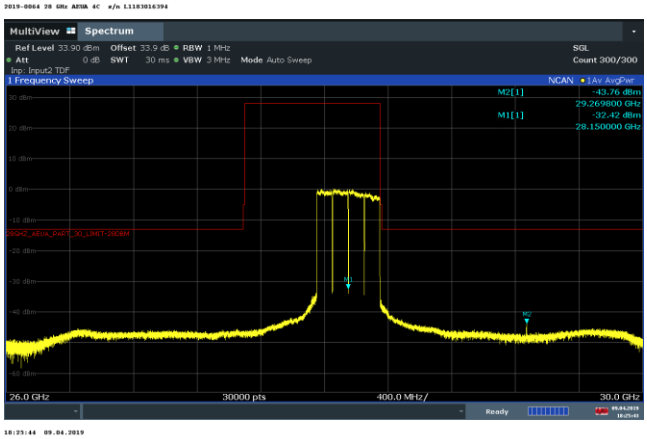
OOBE/EoB - V - 4c Spread Carriers - QPSK+16QAM



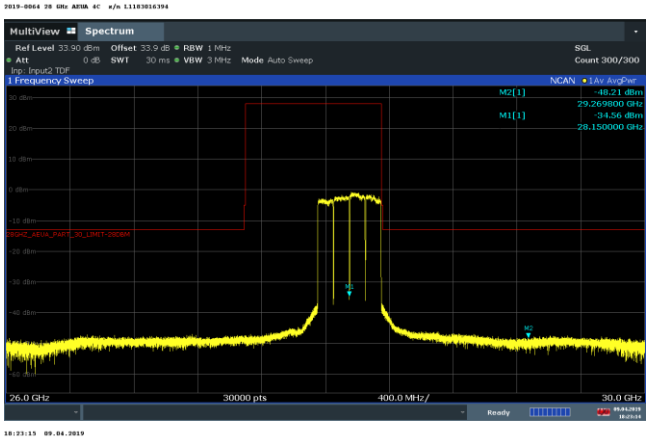
OOBE/EoB - H - 4c Spread Carriers - QPSK+16QAM

4.3.7.2.4 4 Carrier - Right Side of Band OOBE/EoB Band Charts

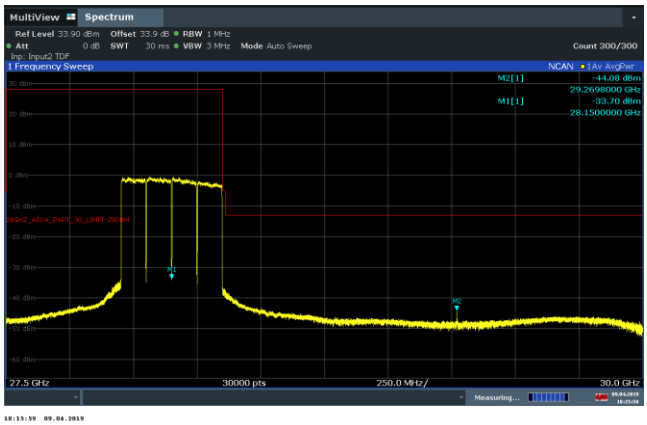
OOBE/EoB - V - 4c Right Side of Band 256QAM



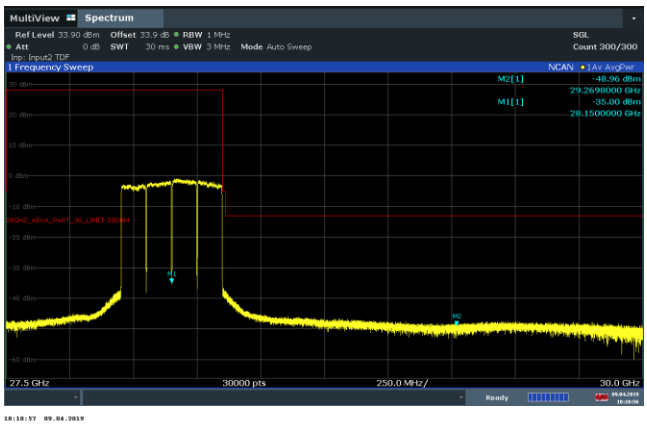
OOBE/EoB - H - 4c Right Side of Band 256QAM



OOBE/EoB - V - 4c Right Side of Band 256QAM

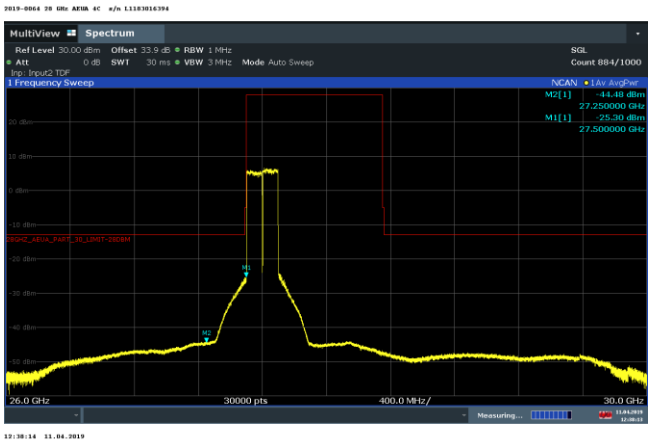


OOBE/EoB - H - 4c Right Side of Band 256QAM

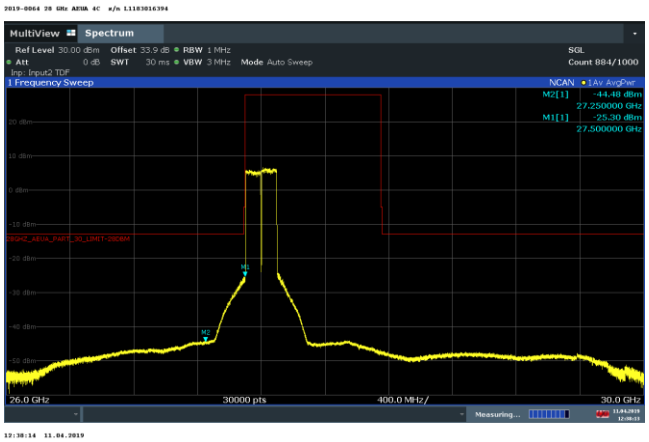


4.3.7.2.5 2 Carrier – Left Side of Band OOBE/EoB Band Charts

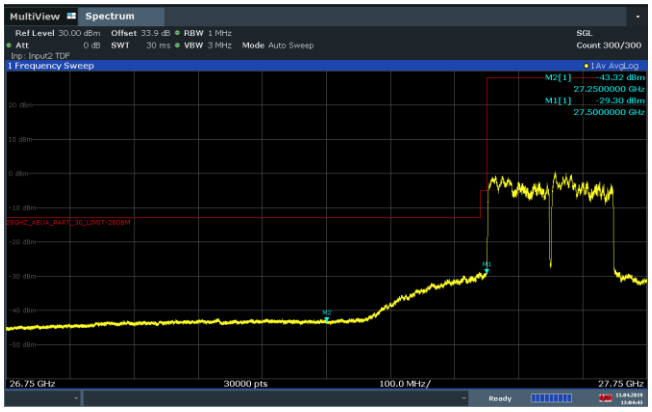
OOBE/EoB - V - 2c Left Side of Band 64QAM



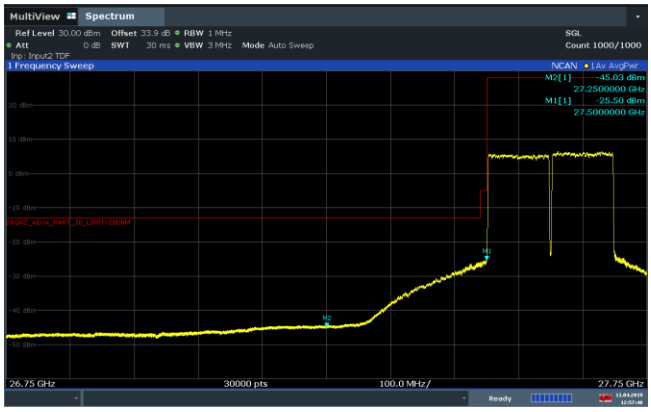
OOBE/EoB - H - 2c Left Side of Band 64QAM



OOBE/EoB - V - 2c Left Side of Band 64QAM

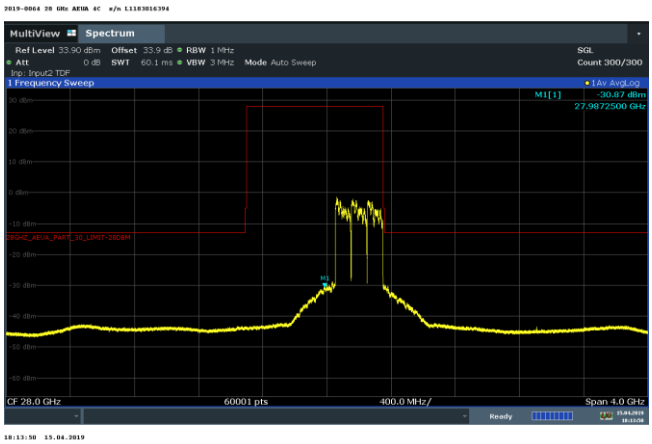


OOBE/EoB - H - 2c Left Side of Band 64QAM



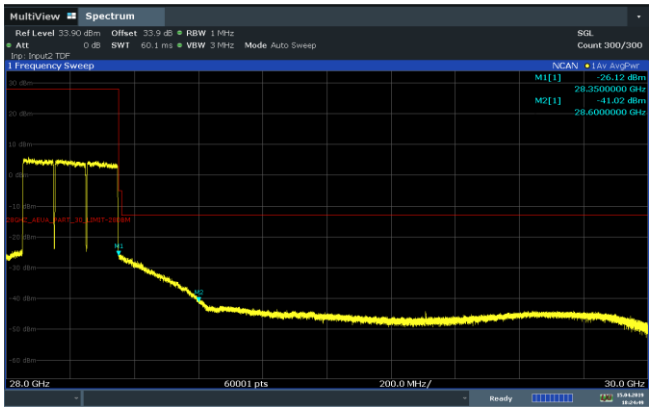
4.3.7.2.6 3 Carrier – Right Side of Band OOBE/EoB Band Charts

OOBE/EoB - V - 3c Right Side of Band QPSK+16QAM

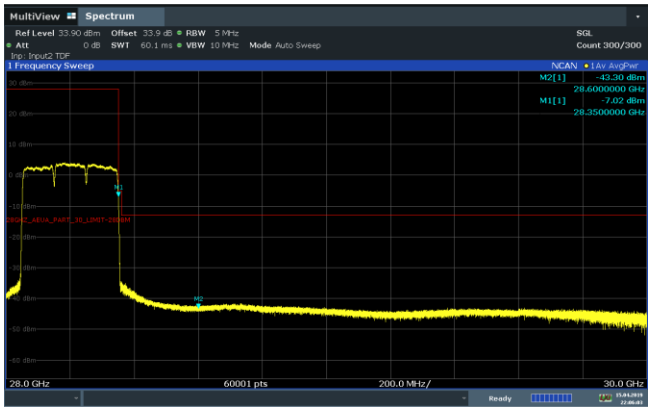


OOBE/EoB - H - 3c Right Side of Band QPSK+16QAM

OOBE/EoB - V - 3c Right Side of Band QPSK+16QAM



OOBE/EoB - H - 3c Right Side of Band QPSK+16QAM



4.4 Section 2.1051 MEASUREMENT REQUIRED: SPURIOUS EMISSIONS AT THE ANTENNA TERMINALS

This test measures the emissions of spurious signals which may come from harmonic, parasitic, intermodulation and frequency conversion products and are outside the necessary bandwidth but excludes Edge-of-Band emissions.

4.4.1 Section 2.1051 Spurious Emissions at Antenna Terminals

Spurious Emissions were investigated per 47CFR Section 2.1057(a)(1) over the frequency range of 30 MHz to 100 GHz as specified in 2.1057(a)(2).

2.1057(a)(2) If the equipment operates at or above 10 GHz and below 30 GHz: to the fifth harmonic of the highest fundamental frequency or to 100 GHz, whichever is lower.

Since there is no antenna terminal, all measurements were performed as radiated measurements and standard radiated emissions. These latter are documented in Section 4.5 "*Section 2.1053 Measurement Required: Field Strength of Spurious Radiation*". The test configuration is shown in Figure 4.4.1 documents the test set up used for the measurements.

The measurements were performed in compliance with ANSI C63.26, C63.26 mmWave JTG and our ISO17025 process. The measurement meets the ANSI C63.26 requirements in paragraphs 5.2.4.4.1 and 5.7 which requires that the number of points in the sweep be > 2 × Span/RBW. The ESU spectrum analyzer measurements examine the 30 MHz to 40 GHz range. The FSW based mmWave transmitter "Radio measurements" test system overlaps the transmit band for 27-29 GHz and extends the frequency range to examine the 40 GHz to 100 GHz range.

4.4.2 Required Limit

The required emission limitation specified in **47CFR 30.203 (a)** was applied to these tests. Based upon the criterion given in Section 30 of the Code and as developed in 4.3.3, the required emission limit for emissions outside a licensee's frequency block is:

47CFR 30.203 (a) (a) The conductive power or the total radiated power of any emission outside a licensee's frequency block shall be -13 dBm/MHz or lower. However, in the bands immediately outside and adjacent to the licensee's frequency block, having a bandwidth equal to 10 percent of the channel bandwidth, the conductive power or the total radiated power of any emission shall be -5 dBm/MHz or lower.

Therefore the limit for emissions >1 MHz outside a licensees frequency block when measured with a RBW of 1 MHz is:

-40 dBm - 3.01 dB = -43.01 dBm for 2x MIMO

4.5 Section 2.1053 MEASUREMENT REQUIRED: FIELD STRENGTH OF SPURIOUS RADIATION

The field strength measurements of radiated spurious emissions were made in a FCC registered ten meter semi-anechoic chamber AR-8, (FCC Registration Number: 395774) **NVLAP** Lab Code: 100275-0 and IC (Filing Number: 6933F-8) which is maintained by Nokia Bell Labs in Murray Hill, New Jersey. The **VBNAEUA-01** (EUT) was configured in semi-anechoic chamber AR-8 in a manner simulating a normal field installation. The product's field installation hardware was used to mount the product to a wooden pole with the bottom of the product 1.5m above the turntable ground plane. The recommendations of ANSI C63.4–2014, C63.26-2015 and C63.26 mmWave JTG were followed for EUT testing setup and cabling. The EUT was configured to operate in a 5G-NR test model per the constraints identified in section 4.2. A photograph of this setup is in Exhibit 12 of the filing package.

The base station was configured into the full power 4 carrier forward beam transmit configuration to transmit two 57dBm EIRP 100 MHz bandwidth 5G-NR multi-carriers, one Vertical and one Horizontal polarization, with the total transmit power of 60 dBm EIRP. This configuration provides the highest Power Spectral Density transmit signal for the product. The product in the below configurations was evaluated over the 30 MHz to 100 GHz frequency range as required.

Table 4.5.1 EUT Configurations

Allowable Test Configuration NRARFCN	AEUA Tx Reference Frequencies GHz	Transmit Active Polarization	Signal Bandwidth, MHz	Modulation	Total Power, dBm EIRP	Radiated Emissions Pass / Fail
2071665 To 2084165	27.54996, To 28.29996	H & V	100	QPSK & 64QAM	60	Pass

4.5.1 Spurious Radiation and Radiated Emissions Requirements Below 40 GHz.

This product meets Part 15B, and Part 30.203 requirements. . FCC Part 15 Class B require emissions to be below 54.5 dBuV/m at 3m. Part 30.203 requires emissions to be below the value generated by a conducted emission of -13 dBm. This is a standard value for wireless products typically defined as

$$-43+10\text{Log}P=-13 \text{ dBm.}$$

The emissions at the Edge of Band were adjusted by the 29 dBi gain of the transmit antenna as the product is designed to operate globally over the 26.5 to 29.5 GHz frequency band. Emissions removed from the transmit band were evaluated identically to other wireless products.

Measurements were performed in compliance with Section 2.1053, FCC publication 442401 and clause 5.5 of ANSI C63.26. For this case the evaluation of acceptable radiated field strength is as follows.

The calculated emission levels were found by:

$$\text{Pmeas (dBm)} + \text{Cable Loss(dB)} + \text{Antenna Factor(dB)} + 107\ (\text{dB}\mu\text{V/dBm}) - \text{Amplifier Gain (dB)} = \text{Field Strength (dB}\mu\text{V/m)}$$

Title 47CFR section 30.203 and 2.1053 contains the requirements for the levels of spurious radiation as a function of the EIRP of the modulated carrier with 100 MHz of bandwidth. The reference level for the

modulated carrier is calculated as the field produced by an isotropic radiator excited by the transmitter output power according to the following relation taken from Reference Data for Radio Engineers, page 27-7, 6th edition, IT&T Corp.

$$\mathbf{E = (120\pi P)^{1/2} = [(30*P)^{1/2}] / R}$$

$$\mathbf{20 \log (E*10^6) - (43 + 10 \log P) = 82.23\ dB\ \mu V/meter}$$

Where: E = Field Intensity in Volts/ meter R = Distance in meters = 3 m
P = Transmitted Power, Watts = 1000 W

The field strength of radiated spurious emissions measured was determined by

$$E\ (\mathrm{dB}\mu\mathrm{V/m}) = V_{\mathrm{meas}}\ (\mathrm{dB}\mu\mathrm{V}) + \text{Cable Loss (dB)} + \text{Antenna Factor (dBi/m)}.$$

Field strength measurements of radiated spurious emissions were made in the 10m semi-anechoic chamber, AR-8 as detailed above. The recommendations of ANSI C63.4 and ANSI C63.26 were followed for EUT testing setup, cabling, and measurement approach and procedures. All the measurement equipment used, including antennas, was calibrated in accordance with ISO 9001 process. The EUT setup diagram is given in the Figure 4.5. The minimum margins to the Part 30.203 limit is as measured in accordance with 2.1053. The test data follows.

4.5.2 Radiated Spurious Emissions Measurements: 40 GHz - 100 GHz:

The radiated spurious emissions spectrum was investigated per 47CFR Section 2.1057(a)(1) for spurious emissions over the frequency range of 40 GHz to 100 GHz. The procedure and methodology followed the recommendations of ANSI C63.4–2014, C63.26-2015 and C63.26 mmWave JTG.

A Rohde & Schwarz FSW 67 with updated firmware was employed with external three port harmonic down converters and 23 dB Standard Gain Horns. Operation of the harmonic down converters utilizes a swept LO with a fixed IF frequency of 1.325 GHz. The IF cable loss for the 6m of cable was 2.06 dB and was corrected internally to the FSW along with the Conversion loss for the harmonic down converters.

Cable loss compensation for the LO cable loss was necessary to enable scan heights from 1-3 meters. The experience of this test indicated that a 3m maximum test height with this product is adequate (0.5 m above the top of product). This will allow for a reduction of the test cables length, will reduce the amount of LO amplification required and reduce IF images which occurred at multiples of the 1.325 GHz IF frequency.

The harmonic down converters provided coverage for 40-60 GHz (U), 60-90 GHz (E) and 90-140 GHz (F) bands. Operation was verified prior to testing by bore-sighting a mmWave signal generator or mmWave source module with an antenna identical to the measurement antenna at the test distance. The location of the maximum beams had previously been ascertained for both vertical and horizontal polarizations. The beam is extremely narrow and radiated power is down 18 dB at just $\pm$ 5 degrees off center. All of the emissions and harmonics were found to be centered on the beam as well.

Two methods were then employed for full coverage scanning of the product. Method one was a parametric scan at different angles and heights. Method two utilized a continuous max hold (average detector) sweep of the product in elevation and azimuth. For this measurement the scan was started at the beam peak location of 356 degrees azimuth, and nominal elevations 176 cm for Vertical 155 cm for Horizontal. The elevation was then swept down to 1m and back up back to 3m and returned to the beam peak. The product was then rotated continuously to 360 degrees back to 0 degrees and back to 356 degrees. This second method provided the minimum margin but required operation without the analyzer

internal noise reduction function. Measurements for 40-60 GHz and 60-90 GHz were performed this way. It should be noted that for method two, averaging of the signal was not performed and this method provides a worst case assessment. Method two could not be used for the 90-100 GHz range as Internal noise reduction was required to have the noise floor below the limit. For all of the measurements no emissions were found outside the steerable angle of the beam. There were >177 scans recorded of the emissions and >186 preliminary scans recorded. The plots presented for emissions above 40 GHz are the maximum levels and provide the clearest representation for emissions in these bands. The initial scans produced with an LO amplifier produced spurious and the retest without the LO amplifier eliminated spurious at images of the IF frequency. The retest documented a much cleaner radiated

4.5.2.1 Bandwidth Limits and Corrections: Radiated Measurements 40 GHz - 100 GHz,

All corrections were made to the signal level as detailed below.

4.5.2.2 Resolution Bandwidth and Number of Measurement Points

For measurements above 40 GHz we performed scans with the required 1 MHz resolution bandwidth and a 10 MHz resolution bandwidth. In all cases the resolution bandwidth and span limitations of ANSI C63.26 were followed so that the "Number of Measurement Points" $\geq$ 2(Span/RBW).
The FSW-67 internal firmware was updated from the initial filing and is now capable of 60,001 data points. Multiple spans, scans and heights were used to evaluate the peak spurious emissions detected. The search for out of beam spurious was appropriately performed with a 10 MHz RBW while final assessment was performed with a 1 MHz RBW.
Since the intended transmission is a 100 MHz signal, the use of a 10 MHz RBW is a suitable methodology for the initial search for spurious.

4.5.2.3 Part 30 Limit:

The -13 dBm emissions limit was not adjusted in any way.

4.5.2.4 Emissions Corrections.

The measured signal was corrected by the FSW for the harmonic downconverter (HDC) conversion loss. In addition a correction consisting of the radiated path loss, the gain of the measurement antenna and a 1 dB IF cable loss (at 1.3 GHz) was applied. There was no correction applied for the product antenna gain as these measurements are outside the transmit frequency range.

$$\text{Emissions Correction} = \text{Path Loss} - \text{Antenna Gain} + \text{IF Cable loss (1dB)}$$

$$\text{Where Free Space Path Loss} = ((4\pi d)/\lambda))^2$$

Table 4.5.2.4 details the correction for the three bands.

Table 4.5.2.4a Radiated Emissions Corrections for 40-60 GHz at 4m .

Frequency	λ	Measurement Distance, d	Path Loss	Measurement Antenna Gain	Emissions Correction Total
GHz	m	m	dB	dB	dB
40.0	0.007500	4.0	76.52	21.80	54.72
42.5	0.007059	4.0	77.05	22.20	54.85
45.0	0.006667	4.0	77.55	22.50	55.05
47.5	0.006316	4.0	78.02	22.70	55.32
50.0	0.006000	4.0	78.46	23.00	55.46
52.5	0.005714	4.0	78.89	23.30	55.59
55.0	0.005455	4.0	79.29	23.40	55.89
57.5	0.005217	4.0	79.68	23.60	56.08
60.0	0.005000	4.0	80.05	23.70	56.35

Table 4.5.2.4b Radiated Emissions Corrections for 60-90 GHz at 4m.

Frequency	λ	Measurement Distance, d	Path Loss	Measurement Antenna Gain	Emissions Correction Total
GHz	m	m	dB	dB	dB
60.0	0.005000	4	80.05	21.80	58.246
65.0	0.004615	4	80.74	22.30	58.441
70.0	0.004286	4	81.38	22.70	58.685
75.0	0.004000	4	81.98	23.00	58.984
80.0	0.003750	4	82.54	23.40	59.145
85.0	0.003529	4	83.07	23.60	59.471
90.0	0.003333	4	83.57	23.80	59.768

Table 4.5.2.4c Radiated Emissions Corrections for 90-100GHz at 3m.

Frequency	λ	Measurement Distance, d	Path Loss	Measurement Antenna Gain	Emissions Correction Total
GHz	m	m	dB	dB	dB
90.0	0.003333	3	81.07	21.90	59.169
95.0	0.003158	3	81.54	22.20	59.339
100.0	0.003000	3	81.98	22.60	59.384
105.0	0.002857	3	82.41	23.00	59.408
110.0	0.002727	3	82.81	23.30	60.512
115.0	0.002609	3	83.20	23.63	59.573
120.0	0.002500	3	83.57	23.83	59.743
125.0	0.002400	3	83.92	24.00	59.922
130.0	0.002308	3	84.26	24.20	60.063
135.0	0.002222	3	84.59	24.40	60.191
140.0	0.002143	3	84.91	24.50	60.407

4.5.3 Field Strength of Spurious Radiation Results:

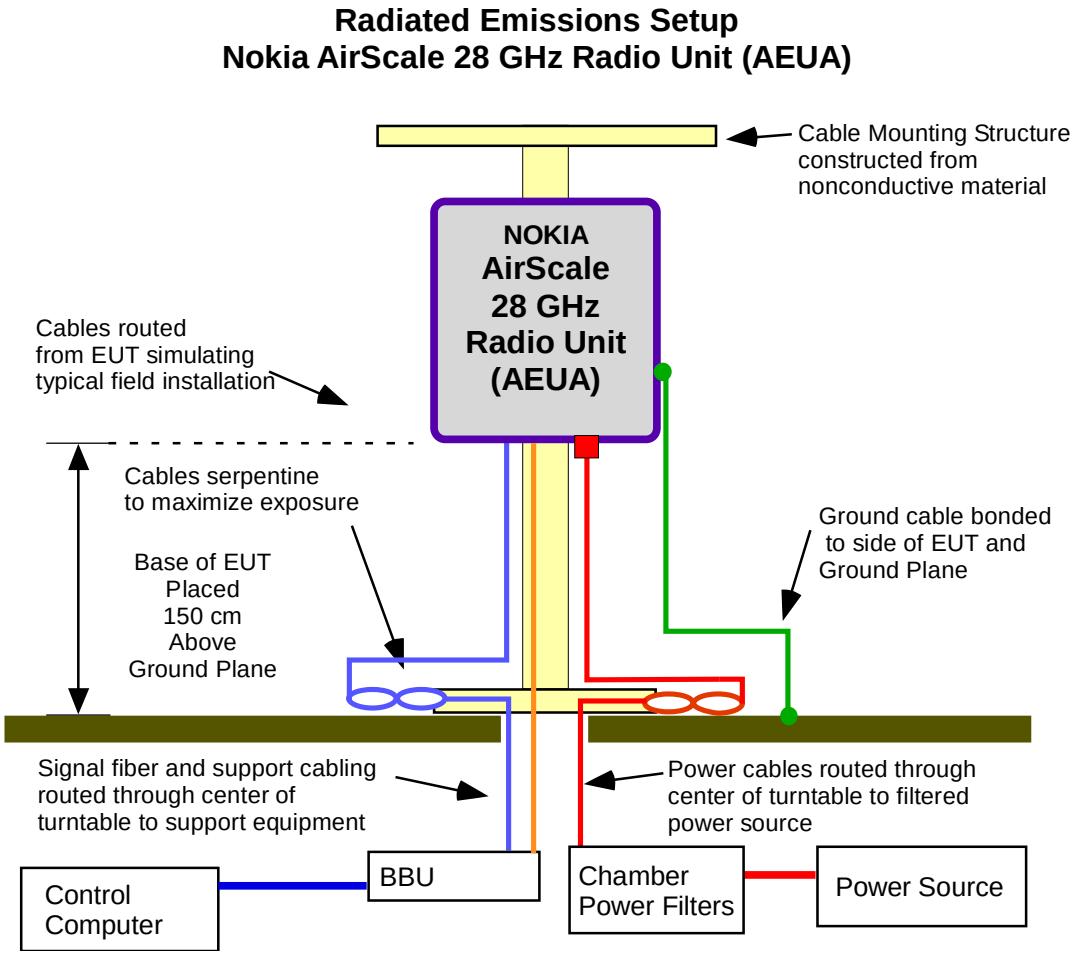
This product meets Part 15B limits below 10 GHz and Part 30 Requirements. For the Title 47CFR section 30.203 and 2.1053 test, the field strength of any spurious radiation, measured at 3m, is required to be less than 82.23 dBμV/meter. Emissions equal to or less than 62.23 dBμV/meter are not reportable.

Presented results show the three mmWave bands as measured with a 10 MHz Resolution Bandwidth and smaller scans at 1 MHz RBW follow. In both sets of measurements the limit is the -13 dBm limit as specified in Part 30.203. Corrections to the emissions levels consisted of only the HDC conversion loss, the Free space Path Loss and measurement antenna gain as detailed in Table 4.5.2.4.

Over the out of band spectrum investigated from 30 MHz to 100 GHz, reportable spurious emissions were detected and determined to be compliant with the Part 30 limit. Additionally, from 30 MHz to 10 GHz all emissions were below 54.5 dBμV/m. This demonstrates that the **AirScale 28 GHz Radio Unit (AEUA) Band 30, FCC ID: VBNAEUA-01**, the subject of this application, complies with FCC Part 15 Class B, and FCC Sections 2.1053, 30.203 and 2.1057 of the Rules.

Photographs of the measurement setup are in the filing exhibits.

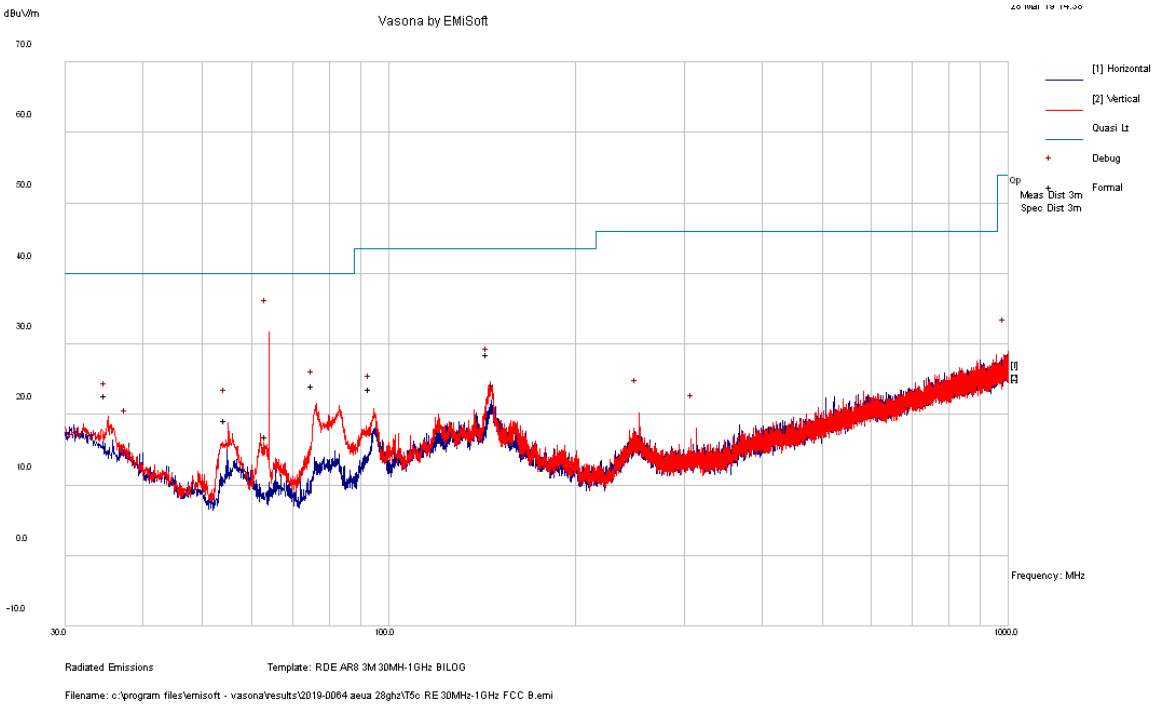
Figure 4.5 Radiated Emissions Product Setup



4.5.4 Transmitter Measurements of Radiated Spurious Emissions

4.5.4.1 Radiated Spurious Emissions 30 MHz – 26.5 GHz

T5C Radiated Emissions - 30MHz-1GHz FCC Class B DC Powered



Results Title:	RDE AR8 3M 30MHz-1GHz BILOG
File Name:	c:\program files\emisoft - vasona\results\2019-0064 aeua 28ghz\T5c RE 30MHz-1GHz FCC B.emi
Test Laboratory:	AR8 MH 25C, 11% RH 1016mB
Test Engineer:	SM/GM
Test Software:	Vasona by EMISoft, version 2.161
Equipment:	Nokia
EUT Details:	AEUA AC 28G Radio Unit, Modulation QPSK, 100MHz BW, 51dBm/polarity, Transmitting @ 27.549GHz, 27.649GHz, 27.750GHz, 27.849GHz.
Configuration:	Powered by 120VAC / 60Hz, Tested to FCC Class B, RE 30M 1GHz, @ 3-Meters, ESU IH69, Bilog Ant E601 with 4dB pad, PCS Filter E980. Sonoma preamp E812, with AR8 cable set for 3 meters. Internal attenuation 10dB, Preview BW (default); Formal BW (default). Support board unpowered.
Date:	2019-03-28 14:38:28

Formal Data

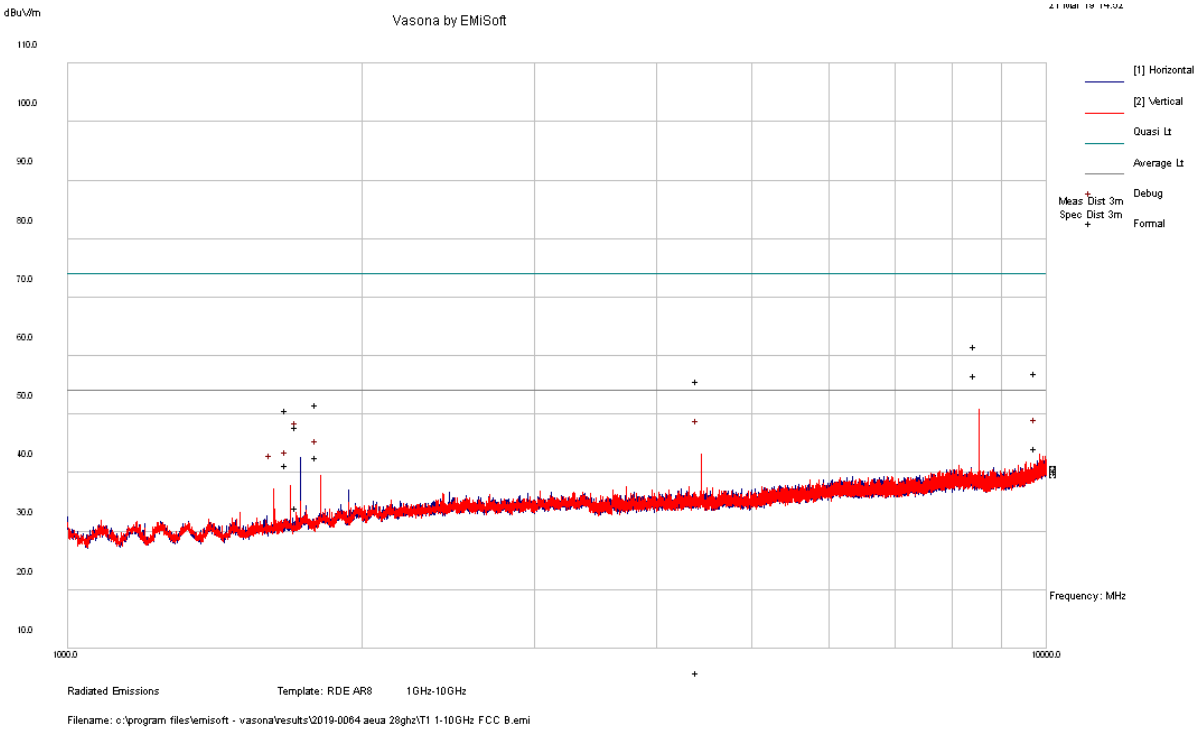
Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol, H/V	Ht, cm	Az deg	Limit dBµV/m	Margin dB	Pass /Fail	Comments
145.923	32.11	1.3	-9.59	23.82	Quasi Max	V	124	291	43.5	-19.68	Pass	
76.307	38.66	0.99	-20.2	19.43	Quasi Max	V	100	305	40	-20.57	Pass	
35.232	29.23	0.77	-12.1	17.93	Quasi Max	V	154	0	40	-22.07	Pass	
94.384	33.5	1.09	-15.7	18.88	Quasi Max	V	134	270	43.5	-24.62	Pass	
55	33.98	0.83	-20.3	14.47	Quasi Max	V	186	11	40	-25.53	Pass	
64	33.03	0.9	-21.8	12.09	Quasi Max	V	114	59	40	-27.91	Pass	

Preview Data

Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol, H/V	Ht, cm	Az deg	Limit dBµV/m	Margin dB	Pass /Fail	Comments
64.000	52.58	0.9	-21.8	31.63	Preview	V	100	45	40	-8.37	Pass	
76.3077	40.8	0.99	-20.2	21.57	Preview	V	100	45	40	-18.43	Pass	
145.923	32.99	1.3	-9.59	24.7	Preview	V	100	45	43.5	-18.8	Pass	
35.2308	31.09	0.77	-12.1	19.79	Preview	V	100	0	40	-20.21	Pass	
55.000	38.36	0.83	-20.3	18.85	Preview	V	100	45	40	-21.15	Pass	
94.3846	35.48	1.09	-15.7	20.86	Preview	V	100	45	43.5	-22.64	Pass	
149.000	27.67	1.31	-9.48	19.51	Preview	H	280	180	43.5	-23.99	Pass	
38.0769	28.8	0.77	-13.6	15.93	Preview	H	380	180	40	-24.07	Pass	
997.564	28.42	2.99	-2.53	28.88	Preview	V	300	90	54	-25.12	Pass	
253.692	30.49	1.66	-11.9	20.24	Preview	V	100	0	46	-25.76	Pass	
312.923	30.35	1.85	-14.1	18.11	Preview	V	100	0	46	-27.89	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

T1 Radiated Emissions 1GHz – 10 GHz FCC Class B DC powered



Results Title:	RDE AR8 1GHz-10GHz
File Name:	c:\program files\emisoft - vasona\results\2019-0064 AEUA 28ghz\T1 1-10GHz FCC B.emi
Test Laboratory:	AR8 MH 23C, 16% RH 1008mB
Test Engineer:	GM
Test Software:	Vasona by EMISoft, version 2.161
Equipment:	Nokia
EUT Details:	AEUA AC 28G Radio Unit, Modulation QPSK, 100MHz BW, 51dBm/polarity, Transmitting @ 27.925GHz, 28.125GHz, 28.325GHz,28.525GHz, - 28.35GHz,
Configuration:	Powered by 120VAC / 60Hz, Tested to FCC Class B, RE 1 G-18GHz, @ 3-Meters, Antenna E1073, Preamp-E447, ESU IH69, Pre-Amp E1356, Horn Ant E1073, 28G-Notch Filter E1315. Internal attenuation 0dB, Preview BW (100 kHz RBW/ 3000 KHz VBW); Formal BW (1MHz RBW). Radiated Emissions; FCC Pt15 Class B, 3 meters, 1GHz-10GHz
Date:	2019-03-21 15:31:29

Formal Data

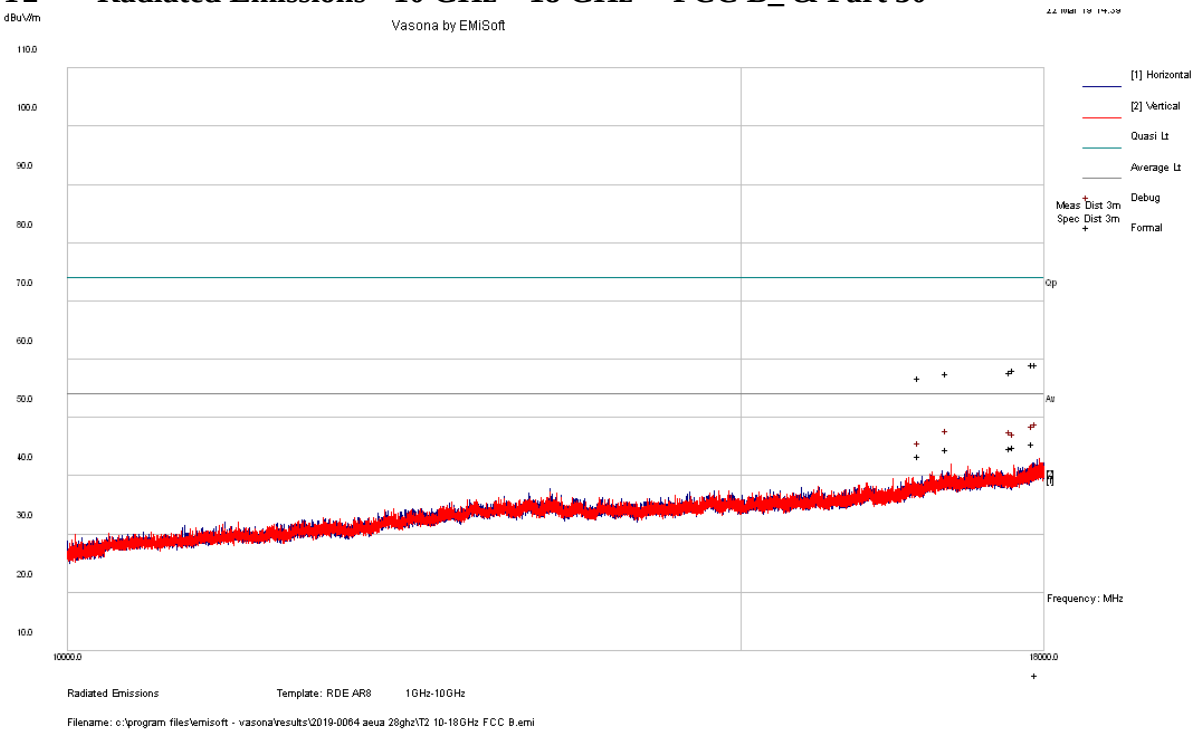
Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol, H/V	Ht, cm	Az deg	Limit dBµV/m	Margin dB	Pass /Fail	Comments
8523.79	42.9	8.85	-1.01	50.74	AvgMax	V	151	1	54	-3.26	Pass	
9830.33	28.77	9.51	-0.05	38.23	AvgMax	V	224	304	54	-15.77	Pass	
1812.3	39.74	4.2	-7.24	36.7	AvgMax	V	100	329	54	-17.3	Pass	
8523.79	47.8	8.85	-1.01	55.64	Peak	V	151	1	74	-18.36	Pass	
1687.54	39.31	4.07	-8.08	35.3	AvgMax	V	126	271	54	-18.7	Pass	
9830.33	41.7	9.51	-0.05	51.16	Peak	V	224	304	74	-22.84	Pass	
4437.57	46.13	6.39	-2.81	49.71	Peak	V	100	28	74	-24.29	Pass	
1728.87	31.83	4.11	-7.8	28.15	AvgMax	H	294	104	54	-25.85	Pass	
1812.3	48.86	4.2	-7.24	45.81	Peak	V	100	329	74	-28.19	Pass	
1687.54	48.76	4.07	-8.08	44.75	Peak	V	126	271	74	-29.25	Pass	
1728.87	45.61	4.11	-7.8	41.92	Peak	H	294	104	74	-32.08	Pass	
4437.57	17.77	6.39	-2.81	21.4	AvgMax	V	100	28	54	-32.6	Pass	

Preview Data

Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol, H/V	Ht, cm	Az deg	Limit dBµV/m	Margin dB	Pass /Fail	Comments
8523.92	42.94	8.85	-1.01	50.78	Preview	V	100	0	54	-3.22	Pass	
9830.33	33.72	9.51	-0.05	43.18	Preview	V	100	308	54	-10.82	Pass	
4437.38	39.53	6.39	-2.81	43.11	Preview	V	100	22	54	-10.89	Pass	
1728.87	46.35	4.11	-7.8	42.66	Preview	H	390	88	54	-11.34	Pass	
1812.42	42.57	4.2	-7.24	39.52	Preview	V	100	286	54	-14.48	Pass	
1687.73	41.74	4.07	-8.08	37.73	Preview	V	100	308	54	-16.27	Pass	
1625.39	41.72	4	-8.52	37.2	Preview	V	100	330	54	-16.8	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.

T2 Radiated Emissions 10 GHz—18 GHz FCC B_ & Part 30



Results Title:	RDE AR8 1GHz-10GHz
File Name:	c:\program files\emisoft - vasona\results\2019-0064 AEUA 28ghz\T2 10-18GHz FCC B.emi
Test Laboratory:	AR8 MH 23C, 16% RH 1008mB
Test Engineer:	GM
Test Software:	Vasona by EMISoft, version 2.161
Equipment:	Nokia
EUT Details:	AEUA AC 28G Radio Unit, Modulation QPSK, 100MHz BW, 51dBm/polarity, Transmitting @ 27.925GHz, 28.125GHz, 28.325GHz, 28.525GHz, - 28.35GHz,
Configuration:	Powered by 120VAC / 60Hz, Tested to FCC Class B, RE 1 G-18GHz, @ 3-Meters, Antenna E1073, Preamp-E447, ESU IH69, Pre-Amp E1356, Horn Ant E1073, 28G-Notch Filter E1315. Internal attenuation 0dB, Preview BW (100 kHz RBW/ 3000 KHz VBW); Formal BW (1MHz RBW). Radiated Emissions; FCC Pt15 Class B, 3 meters, 10GHz-18GHz
Date:	2019-03-22 14:44:25

Formal Data

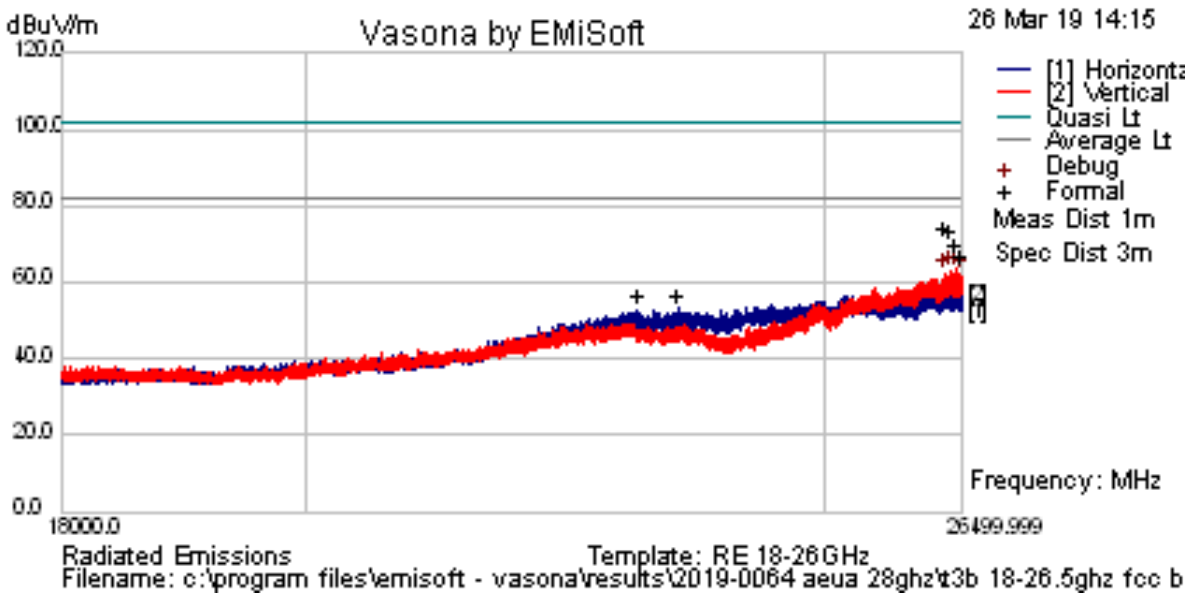
Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol, H/V	Ht, cm	Az deg	Limit dBµV/m	Margin dB	Pass /Fail	Comments
17951.3	19.1	13.4	7.2	39.7	Average	V	260	281	54	-14.3	Pass	
17921.7	19.09	13.41	7.15	39.65	Average	H	171	211	54	-14.35	Pass	
17715.1	18.69	13.26	7.03	38.98	Average	H	148	310	54	-15.02	Pass	
17677.2	18.56	13.23	7.01	38.8	Average	V	229	244	54	-15.2	Pass	
17017.1	18.6	12.74	7.23	38.57	Average	V	123	55	54	-15.43	Pass	
16728.3	18.31	12.59	6.69	37.59	Average	H	280	256	54	-16.41	Pass	
17951.3	32.61	13.43	7.16	53.2	Peak	V	260	281	74	-20.8	Pass	
17921.7	32.61	13.41	7.15	53.16	Peak	H	171	211	74	-20.84	Pass	
17715.1	31.97	13.26	7.03	52.26	Peak	H	148	310	74	-21.74	Pass	
17677.2	31.64	13.23	7.01	51.88	Peak	V	229	244	74	-22.12	Pass	
17017.1	31.63	12.74	7.23	51.6	Peak	V	123	55	74	-22.4	Pass	
16728.3	31.59	12.59	6.69	50.87	Peak	H	280	256	74	-23.13	Pass	

PREVIEW DATA

Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol, H/V	Ht, cm	Az deg	Limit dBµV/m	Margin dB	Pass /Fail	Comments
17951.3	22.39	13.43	7.16	42.99	Preview	V	200	88	54	-11.01	Pass	
17921.7	22.13	13.41	7.15	42.69	Debug	H	100	354	54	-11.31	Pass	
17017.1	21.94	12.74	7.23	41.91	Debug	V	100	354	54	-12.09	Pass	
17677.2	21.41	13.23	7.01	41.65	Debug	V	100	354	54	-12.35	Pass	
17715.1	21.08	13.26	7.03	41.37	Debug	H	100	354	54	-12.63	Pass	
16728.3	20.46	12.59	6.69	39.74	Debug	H	100	354	54	-14.26	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.

T3c Radiated Emissions 18GHz-26.5GHz FCC Part 30 @ 3m



Results Title:	RE 18-26GHz
File Name:	c:\program files\emisoft - vasona\results\2019-0064 AEUA 28ghz\T3b 18-26.5GHz FCC B.emi
Test Laboratory:	AR8 MH 24C, 24% RH 978mB
Test Engineer:	MJS / GM
Test Software:	Vasona by EMISoft, version 2.161
Equipment:	Nokia
EUT Details:	AEUA AC 28G Radio Unit, Modulation QPSK, 100MHz BW, 51dBm/polarity, Transmitting @ 27.999GHz, 28.0999GHz, 28.2GHz,28.2999GHz.
Configuration:	Powered by 120VAC / 60Hz, Tested to FCC Class B, RE 18 G-26.5GHz, @ 3-Meters, ESU IH69, Pre-Amp E1356, Horn Ant E513, 28G-Notch Filter E1315. Internal attenuation 0dB, Preview BW (30 kHz RBW/ 3000 KHz VBW); Formal BW (1MHz RBW).
Date:	2019-03-26 14:15:43

Formal Data

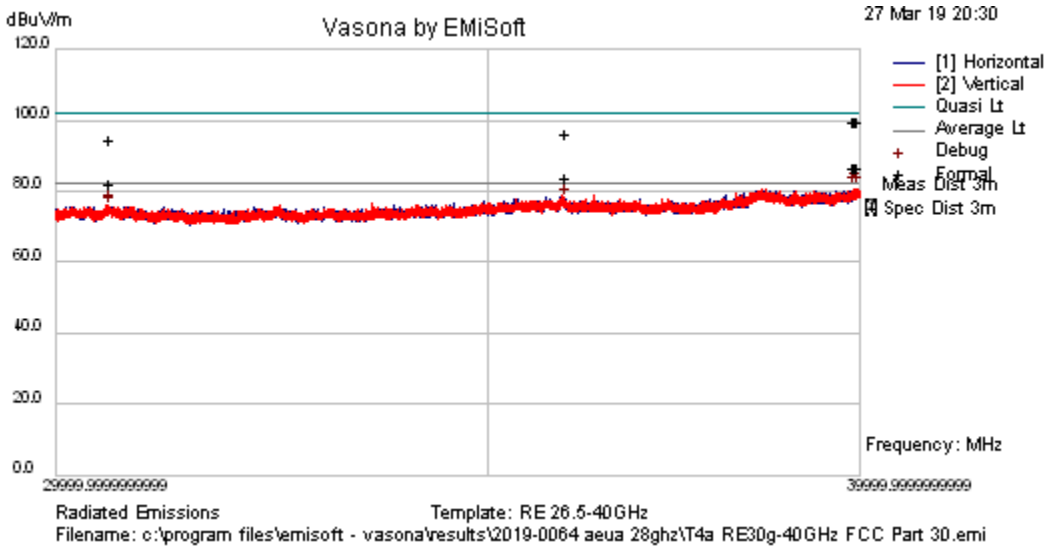
Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol, H/V	Ht, cm	Az deg	Limit dBµV/m	Margin dB	Pass /Fail	Comments
26451.668	45.4	16.8	14.7	76.9	Average	V	185	2	82.2	-5.3	Pass	
26376.193	44.6	17.1	14.5	76.2	Average	V	174	2	82.2	-6.1	Pass	
26491.923	43.9	16.7	14.7	75.4	Average	V	172	2	82.2	-6.9	Pass	
26319.632	43.1	17.2	14.4	74.7	Average	V	172	2	82.2	-7.5	Pass	
23467.792	27.3	18.1	12	57.4	Average	H	254	26	82.2	-24.8	Pass	
23058.367	26.7	17.9	12.6	57.2	Average	H	221	28	82.2	-25	Pass	

Preview Data

Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol, H/V	Ht, cm	Az deg	Limit dBµV/m	Margin dB	Pass /Fail	Comments
26451.668	41.54	16.84	14.65	73.04	Preview	V	175	0	91.77	-18.73	Pass	
26376.193	41.07	17.07	14.49	72.64	Preview	V	175	0	91.77	-19.13	Pass	
26491.923	40.57	16.72	14.73	72.03	Preview	V	175	0	91.77	-19.74	Pass	
26319.632	40.37	17.24	14.38	71.99	Preview	V	175	0	91.77	-19.78	Pass	
23467.792	32.47	18.09	12.01	62.57	Preview	H	150	352	91.77	-29.2	Pass	
23058.367	31.69	17.92	12.62	62.23	Preview	H	175	352	91.77	-29.54	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.

T4a Radiated Emissions 30G-40 GHz FCC Part 30 @ 3m



Results Title:	RE 26.5-40GHz
File Name:	c:\program files\emisoft - vasona\results\2019-0064 AEUA 28 GHz\T4a RE30g-40GHz FCC Part 30.emi
Test Laboratory:	AR8 MH 25C, 24% RH 1016mB
Test Engineer:	MJS/GM
Test Software:	Vasona by EMISoft, version 2.161
Equipment:	Nokia
EUT Details:	AEUA AC 28G Radio Unit, Modulation QPSK, 100MHz BW, 51dBm/polarity, Transmitting @ 27.549GHz, 27.649GHz, 27.750GHz, 27.849GHz.
Configuration:	Powered by 120VAC / 60Hz, Tested to FCC Class B, RE 30 G-40GHz, @ 3-Meters, ESU IH69, Horn Ant E1328 28G-Notch Filter E1315. 7M-L1 cable. Internal attenuation 0dB, Preview BW (30 kHz RBW/ 3000 KHz VBW); Formal BW (1MHz RBW).
Date:	2019-03-27 20:30:31

Formal Data

Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol, H/V	Ht, cm	Az deg	Limit dBµV/m	Margin dB	Pass /Fail	Comments
39971.2	26.29	17.66	38	81.95	Average	V	161	209	82.23	-0.28	Pass	Tx Band
39935.3	26.17	17.64	37.99	81.8	Average	V	127	264	82.23	-0.43	Pass	Tx Band
39913.8	26.04	17.63	37.98	81.65	Average	H	220	225	82.23	-0.58	Pass	Tx Band
36007.7	25.64	16.1	37.01	78.76	Average	H	109	160	82.23	**-3.47**	Pass	
30588.2	25.76	15.12	36.36	77.25	Average	V	220	148	82.23	-4.98	Pass	
30597.1	25.69	15.13	36.37	77.19	Average	H	233	263	82.23	-5.04	Pass	

Preview Data

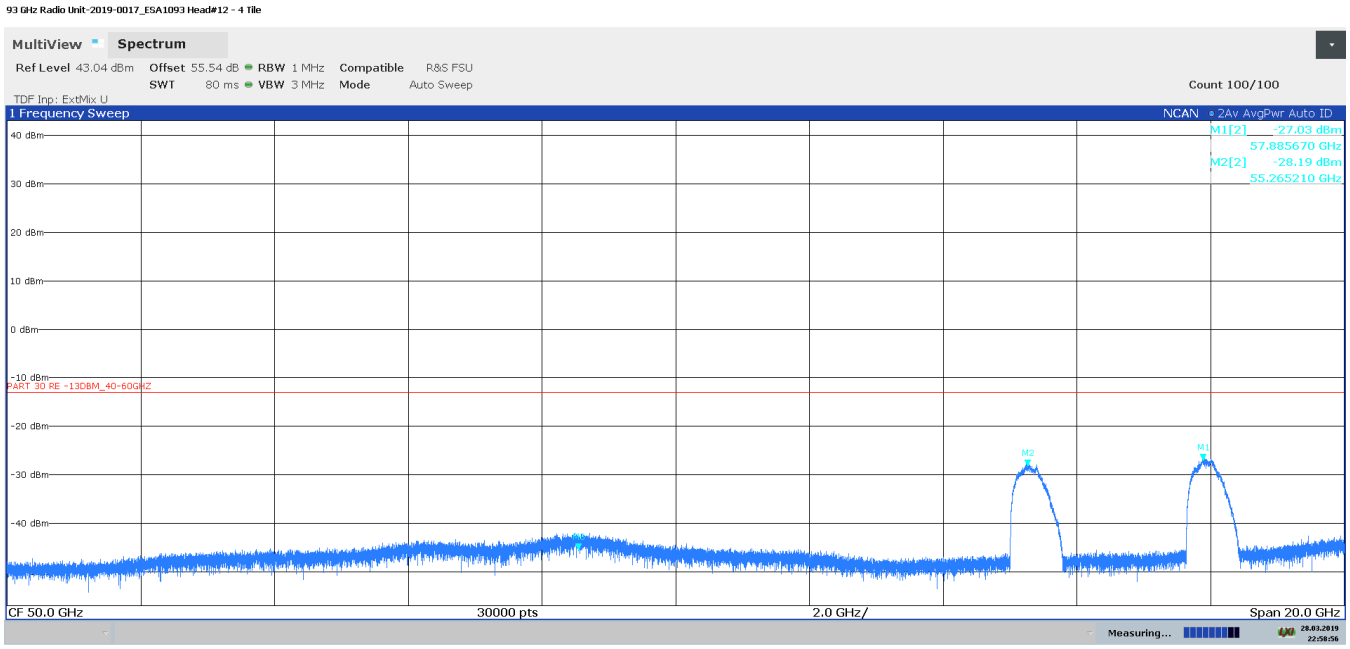
Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol, H/V	Ht, cm	Az deg	Limit dBµV/m	Margin dB	Pass /Fail	Comments
39935.3	25.18	17.64	37.99	80.81	Preview	V	225	330	82.23	-1.42	Pass	
39913.8	23.97	17.63	37.98	79.58	Debug	H	201	354	82.23	-2.65	Pass	
39971.2	23.66	17.66	38	79.32	Debug	V	100	354	82.23	-2.91	Pass	
36007.7	23.2	16.1	37.01	76.32	Debug	H	201	354	82.23	-5.91	Pass	
30597.1	22.9	15.13	36.37	74.39	Debug	H	201	354	82.23	-7.84	Pass	
30588.2	22.68	15.12	36.36	74.17	Debug	V	100	354	82.23	-8.06	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.

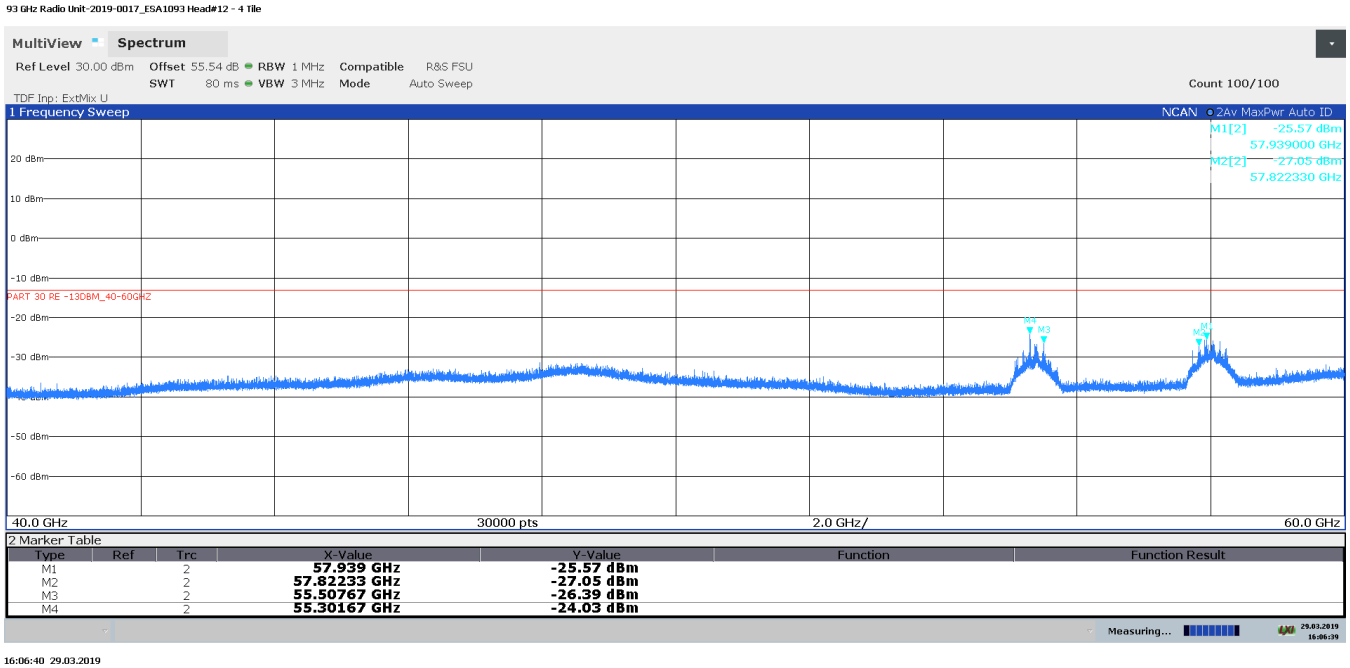
4.5.4.2 Radiated Spurious Emissions - 40GHz – 105 GHz

Maximum Measured Radiated Emissions -U Band 40GHz-60GHz FCC B Part 30

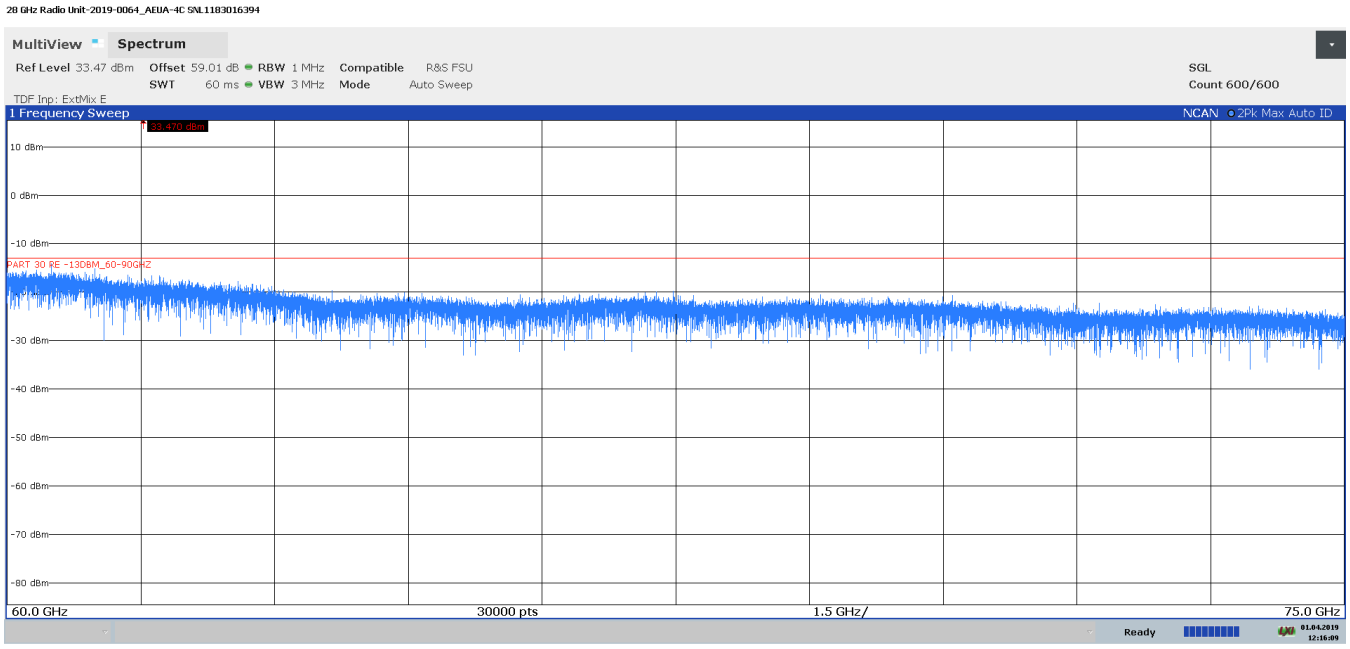
Vertical Polarization - 1 MHz RBW



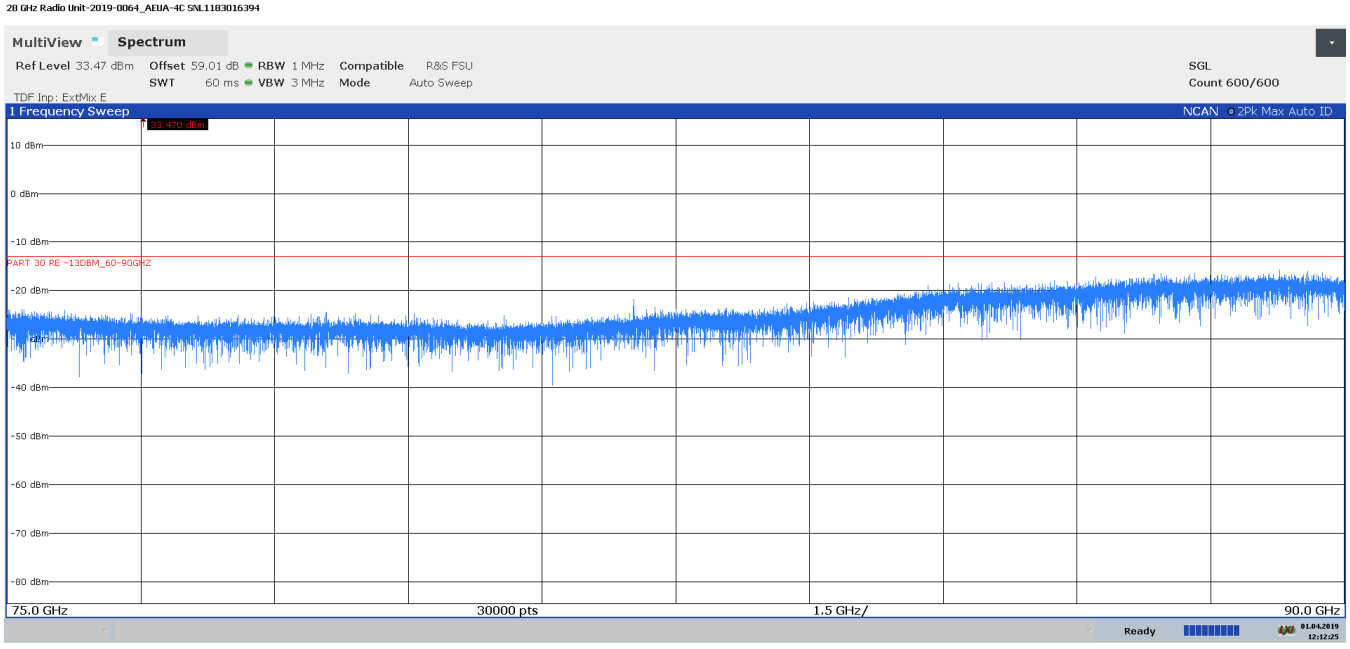
Horizontal Polarization - 1 MHz RBW



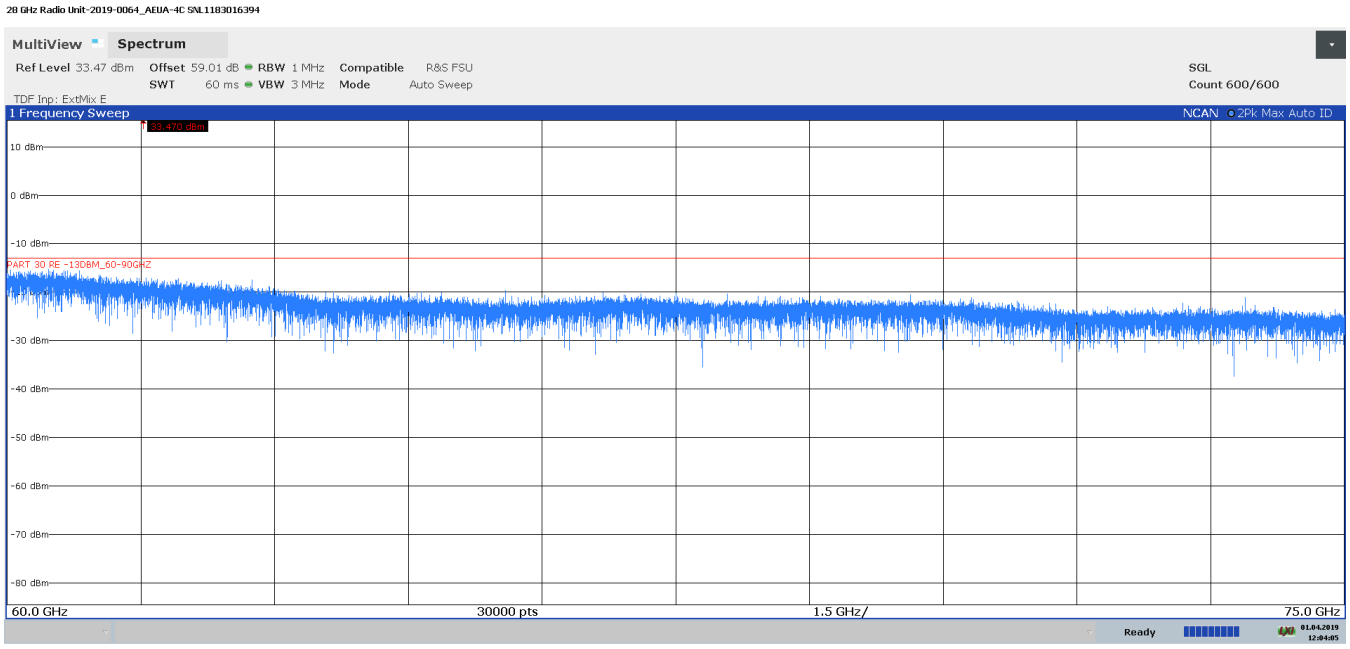
Maximum Measured Radiated Emissions -E Band 60GHz-75GHz FCC B Part 30 Vertical Polarization - 1 MHz RBW



Maximum Measured Radiated Emissions -E Band 75GHz-90GHz FCC B Part 30 Vertical Polarization - 1 MHz RBW

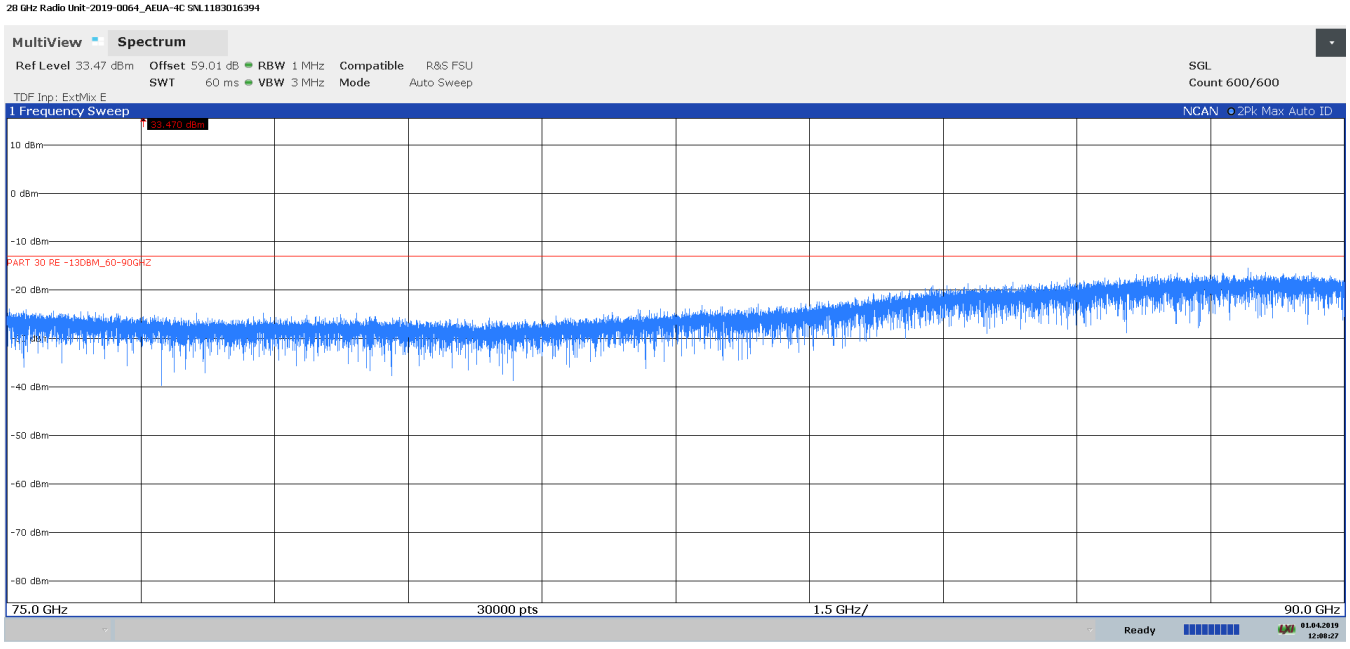


Maximum Measured Radiated Emissions -E Band 60GHz-75GHz FCC B Part 30 Horizontal Polarization - 1 MHz RBW



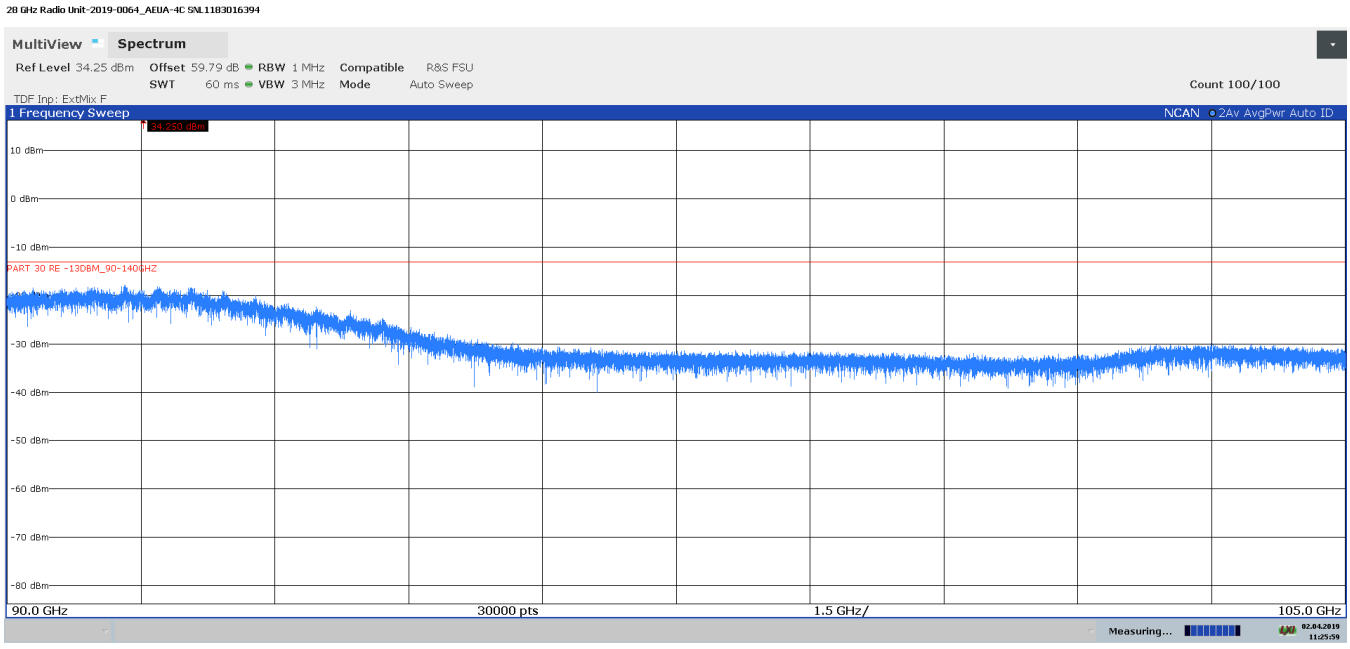
12:04:06 01.04.2019

Maximum Measured Radiated Emissions -E Band 75GHz-90GHz FCC B Part 30 Horizontal Polarization - 1 MHz RBW

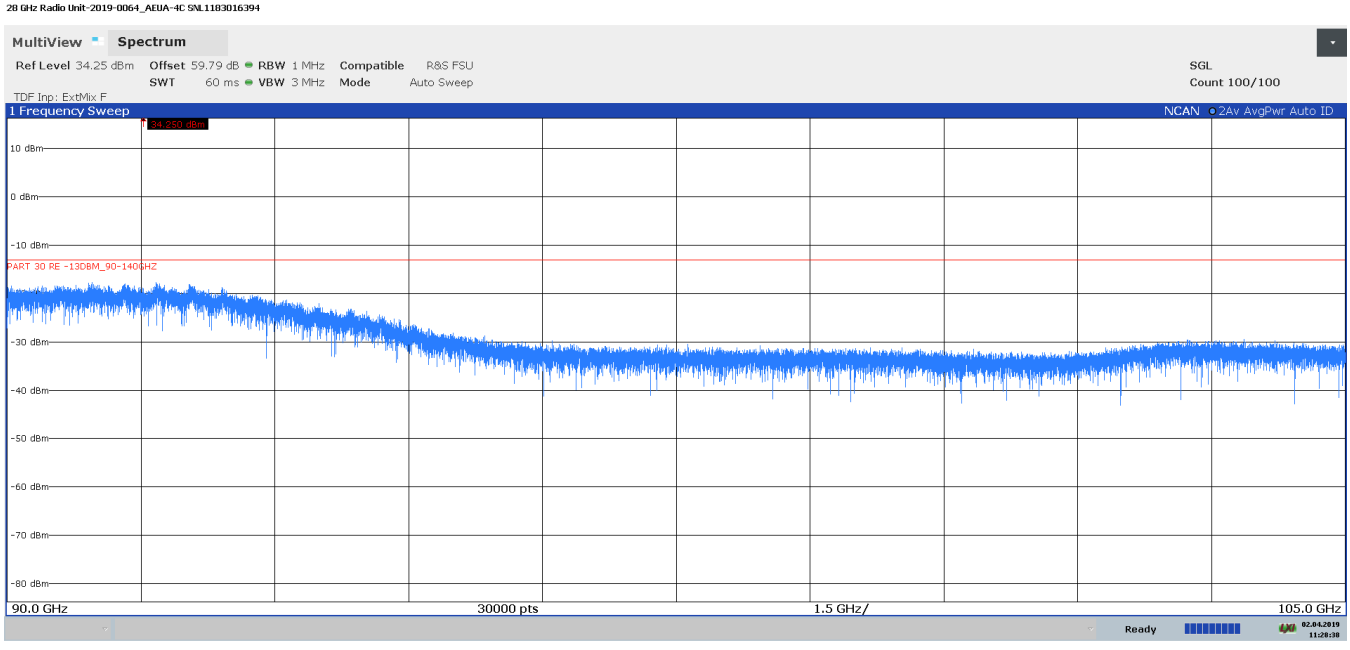


12:08:28 01.04.2019

Maximum Measured Radiated Emissions -F Band 90GHz-105GHz FCC B Part 30 Vertical Polarization – 1. MHz RBW



Horizontal Polarization - 1 MHz RBW



4.6 Section 2.1055 MEASUREMENT REQUIRED: FREQUENCY STABILITY

Frequency stability was measured as part of the original filing under **VBNAEUA-01**. Since there was no change to the frequency generating or stabilizing circuitry frequency stability testing is not required.

4.6.1 Previously Tested Frequency Stability Test Article and Configuration

The unit under test is identified as follows:

Series	Vendor	Serial Number	Comcode	Version
AEUA	Nokia	L1182710698	474864A.X21	DC
AEUA	Nokia	L1182902829	474214A.101	AC

4.6.2 Previously Tested Frequency Stability Results:

The worst case Frequency Stability over temperature and voltage for the DC Product was **+446.71 Hz** which is **-0.0159 ppm.**
The worst case Frequency Stability over temperature and voltage for the AC Product was **+878.56 Hz** which is **-0.0314 ppm.**
This are within the +/- 0.05ppm desired performance required for LTE operation.

4.7 List of Test Equipment

4.7.1 List of Radiated Emissions Test Equipment

The following equipment was used for the measurement of Radiated Emissions.

Asset ID	Manufacturer	Type	Description	Model	Serial	Cal Date	Cal Due	Cal Type
E513	EMC Test Systems	Horn Antenna	Double Ridged Horn 18-40 GHz	3116	2539	2017-06-16	2019-06-16	Requires Calibration
E1073	ETS Lindgren	Horn Antenna	Double-Ridged Horn 1-18 GHz	3117	00135198	2017-06-09	2019-06-09	Requires Calibration
E1255	ETS Lindgren	Multi-Device Controller		2090	00078509			Calibration Not Required
E481	Hewlett Packard	HP-IB Extender		37204	3212U31136			Calibration Not Required
E479	Hewlett Packard	HP-IB Extender		37204	3212U31137			Calibration Not Required
E1356	Hewlett Packard	Pre-Amplifier	Pre-Amplifier 1-26.5GHz	8449B	3008A01353	2018-09-10	2020-09-10	Requires Calibration
E447	Hewlett Packard	Pre-Amplifier	Preamplifier 1-26.5 GHz	8449B	3008A01384	2018-04-10	2020-04-10	Requires Calibration
E1328	A-Info	Horn Antenna	26.5-40GHz WR28 25 dB	LB-28-25-C2-KF	J202023250	2018-10-16	2021-10-16	Requires Calibration
E601	A.H. Systems Inc.	Bilogical Antenna	25 - 2000 MHz	SAS-521-2	408	2017-07-11	2019-07-11	Requires Calibration
E812	Sonoma Instrument Co.	Amplifier	9kHz-1GHz Vasona File TRANS 261	310N	186744	2018-09-14	2020-09-14	Requires Calibration
E980	Trilithic	Low Pass Filter	PCS	10LC1790-3-AA	PCS-LPF-12			Calibration Not Required
E1338r	KeySight Technologies	MXA Signal Analyzer		N9020B	MY57431033	2018-08-2	2019-08-22	Requires Calibration
E1264	KeySight Technologies	Signal Generator		E8257D	MY53402943	2017-08-28	2019-08-28	Requires Calibration
E485	Kikusui	Power Supply	DC 55 Volts 120 Amps	PAD 55-120L	DL000416			Verification
E1315	RS Microwave Company, Inc.	Microwave Filter		P/N 60733A	007			Verification
E1308	Rohde & Schwarz	Harmonic Mixer	Down Converter 90-140GHz	FS-Z140	101008			Factory
E1311	Rohde & Schwarz	Harmonic Mixer	Down Converter 40-60GHz	FS-Z60	100977			Factory
E1312	Rohde & Schwarz	Harmonic Mixer	Down Converter 60-90GHz	FS-Z90	101719			Factory
E1260	Rohde & Schwarz	Spectrum Analyzer	20Hz- 67GHz	FSW67	104007	2018-02-12	2020-02-12	Requires Calibration
EIH69	Rohde & Schwarz	Test Receiver	EMI 20 Hz – 40 GHz -	ESU40	100247	2018-05-22	2020-05-22	Requires Calibration
E907	Rohde & Schwarz	Test Receiver	EMI 20Hz to 40 GHz-	ESIB40	100101	2018-04-17	2020-04-17	Requires Calibration
E1332	Sage Millimeter, Inc.	Horn Antenna	E-band pyramidal horn antenna - 60 to 90 GHz.	SAR-2309-12-S2	14853-01			Factory

Asset ID	Manufacturer	Type	Description	Model	Serial	Cal Date	Cal Due	Cal Type
E1332	Sage Millimeter, Inc.	Horn Antenna	E-band pyramidal horn antenna - 60 to 90 GHz.	SAR-2309-12-S2	14853-01			Factory
E1335	Sage Millimeter, Inc.	Horn Antenna	F-band pyramidal horn antenna - 90 to 140 GHz	SAR-2309-08-S2	14853-02			Factory
E1340	Sage Millimeter, Inc.	Horn Antenna	Pyramidal horn antenna - 26.5 to 40 GHz, 25 dB gain	SAR-2507-28-S2	15309-01			Factory
E1330	Sage Millimeter, Inc.	Horn Antenna	U-band pyramidal horn antenna - 40 to 60 GHz	SAR-2309-19-S2	14853-01			Factory
E1331	Sage Millimeter, Inc.	Horn Antenna	U-band pyramidal horn antenna - 40 to 60 GHz	SAR-2309-19VF-R2	14853-01			Factory
E889	Weinschel	Attenuator	6 dB DC-18GHz 5 Watt	2-6	BX3438	5/23/18	5/23/20	

4.8 PHOTOGRAPHS OF THE TEST SETUPS

Response:

The photographs of the test setups for the **AirScale 28 GHz Radio Unit (AEUA) Band 30, FCC ID: VBNAEUA-01** are provided in the Filing exhibits.

4.9 FACILITIES AND ACCREDITATION

Measurement facilities at Nokia, Global Product Compliance Laboratory (GPCL) a member of the Nokia family of companies, was used to collect the measurement data in the test report. The laboratory, which is part of Nokia Bell Labs, is located at 600-700 Mountain Avenue, Murray Hill, New Jersey 07974-0636 USA.

The field strength measurements of radiated spurious emissions were made in a FCC registered three meter semi-anechoic chamber AR-8, (FCC Registration Number: 395774) **NVLAP** Lab Code: 100275-0 and IC (Filing Number: 6933F-8) which is maintained by Nokia Bell Labs in Murray Hill, New Jersey. The sites were constructed and are continuously in conformance with the requirements of ANSI C63.4 and CISPR Publication 22.

Nokia Global Product Compliance Laboratory FCC OET Accredited Test Firm Scope List is accessible at:

https://apps.fcc.gov/oetcf/eas/reports/ViewTestFirmAccredScopes.cfm?calledFromFrame=N&RequestTimeout=500&regnum_specified=N&test_firm_id=7007

and is as listed in the Table below.

OET Accredited Test Firm Scope List

Test Firm: Nokia, Global Product Compliance Lab

Scope	FCC Rule Parts	Maximum Assessed Frequency, MHz	Status	Expiration Date	Recognition Date
Unintentional Radiators	FCC Part15, Subpart B	40000	Approved	9/30/2018	7/6/2017
Intentional Radiators	FCC Part 15 Subpart C	40000	Approved	9/30/2018	6/5/2018
U-NII without DFS Intentional Radiators	FCC Part 15, Subpart E	40000	Approved	9/30/2018	6/5/2018
U-NII with DFS Intentional Radiators	FCC Part 15, Subpart E	40000	Approved	9/30/2018	6/5/2018
Commercial Mobile Services	Part 22 (cellular), Part 24, Part 25 (below 3 GHz), Part 27	40000	Approved	9/30/2018	6/5/2018
General Mobile Radio Services	Part 22 (non-cellular), Part 90 (below 3 GHz), Part 95 (below 3 GHz), Part 97 (below 3 GHz), Part 101 (below 3 GHz)	40000	Approved	9/30/2018	6/5/2018
Citizens Broadband Radio Services	Part 96	40000	Approved	9/30/2018	7/6/2017
Microwave and Millimeter Bands Radio Services	Part 25, Part30, Part 74, Part 90 (90M DSRC, Y, Z), Part 95 (M & L), Part 101	200000	Approved	9/30/2018	7/6/2017

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

NVLAP®

Certificate of Accreditation to ISO/IEC 17025:2005

NVLAP LAB CODE: 100275-0

Nokia, Global Product Compliance Lab
Murray Hill, NJ

is accredited by the National Voluntary Laboratory Accreditation Program for specific services, listed on the Scope of Accreditation, for:

Electromagnetic Compatibility & Telecommunications

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communique dated January 2009).

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

DEPARTMENT OF COMMERCE · UNITED STATES OF AMERICA

For the National Voluntary Laboratory Accreditation Program

5. APPENDIX A - CALIBRATION CERTIFICATES.

The attached Calibration certificates represent the Harmonic Downconverters used in this testing.