

Global Product Compliance Laboratory  
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Room 5B-108  
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**TESTING**  
NVLAP LAB CODE: 100275-0

## **FCC Certification Part 30 Test Report**

### **Product Evaluated**

**AirScale 28 GHz Radio Unit (AEUB) Band 30, 8 Carrier  
AEUB, 8c  
FCC ID: 2AD8UAEUB01**

### **Customer**

**Nokia Solutions and Networks, OY**  
2000 Lucent Lane  
Naperville, Illinois 60563

### **Test Laboratory**

**Nokia Bell Labs**  
**Nokia, Global Product Compliance Laboratory**  
600-700 Mountain Avenue, Rm 5B-108  
Murray Hill, New Jersey 07974-0636 USA

**Date: April 9, 2020**

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**Revisions**

| Date     | Revision | Section | Change                                                                      |
|----------|----------|---------|-----------------------------------------------------------------------------|
| 4/3/2020 | 0        |         | Initial Release                                                             |
| 4/9/2020 | 1        |         | TOC pgs. 3 & 4, Standards reference pgs. 5 & 11, Footer revision pgs. 5-end |
|          |          |         |                                                                             |
|          |          |         |                                                                             |

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4/9/2020

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4/9/2020

Technical Manager  
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## 1. ATTESTATION OF TEST RESULTS

|                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Company Name</b>          | <b>Nokia Solutions and Networks, OY</b><br>2000 Lucent Lane<br>Naperville, Illinois 60563                                                                                                                                                                                                                                                                                                                                                           |
| <b>FCC ID</b>                | <b>2AD8UAEUB01</b>                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Product Name</b>          | <b>AirScale 28 GHz Radio Unit (AEUB) Band 30 8Ccarrier</b>                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Model Name</b>            | <b>AEUB</b>                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Part No</b>               | 474608A.102,                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Serial Number(s)</b>      | AC/DC Model: L1192504423                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Test Standard(s)</b>      | <ul style="list-style-type: none"> <li>• 47 CFR FCC Parts 2</li> <li>• KDB 971168 D01 Power Measurement License Digital Systems v03r01 April 9, 2018</li> <li>• KDB 662911 D01 Multiple Transmitter Output v02r01 Oct 2013</li> <li>• KDB 842590 D01 Upper Microwave Flexible Use Service v01 – April 2019</li> <li>• Procedures on TRP Compliance for Out of Band and Spurious Emissions C63.26 mmWave JTG - Version # 1 July 14th 2018</li> </ul> |
| <b>Reference(s)</b>          | <ul style="list-style-type: none"> <li>• 47 CFR FCC Part 2 and Part 30</li> <li>• ANSI C63.26 (2015)</li> <li>• ANSI C63.4 (2014)</li> <li>• TR 14-1001, MMW Measurements with Harmonic Mixers (April-4-2014)</li> </ul>                                                                                                                                                                                                                            |
| <b>Frequency Band</b>        | (Tx: 27.5 – 28.35 GHz ), NR Band n261                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Technology</b>            | 5G-New Radio, LTE-TDD: 97M5G7W,                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Test Frequency Range</b>  | 10MHz – 100GHz                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Operation Mode(s)</b>     | 2x 57dBm EIRP, 60 dBm EIRP Total. 5 – 8 carriers MIMO                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Submission Type</b>       | Class II Permissive Change                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>FCC Part 15 Subpart B</b> | Compliance with Class B                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Test Date</b>             | March 3, through April 3, 2020                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Test Laboratory</b>       | Nokia Global Product Compliance Laboratory<br>600-700 Mountain Avenue, Rm 5B-108<br>Murray Hill, New Jersey 07974-0636 USA<br><b>NVLAP Lab Code: 100275-0 FCC Registration Number: 395774</b>                                                                                                                                                                                                                                                       |

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<br>(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                   | Pass               |

### 2.1 Measurement Uncertainty

The results of the calculations to estimate uncertainties for the several

**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    | ±5.4 dB                    |
|                                                                                   |                                                 | 30 MHz – 200 MHz V   | ±5.4 dB                    |
|                                                                                   |                                                 | 200 MHz – 1000 MHz H | ±4.7 dB                    |
|                                                                                   |                                                 | 200 MHz – 1000 MHz V | ±4.7 dB                    |
|                                                                                   |                                                 | 1 GHz- 18 GHz        | ±3.3 dB                    |

| Antenna Port Test                 | Signal Bandwidth                                      | Frequency Range                                                            | Expanded Uncertainty (k=2), Amplitude |
|-----------------------------------|-------------------------------------------------------|----------------------------------------------------------------------------|---------------------------------------|
| Occupied Bandwidth, Edge of Band, | 10 Hz<br>100 Hz<br>10 kHz to 1 MHz<br>1MHz to 100 MHz | 9 kHz to 20 MHz<br>20 MHz to 1 GHz<br>1 GHz to 10 GHz<br>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 and 64QAM                                                          |
| Operating Frequency Range | TDD (Tx/Rx: 27.5-28.35 GHz),                                                                             |
| Channel Bandwidth         | 100 MHz, 8 carriers                                                                                      |
| 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          | 474608A.102                                                                                              |
| 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         | 5G-NR 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 (GHz) | Raster Delta , MHz |
|---------|--------------------------------------|--------------------|
| 2071674 | 27.550510                            | 99.96              |
| 2073340 | 27.650470                            | 99.96              |
| 2075006 | 27.750430                            | 99.96              |
| 2076672 | 27.850390                            | 99.96              |
| 2078338 | 27.950350                            | 99.96              |
| 2080004 | 28.050310                            | 99.96              |
| 2081670 | 28.150270                            | 99.96              |
| 2083336 | 28.250230                            | 99.96              |

### 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 filing package.

### 3.3 Antenna Far Field Determination Distance

The Moongilan Test (1) was performed to determine the far field boundary location using calculations and low power measurements. For the antenna array we can calculate the Fraunhofer distance from

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

where  $d_{ff}$  = Far Field distance in meters,

D is the maximum size of the radiating array

$\lambda$  = wavelength of the operating signal in meters

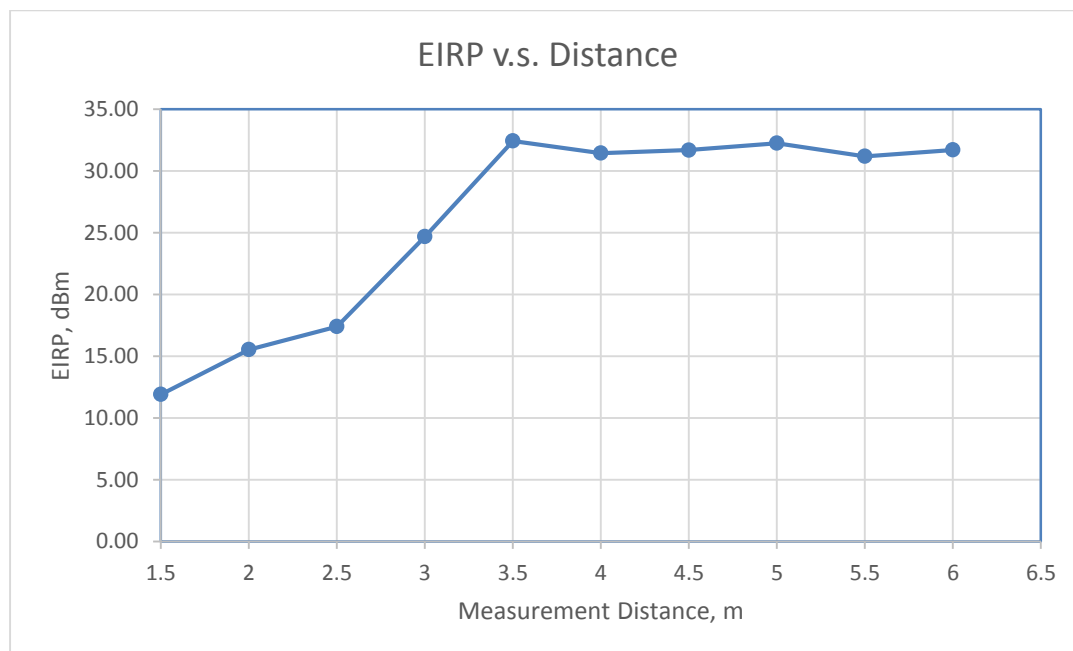
The antenna patch are 9.2 cm x 9.2 cm and the patches are 15 cm apart .

At 28 GHz the diagonal 9.2 x 9.2 cm array dimensions results in a far field distance  $d_{ff}$  of 3.16 meters.

Measurements for the Moongilan Test were performed at low power using a standard gain horn antenna. In the horizontal polarization the determined boundary was 3.5 m, which matches the horizontal dimension.

To eliminate any inconsistency all Power, OBW and OOB measurements were made at 4 m.

(1) *The Moongilan Test is named in honor of the late Dheena Moongilan who discovered it and formulated its use into C63.26.*



#### 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 Original Authorization |
|-------------------------------------------------|-----------------------------------------------------|------------------------------------------|
| 2.1046, 30.202 (a)                              | RF Power Output<br>(a) Power Limits, EIRP, PSD      | Yes                                      |
| 2.1047,                                         | Modulation Characteristics                          | Yes                                      |
| 2.1049, 30.203                                  | (a) Occupied Bandwidth<br>(b) Out-of-Band Emissions | Yes                                      |
| 2.1051, 30.203                                  | Spurious Emissions at Antenna Terminals             | Yes                                      |
| 2.1053, 30.203,<br>30.204, 15.109(a)<br>Class B | Field Strength of Spurious Radiation                | Yes                                      |
| 2.1055,                                         | Measurement of Frequency Stability                  | Yes                                      |

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**

|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Test Standard(s)</b> | <ul style="list-style-type: none"> <li>• 47 CFR FCC Parts 2</li> <li>• KDB 971168 D01 Power Measurement License Digital Systems v03r01 April 9, 2018</li> <li>• KDB 662911 D01 Multiple Transmitter Output v02r01 Oct 2013</li> <li>• KDB 842590 D01 Upper Microwave Flexible Use Service v01 – April 2019</li> <li>Procedures on TRP Compliance for Out of Band and Spurious Emissions C63.26 mmWave JTG - Version # 1 July 14th 2018</li> </ul> |
| <b>Reference(s)</b>     | <ul style="list-style-type: none"> <li>• 47 CFR FCC Part 2 and Part 30</li> <li>• ANSI C63.26 (2015)</li> <li>• ANSI C63.4 (2014)</li> <li>• TR 14-1001, MMW Measurements with Harmonic Mixers (April-4-2014)</li> </ul>                                                                                                                                                                                                                          |

#### 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 (AEUB), FCC ID: 2AD8UAEUB01**, 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 +29 dBi internal antenna arrays and substitution of the Tx antennas is not possible.

##### 4.1.1 RF Power Output Measurement

Power measurements of the 5G New Radio transmit signal were conducted with FSW Spectrum Analyzers per KDB 971168 D01. Measurements were performed at a distance of 4m. 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 and 64QAM. These were 3GPP standard base station test models for QPSK+16QAM and 64QAM modulation. The per channel and total carrier power level was documented on each data sheet for Channel Power.

The maximum rated average EIRP at the 4m boundary distance was measured for the 8 carrier configuration for the QPSK, 16 QAM and 64QAM modulation. These fill the entire 27.5-28.35 GHz frequency spectrum.

Additional measurements were performed in the three different Modulations modes for the five, six and seven carrier configuration documenting MIMO operation

##### 4.1.1.1 RF Power Output Results

The Power output measurement results verified the expected performance of 57 dBm EIRP per polarization which is 60 dBm total. The maximum measured level for a single polarization was **57.61** dBm with a maximum total power of 60.4 dBm for any configuration tested. 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. Sample data plots are detailed below.

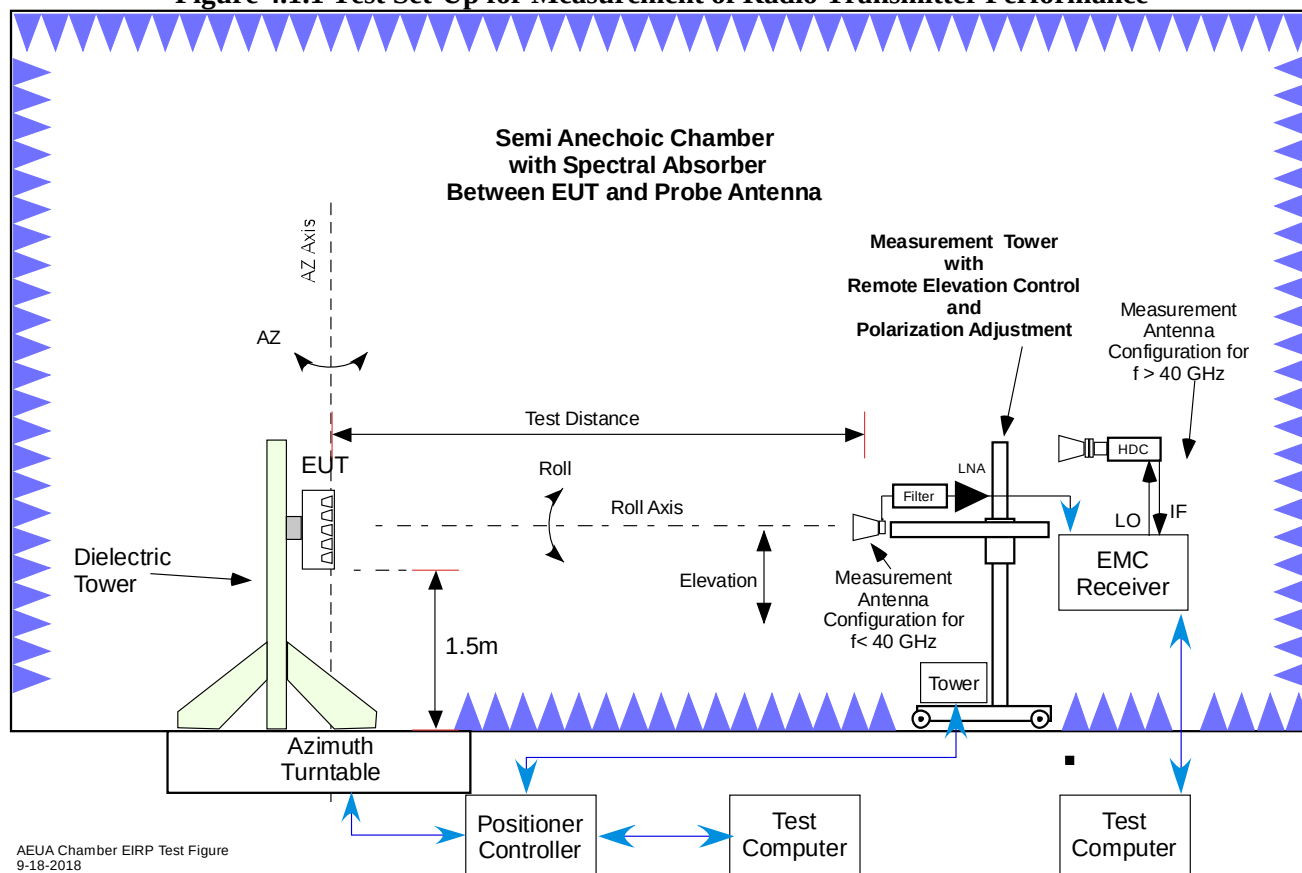
##### 4.1.1.2 RF Power Output Data

Table 4.1.1.1 below summarizes the Total Measured EIRP for the different configurations and modulations for 5 carrier, 6 carrier, 7 carrier and 8 carrier configurations. Sample data plots follow.

**Table 4.1.1.1 Summary of Channel Power Measurements**

| Location<br>in Band | Carrier<br>Frequencies,<br>GHz                                                   | # of<br>carriers | Modulation | Horizontal<br>Polarization<br>Total Channel<br>Power,<br>EIRP | Vertical<br>Polarization<br>Total Channel<br>Power,<br>EIRP | Sum Total<br>Channel<br>Power<br>EIRP |
|---------------------|----------------------------------------------------------------------------------|------------------|------------|---------------------------------------------------------------|-------------------------------------------------------------|---------------------------------------|
|                     |                                                                                  |                  |            | dBm                                                           | dBm                                                         | dBm                                   |
| <b>Left</b>         | 27.55056<br>27.65052<br>27.75048<br>27.85044<br>27.9504                          | 5                | QPSK       | 57.15                                                         | 57.08                                                       | 60.13                                 |
| <b>Center</b>       | 27.65052<br>27.75048<br>27.85044<br>27.9504<br>28.05036<br>28.15032              | 6                | 16QAM      | 57.10                                                         | 57.02                                                       | 60.07                                 |
| <b>Right</b>        | 27.65052<br>27.75048<br>27.85044<br>27.9504<br>28.05036<br>28.15032<br>28.25028, | 7                | 64QAM      | 57.10                                                         | 57.00                                                       | 60.06                                 |
| <b>Left</b>         | 27.55056<br>To<br>28.25028                                                       | 8                | QPSK       | 57.02                                                         | 57.22                                                       | 60.13                                 |
| <b>Center</b>       | 27.55056<br>To<br>28.25028                                                       | 8                | 16QAM      | 57.15                                                         | 57.61                                                       | 60.40                                 |
| <b>Right</b>        | 27.55056<br>To<br>28.25028                                                       | 8                | 64QAM      | 57.04                                                         | 57.10                                                       | 60.04                                 |

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



## Channel Power Measurements, 4m, 5 Carrier - QPSK - Left Side of Band

### QPSK - Horizontal –



## Channel Power Measurements, 4m, 6 Carrier - 16QAM - Center of Band

### Horizontal –

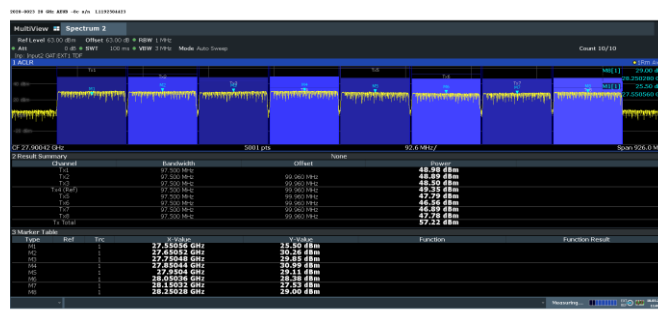


## Channel Power Measurements, 4m, 7 Carrier - 64QAM - Right Side of Band

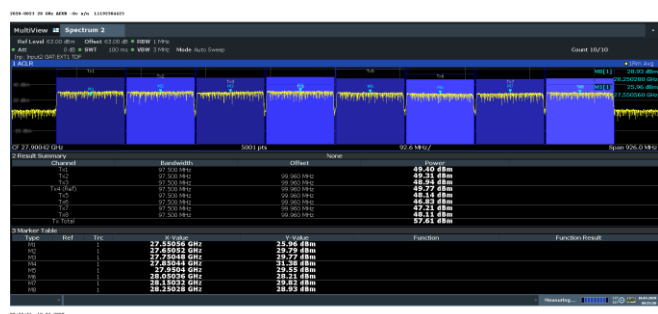
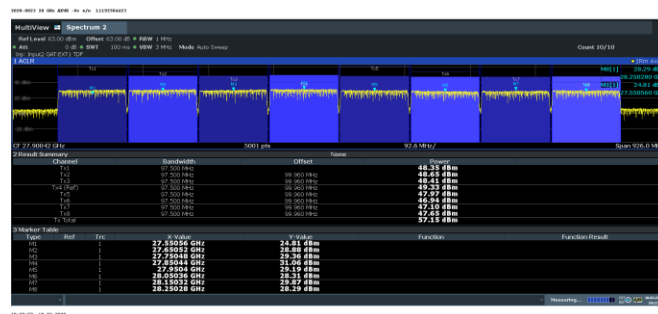
### Horizontal –



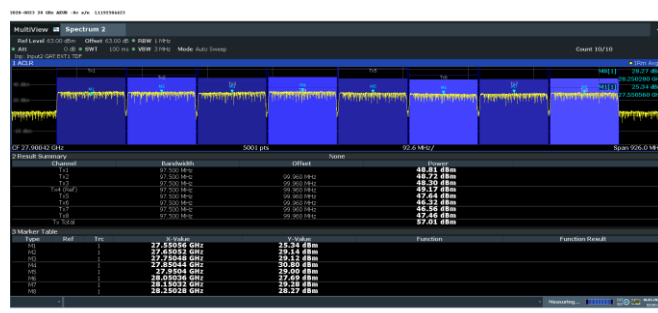
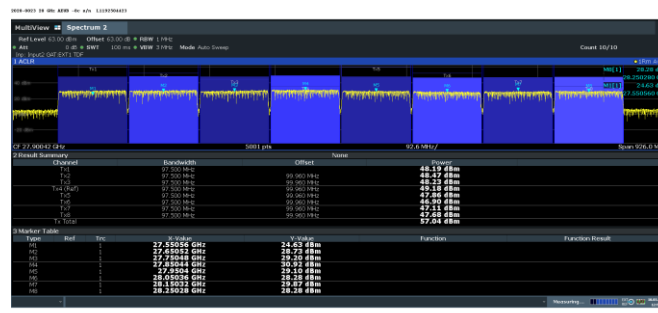
### Channel Power Measurements, 4m, 8 Carrier - QPSK



### Channel Power Measurements, 4m, 8 Carrier - 16QAM



### Channel Power Measurements, 4m, 8 Carrier - 64QAM



## **4.2 Section 2.1047 MEASUREMENT REQUIRED: MODULATION CHARACTERISTICS**

The **2AD8UAEUB01** 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 is expected Q4 of 2018. This present evolutionary nature of 5G-NR prevents all of the nominal EVM measurements from being performed at this time. However, 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 with the final format of Release 16. A Class II change is planned for this unit for Multi-carrier operation and Release 16 should be testable at that time.

### **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 an 85 GHz FSW 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:**

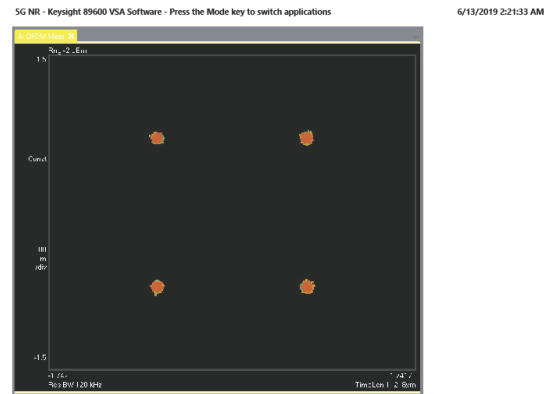
The typical measured modulation characteristics of the EUT are shown below:

Figure 4.2 Modulation Results

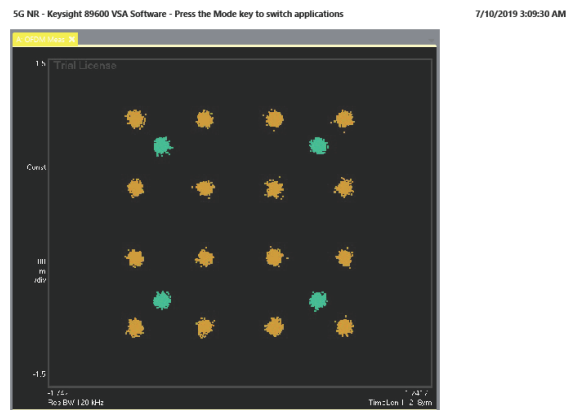
Sample QPSK 27.54996 GHz Vertical



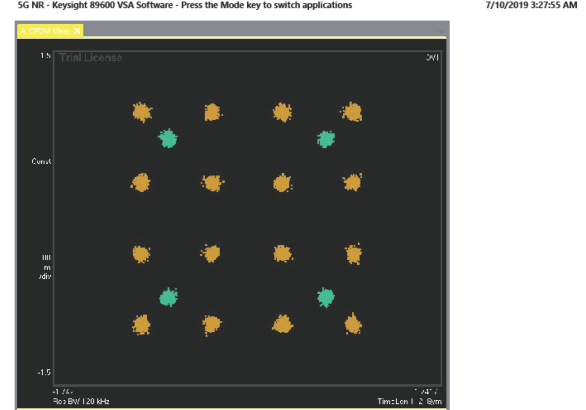
Sample QPSK 27.54996 GHz Horizontal



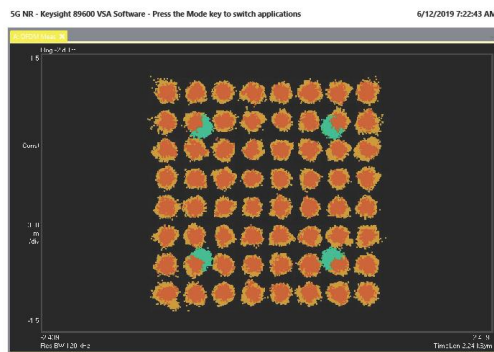
Sample 16QAM 27.6 GHz Vertical



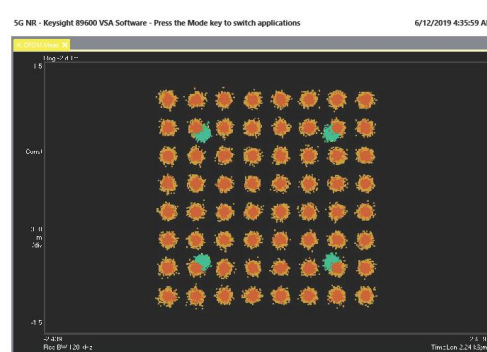
Sample 16QAM 27.6 GHz Horizontal



Sample 16QAM 27.6 GHz Vertical



Sample 16QAM 27.6 GHz Horizontal



#### **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, individual carriers 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. The aggregated 4 carrier configurations were measured with RBW's of 5 MHz and 10 MHz.

##### **4.3.1 Results - Occupied Bandwidth (Signal Bandwidth)**

The 99% occupied bandwidth was measured with a Rohde & Schwarz FSW spectrum analyzer using the occupied bandwidth functionality. The results for multiple configurations and modulations are tabulated in Table 4.3.1 below. The maximum measured individual carrier was 97.41 MHz. The measurement of 4 adjacent carriers resulted in a maximum 4 carrier bandwidth of 395.5 MHz. The results shows that the measured signals are within the parameters of the 97M5G7W emissions designator. Sample carrier measurements are documented in Figure 4.3.1 below.

**Table 4.3.1 Occupied Bandwidth - Signal Bandwidth Measurements**

| Location in Band | Carrier Frequencies, GHz | # of carriers | Modulation | Horizontal Polarization Occupied Signal Bandwidth | Vertical Polarization Occupied Signal Bandwidth |
|------------------|--------------------------|---------------|------------|---------------------------------------------------|-------------------------------------------------|
|                  |                          |               |            | MHz                                               | MHz                                             |
| Left             | 27.55056                 | 5             | QPSK       | 492.42                                            | 490.96                                          |
|                  | 27.65052                 |               |            |                                                   |                                                 |
|                  | 27.75048                 |               |            |                                                   |                                                 |
|                  | 27.85044                 |               |            |                                                   |                                                 |
|                  | 27.9504                  |               |            |                                                   |                                                 |
| Center           | 27.65052                 | 6             | 16QAM      | 589.67                                            | 589.12                                          |
|                  | 27.75048                 |               |            |                                                   |                                                 |
|                  | 27.85044                 |               |            |                                                   |                                                 |
|                  | 27.9504                  |               |            |                                                   |                                                 |
|                  | 28.05036                 |               |            |                                                   |                                                 |
| Right            | 28.15032                 | 7             | 64QAM      | 689.63                                            | 690.48                                          |
|                  | 27.65052                 |               |            |                                                   |                                                 |
|                  | 27.75048                 |               |            |                                                   |                                                 |
|                  | 27.85044                 |               |            |                                                   |                                                 |
|                  | 27.9504                  |               |            |                                                   |                                                 |
| Left             | 28.05036                 | 8             | QPSK       | 788.38                                            | 789.67                                          |
|                  | 28.15032                 |               |            |                                                   |                                                 |
|                  | 28.25028,                |               |            |                                                   |                                                 |
| Center           | 27.55056                 | 8             | 16QAM      | 789.00                                            | 789.99                                          |
|                  | To                       |               |            |                                                   |                                                 |
|                  | 28.25028                 |               |            |                                                   |                                                 |
| Right            | 27.55056                 | 8             | 64QAM      | 789.20                                            | 789.45                                          |
|                  | To                       |               |            |                                                   |                                                 |
|                  | 28.25028                 |               |            |                                                   |                                                 |

#### 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 8 carrier bandwidth of the AEUB is defined as follows. The individual carriers, 97.5 MHz maximum, are spaced 99.96 MHz apart and do not overlap. The overall signal bandwidth for 4 adjacent carriers is depicted in Figure 4.3.1.1. The formula for calculated Aggregated Bandwidth for N carriers is:

$$\text{Calculated Bandwidth} = 99.96(N-1) + 97.5$$

Where 99.96 MHz is the spacing between carrier centers and 97.5 is the individual Signal Bandwidth

#### Results

For N=8-The Calculated Bandwidth is 797.22 MHz. The maximum measured value was 789.99 MHz

For N=7-The Calculated Bandwidth is 697.26MHz. The maximum measured value was 690.5 MHz

For N=6-The Calculated Bandwidth is 597.3 MHz. The maximum measured value was 589.67 MHz

For N=5-The Calculated Bandwidth is 497.34MHz. The maximum measured value was 492.42 MHz

The following calculated values will be used for the emissions designators.

$$\text{Total Carrier Aggregation Bandwidth} = (n-1)(99.96 \text{ MHz}) + 97.5 \text{ MHz}$$

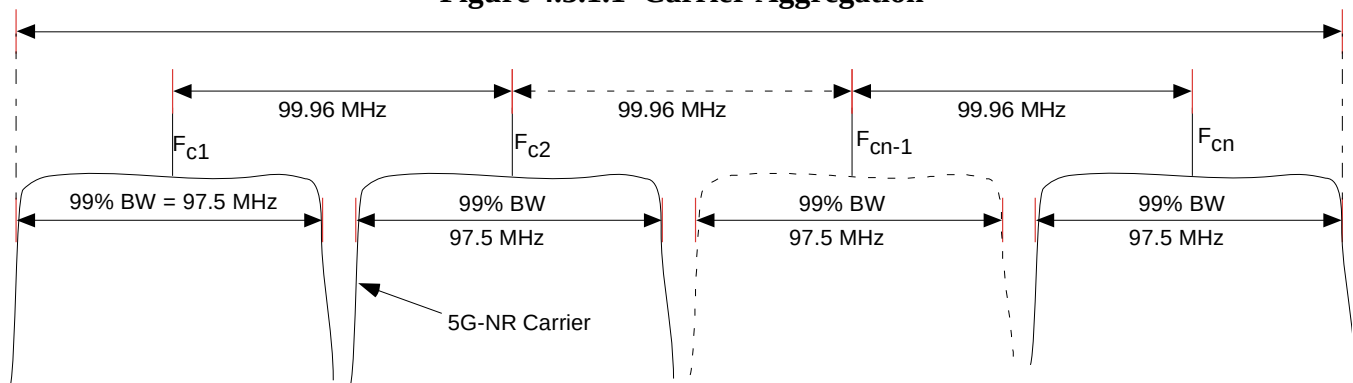
$$5 \text{ carrier} = (5-1)(99.96 \text{ MHz}) + 97.5 \text{ MHz} = 497.3 \text{ MHz} = 498\text{MG7W}$$

$$6 \text{ carrier} = (6-1)(99.96 \text{ MHz}) + 97.5 \text{ MHz} = 597.3 \text{ MHz} = 598\text{MG7W}$$

$$7 \text{ carrier} = (7-1)(99.96 \text{ MHz}) + 97.5 \text{ MHz} = 697.3 \text{ MHz} = 698\text{MG7W}$$

$$8 \text{ carrier} = (8-1)(99.96 \text{ MHz}) + 97.5 \text{ MHz} = 797.2 \text{ MHz} = 798\text{MG7W}$$

Figure 4.3.1.1 Carrier Aggregation

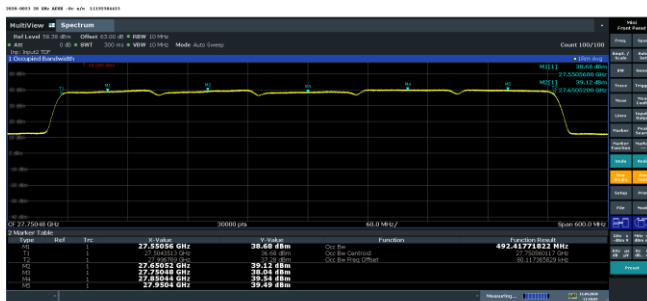


Carrier Aggregation nx(97M5)  
WSM 11-05-19

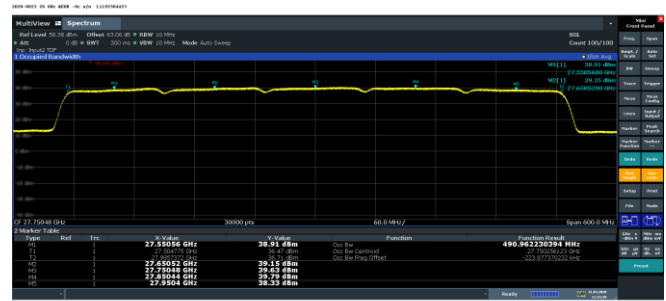
Figure 4.3.1- Occupied Bandwidth - Typical Signal Bandwidth

99% Signal Bandwidth  
5 Carrier QPSK  
Horizontal

10 MHz RBW



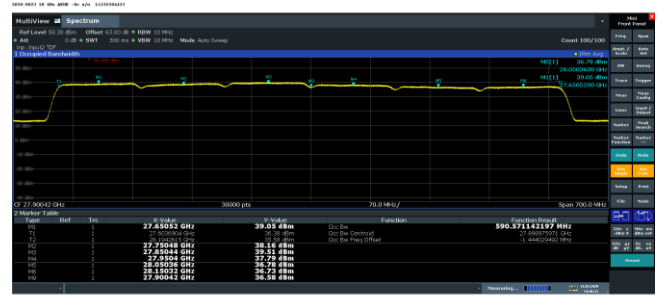
Vertical



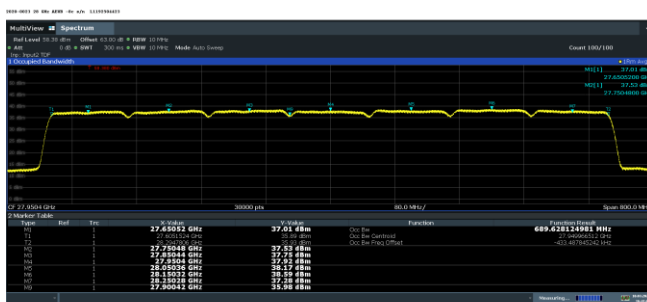
6 Carrier -16QAM  
Horizontal



Vertical



7 Carrier -64QAM  
Horizontal



Vertical

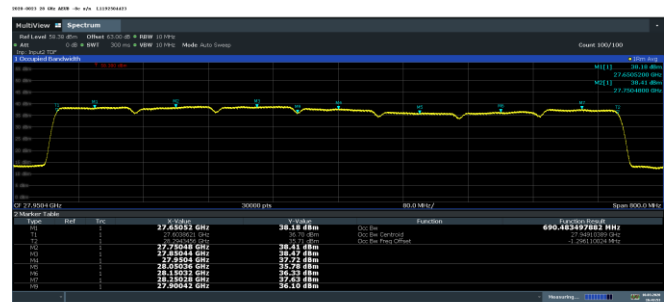
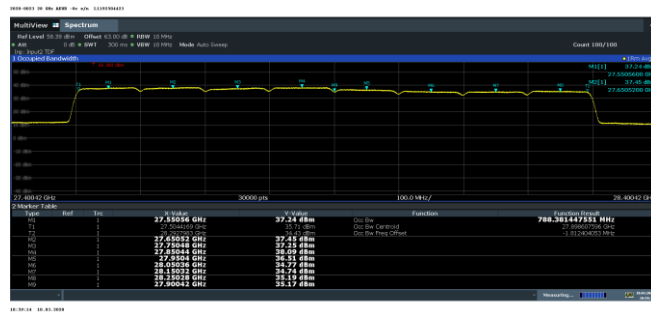


Figure 4.3.1 *continued*- Occupied Bandwidth - Typical Signal Bandwidth

99% Signal Bandwidth

10 MHz RBW

8 Carrier QPSK  
Horizontal



Vertical



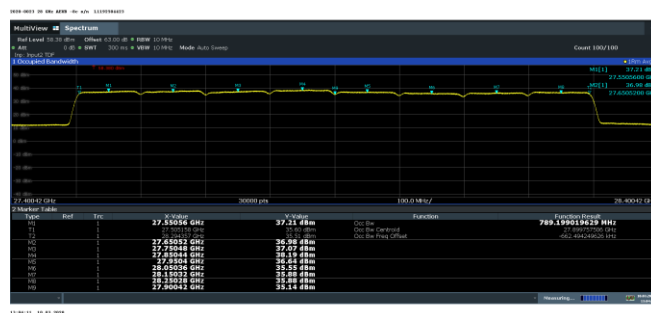
8 Carrier -16QAM  
Horizontal



Vertical



8 Carrier -64QAM  
Horizontal



Vertical



#### 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 **2AD8UAEUB01** 28 GHz Radio Unit presently supports 5G-New Radio LTE TDD technologies. This evaluation addresses 2x2 MIMO operation with one through eight 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 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 edge of band measurements performed at the specified resolution bandwidth of 1 MHz. The following relationship was used to provide the correct level different resolution bandwidths..

$$10*\log (\text{Resolution Bandwidth/ Transmit Bandwidth}) = \text{Signal Offset (1)}$$

#### 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 Table 4.3.6 below. 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. 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 and correction factors used for the measurement distance of 4 m including the AEUB product gain.

**Table 4.3.6 - OOBE Offset and Correction Factors for 4m Measurement Distance**

| Freq. | Free Space Path Loss, PL | Measurement Antenna Gain, G1 | Measurement Cable Loss, L1 | Offset for Channel Power PL-G1+L1 | AEUB Antenna Gain | Total | Offset for OOBE | OOBE Transducer Factor |
|-------|--------------------------|------------------------------|----------------------------|-----------------------------------|-------------------|-------|-----------------|------------------------|
| GHz   | dB                       | dBi                          | dB                         | dB                                | dBi- IEEE         | dB    | dB              | dB                     |
| 26.00 | 72.78                    | 22.81                        | 12.58                      | 62.56                             | 27.2              | 35.36 | 34.5            | 0.856                  |
| 26.50 | 72.95                    | 22.91                        | 12.61                      | 62.65                             | 27.5              | 35.15 | 34.5            | 0.652                  |
| 27.00 | 73.11                    | 22.82                        | 12.63                      | 62.92                             | 27.9              | 35.02 | 34.5            | 0.518                  |
| 27.50 | 73.27                    | 23.25                        | 12.77                      | 62.79                             | 28.2              | 34.59 | 34.5            | 0.086                  |
| 28.00 | 73.43                    | 23.12                        | 12.90                      | 63.21                             | 28.5              | 34.71 | 34.5            | 0.207                  |
| 28.50 | 73.58                    | 23.42                        | 13.03                      | 63.19                             | 28.7              | 34.49 | 34.5            | -0.014                 |
| 29.00 | 73.73                    | 23.50                        | 13.15                      | 63.39                             | 29.0              | 34.39 | 34.5            | -0.114                 |
| 29.50 | 73.88                    | 23.66                        | 13.26                      | 63.48                             | 28.7              | 34.78 | 34.5            | 0.279                  |
| 30.00 | 74.03                    | 23.64                        | 13.36                      | 63.74                             | 28.5              | 35.24 | 34.5            | 0.742                  |
| 30.50 | 74.17                    | 23.83                        | 13.51                      | 63.84                             | 26.0              | 37.84 | 34.5            | 3.345                  |

**OOBE Correction Factors** = Free Space Path Loss – Measurement Antenna Gain + Cable Loss – Product Gain.

The following sample calculation is the correction for 30 GHz;

Sample calculation at 30 GHz: Correction = 74.03 dB -23.64dBi + 13.36dB – 28.5 dBi = 35.24 dB  
= Offset Value (34.5 dB) + Transducer Factor (0.742 dB)

All measurements were made using a flat offset of 34.5 dB and the transducer factor from the Table 4.3.6.

#### 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 =  $\frac{1}{2}$  the Resolution Bandwidth of the measurement were not used.

##### 4.3.7.1 Results - Occupied Bandwidth-Edge of Block Emissions

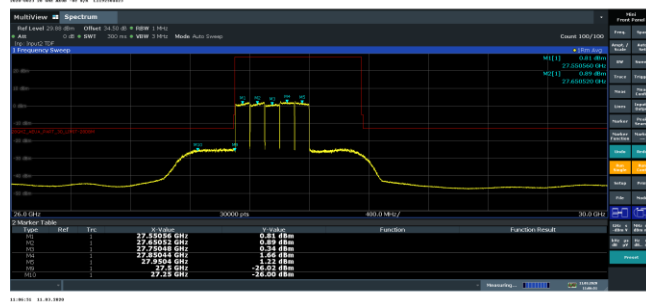
The occupied bandwidth plots for operation at the left side, center and the right side of the band for the 100 MHz signal bandwidth are below. The mask accurately depicts the limits for the Part 30 NAR Band to determine compliance with FCC requirements. The mask limits include the appropriate considerations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

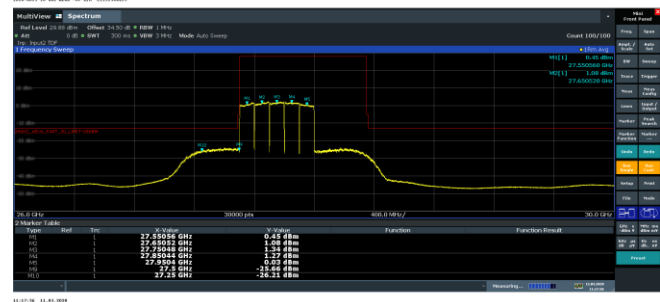
The measurement results of the occupied bandwidth and the out-of-band emissions as documented in the plots and Table 4.3.7.1 demonstrate the full compliance with the Rules of the Commission for the operating band.

Figure 4.3.7.1 - Occupied Bandwidth - OOBE/EoB Band

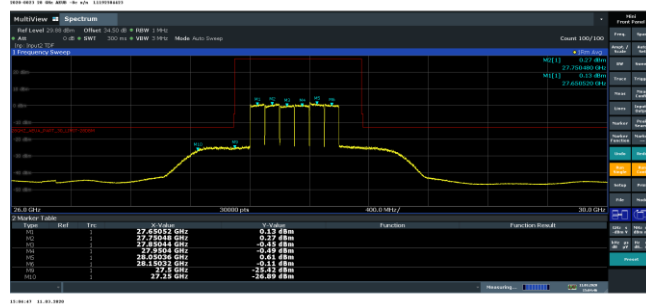
### Left Side of Band - Five Carrier - QPSK OOBE/EoB – Horizontal Polarization



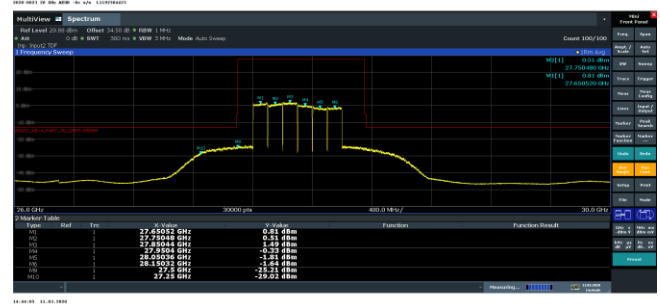
### OOBE/EoB – Vertical Polarization



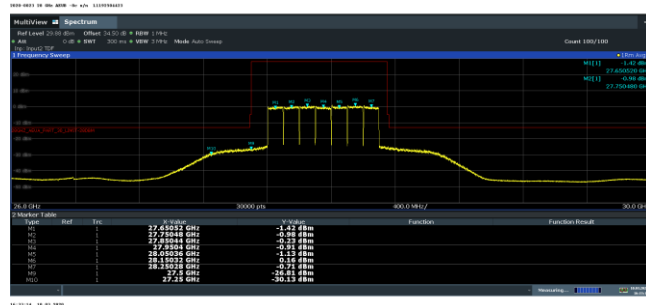
### Middle of Band – Six Carrier - 16QAM OOBE/EoB – Horizontal Polarization



### OOBE/EoB – Vertical Polarization



### Right Side of Band - Seven Carrier - 64QAM OOBE/EoB – Horizontal Polarization



### OOBE/EoB – Vertical Polarization

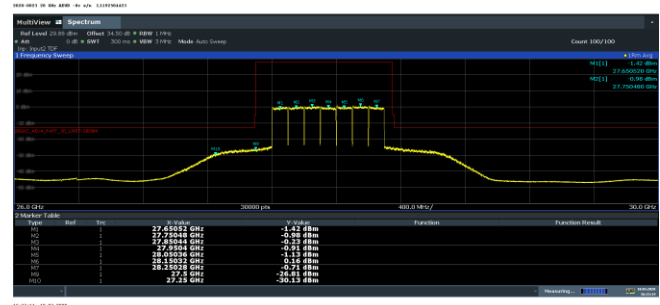
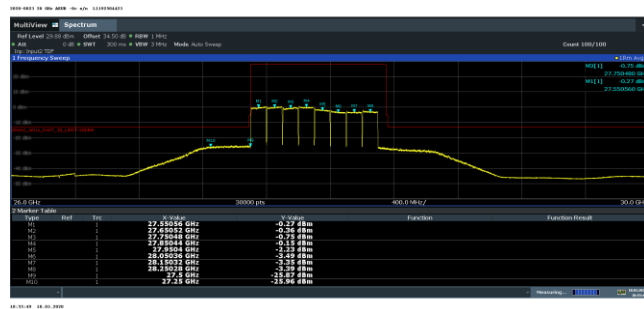


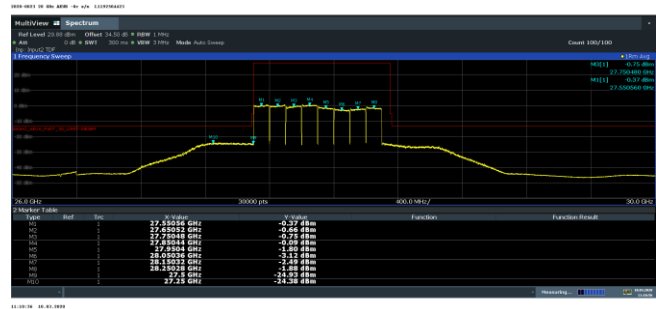
Figure 4.3.7.1 - continued-

## Occupied Bandwidth - OOB/EoB Band

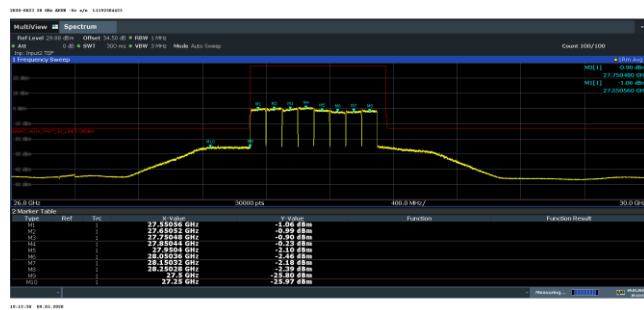
### Eight Carrier - QPSK OOB/EoB – Horizontal Polarization



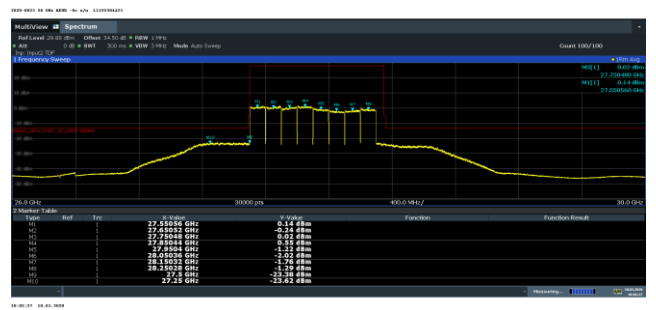
### OOB/EoB – Vertical Polarization



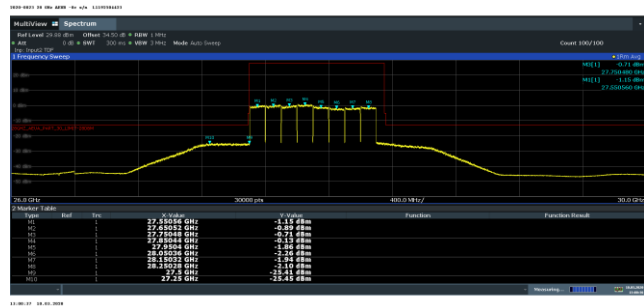
### Eight Carrier - 16QAM OOB/EoB – Horizontal Polarization



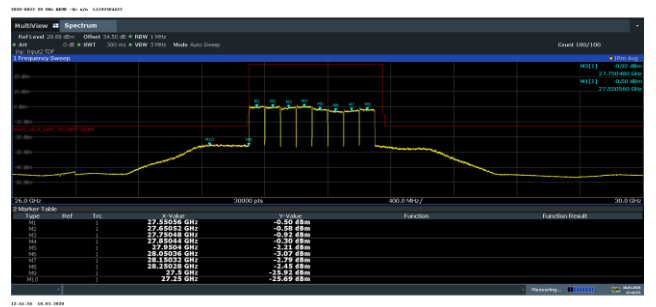
### OOB/EoB – Vertical Polarization



### Eight Carrier - 64QAM OOB/EoB – Horizontal Polarization



### OOB/EoB – Vertical Polarization



#### 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  $> 2 \times \text{Span/RBW}$ . The ESU spectrum analyzer measurements examine the 30 MHz to 40 GHz range. The FSW based mmWave transmitter 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.

#### 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 **2AD8UAEUB01** (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 tower 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 forward beam transmit configuration to transmit two 57dBm EIRP 100 MHz bandwidth 5G-NR beams. The beams, one Vertical and one Horizontal polarization, consisting of eight 100 MHz carriers with the total transmit power of 60 dBm EIRP. This configuration provides the widest 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**

| Test Configuration<br>NRARFCN | AEUB Tx Reference Frequencies<br>GHz | Transmit Active Polarization | Signal Bandwidth, MHz | Modulation | Total Power, dBm EIRP | Radiated Emissions Pass / Fail |
|-------------------------------|--------------------------------------|------------------------------|-----------------------|------------|-----------------------|--------------------------------|
| 2071665<br>To<br>2084165      | 27.54996,<br>To<br>28.29996          | H & V                        | 100                   | 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

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

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:

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

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.

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

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

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

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

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 85 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 349 degrees azimuth, and nominal elevations 186 cm. 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 349 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 >97 scans recorded of the emissions. The plots presented for emissions above 40 GHz are the maximum levels and provide the clearest representation for emissions in these bands.

#### 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 # of 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”  $\geq 2(\text{Span}/\text{RBW})$ . The FSW-85 is capable of 100,001 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 4.5 m .**

| Frequency | $\lambda$ | Measurement Distance, d | Path Loss | Measurement Antenna Gain | IF Cable Loss | Emissions Correction Total |
|-----------|-----------|-------------------------|-----------|--------------------------|---------------|----------------------------|
| GHz       | m         | m                       | dB        | dB                       | dB            | dB                         |
| 40.0      | 0.007500  | 4.5                     | 77.55     | 21.80                    | 1.03          | 56.78                      |
| 42.5      | 0.007059  | 4.5                     | 78.07     | 22.20                    | 1.03          | 56.90                      |
| 45.0      | 0.006667  | 4.5                     | 78.57     | 22.50                    | 1.03          | 57.10                      |
| 47.5      | 0.006316  | 4.5                     | 79.04     | 22.70                    | 1.03          | 57.37                      |
| 50.0      | 0.006000  | 4.5                     | 79.49     | 23.00                    | 1.03          | 57.52                      |
| 52.5      | 0.005714  | 4.5                     | 79.91     | 23.30                    | 1.03          | 57.64                      |
| 55.0      | 0.005455  | 4.5                     | 80.31     | 23.40                    | 1.03          | 57.94                      |
| 57.5      | 0.005217  | 4.5                     | 80.70     | 23.60                    | 1.03          | 58.13                      |
| 60.0      | 0.005000  | 4.5                     | 81.07     | 23.70                    | 1.03          | 58.40                      |

**Table 4.5.2.4b Radiated Emissions Corrections for 60-90 GHz at 4.5 m.**

| Frequency | $\lambda$ | Measurement Distance, d | Path Loss | Measurement Antenna Gain | IF Cable Loss | Emissions Correction Total |
|-----------|-----------|-------------------------|-----------|--------------------------|---------------|----------------------------|
| GHz       | m         | m                       | dB        | dB                       | dB            | dB                         |
| 60.0      | 0.005000  | 4.5                     | 81.07     | 21.80                    | 1.03          | 60.299                     |
| 65.0      | 0.004615  | 4.5                     | 81.76     | 22.30                    | 1.03          | 60.494                     |
| 70.0      | 0.004286  | 4.5                     | 82.41     | 22.70                    | 1.03          | 60.738                     |
| 75.0      | 0.004000  | 4.5                     | 83.01     | 23.00                    | 1.03          | 61.037                     |
| 80.0      | 0.003750  | 4.5                     | 83.57     | 23.40                    | 1.03          | 61.198                     |
| 85.0      | 0.003529  | 4.5                     | 84.09     | 23.60                    | 1.03          | 61.524                     |
| 90.0      | 0.003333  | 4.5                     | 84.59     | 23.80                    | 1.03          | 61.821                     |

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

| Frequency | $\lambda$ | Measurement Distance, d | Path Loss | Measurement Antenna Gain | IF Cable Loss | Emissions Correction Total |
|-----------|-----------|-------------------------|-----------|--------------------------|---------------|----------------------------|
| GHz       | m         | m                       | dB        | dB                       | dB            | dB                         |
| 90.0      | 0.003333  | 3                       | 81.07     | 21.90                    | 1.03          | 60.20                      |
| 95.0      | 0.003158  | 3                       | 81.54     | 22.20                    | 1.03          | 60.27                      |
| 100.0     | 0.003000  | 3                       | 81.98     | 22.60                    | 1.03          | 60.41                      |
| 105.0     | 0.002857  | 3                       | 82.41     | 23.00                    | 1.03          | 60.49                      |
| 110.0     | 0.002727  | 3                       | 82.81     | 23.30                    | 1.03          | 60.54                      |
| 115.0     | 0.002609  | 3                       | 83.20     | 23.63                    | 1.03          | 60.63                      |
| 120.0     | 0.002500  | 3                       | 83.57     | 23.83                    | 1.03          | 60.75                      |
| 125.0     | 0.002400  | 3                       | 83.92     | 24.00                    | 1.03          | 60.90                      |
| 130.0     | 0.002308  | 3                       | 84.26     | 24.20                    | 1.03          | 61.11                      |
| 135.0     | 0.002222  | 3                       | 84.59     | 24.40                    | 1.03          | 61.27                      |
| 140.0     | 0.002143  | 3                       | 84.91     | 24.50                    | 1.03          | 61.44                      |

#### 4.5.3 Field Strength of Spurious Radiation Results:

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.

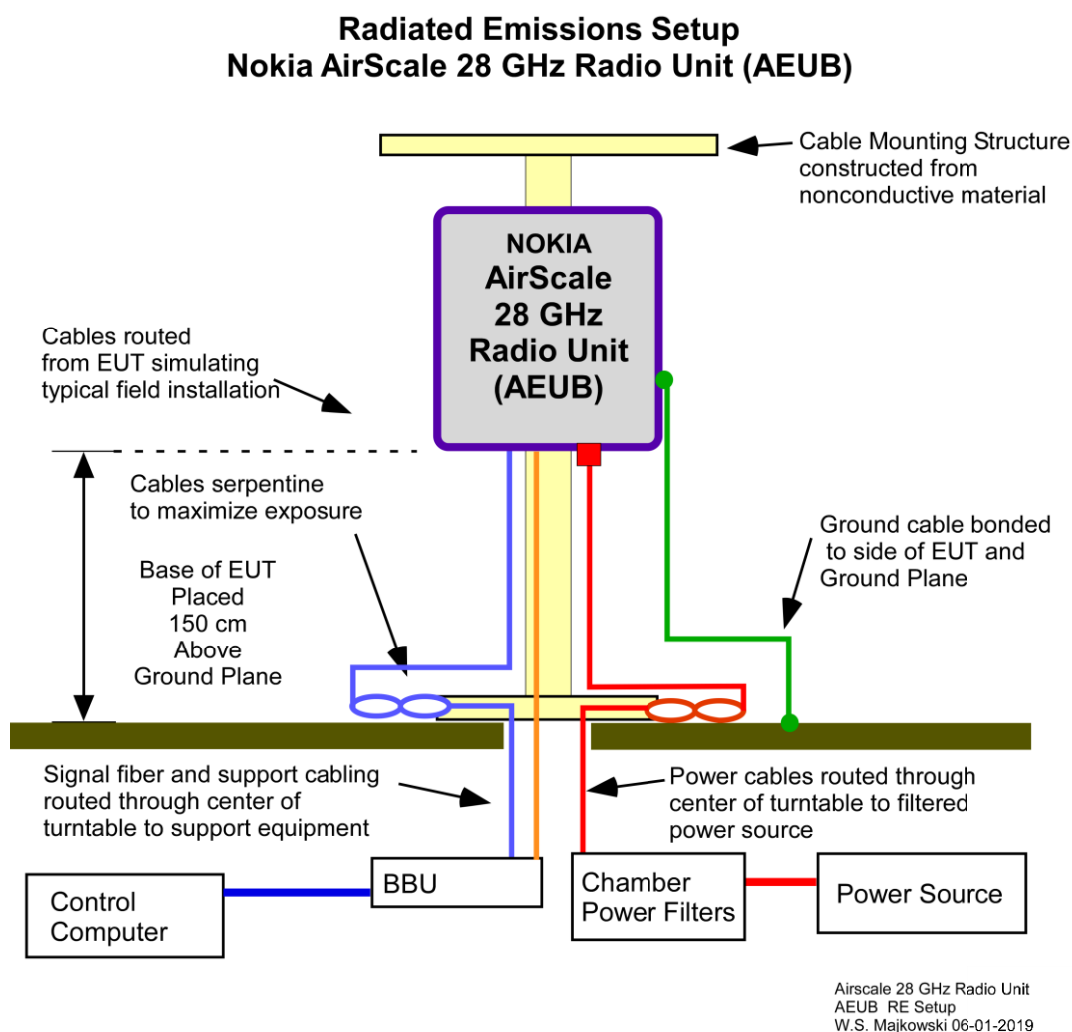
Reportable emissions were only found in the 30 GHz to 40 GHz frequency range where there was insufficient dynamic range to document 20 dB margin to the 82.23 dBm limit. The worst case emissions at 29286.568 MHz demonstrated -10.71 dB of margin to the Part 30 Limit.

Presented results include that range and the three mmWave bands as measured with a 1 MHz Resolution Bandwidth. 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 (AEUB) Band 30, FCC ID: VBN2AD8UAEUB01**, 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

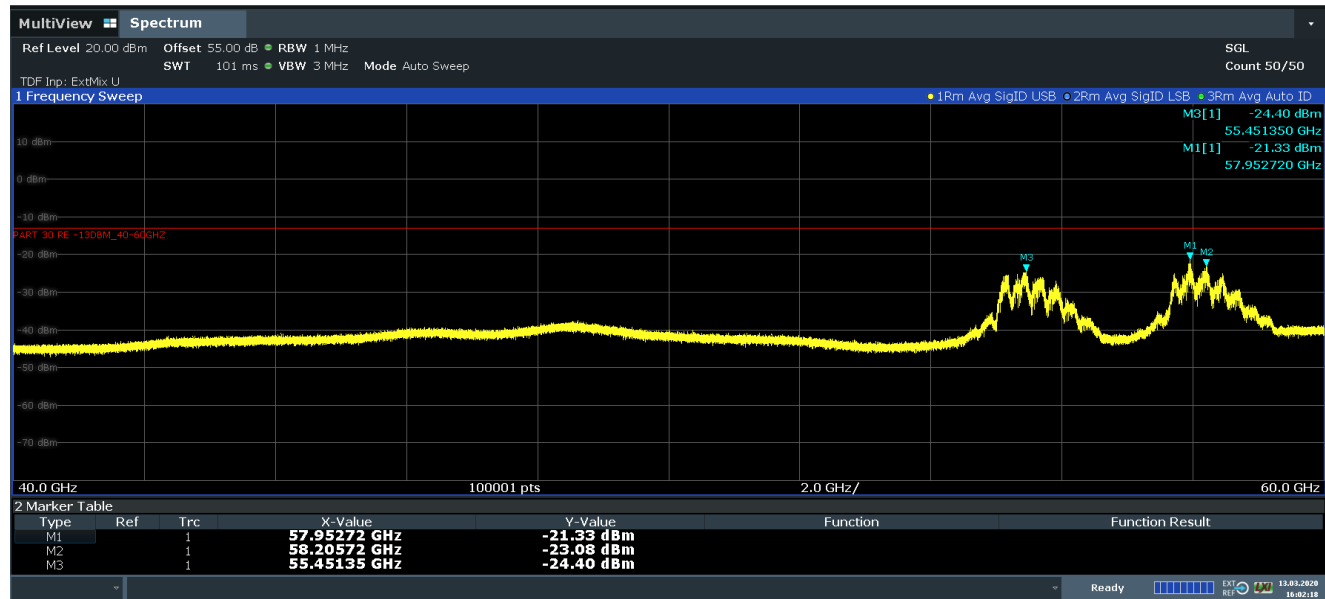




## Maximum Measured Radiated Emissions -U Band 40GHz-60GHz FCC B Part 30

### Vertical Polarization - 1 MHz RBW

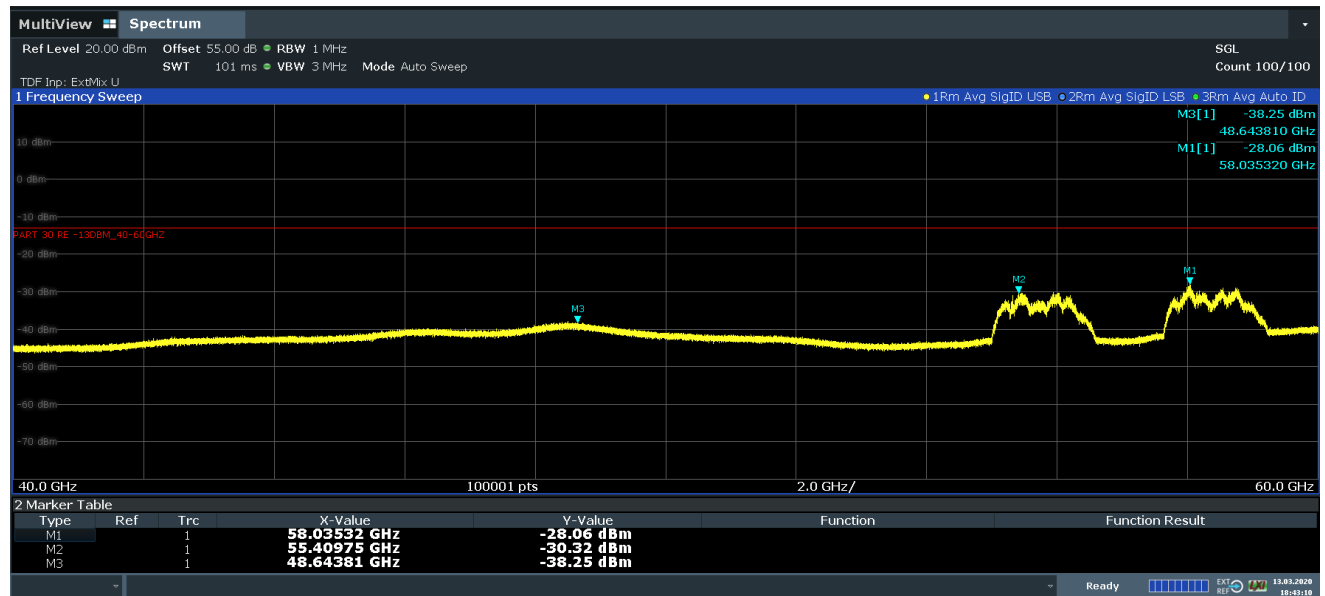
2020-0023 28 GHz AEUB -8c s/n L1192504423



16:02:19 13.03.2020

### Horizontal Polarization - 1 MHz RBW

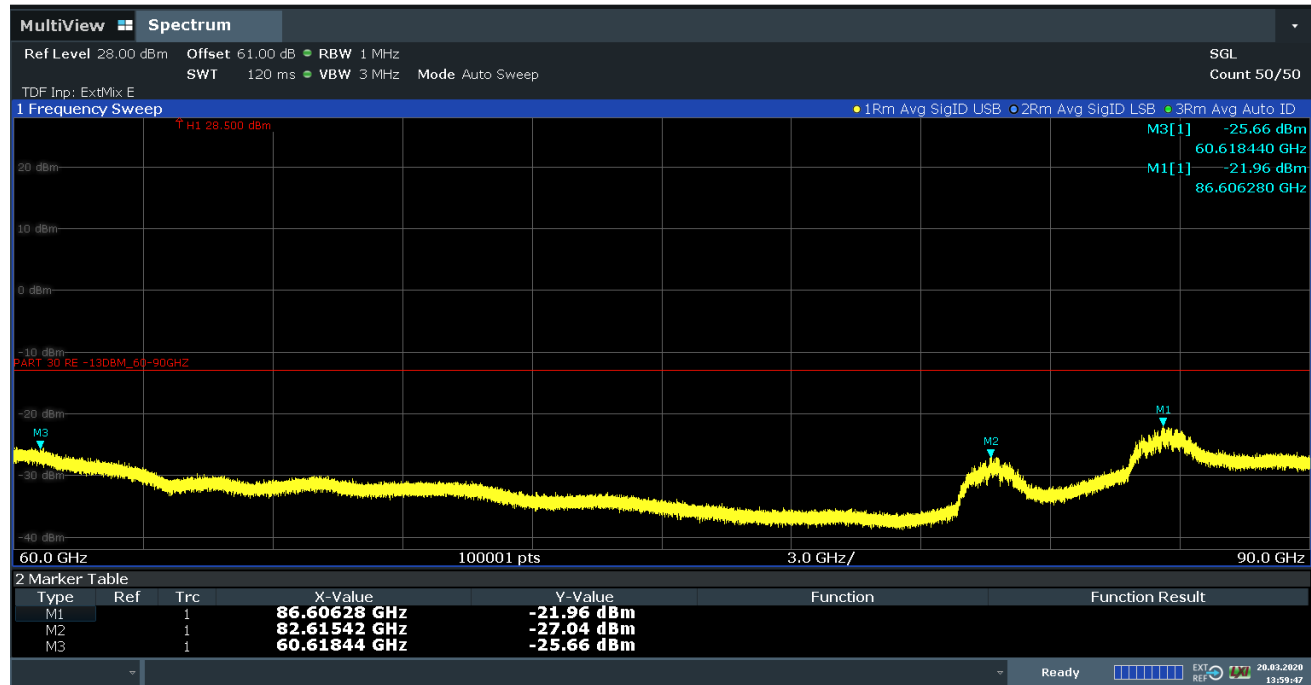
2020-0023 28 GHz AEUB -8c s/n L1192504423



10:43:11 13.03.2020

## Maximum Measured Radiated Emissions -E Band 60GHz-90GHz FCC B Part 30 Vertical Polarization - 1 MHz RBW

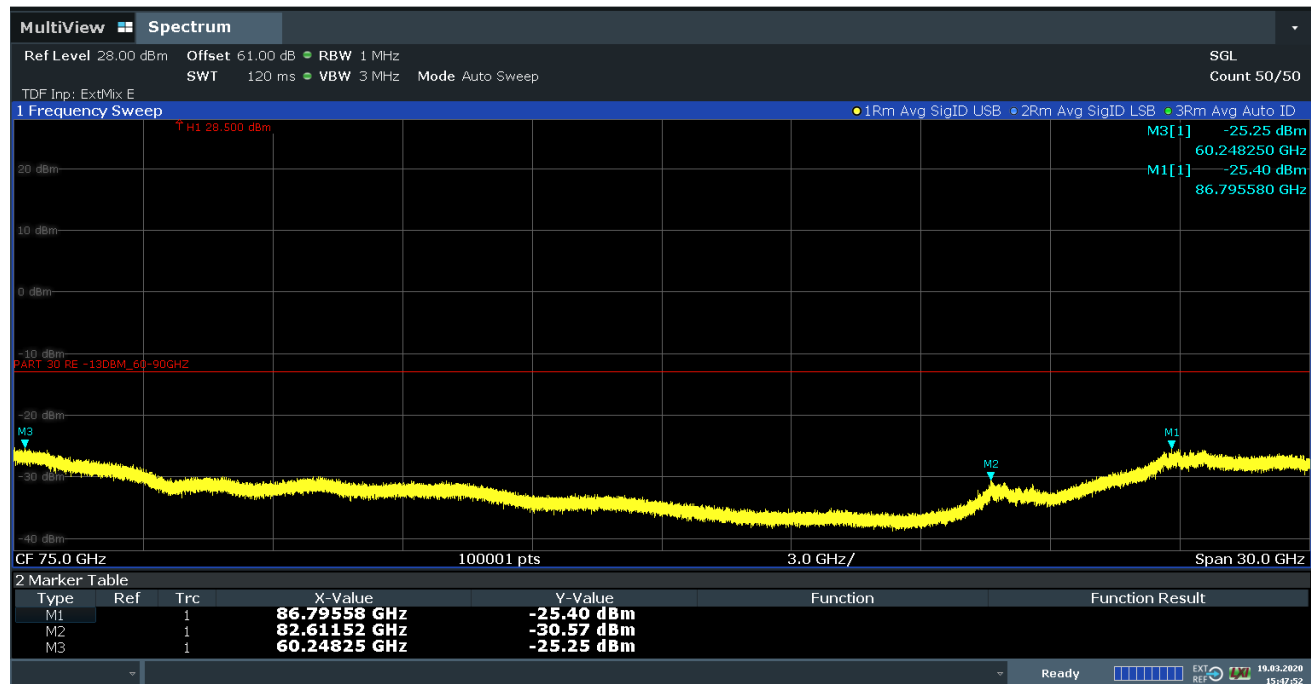
2020-0023 28 GHz AEUB -8c s/n L1192504423



13:59:48 20.03.2020

## Horizontal Polarization - 1 MHz RBW

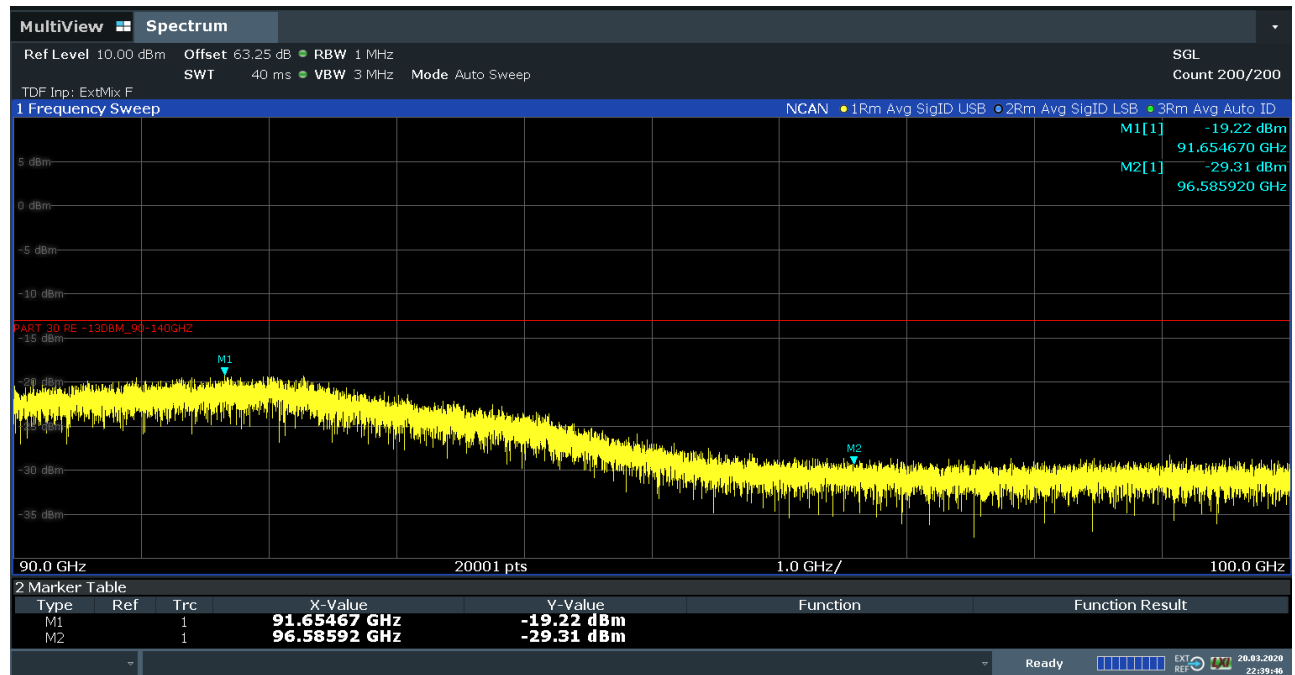
2020-0023 28 GHz AEUB -8c s/n L1192504423



15:47:52 19.03.2020

## Maximum Measured Radiated Emissions -F Band 90GHz-100GHz FCC B Part 30 Vertical Polarization - 1 MHz RBW

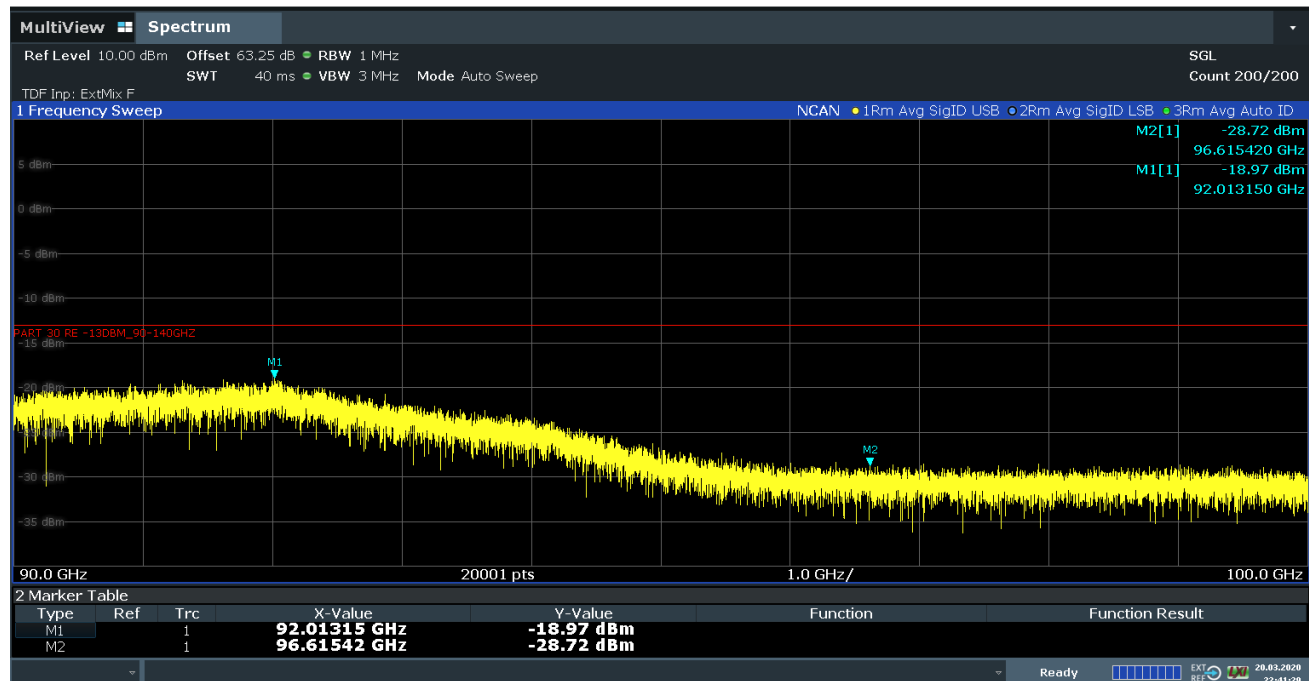
2020-0023 28 GHz AEUB -8c s/n L1192504423



22:39:46 20.03.2020

## Horizontal Polarization - 1 MHz RBW

2020-0023 28 GHz AEUB -8c s/n L1192504423



22:41:30 20.03.2020

#### **4.6 Section 2.1055 MEASUREMENT - NOT REQUIRED -FREQUENCY STABILITY**

The measurement of frequency stability was performed during the original filing tests. There has been no change to the frequency generating and stabilizing circuitry. Additional frequency stability testing is therefore not required. The original results are below:

##### **4.6.1 Frequency Stability Results:**

The worst case Frequency Stability over temperature and voltage for the product with DC power was - **645.61 Hz** which is **-0.0231 ppm**.

The worst case Frequency Stability over temperature and voltage for the product with AC power was - **648.06 Hz** which is **-0.0232 ppm**.

This are within the +/- 0.05ppm desired performance required for 5G-NR operation.

## 4.7 LIST OF TEST EQUIPMENT

### 4.7.1 List of Radiated Emissions and Radio Radio Measurements 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                 |
|------------------------|----------------------------|-------------------------|-------------------------------------|----------------|------------|----------------------------------------|------------|--------------------------|
| <a href="#">E1328</a>  | A-Info                     | Horn Antenna            | 26.5-40GHz<br>WR28 dB               | LB-28-25-C2-KF | J202023250 | 2018-10-16                             | 2021-10-16 | Requires Calibration     |
| <a href="#">E1363</a>  | A-Info                     | Horn Antenna            | 26.5-40GHz<br>WR28 dB               | LB-28-25-C2-KF | J202062675 | 2018-10-16                             | 2021-10-16 | Requires Calibration     |
| <a href="#">E1373</a>  | A-Info                     | Horn Antenna            | 26.5-40GHz<br>WR28 dB               | LB-28-25-C2-KF | J202062735 | 2018-12-05                             | 2021-12-05 | Requires Calibration     |
| <a href="#">E950</a>   | Agilent Technologies       | Power Meter             | P-Series                            | N1911A         | MY45101984 | 2018-03-29                             | 2020-03-29 | Requires Calibration     |
| <a href="#">E949</a>   | Agilent Technologies       | Power Sensor            | -35 - +20 dBm<br>0.05 -18 GHz       | N1921A         | MY45242502 | 2018-04-02                             | 2020-04-02 | Requires Calibration     |
| <a href="#">E1356</a>  | Hewlett Packard            | Pre-Amplifier           | Pre-Amplifier<br>1-26.5GHz          | 8449B          | 3008A01353 | 2018-09-10                             | 2020-09-10 | Requires Calibration     |
| <a href="#">E447</a>   | Hewlett Packard            | Pre-Amplifier           | Pre-amplifier<br>1-26.5 GHz         | 8449B          | 3008A01384 | 2018-04-10                             | 2020-04-10 | Requires Calibration     |
| <a href="#">E602</a>   | A.H. Systems Inc.          | Biological Antenna      | 25 - 2000 MHz                       | SAS-521-2      | 410        | 2019-02-11                             | 2021-02-11 | Requires Calibration     |
| <a href="#">E1255</a>  | ETS Lindgren               | Multi-Device Controller |                                     | 2090           | 00078509   |                                        |            | Calibration Not Required |
| <a href="#">E1338r</a> | KeySight Technologies      | MXA Signal Analyzer     | 10 Hz-44 GHz                        | N9020B         | MY57431033 | 2018-08-2                              | 2018-08-22 | Requires Calibration     |
| <a href="#">E1264</a>  | KeySight Technologies      | PSG Signal Generator    | Analog Sig<br>Gen 100kHz-<br>67 GHz | E8257D         | MY53402943 | 2017-08-28                             | 2019-08-28 | Requires Calibration     |
| <a href="#">E485</a>   | Kikusui                    | Power Supply            | DC 55 Volts<br>120 Amps             | PAD 55-120L    | DL000416   |                                        |            | Verification             |
| <a href="#">E1315</a>  | RS Microwave Company, Inc. | Microwave Filter        |                                     | P/N 60733A     | 007        |                                        |            | Verification             |
| <a href="#">E1308</a>  | Rohde & Schwarz            | Harmonic Mixer          | Down Converter<br>90-140GHz         | FS-Z140        | 101008     | 2017-04-06<br>in Service<br>2018-07-01 |            | Factory                  |
| <a href="#">E1311</a>  | Rohde & Schwarz            | Harmonic Mixer          | Down Converter<br>40-60GHz          | FS-Z60         | 100977     | 2017-12-21<br>in Service<br>2018-07-01 |            | Factory                  |
| <a href="#">E1312</a>  | Rohde & Schwarz            | Harmonic Mixer          | Down Converter<br>60-90GHz          | FS-Z90         | 101719     | 2017-08-09<br>in Service<br>2018-07-01 |            | Factory                  |
| <a href="#">E907</a>   | Rohde & Schwarz            | Test Receiver           | 20 Hz-40 GHz                        | ESIB40         | 100101     | 2018-04-17                             | 2020-04-17 | Requires Calibration     |
| <a href="#">EIH69</a>  | Rohde & Schwarz            | Test Receiver           | 20 Hz-40 GHz                        | ESU40          | 100247     | 2018-05-22                             | 2020-05-22 | Requires Calibration     |
| <a href="#">E1384</a>  | Rohde & Schwarz            | Spectrum Analyzer       | 2 Hz - 85 GHz                       | FSW85          | 101537     | 2018-12-17                             | 2020-12-17 | Requires Calibration     |

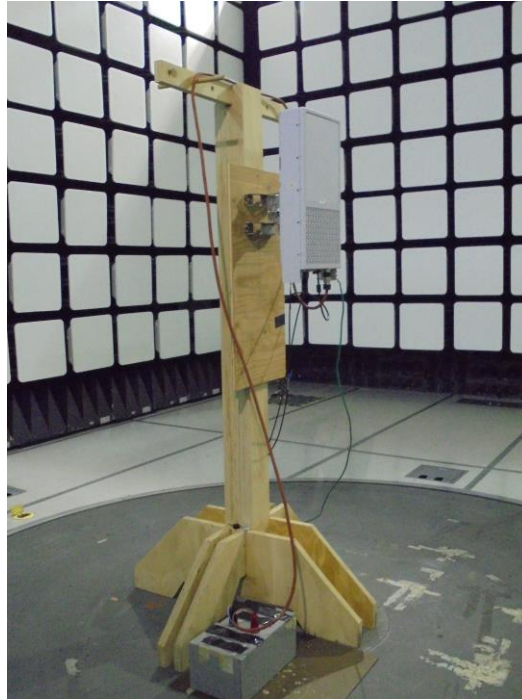
| Asset ID              | Manufacturer          | Type            | Description                                         | Model            | Serial     | Cal Date   | Cal Due    | Cal Type             |
|-----------------------|-----------------------|-----------------|-----------------------------------------------------|------------------|------------|------------|------------|----------------------|
| <a href="#">E1332</a> | Sage Millimeter, Inc. | Horn Antenna    | E-band pyramidal horn antenna - 60 to 90 GHz.       | SAR-2309-12-S2   | 14853-01   |            |            | Factory              |
| <a href="#">E1335</a> | Sage Millimeter, Inc. | Horn Antenna    | F-band pyramidal horn antenna - 90 to 140 GHz       | SAR-2309-08-S2   | 14853-02   |            |            | Factory              |
| <a href="#">E1340</a> | Sage Millimeter, Inc. | Horn Antenna    | Pyramidal horn antenna - 26.5 to 40 GHz, 25 dB gain | SAR-2507-28-S2   | 15309-01   |            |            | Factory              |
| <a href="#">E1330</a> | Sage Millimeter, Inc. | Horn Antenna    | U-band pyramidal horn antenna - 40 to 60 GHz        | SAR-2309-19-S2   | 14853-01   |            |            | Factory              |
| <a href="#">E1331</a> | Sage Millimeter, Inc. | Horn Antenna    | U-band pyramidal horn antenna - 40 to 60 GHz        | SAR-2309-19VF-R2 | 14853-01   |            |            | Factory              |
| <a href="#">E812</a>  | Sonoma Instrument Co. | Amplifier       | 9kHz-1GHz Vasona File TRANS 261                     | 310N             | 186744     | 2018-09-14 | 2020-09-14 | Requires Calibration |
| <a href="#">E980</a>  | Trilithic             | Low Pass Filter | PCS 0.01-2 GHz                                      | 10LC1790-3-AA    | PCS-LPF-12 |            |            | Verification         |
| <a href="#">E520</a>  | EMC Test Systems      | Horn Antenna    | Double Ridged Horn 18-40 GHz                        | 3116             | 2537       | 2018-08-09 | 2020-08-09 | Requires Calibration |
| <a href="#">E057</a>  | EMCO                  | Horn Antenna    | Double Ridged Horn 1-18 GHz                         | 3115             | 9006-3460  | 2017-05-24 | 2019-05-24 | Requires Calibration |
| <a href="#">E889</a>  | Weinschel             | Attenuator      | 6 dB DC-18GHz 5 Watt                                | 2-6              | BX3438     | 5/23/18    | 5/23/20    |                      |
| <a href="#">E1150</a> | Extech                | Data Logger     | Pressure Humidity Temp Data Logger                  | SD700            | Q752767    | 2019-01-16 | 2021-01-16 | Requires Calibration |

#### 4.8 PHOTOGRAPHS OF THE TEST SETUPS

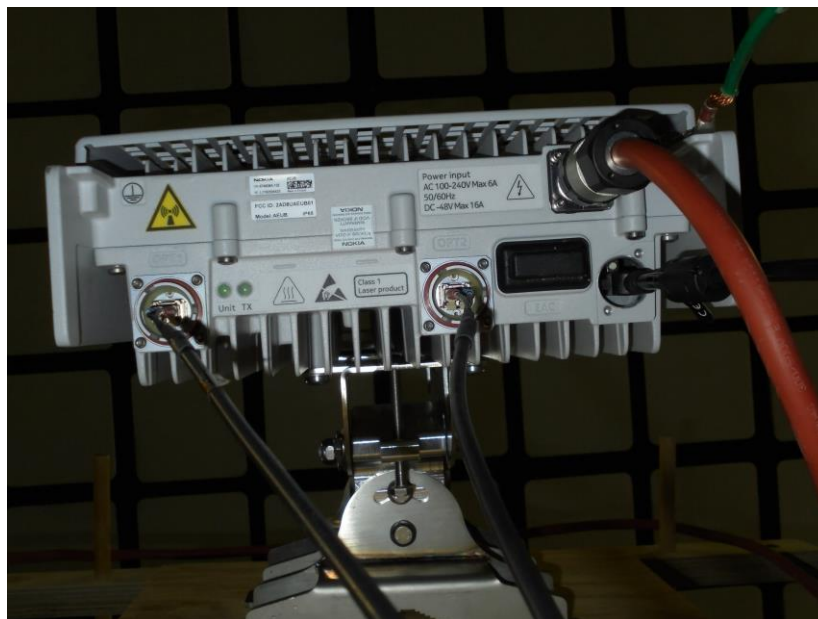
**Response:**

The photographs of the test setups for the **AirScale 28 GHz Radio Unit (AEUB) Band 30, FCC ID: 2AD8UAEUB01** are provided in the Filing exhibits.

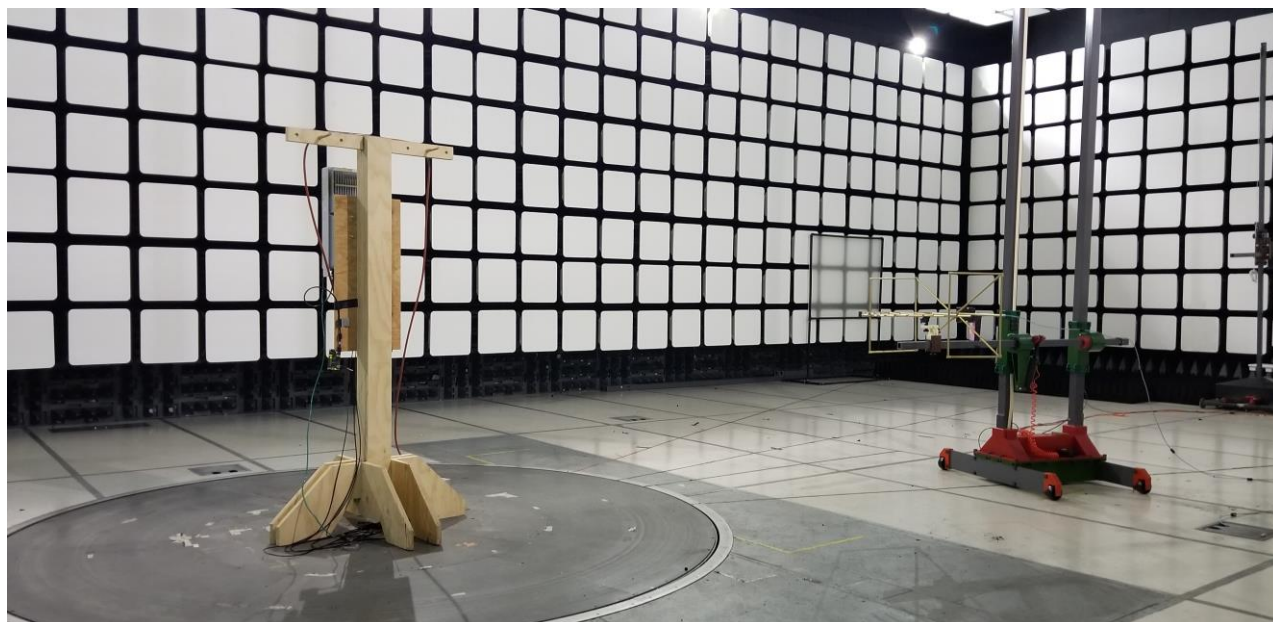
##### 4.8.1 Radiated Emissions and Radio Measurements Test Photos



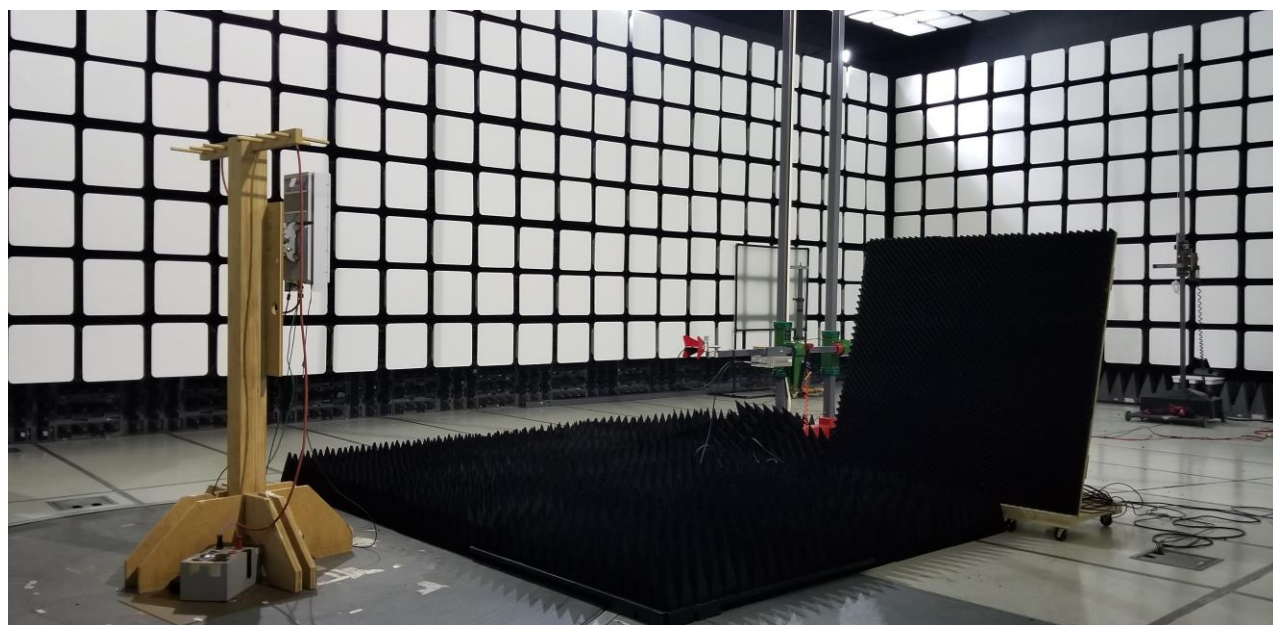
**Product Set up on Tower**



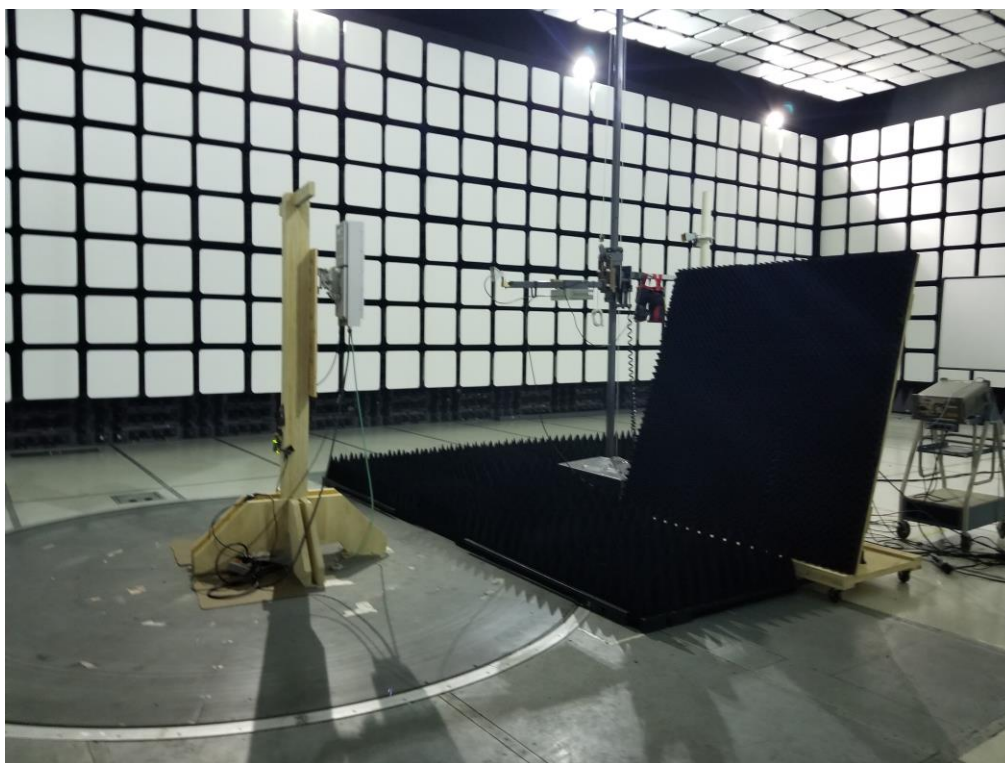
**Base of Unit**



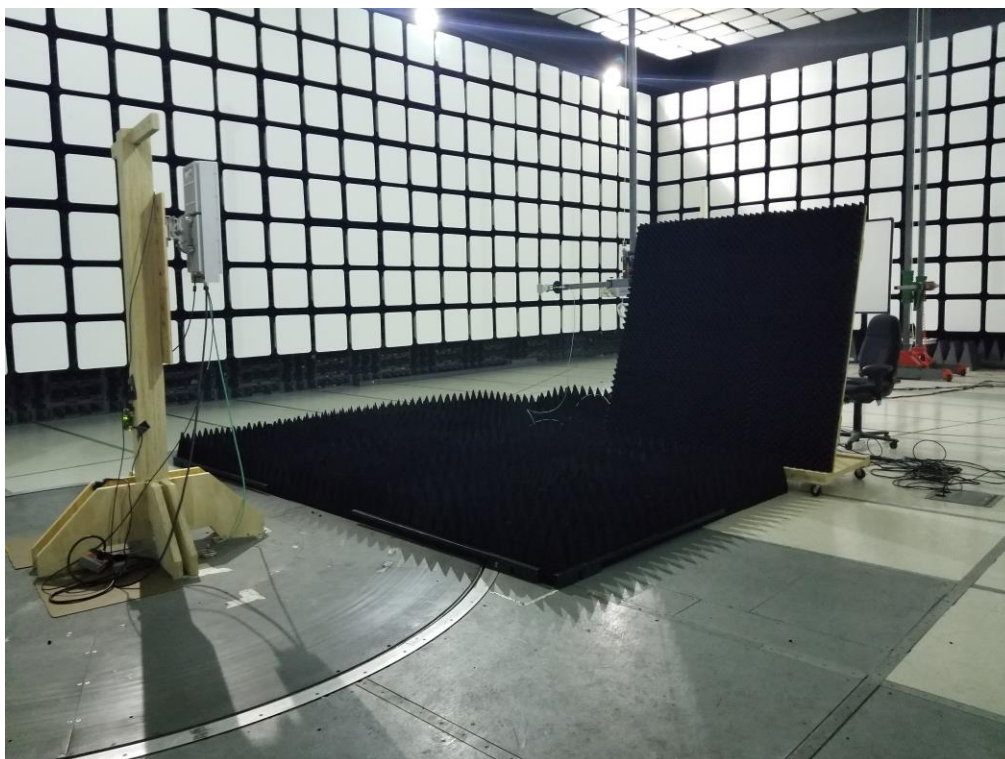
**30 MHz- 1 GHz**



**1 GHz – 18 GHz**

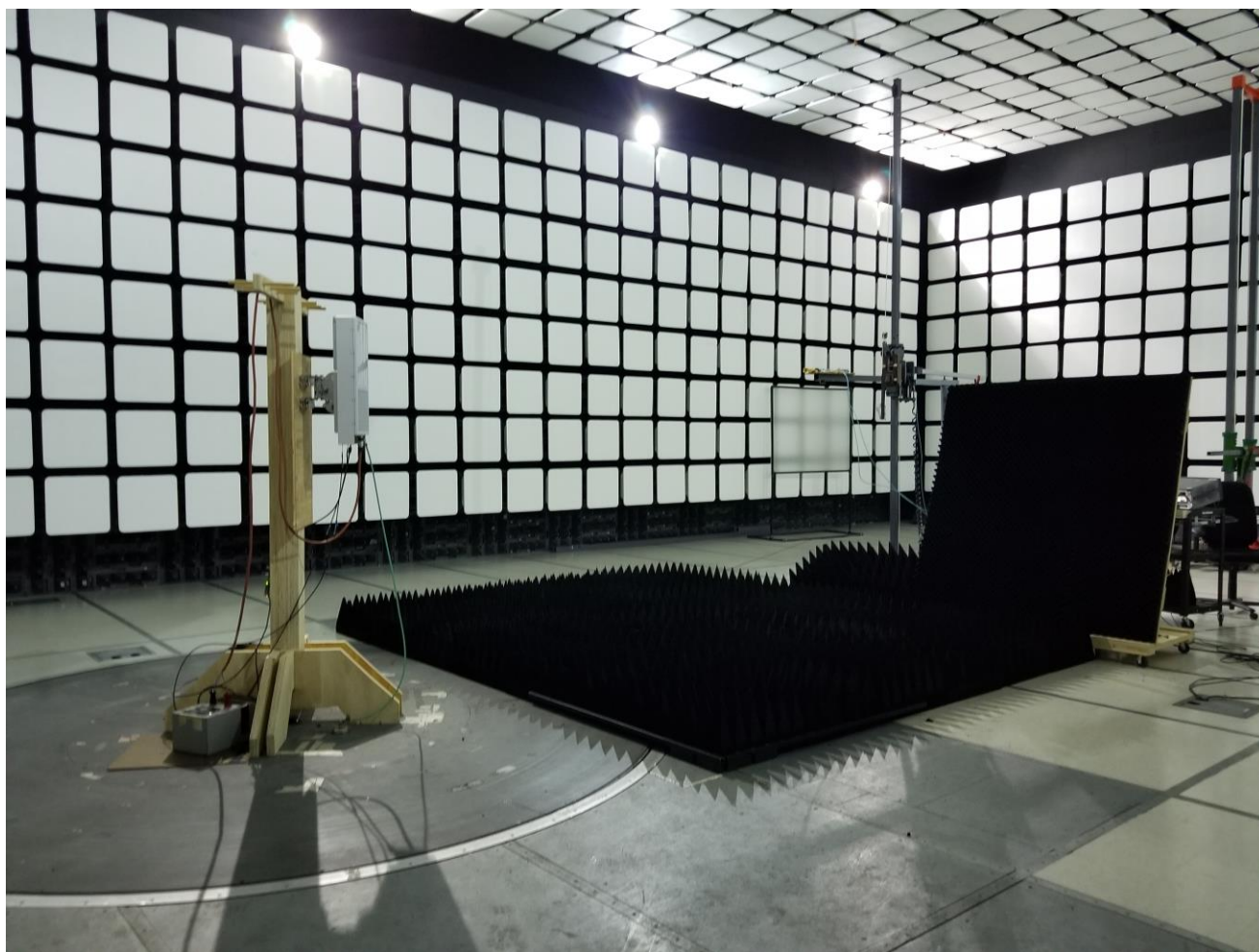


**18 GHz – 26.5 GHz**



**Radiated Radio Measurements 26.5 GHz – 40 GHz**

## Typical Radiated Emissions 40 GHz – 100 GHz



#### 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](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.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                     |                                                                                                    |                                                                                     |                                                                                                    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|
| <p>United States Department of Commerce<br/>National Institute of Standards and Technology</p> <p><b>NVLAP<sup>®</sup></b></p> <hr/> <p><b>Certificate of Accreditation to ISO/IEC 17025:2005</b></p> <hr/> <p>NVLAP LAB CODE: 100275-0</p> <p><b>Nokia, Global Product Compliance Lab</b><br/>Murray Hill, NJ</p> <p><i>is accredited by the National Voluntary Laboratory Accreditation Program for specific services,<br/>listed on the Scope of Accreditation, for:</i></p> <p><b>Electromagnetic Compatibility &amp; Telecommunications</b></p> <p><i>This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005.<br/>This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality<br/>management system (refer to joint ISO-ILAC-IAF Communiqué dated January 2009).</i></p> <table><tr><td><p>2017-08-17 through 2018-09-30</p><hr/><p>Effective Dates</p></td><td></td><td><p><i>[Signature]</i></p><hr/><p>For the National Voluntary Laboratory Accreditation Program</p></td></tr></table> |                                                                                     | <p>2017-08-17 through 2018-09-30</p> <hr/> <p>Effective Dates</p>                                  |  | <p><i>[Signature]</i></p> <hr/> <p>For the National Voluntary Laboratory Accreditation Program</p> |
| <p>2017-08-17 through 2018-09-30</p> <hr/> <p>Effective Dates</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  | <p><i>[Signature]</i></p> <hr/> <p>For the National Voluntary Laboratory Accreditation Program</p> |                                                                                     |                                                                                                    |

## **5. APPENDIX A - CALIBRATION CERTIFICATES.**

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