NOKIA Bell Labs

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

FCC Certification Part 30 Test Report

Product Evaluated

AEUA / AEUF 28 GHz 3rd Gen 8 CC
FCC ID: VBNAEUA-01

Customer

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

Test Laboratory

Nokia Bell Labs
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Date: June 5, 2020

Revisions

Date	Revision	Section	Change
6/05/2020	0		Initial Release

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6/5/2020

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1. ATTESTATION OF TEST RESULTS

Company Name	**Nokia Solutions and Networks, OY** 2000 Lucent Lane Naperville, Illinois 60563
FCC ID	**2AD8UAEUB01**
Product Name	**AEUA / AEUF 28 GHz 3rd Gen 8 CC**
Model Name	**AEUA / AEUF**
Part No	474864A.X21
Serial Number(s)	AC/DC Model: L1182710698
Test Standard(s)	• 47 CFR FCC Parts 2 • KDB 971168 D01 Power Measurement License Digital Systems v03r01 April 9, 2018 • KDB 662911 D01 Multiple Transmitter Output v02r01 Oct 2013 • KDB 842590 D01 Upper Microwave Flexible Use Service v01 – April 2019 • Procedures on TRP Compliance for Out of Band and Spurious Emissions C63.26 mmWave JTG - Version # 1 July 14th 2018
Reference(s)	• 47 CFR FCC Part 2 and Part 30 • ANSI C63.26 (2015) • ANSI C63.4 (2014) • TR 14-1001, MMW Measurements with Harmonic Mixers (April-4-2014)
Frequency Band	(Tx: 27.5 – 28.35 GHz), NR Band n261
Technology	5G-New Radio, LTE-TDD: 97M5G7W,
Test Frequency Range	10MHz – 100GHz
Operation Mode(s)	2x 57dBm EIRP, 60 dBm EIRP Total. 5 – 8 carriers MIMO
Submission Type	Class II Permissive Change
FCC Part 15 Subpart B	Compliance with Class B
Test Date	May 18, 2020 to June 5, 2020
Test Laboratory	Nokia Global Product Compliance Laboratory 600-700 Mountain Avenue, Rm 5B-108 Murray Hill, New Jersey 07974-0636 USA **NVLAP** Lab Code: 100275-0 **FCC Registration Number: 395774**

This is to certify that the above product has been evaluated and found to be in compliance with the Rules and Regulations set forth in the above standard(s). The data and the descriptions about the test setup, procedures and configuration presented in this report are accurate. The results of testing in this report apply only to the product/system which was tested. Other similar equipment will not necessarily produce the same results due to production tolerance and measurement uncertainties.

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

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

2. SUMMARY OF THE TEST RESULTS

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

Note 1: 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.

2.1 Measurement Uncertainty

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

Worst-Case Estimated Measurement Uncertainties

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

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

3. GENERAL INFORMATION

3.1 Product Descriptions

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

Table 3.1.1 Product Specifications

Specification Items	Description
Product Type	Compact Base Station LTE Module (2Tx, 2Rx), 2x2 MIMO
Radio Type	Intentional Transceiver
Power Type	115 VAC & -48 VDC
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 / polarizations. 60 dBm EIRP Total
Antenna Gain	29 dBi
Operating Mode	2x2 MIMO (2 duplex Tx/Rx Ports)
Software Version	FLF17SP
Hardware Version	474864A.X21
Serial Number	AC/DC Model: L1182710698
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 TDD Reference Center Frequencies, for n261 with 100 MHz Carriers

TDD Center Reference Frequency (GHz)	Raster Delta, MHz
27.55056	99.96
27.65052	99.96
27.75048	99.96
27.85044	99.96
27.95040	99.96
28.05036	99.96
28.15032	99.96
28.25028	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

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

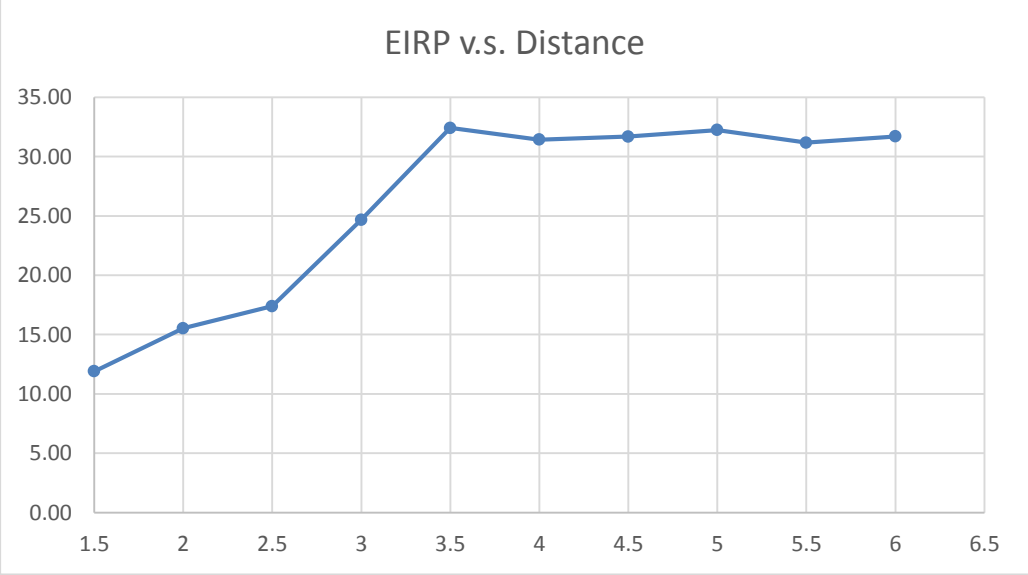
$$d_{ff} = 2D^2/\lambda$$

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

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

The Moongilan Test (1) was performed to determine the far field boundary location using calculations and low power measurements. The test experimentally determines the boundary distance for the far field.
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.
To eliminate any inconsistancy all Power, OBW and OOBE 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 Class II Authorization
2.1046, 30.202 (a)	**RF Power Output** **(a) Power Limits, EIRP, PSD**	**Yes**
2.1047,	**Modulation Characteristics**	**Yes**
2.1049, 30.203	**(a) Occupied Bandwidth** **(b) Out-of-Band Emissions**	**Yes**
2.1051, 30.203	**Spurious Emissions at Antenna Terminals**	**Yes**
2.1053, 30.203, 30.204, 15.109(a) Class B	**Field Strength of Spurious Radiation**	**Yes**
2.1055,	**Measurement of Frequency Stability**	**No**

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

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

Test Standard(s)	• 47 CFR FCC Parts 2 • KDB 971168 D01 Power Measurement License Digital Systems v03r01 April 9, 2018 • KDB 662911 D01 Multiple Transmitter Output v02r01 Oct 2013 • KDB 842590 D01 Upper Microwave Flexible Use Service v01r01 – April 2020 Procedures on TRP Compliance for Out of Band and Spurious Emissions C63.26 mmWave JTG - Version # 1 July 14th 2018
Reference(s)	• 47 CFR FCC Part 2 and Part 30 • ANSI C63.26 (2015) • ANSI C63.4 (2014) • TR 14-1001, MMW Measurements with Harmonic Mixers (April-4-2014)

4.1 Section 2.1046 MEASUREMENT REQUIRED: RF POWER OUTPUT

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

The VBNAEUA-01 LTE TDD transmit carrier operation, the **Nokia AirScale 28 GHz Radio Unit (AEUA), FCC ID: VBNAEUA-01,** is 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. Under Part 30 the average power of the sum of all antenna elements is limited to an equivalent isotopically radiated power (EIRP) density of +75dBm/100 MHz.

The product incorporates internal antennas and substitution of antennas is not possible. The product is designed to operate under Part 30 rules for Band n261 and its radiated power is under digital control.

4.1.1 RF Power Output Measurement

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

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

4.1.1.1 RF Power Output Results

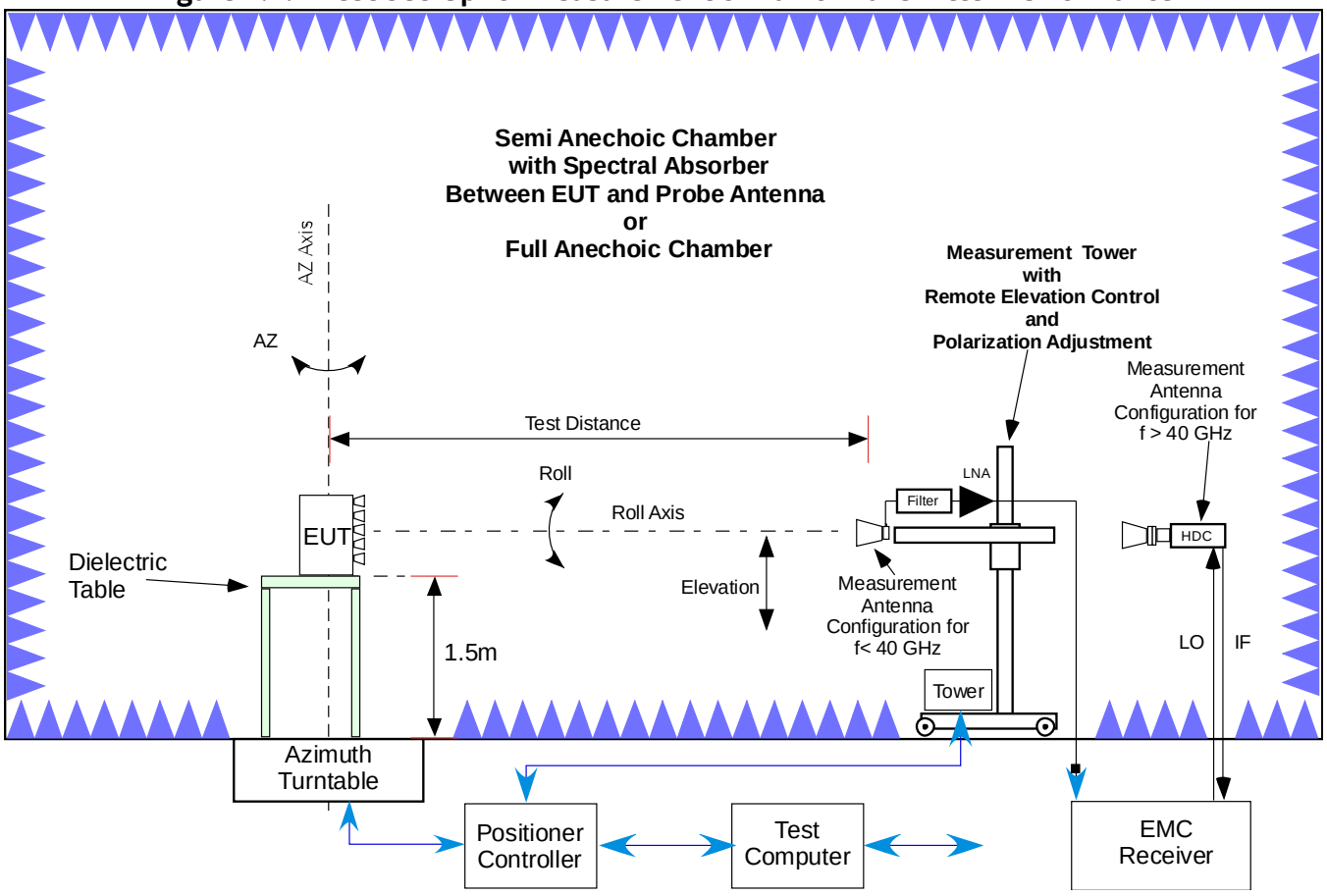
Power output measurements verified the expected performance of 57 dBm EIRP per polarization for a Total Power of 60 dBm. The maximum measured level was 57.44 dBm for a single polarization and 60.35 dBm total. This level is well within the maximum Part 30.202a limit of 75 dBm EIRP. Measurements were performed for each modulation.

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

Table 4.1.1.1 – Channel Power Measurements

Location in Band	# of carriers	Modulation	Polarization		
			Horizontal	Vertical	Horizontal + Vertical
			Total Measured Channel Power (dBm)		Total Power (dBm)
Left	5	QPSK	57.09	57.26	60.19
Middle	6	16QAM	57.30	57.26	60.29
Right	7	64QAM	57.24	57.44	60.35
All	8	QPSK	57.26	57.39	60.34
All	8	16QAM	57.34	57.28	60.32
All	8	64QAM	57.26	57.41	60.35

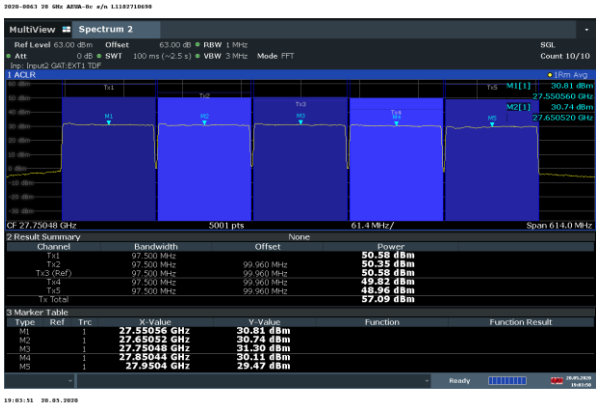
Figure 4.1.1 Test Set-Up for Measurement of Radio Transmitter Performance



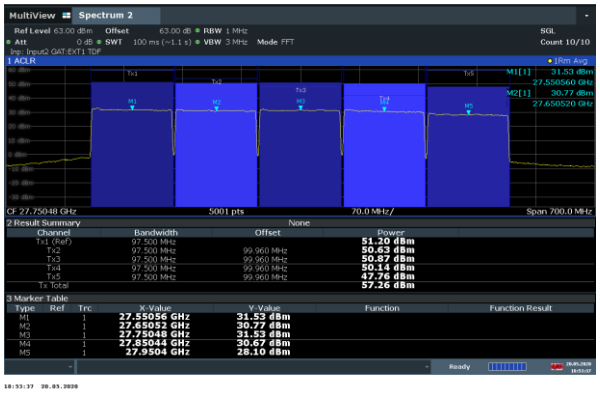
4.1.1.1.1 Channel Power Measurement Plots

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

Horizontal

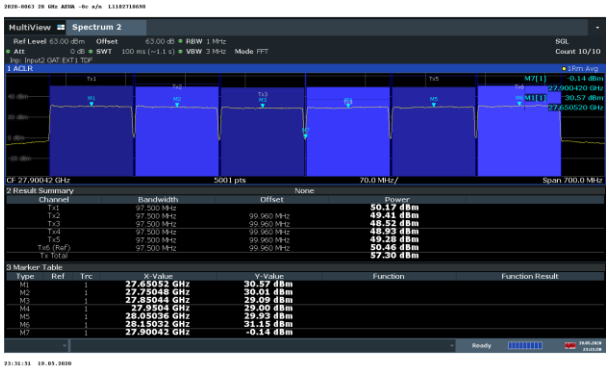


Vertical

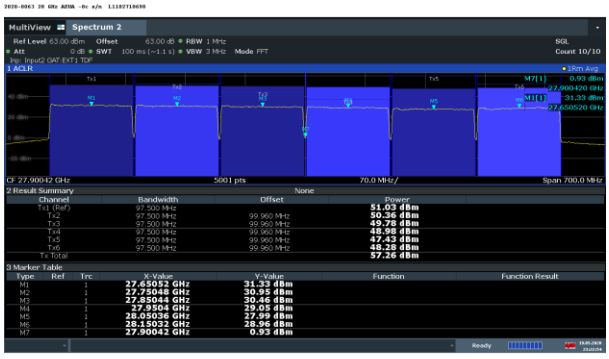


Channel Power Measurements, 4m, 6 Carrier – 16QAM – Middle of Band

Horizontal

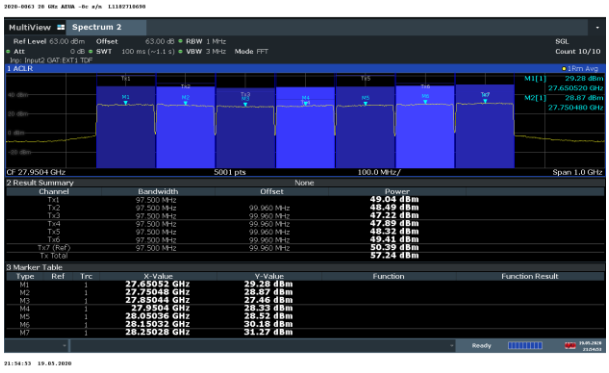


Vertical

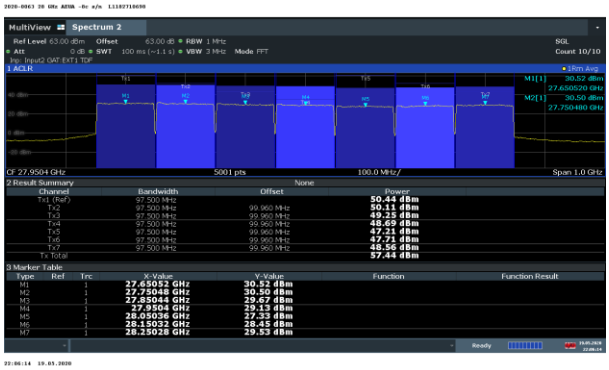


Channel Power Measurements, 4m, 7 Carrier – 64QAM – Right Side of Band

Horizontal

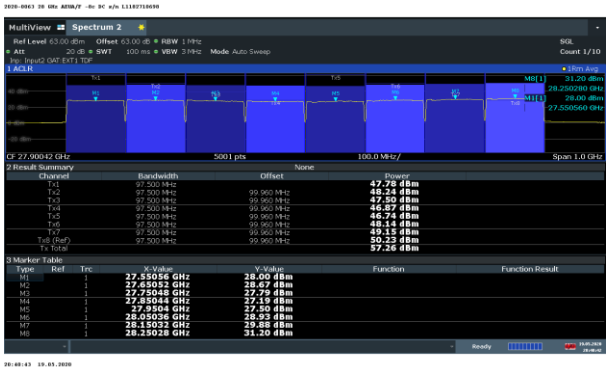


Vertical

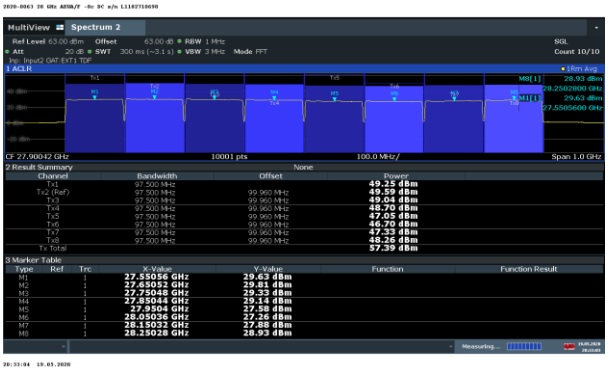


Channel Power Measurements, 4m, 8 Carrier – QPSK – All of Band

Horizontal

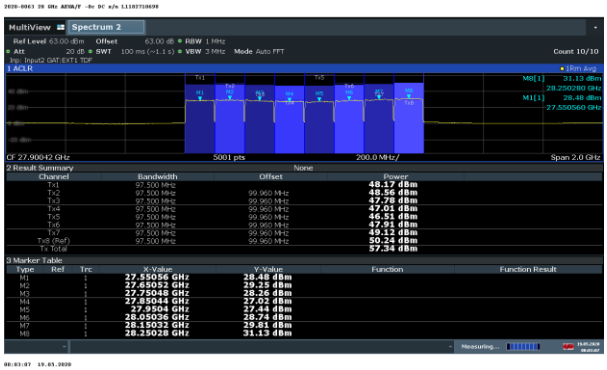


Vertical

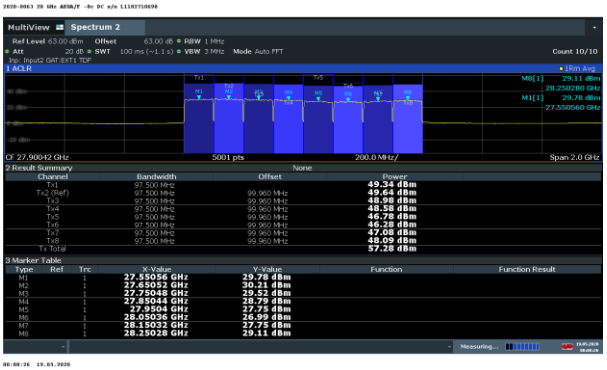


Channel Power Measurements, 4m, 8 Carrier – 16QAM – All of Band

Horizontal

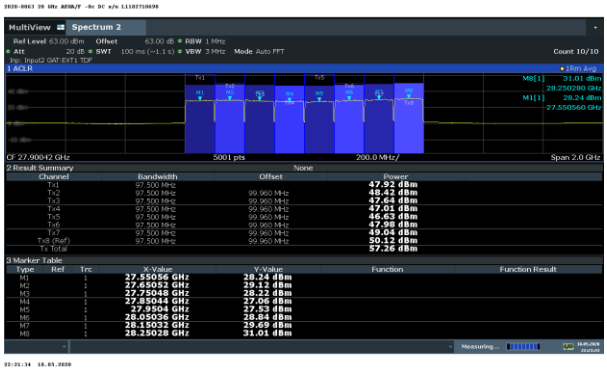


Vertical

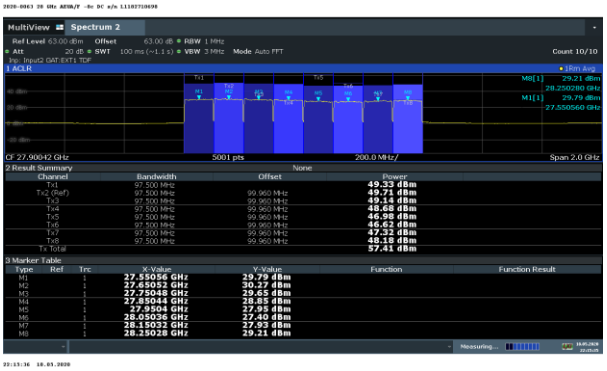


Channel Power Measurements, 4m, 8 Carrier – 64QAM – All of Band

Horizontal



Vertical



4.2 Section 2.1047 MEASUREMENT REQUIRED: MODULATION CHARACTERISTICS

The **VBNAEUA-01** supports the 5G New Radio Modulation Format based upon LTE TDD technologies. LTE utilizes Orthogonal Frequency Division Multiplexing (OFDM) which splits the carrier frequency bandwidth into many small subcarriers. Each individual subcarrier can be modulated with a QPSK, 16QAM or 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 16QAM symbol carries 4 bits of information. In 64QAM, there are 64 possible symbol states and each 64QAM 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 constellations were used 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.

4.2.1 Modulation Characteristics Measurement

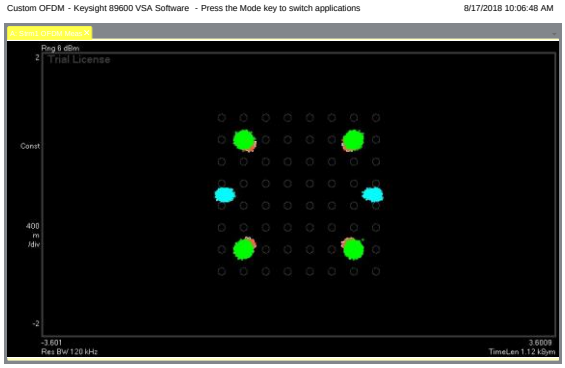
The measurements were performed at a distance of 4 m from the unit utilizing the test configuration in Figure 4.4.1 utilizing a 44 GHz MXA Signal analyzer. Representative screen plots of the modulation measurement are attached below for the various subcarrier configurations and Various Polarizations.

4.2.2 Modulation Measurements Results:

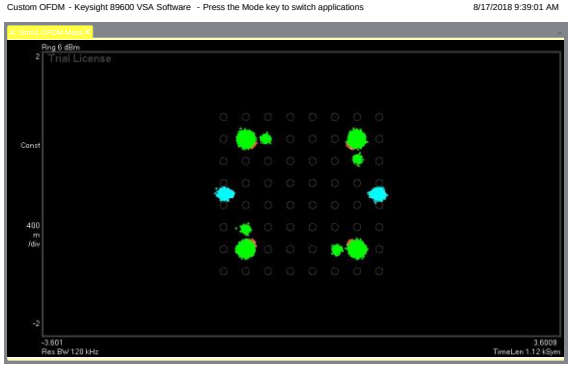
The typical measured modulation characteristics of the EUT are shown below:

Figure 4.2 Modulation Results

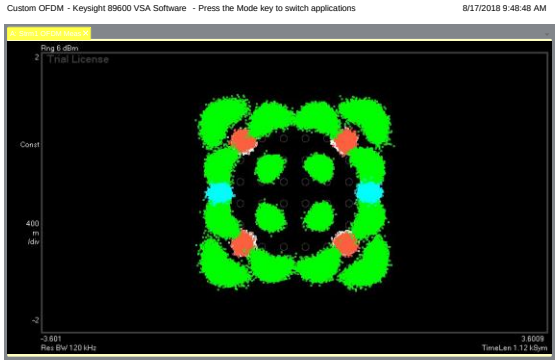
Sample QPSK 27.6GHz Vertical Polarization



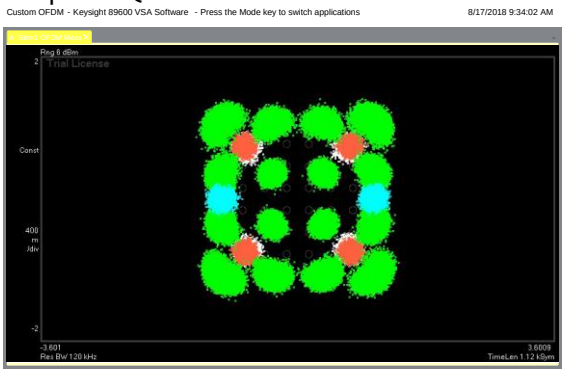
Sample QPSK 27.6GHz Horizontal Polarization



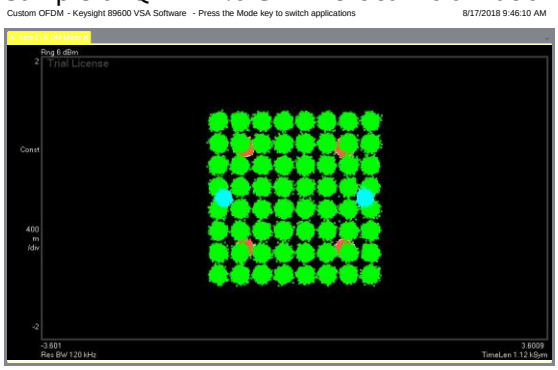
Sample 16QAM 27.6 GHz Vertical Polarization



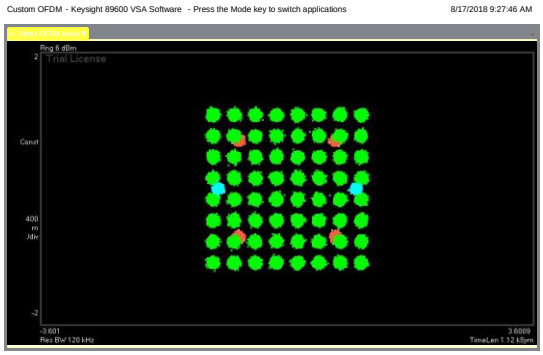
Sample 16QAM 27.6 GHz Horizontal Polarization



Sample 64QAM 27.6 GHz Vertical Polarization



Sample 64QAM 27.6 GHz Horizontal Polarization



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

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

The occupied bandwidth (OBW) is usually defined either as the 99% power OBW or a relative OBW. The 99% OBW is the signal bandwidth such that, below its lower and above its upper frequency limits, the mean power radiated or conducted are each equal to 0.5 percent of the total mean power radiated or conducted by a given emission. The relative 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 X dB below the transmitter power, where the value of X is typically specified as 26.

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.

4.3.1 Results Occupied Bandwidth (Signal Bandwidth)

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

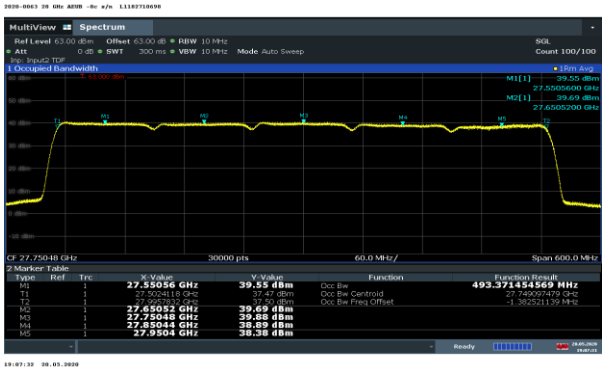
Tabular Data – Occupied Bandwidth

Location in Band	Carrier Frequencies (GHz)	Number of Carriers	Modulation	Horizontal Polarization Occupied Signal Bandwidth (MHz)	Vertical Polarization Occupied Signal Bandwidth (MHz)
Left	27.55056 to 27.95040	5	QPSK	493.371	491.523
Middle	27.65052 to 28.15032	6	16QAM	593.458	592.608
Right	27.65052 to 28.25028	7	64QAM	691.789	690.913
All	27.55056 to 28.25028	8	QPSK	790.060	788.811
All	27.55056 to 28.25028	8	16QAM	790.336	788.902
All	27.55056 to 28.25028	8	64QAM	790.107	788.679

4.3.1.1 99% Signal Bandwidth 10 MHz RBW Plots

5 Carrier QPSK

Horizontal



Vertical

6 Carrier 16QAM

Horizontal

Vertical

7 Carrier 64QAM

Horizontal

Vertical

8 Carrier QPSK

Horizontal

Vertical

8 Carrier 16QAM

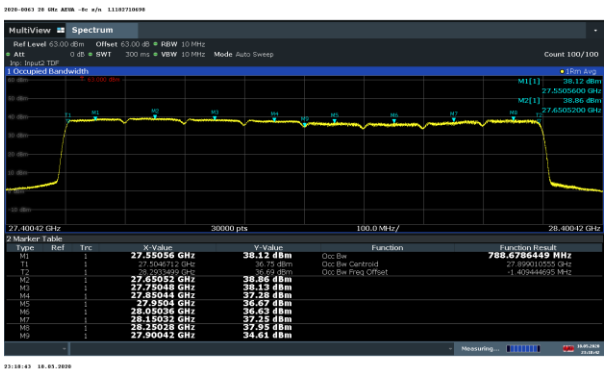
Horizontal

Vertical

8 Carrier 64QAM

Horizontal

Vertical



4.3.2 Occupied Bandwidth-Edge of Block Emissions

Classical Occupied Bandwidth – Edge of Block Emissions is an evaluation of the transmit carrier compliance with edge of block/edge of band requirements. This measurement documents the product's ability to maintain compliance with FCC Parts 2 and Part 30.203 limitations on emissions outside the block of operation.

The **VBNAEUA-01** 28 GHz Radio Unit presently supports single 5G-New Radio LTE TDD technologies. This evaluation addresses 2x2 MIMO operation with 100 MHz carriers. In each test configuration the carriers were configured at the left side, center and right side of the band as appropriate. Power was set to the total per polarization maximum and channel power measurements were performed prior to other measurements. 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 multiple mixed 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 96.41 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

The typical MIMO adjustments were imposed to adjust for multiple signals which could add to generate additional interference. When considered these signals were the same polarization. The cross polarization eliminates that possibility and so no MIMO adjustment was used.

For the 5G-NR LTE system there is no carrier without modulation. Since the 5G-NR LTE signal is broadband and is 100 MHz wide, all of the measurements performed at narrower resolution bandwidths need to be evaluated with limits adjusted for the reduction in signal energy. The following relationship was used to provide the correct level for an unmodulated carrier vs. the modulated signal.

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

4.3.5 Mask Parameters

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

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

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

4.3.6 Measurement Path Corrections

The measured power at the spectrum analyzer input was corrected for calculated free space loss, cable loss measurement antenna gain and the product antenna gain over its applicable frequency range as documented in Exhibit 6 of the filing and the table below. This is the same procedure as was previously used in other filings filed under Part 30. This is appropriate for Out Of Band Emissions / Edge of Band emissions only for the frequency range that the transmit antenna has documentable and consistent gain. Since different products have different gain responses vs frequency, the documentable antenna gain of the product applies only for the operational frequency range of the products antenna gain.

This adjustment was not used outside the OOBE/EoB frequency range. Table 4.3.6 below lists the offset and correction factors used for the measurement distance of 4m including the AEUA product gain.

Table 4.3.6 Offset and Correction Factors

Frequency	Free Space Path Loss, PL	Measurement Antenna Gain, G1	Measurement Cable Loss, L1	PL-G1+L1	AEUA Antenna Gain	Total
GHz	dB	dBi	dB	dB	dBi	dB
26.00	72.78	22.81	12.58	62.56	27.70	34.86
26.50	72.95	22.91	12.61	62.65	28.20	34.45
27.00	73.11	22.82	12.63	62.92	28.50	34.42
27.50	73.27	23.25	12.77	62.79	28.55	34.24
28.00	73.43	23.12	12.90	63.21	28.65	34.56
28.50	73.58	23.42	13.03	63.19	28.55	34.64
29.00	73.73	23.50	13.15	63.39	28.50	34.89
29.50	73.88	23.66	13.26	63.48	28.40	35.08
30.00	74.03	23.64	13.36	63.74	28.25	35.49
30.50	74.17	23.83	13.51	63.84	26.90	36.94
31.00	74.31	23.88	13.63	64.06	25.70	38.36
31.50	74.45	23.95	13.76	64.26	22.30	41.96
32.00	74.59	23.95	13.89	64.53	18.80	45.73

Sample calculation:

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

The following sample calculation is the correction for 30 GHz;

Offset Value = 35.49 dB = 74.03 dB -23.64dBi + 13.36dB - 29.90 dBi

The measurements were made using a flat offset of 34 dB with a transducer factor table used for the delta values which across the majority of the range was within +/- 0.9 dB.

4.3.7 Edge of Band Measurements

The measurements were performed with an FSW spectrum analyzer in compliance with the procedure and requirements of ANSI C63.26. The test set-up diagram in Figure 4.1.1 is used for RF Power, Modulation, Occupied Bandwidth, Edge-of-Band emissions and Radiated Spurious Emissions.

Testing was performed for the 100 MHz carrier configurations at the left side, center and right side of the Part 30 Band.

Mask parameters were as stated in Table 4.3.5. Mask Edge Offsets = ½ the Resolution Bandwidth of the measurement were not used.

4.3.7.1 Results - Occupied Bandwidth-Edge of Block Emissions

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

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

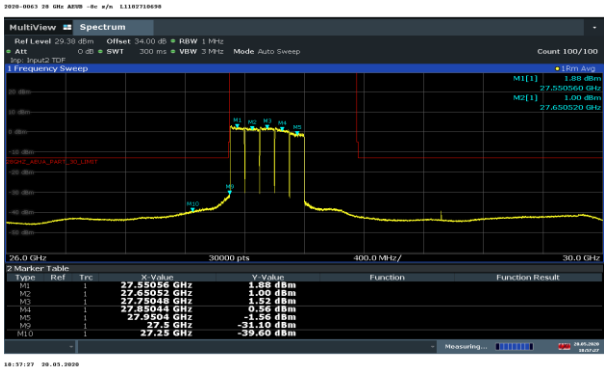
The measurement results of the occupied bandwidth and the out-of-band emissions as documented in the plots and Table 4.3.6.1 demonstrate the full compliance with the Rules of the Commission for the operating band.

The Occupied Bandwidth and Edge-of-Band emissions measurements were made as a radiated measurement at a distance of 4m.

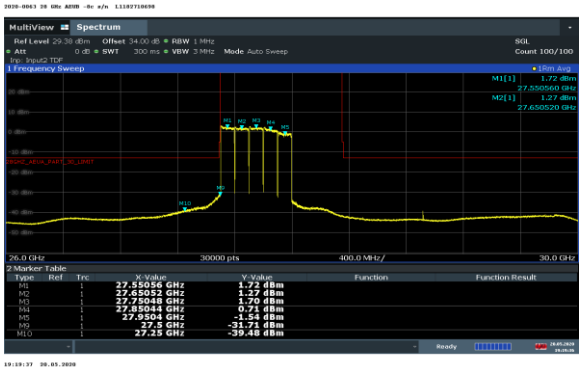
4.3.7.1.1 Occupied Bandwidth Edge of Band Plots

5 Carrier - QPSK

OOBE/EoB – Horizontal Polarization

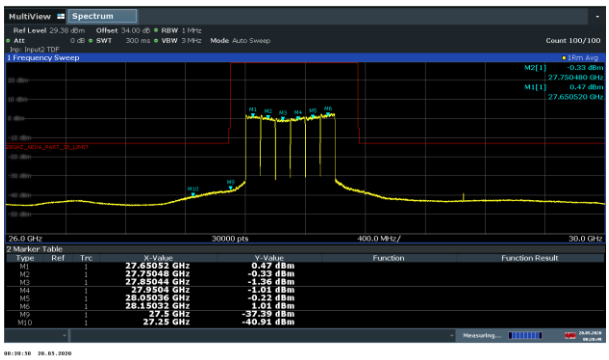


OOBE/EoB – Vertical Polarization

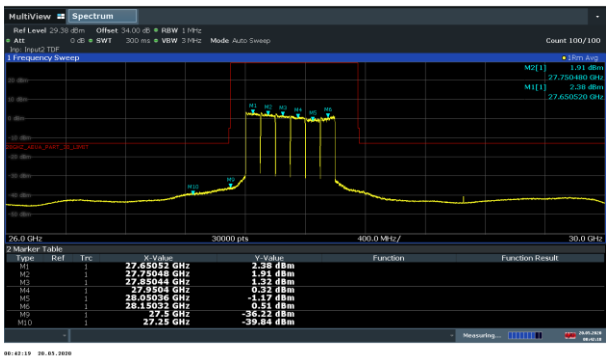


6 Carrier – 16QAM

OOBE/EoB – Horizontal Polarization

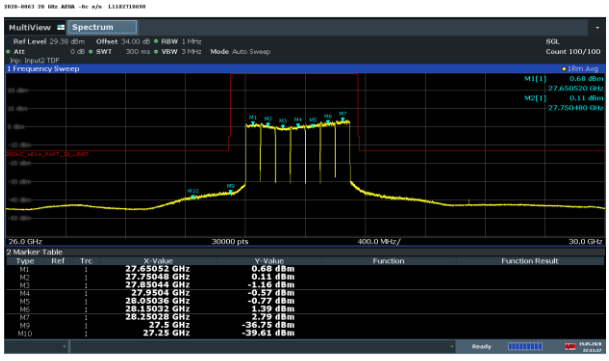


OOBE/EoB – Vertical Polarization

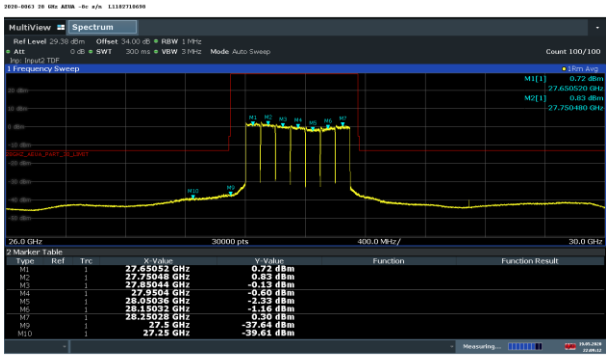


7 Carrier – 64QAM

OOBE/EoB – Horizontal Polarization

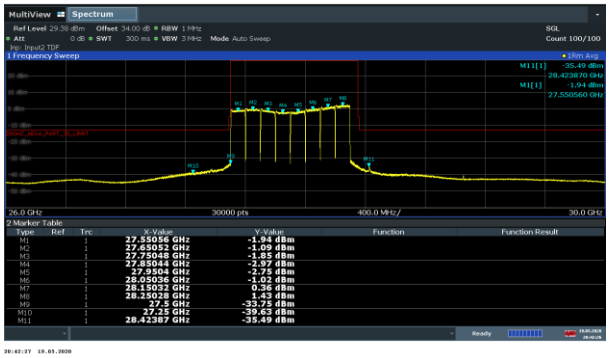


OOBE/EoB – Vertical Polarization

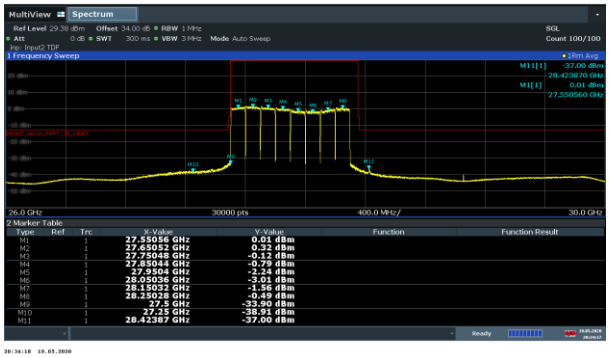


8 Carrier - QPSK

OOBE/EoB – Horizontal Polarization

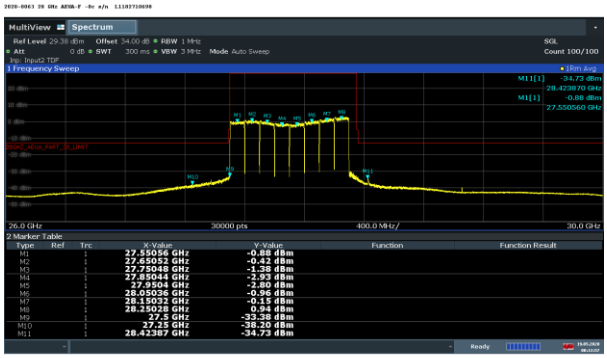


OOBE/EoB – Vertical Polarization

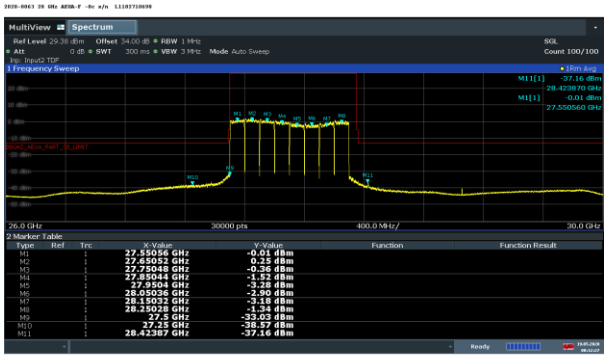


8 Carrier – 16QAM

OOBE/EoB – Horizontal Polarization

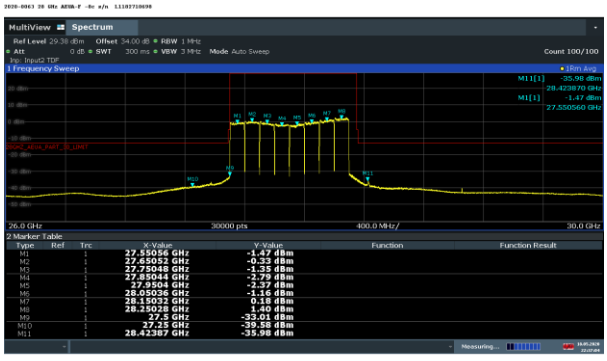


OOBE/EoB – Vertical Polarization

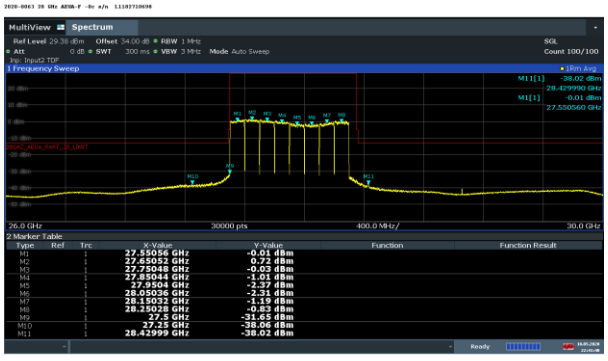


8 Carrier – 64QAM

OOBE/EoB – Horizontal Polarization



OOBE/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 × 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.

Therefore, the limit for emissions >1 MHz outside a licensee's frequency block when measured with a RBW of 1 MHz is:

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

4.5 Section 2.1053 MEASUREMENT REQUIRED: FIELD STRENGTH OF SPURIOUS RADIATION

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

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

Table 4.5.1 EUT Configurations

AEUA Tx Reference Frequencies GHz	Transmit Active Polarization	Signal Bandwidth, MHz	Modulation	Total Power, dBm EIRP	Radiated Emissions Pass / Fail
27.55056 to 28.25028	H & V	100	64QAM	60	Pass

4.5.1 Spurious Radiation and Radiated Emissions Requirements.

This product meets Part 15B, and Part 30.203 requirements. FCC Part 15 Class B require emissions to be below 54.5 dBμV/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+10LogP=-13 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:

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

Title 47CFR section 30.203 and 2.1053 contains the requirements for the levels of spurious radiation as a function of the EIRP of the modulated carrier with 100 MHz of bandwidth. The reference level for the modulated carrier is calculated as the field produced by an isotropic radiator excited by the transmitter output power according to the following relation taken from Reference Data for Radio Engineers, page 27-7, 6th edition, IT&T Corp.

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

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

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 for evaluation (0.5 m above the top of product). This allows 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 + 5 degrees off center. All of the emissions and harmonics were found to be centered on the beam as well.

Based upon previous testing full coverage scanning of the product utilizing parametric scanning at different angles and heights. For this measurement the scan was started at the beam peak location of 13 degrees azimuth, and nominal elevations of 174 cm for the Vertical and 148 cm for Horizontal. The elevation was then swept down to 1m and back up back to 3m and returned to the beam peak. The product was then rotated continuously to 360 degrees back to 0 degrees and back to 13 degrees. For all of the measurements no emissions were found outside the steerable angle of the beam. There were >56 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 # of Points $\geq$ 2(Span/RBW).
The FSW-85 is limited to 10001 data points. Multiple spans were used when necessary to evaluate the peak spurious emissions detected. The assessment of out of beam spurious was performed with a 1 MHz RBW.

4.5.2.3 Part 30 Limit:

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

4.5.2.4 Emissions Corrections

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

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

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

Table 4.5.2.4 details the correction for the three bands.

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

Frequency	λ	Measurement Distance, d	Path Loss	Measurement Antenna Gain	IF Cable Loss	Emissions Correction Total
GHz	m	m	dB	dB	dB	dB
40.0	0.0075	4	76.52	21.80	1.03	55.75
42.5	0.0071	4	77.05	22.20	1.03	55.87
45.0	0.0067	4	77.55	22.50	1.03	56.07
47.5	0.0063	4	78.02	22.70	1.03	56.34
50.0	0.0060	4	78.46	23.00	1.03	56.49
52.5	0.0057	4	78.89	23.30	1.03	56.61
55.0	0.0055	4	79.29	23.40	1.03	56.91
57.5	0.0052	4	79.68	23.60	1.03	57.10
60.0	0.0050	4	80.05	23.70	1.03	57.37

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

Frequency	λ	Measurement Distance, d	Path Loss	Measurement Antenna Gain	IF Cable Loss	Emissions Correction Total
GHz	m	m	dB	dB	dB	dB
60.0	0.0050	4	80.05	21.80	1.03	59.276
65.0	0.0046	4	80.74	22.30	1.03	59.471
70.0	0.0043	4	81.38	22.70	1.03	59.715
75.0	0.0040	4	81.98	23.00	1.03	60.014
80.0	0.0038	4	82.54	23.40	1.03	60.175
85.0	0.0035	4	83.07	23.60	1.03	60.501
90.0	0.0033	4	83.57	23.80	1.03	60.798

Table 4.5.2.4c Radiated Emissions Corrections for 90-100GHz at 4m

Frequency	λ	Measurement Distance, d	Path Loss	Measurement Antenna Gain	IF Cable Loss	Emissions Correction Total
GHz	m	m	dB	dB	dB	dB
90.0	0.0033	4	83.57	21.90	1.03	62.698
95.0	0.0032	4	84.04	22.30	1.03	62.767
100.0	0.0030	4	84.48	22.60	1.03	62.913
105.0	0.0029	4	84.91	22.95	1.03	62.987
110.0	0.0027	4	85.31	23.30	1.03	63.041
115.0	0.0026	4	85.70	23.60	1.03	63.127
120.0	0.0025	4	86.07	23.85	1.03	63.247
125.0	0.0024	4	86.42	24.05	1.03	63.401
130.0	0.0023	4	86.76	24.18	1.03	63.612
135.0	0.0022	4	87.09	24.35	1.03	63.770
140.0	0.0021	4	87.41	24.50	1.03	63.936

4.5.3 Field Strength of Spurious Radiation Results:

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

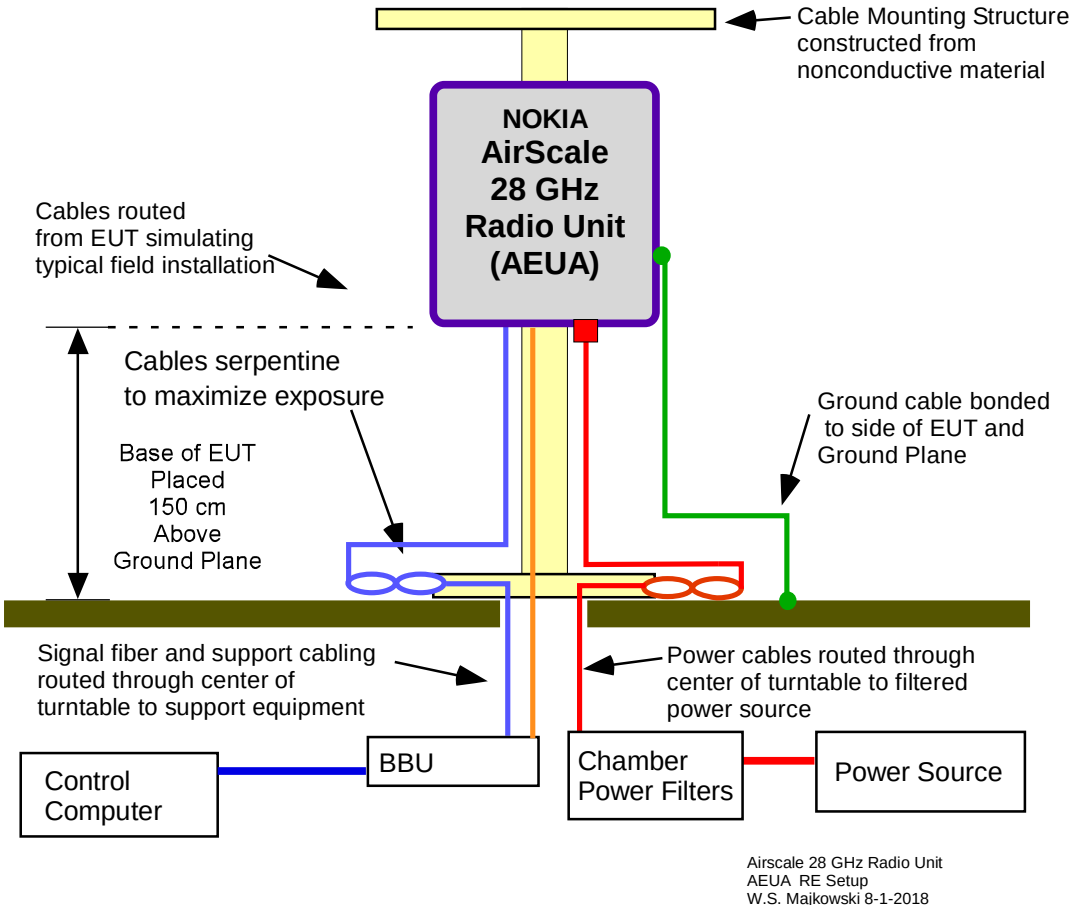
Presented results show the three mmWave bands as measured with a 1 MHz Resolution Bandwidth. In these measurements the limit is the -13 dBm limit as specified in Part 30.203. Corrections to the emissions levels consisted of only the HDC conversion loss, the Free space Path Loss and measurement antenna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

Over the out of band spectrum investigated from 30 MHz to 100 GHz, reportable spurious emissions were detected and determined to be compliant with the Part 30 limit. The worst case Part 30 margin was 12.6 dB at 28500.922 MHz. Additionally, from 30 MHz to 26.5 GHz all emissions were below 54.5 dBμV/m. This demonstrates that the **AirScale 28 GHz Radio Unit (AEUA) Band 30, FCC ID: VBNAEUA-01**, the subject of this application, complies with FCC Part 15 Class B, and FCC Sections 2.1053, 30.203 and 2.1057 of the Rules.

Photographs of the measurement setup are in the filing exhibits.

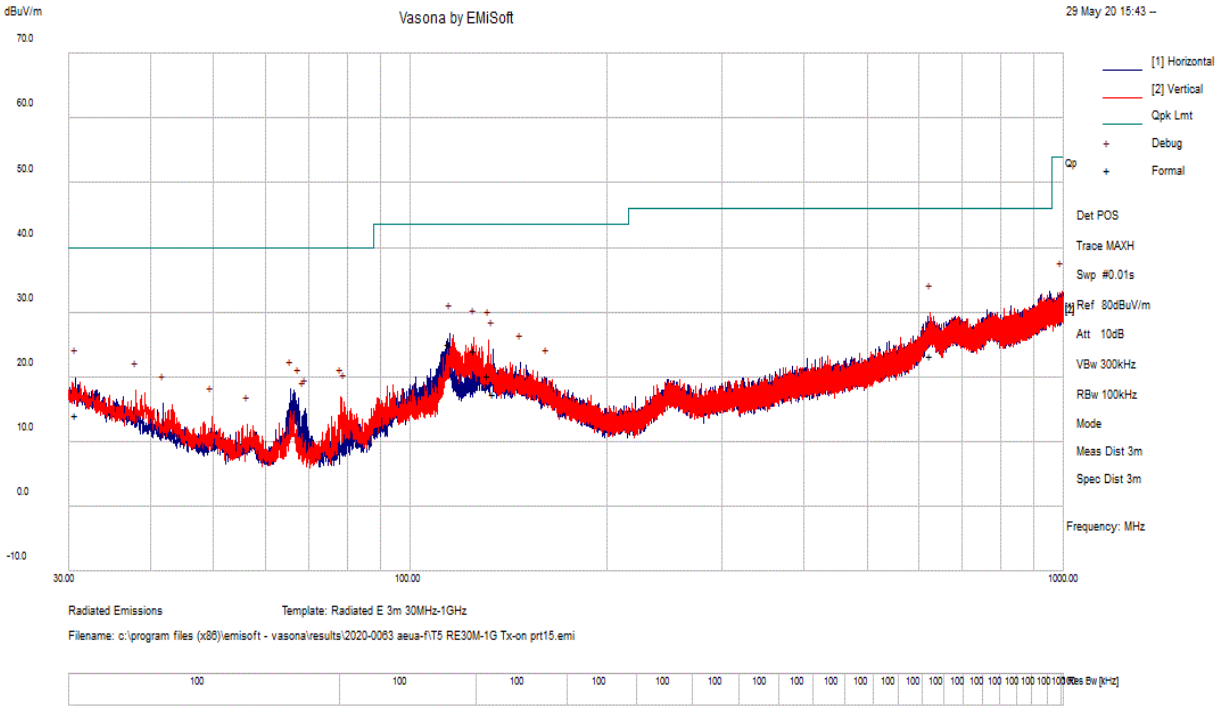
Figure 4.5 Radiated Emissions Product Setup

Radiated Emissions Setup
Nokia AirScale 28 GHz Radio Unit (AEUA)



4.5.4 Transmitter Measurements of Radiated Spurious Emissions

T5a Radiated Emissions 30MHz - 1GHz Tx-On Part 15B



Test Information

Results Title	Radiated Emissions 3m 30MHz-1GHz
File Name	T5a RE30M-1G Tx-on prt15 Final.emi
Test Laboratory	Global Product Compliance Lab
Test Engineer	WSM / MJS
Test Software	Vasona by EMISoft, version 6.061
Equipment	Nokia Wireless
EUT Details	28 GHz AEUA & AEUF -8C SNL1182710698. With LMI board cable disconnected.
Configuration	Powered by -48VDC, RTM1.1, Antenna - E566, Preamp- E813, Analyzer E1H69-ESU, and LPF - E980. RE 30M-1 GHz. To FCC Part 15B limits @3-Meters. Tx -on testing.
Date	2020-05-29 18:49:11

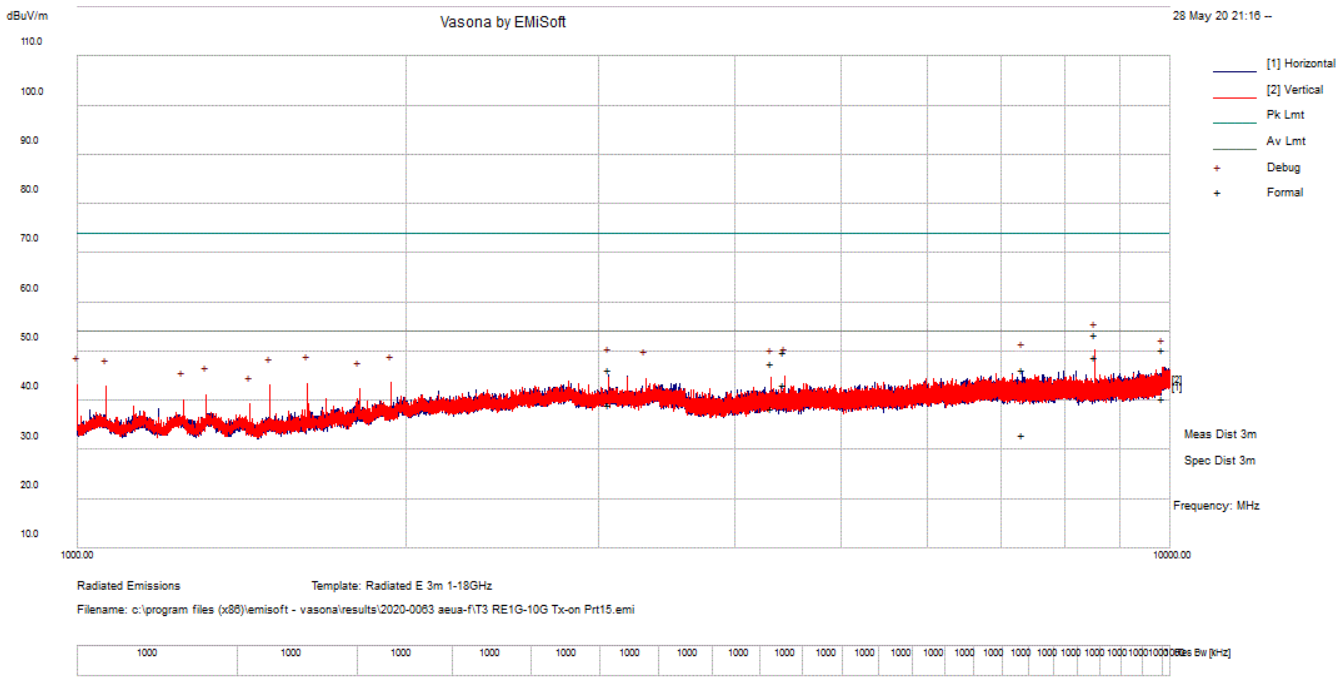
Formal Data

Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol H/V	Ht. cm	Az. Deg.	Limit dBµV/m	Margin dB	Pass /Fail	Comments
114.834	34.82	1.45	-11.15	25.12	QuasiMax	H	139	145	43.50	-18.38	Pass	
125.007	32.12	1.51	-9.55	24.08	QuasiMax	V	236	327	43.50	-19.42	Pass	
625.376	23.11	3.34	-3.04	23.41	QuasiMax	V	164	139	46.00	-22.59	Pass	
131.392	28.12	1.55	-9.44	20.23	QuasiMax	V	249	355	43.50	-23.27	Pass	
30.798	23.21	0.80	-9.76	14.25	QuasiMax	H	246	44	40.00	-25.75	Pass	
134.103	25.30	1.57	-9.39	17.47	QuasiMax	H	182	179	43.50	-26.03	Pass	

Preview Data

Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol H/V	Ht. cm	Az. Deg.	Limit dBµV/m	Margin dB	Pass /Fail	Comments
624.960	29.55	3.34	-3.01	29.88	Debug	V	350	270	46.00	-16.12	Pass	
115.008	36.37	1.45	-11.12	26.70	Debug	H	102	135	43.50	-16.80	Pass	
125.064	34.01	1.51	-9.55	25.97	Debug	V	202	180	43.50	-17.53	Pass	
131.904	33.56	1.56	-9.43	25.69	Debug	V	302	0	43.50	-17.81	Pass	
133.800	31.97	1.57	-9.40	24.14	Debug	H	102	135	43.50	-19.36	Pass	
30.720	28.73	0.80	-9.72	19.81	Debug	H	350	180	40.00	-20.19	Pass	
992.885	29.71	5.09	-1.60	33.20	Debug	V	302	270	54.00	-20.80	Pass	
147.384	29.65	1.64	-9.18	22.11	Debug	H	150	180	43.50	-21.39	Pass	
65.568	37.49	1.12	-20.55	18.06	Debug	H	250	135	40.00	-21.94	Pass	
38.064	30.64	0.88	-13.63	17.90	Debug	V	202	315	40.00	-22.10	Pass	
78.360	34.83	1.21	-19.23	16.81	Debug	V	102	315	40.00	-23.19	Pass	
67.464	36.23	1.13	-20.60	16.76	Debug	H	150	315	40.00	-23.24	Pass	
161.904	29.02	1.72	-10.93	19.81	Debug	H	250	135	43.50	-23.69	Pass	
79.272	33.89	1.22	-19.08	16.02	Debug	V	102	180	40.00	-23.98	Pass	
41.856	30.42	0.92	-15.48	15.87	Debug	H	350	315	40.00	-24.13	Pass	
69.216	34.60	1.14	-20.65	15.10	Debug	H	250	315	40.00	-24.90	Pass	
68.688	34.16	1.14	-20.64	14.67	Debug	H	250	0	40.00	-25.33	Pass	
49.656	31.34	0.99	-18.47	13.85	Debug	V	102	135	40.00	-26.15	Pass	
56.376	31.29	1.05	-19.76	12.57	Debug	V	102	225	40.00	-27.43	Pass	

T3a Radiated Emissions 1GHz - 10GHz Tx-On



Test Information

Results Title	Radiated Emissions 3m 1-18GHz
File Name	T3a RE1G-10G Tx-on Prt15.emi
Test Laboratory	Global Product Compliance Lab
Test Engineer	MJS
Test Software	Vasona by EMISoft, version 6.061
Equipment	Nokia Wireless
EUT Details	28 GHz AEUA & AEUF -8C SNL1182710698
Configuration	Powered by -48VDC, RTM1.1, Antenna - E1074, Preamp- E447, Analyzer E1H69-ESU, and Notch Filter - E1315. RE 1g-10 GHz. To FCC Part 15B limits @3-Meters. Tx -on testing.
Date	2020-05-28 22:34:29

Formal Data

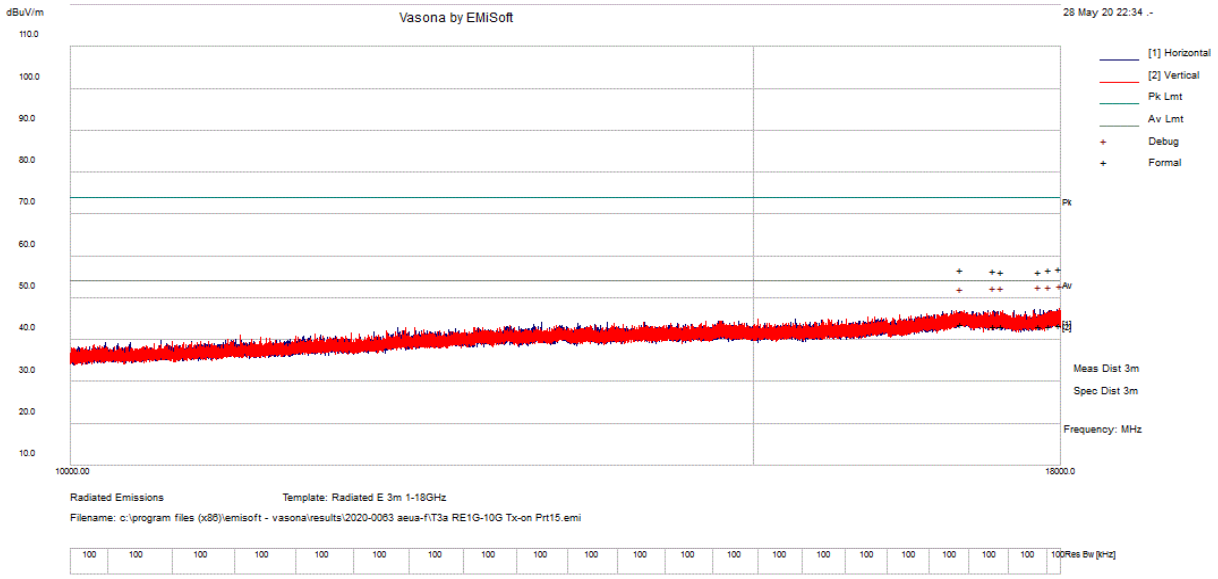
Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol H/V	Ht. cm	Az. Deg.	Limit dBµV/m	Margin dB	Pass /Fail	Comments
8532.221	45.19	6.48	-2.66	49.01	AvgMax	V	172	273	54.00	-4.99	Pass	
4437.459	42.89	4.67	-4.14	43.42	AvgMax	V	123	273	54.00	-10.58	Pass	
9830.345	35.82	6.82	-2.05	40.60	AvgMax	V	110	322	54.00	-13.40	Pass	
3062.352	41.32	3.89	-6.08	39.13	AvgMax	H	171	52	54.00	-14.87	Pass	
4312.527	38.27	4.60	-4.30	38.57	AvgMax	V	162	299	54.00	-15.43	Pass	
8532.221	49.54	6.48	-2.66	53.37	PeakMax	V	172	273	74.00	-20.63	Pass	
7329.887275	29.73	6.04	-2.59	33.18	AvgMax	H	127	341	54.00	-20.82	Pass	
9830.345	45.70	6.82	-2.05	50.48	PeakMax	V	110	322	74.00	-23.52	Pass	
4437.459	49.45	4.67	-4.14	49.98	PeakMax	V	123	273	74.00	-24.02	Pass	
4312.527	47.27	4.60	-4.30	47.57	PeakMax	V	162	299	74.00	-26.43	Pass	
3062.352	48.59	3.89	-6.08	46.40	PeakMax	H	171	52	74.00	-27.60	Pass	
7329.887275	42.78	6.04	-2.59	46.23	PeakMax	H	127	341	74.00	-27.77	Pass	

Preview Data

Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol H/V	Ht. cm	Az. Deg.	Limit dBµV/m	Margin dB	Pass /Fail	Comments
8532.49567	46.33	6.48	-2.66	50.15	Debug	V	175	270	54.00	-3.85	Pass	
9830.24548	41.94	6.82	-2.05	46.71	Debug	V	175	0	54.00	-7.29	Pass	
7329.887275	42.55	6.04	-2.59	46.01	Debug	H	175	225	54.00	-7.99	Pass	
3062.30194	47.33	3.89	-6.08	45.14	Debug	H	175	270	54.00	-8.86	Pass	
4437.771505	44.47	4.67	-4.14	45.01	Debug	V	175	270	54.00	-8.99	Pass	
4312.236595	44.34	4.60	-4.30	44.65	Debug	V	175	225	54.00	-9.35	Pass	
3312.56962	46.04	4.03	-5.69	44.39	Debug	V	175	225	54.00	-9.61	Pass	
1937.70166	48.37	3.13	-7.90	43.60	Debug	V	175	225	54.00	-10.40	Pass	
1625.067595	50.78	2.87	-10.26	43.39	Debug	V	175	315	54.00	-10.61	Pass	
1000.000	53.15	2.43	-12.39	43.19	Debug	V	175	225	54.00	-10.81	Pass	
1500.13429	51.61	2.76	-11.33	43.04	Debug	V	175	270	54.00	-10.96	Pass	
1062.366385	52.57	2.48	-12.23	42.82	Debug	V	175	225	54.00	-11.18	Pass	
1812.367285	48.04	3.04	-8.80	42.28	Debug	V	175	270	54.00	-11.72	Pass	
1312.634065	50.15	2.65	-11.68	41.12	Debug	V	175	352	54.00	-12.88	Pass	
1250.067145	49.27	2.61	-11.81	40.07	Debug	V	175	352	54.00	-13.93	Pass	
1437.767905	47.93	2.72	-11.44	39.21	Debug	V	175	315	54.00	-14.79	Pass	

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

T4 Radiated Emissions 10GHz - 18GHz Tx-On



Test Information

Results Title	Radiated Emissions 3m 1-18GHz
File Name	T4 RE10G-18G Tx-on Prt15.emi
Test Laboratory	Global Product Compliance Lab
Test Engineer	MJS / JY
Test Software	Vasona by EMISoft, version 6.061
Equipment	Nokia Wireless
EUT Details	28 GHz AEUA & AEUF -8C SNL1182710698
Configuration	Powered by -48VDC, RTM1.1, Antenna - E1074, Preamp- E447, Analyzer E1H69-ESU, and Notch Filter - E1315. RE 10g-18 GHz. To FCC Part 15B limits @3-Meters. Tx -on testing.
Date	2020-05-29 10:42:39

Formal Data

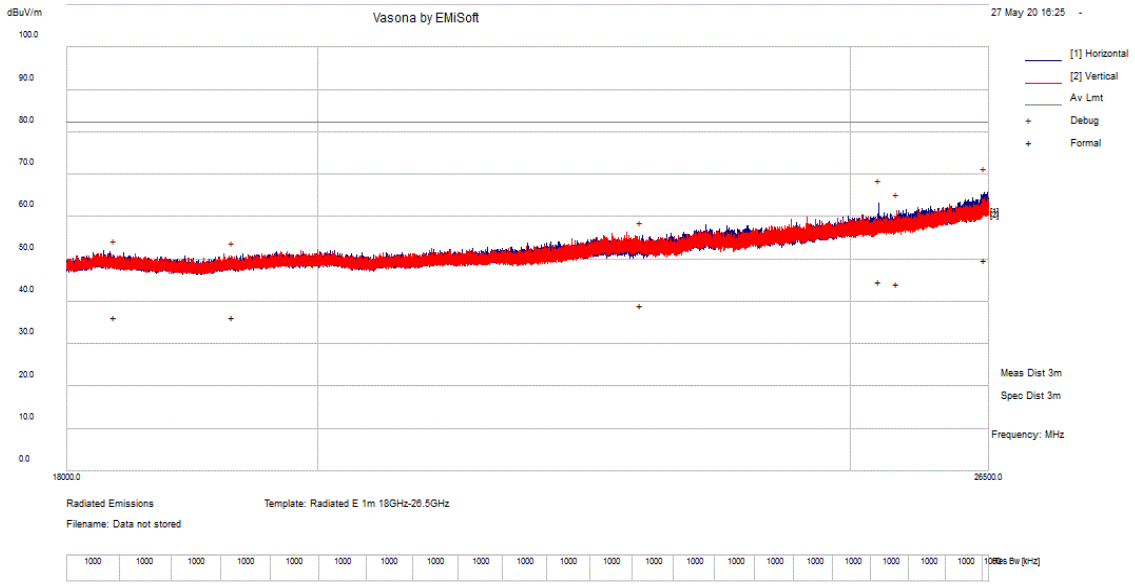
Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol H/V	Ht. cm	Az. Deg.	Limit dBµV/m	Margin dB	Pass /Fail	Comments
16962.970	29.70	9.28	4.80	43.77	AvgMax	V	205	297	54.00	-10.23	Pass	
17981.867	29.67	9.69	4.15	43.50	AvgMax	V	155	245	54.00	-10.50	Pass	
17878.821	29.62	9.63	4.15	43.39	AvgMax	H	215	249	54.00	-10.61	Pass	
17298.891	29.70	9.23	4.43	43.37	AvgMax	H	148	300	54.00	-10.63	Pass	
17773.940	29.64	9.58	4.14	43.36	AvgMax	H	101	83	54.00	-10.64	Pass	
17385.133	29.78	9.20	4.30	43.29	AvgMax	V	241	351	54.00	-10.71	Pass	
17981.867	43.33	9.69	4.15	57.17	PeakMax	V	155	245	74.00	-16.83	Pass	
16962.970	42.76	9.28	4.80	56.84	PeakMax	V	205	297	74.00	-17.16	Pass	
17878.821	42.90	9.63	4.15	56.67	PeakMax	H	215	249	74.00	-17.33	Pass	
17298.891	42.96	9.23	4.43	56.63	PeakMax	H	148	300	74.00	-17.37	Pass	
17385.133	42.88	9.20	4.30	56.38	PeakMax	V	241	351	74.00	-17.62	Pass	
17773.940	42.62	9.58	4.14	56.34	PeakMax	H	101	83	74.00	-17.66	Pass	

Preview Data

Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol H/V	Ht. cm	Az. Deg.	Limit dBµV/m	Margin dB	Pass /Fail	Comments
17993.679	33.50	9.69	4.15	47.34	NoTune	V	100	176	54.00	-6.66	Pass	
16962.970	32.54	9.28	4.80	46.62	Debug	V	99	352	54.00	-7.38	Pass	
17385.133	33.21	9.20	4.30	46.71	Debug	V	99	352	54.00	-7.29	Pass	
17298.891	33.10	9.23	4.43	46.76	Debug	H	99	352	54.00	-7.24	Pass	
17773.940	33.43	9.58	4.14	47.15	Debug	H	99	352	54.00	-6.85	Pass	
17878.821	33.16	9.63	4.15	46.94	Debug	H	99	352	54.00	-7.06	Pass	

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

T2 Radiated Emissions 18GHz – 26.5GHz Tx-On



Test Information

Results Title	Radiated Emissions 3m 18GHz-26.5GHz
File Name	T2 RE18G-26.5G Tx-on Prt30.emi
Test Laboratory	Global Product Compliance Lab
Test Engineer	JY / MJS
Test Software	Vasona by EMISoft, version 6.061
Equipment	Nokia Wireless
EUT Details	28 GHz AEUA & AEUF -8C SNL1182710698
Configuration	Powered by -48VDC, RTM1.1, Antenna - E513, Preamp- E1387, Analyzer E1384, and Notch Filter - E1315. RE 18GHz-26.5 GHz. To FCC Part 30 limits @3-Meters. Tx -on testing.
Date	2020-05-27 16:29:01

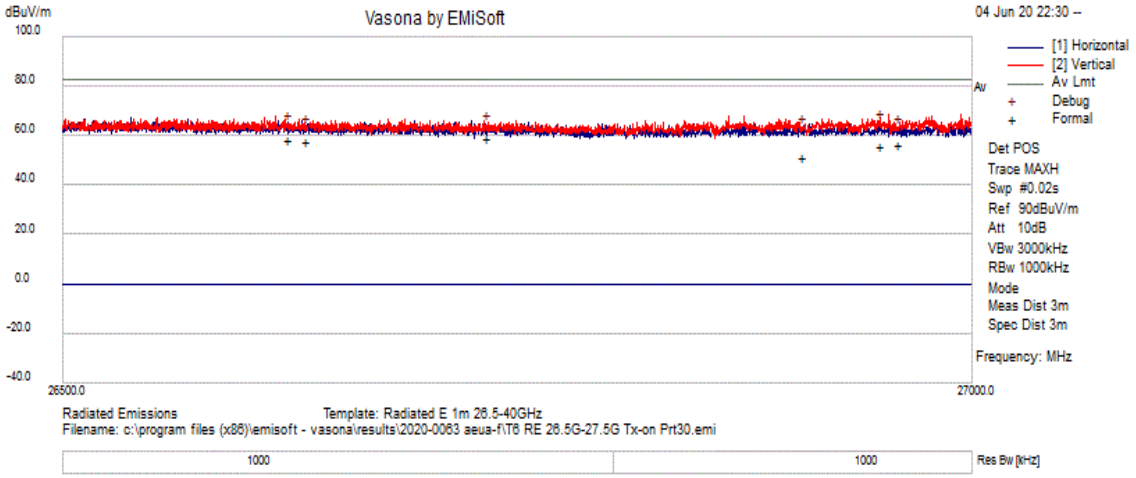
Formal Data

Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol H/V	Ht. cm	Az. Deg.	Limit dBµV/m	Margin dB	Pass /Fail	Comments
26452.810	42.28	11.94	-4.33	49.89	AvgMax	H	135	9	82.23	-32.34	Pass	
25309.233	38.53	11.23	-5.07	44.69	AvgMax	H	102	6	82.23	-37.54	Pass	
25494.102	37.84	11.30	-4.99	44.14	AvgMax	V	102	46	82.23	-38.09	Pass	
22895.595	34.32	10.67	-5.85	39.13	AvgMax	V	162	0	82.23	-43.10	Pass	
18362.133	34.34	10.05	-7.96	36.42	AvgMax	V	150	106	82.23	-45.81	Pass	
19301.528	33.51	9.87	-7.06	36.32	AvgMax	V	101	70	82.23	-45.91	Pass	

Preview Data

Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol H/V	Ht. cm	Az. Deg.	Limit dBµV/m	Margin dB	Pass /Fail	Comments
26452.810	58.14	11.94	-4.33	65.75	Debug	H	150	22	82.23	-16.48	Pass	
25309.233	56.90	11.23	-5.07	63.06	Debug	H	100	22	82.23	-19.17	Pass	
19301.528	45.35	9.87	-7.06	48.15	Debug	V	100	352	82.23	-34.08	Pass	
25494.102	53.42	11.30	-4.99	59.73	Debug	V	100	352	82.23	-22.50	Pass	
18362.133	46.62	10.05	-7.96	48.71	Debug	V	100	352	82.23	-33.52	Pass	
22895.595	48.40	10.67	-5.85	53.22	Debug	V	100	352	82.23	-29.01	Pass	

T6a Radiated Emissions 26.5-27.0 GHz Tx-On



Test Information

Results Title	Radiated Emissions 3m 26.5-27GHz
File Name	T6a RE 26.5G-27.0G Tx-on Prt30.emi
Test Laboratory	Global Product Compliance Lab
Test Engineer	WSM / MJS
Test Software	Vasona by EMISoft, version 6.061
Equipment	Nokia Wireless
EUT Details	28 GHz AEUA & AEUF -8C SNL1182710698. With LMI board cable connected.
Configuration	Powered by -48VDC, RTM1.1, Antenna - E1373, Preamp- E1469, Analyzer EIH69, and Notch Filter - E1315. RE 26.5GHz-27.0 GHz. To FCC Part 30 limits @3-Meters. (1MHz RBW/ 3000 KHz VBW); Formal BW (1MHz RBW) Tx -on testing.
Date	2020-06-04 23:06:04

Formal Data

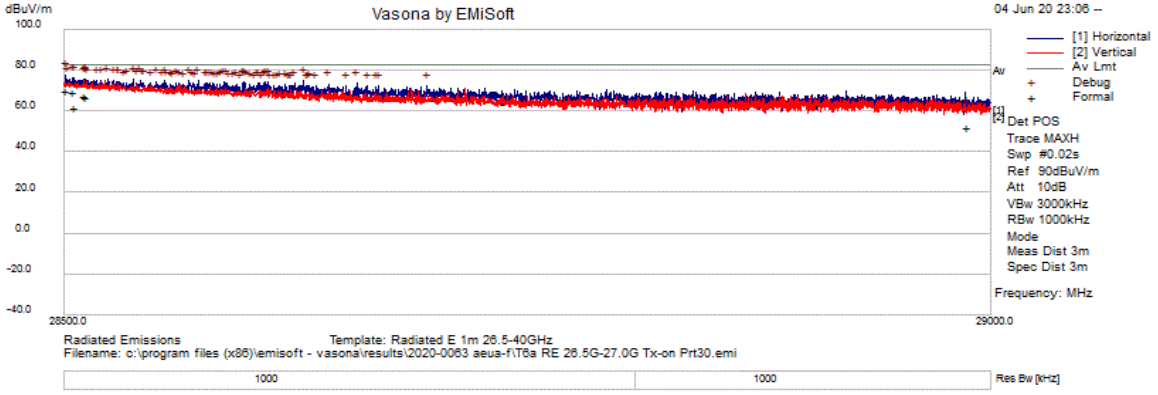
Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol H/V	Ht. cm	Az. Deg.	Limit dBµV/m	Margin dB	Pass /Fail	Comments
26732.087	46.79	12.23	-0.11	58.92	AvgMax	V	176	12	82.23	-23.31	Pass	
26622.881	46.12	12.18	-0.02	58.28	AvgMax	V	168	9	82.23	-23.95	Pass	
26632.836	45.47	12.18	-0.03	57.62	AvgMax	H	144	13	82.23	-24.61	Pass	
26959.403	43.83	12.35	0.05	56.24	AvgMax	H	153	11	82.23	-25.99	Pass	
26949.327	43.47	12.35	0.02	55.84	AvgMax	H	161	11	82.23	-26.39	Pass	
26906.291	39.32	12.32	-0.08	51.56	AvgMax	V	171	33	82.23	-30.67	Pass	

Preview Data

Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol H/V	Ht. cm	Az. Deg.	Limit dBµV/m	Margin dB	Pass /Fail	Comments
26959.403	48.85	12.35	0.05	61.25	Debug	H	150	51	82.23	-20.98	Pass	
26632.836	49.22	12.18	-0.03	61.37	Debug	H	176	13	82.23	-20.86	Pass	
26949.327	50.65	12.35	0.02	63.02	Debug	H	176	1	82.23	-19.21	Pass	
26906.291	48.98	12.32	-0.08	61.22	Debug	V	176	1	82.23	-21.01	Pass	
26622.881	50.51	12.18	-0.02	62.67	Debug	V	176	1	82.23	-19.56	Pass	
26732.087	50.21	12.23	-0.11	62.34	Debug	V	176	1	82.23	-19.89	Pass	

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

T6b Radiated Emissions 28.5G-29G Tx-on Part 30



Test Information

Results Title	Radiated Emissions 3m 28.5-29GHz
File Name	T6b RE28.5G-29G Tx-on Prt30.emi
Test Laboratory	Global Product Compliance Lab
Test Engineer	WSM / MJS
Test Software	Vasona by EMISoft, version 6.061
Equipment	Nokia Wireless
EUT Details	28 GHz AEUA & AEUF -8C SNL1182710698. With LMI board cable connected.
Configuration	Powered by -48VDC, RTM1.1, Antenna - E1373, Preamp- E1469, Analyzer EIH69, and Notch Filter - E1315. RE 28.5GHz-29.0 GHz. To FCC Part 30 limits @3-Meters. (1MHz RBW/ 3000 KHz VBW); Formal BW (1MHz RBW) Tx -on testing.
Date	2020-06-05 17:16:22

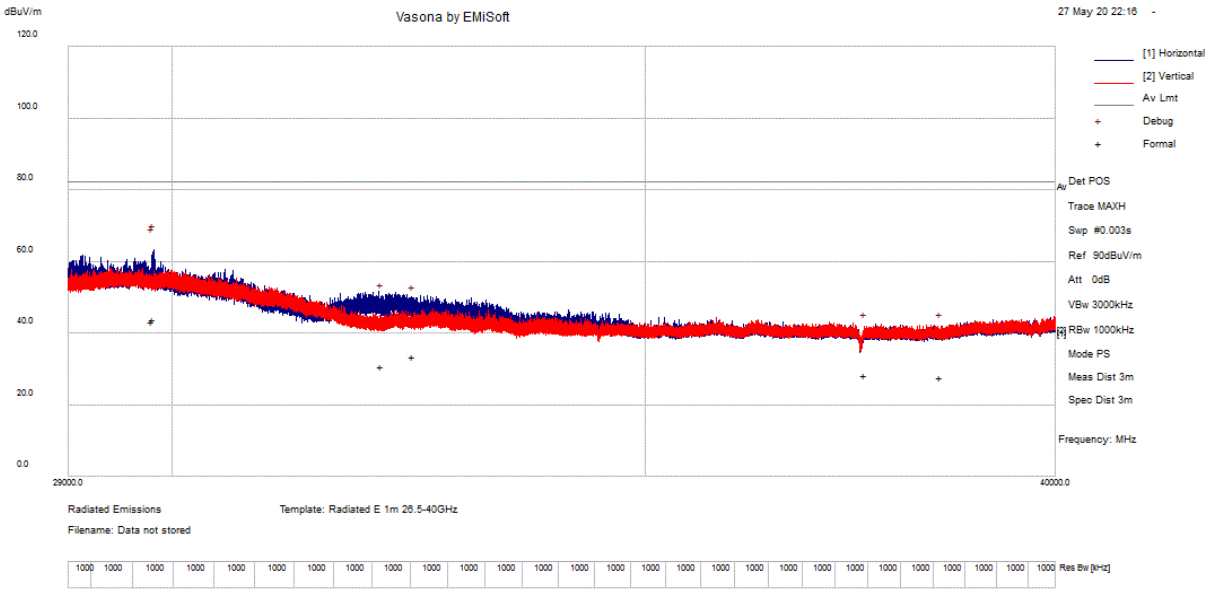
Formal Data

Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol H/V	Ht. cm	Az. Deg.	Limit dBµV/m	Margin dB	Pass /Fail	Comments
28500.922	41.26	28.55	-0.17	69.63	AvgMax	H	157	12	82.23	**-12.60**	Pass	
28504.459	41.21	28.27	-0.17	69.31	AvgMax	H	153	14	82.23	-12.92	Pass	
28510.455	39.85	27.79	-0.18	67.46	AvgMax	H	144	10	82.23	-14.77	Pass	
28511.223	39.42	27.73	-0.18	66.97	AvgMax	H	147	9	82.23	-15.26	Pass	
28505.381	33.62	28.19	-0.17	61.64	AvgMax	H	106	6	82.23	-20.59	Pass	
28987.142	39.33	12.92	-0.25	51.99	AvgMax	V	170	22	82.23	-30.24	Pass	

Preview Data

Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol H/V	Ht. cm	Az. Deg.	Limit dBµV/m	Margin dB	Pass /Fail	Comments
28500.922	49.24	28.55	-0.17	77.61	Debug	H	150	22	82.23	-4.62	Pass	
28504.459	47.89	28.27	-0.17	75.99	Debug	H	150	22	82.23	-6.24	Pass	
28505.381	47.85	28.19	-0.17	75.87	Debug	H	150	22	82.23	-6.36	Pass	
28511.223	48.22	27.73	-0.18	75.77	Debug	H	150	22	82.23	-6.46	Pass	
28510.455	47.84	27.79	-0.18	75.45	Debug	H	150	22	82.23	-6.78	Pass	
28501.384	47.12	28.51	-0.17	75.45	Debug	H	150	22	82.23	-6.78	Pass	
28523.062	48.72	26.79	-0.18	75.32	Debug	H	150	22	82.23	-6.91	Pass	
28537.053	49.76	25.68	-0.19	75.25	Debug	H	150	22	82.23	-6.98	Pass	
28540.589	49.88	25.40	-0.19	75.09	Debug	H	150	22	82.23	-7.14	Pass	
28511.531	47.50	27.70	-0.18	75.03	Debug	H	150	22	82.23	-7.20	Pass	
28519.526	47.87	27.07	-0.18	74.76	Debug	H	150	22	82.23	-7.47	Pass	
28987.142	47.15	12.92	-0.25	59.82	Debug	V	124	138	82.23	-22.41	Pass	

T1a Radiated Emissions 29GHz – 40GHz Tx On Part 30



Test Information

Results Title	Radiated E 1m 26.5-40GHz
File Name	T1a RE29g-40G Tx-on Prt30.emi
Test Laboratory	Global Product Compliance Lab
Test Engineer	MJS
Test Software	Vasona by EMISoft, version 6.061
Equipment	Nokia Wireless
EUT Details	28 GHz AEUA & AEUF -8C SNL1182710698
Configuration	Powered by -48VDC, RTM1.1, Antenna - E1373, Preamp- E1387, Analyzer E1384, and Notch Filter - E1315. RE 26.5GHz-27.5 GHz. To FCC Part 30 limits @3-Meters. Tx -on testing.
Date	2020-05-27 22:19:56

Formal Data

Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol H/V	Ht. cm	Az. Deg.	Limit dBµV/m	Margin dB	Pass /Fail	Comments
29816.983	46.17	12.30	-14.43	44.03	AvgMax	H	148	4	82.23	-38.20	Pass	
29805.486	45.45	12.30	-14.44	43.32	AvgMax	H	156	4	82.23	-38.91	Pass	
32444.421	35.00	13.38	-14.84	33.54	AvgMax	H	171	50	82.23	-48.69	Pass	
32112.258	32.14	13.33	-14.67	30.80	AvgMax	V	102	1	82.23	-51.43	Pass	
37586.804	32.53	13.80	-18.09	28.24	AvgMax	V	148	41	82.23	-53.99	Pass	
38522.950	31.84	14.01	-18.18	27.67	AvgMax	V	159	37	82.23	-54.56	Pass	

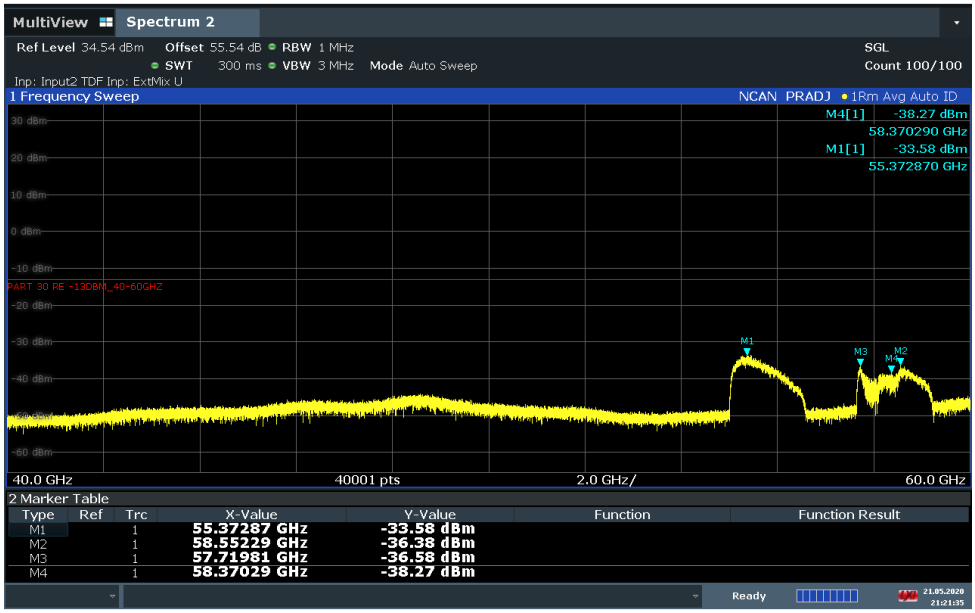
Preview Data

Freq. MHz	Raw dBµV	Cable dB	Factor dB	Level dBµV/m	Emission Type	Pol H/V	Ht. cm	Az. Deg.	Limit dBµV/m	Margin dB	Pass /Fail	Comments
29816.983	65.49	12.30	-14.43	63.35	Debug	H	150	22	82.23	-18.88	Pass	
29805.486	64.68	12.30	-14.44	62.55	Debug	H	150	22	82.23	-19.68	Pass	
32112.258	48.27	13.33	-14.67	46.93	Debug	V	100	352	82.23	-35.30	Pass	
32444.421	47.65	13.38	-14.84	46.19	Debug	H	151	352	82.23	-36.04	Pass	
38522.950	42.98	14.01	-18.18	38.81	Debug	V	100	352	82.23	-43.42	Pass	
37586.804	43.09	13.80	-18.09	38.80	Debug	V	100	352	82.23	-43.43	Pass	

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

Vertical Polarization - 1 MHz RBW

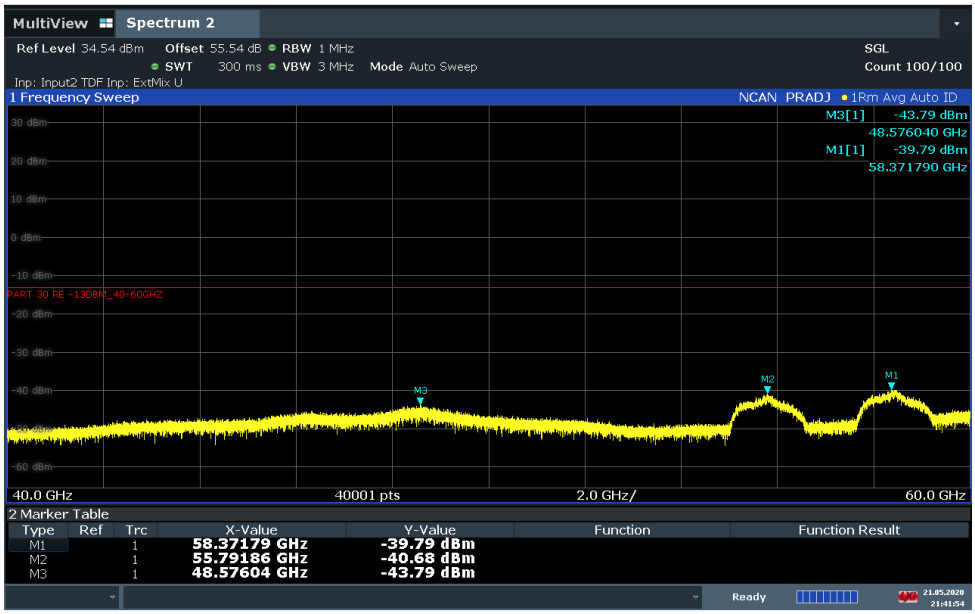
2020-0063 28 GHz AEUA-F SN L1182710698



21:21:35 21.05.2020

Horizontal Polarization - 1 MHz RBW

2020-0063 28 GHz AEUA-F SN L1182710698

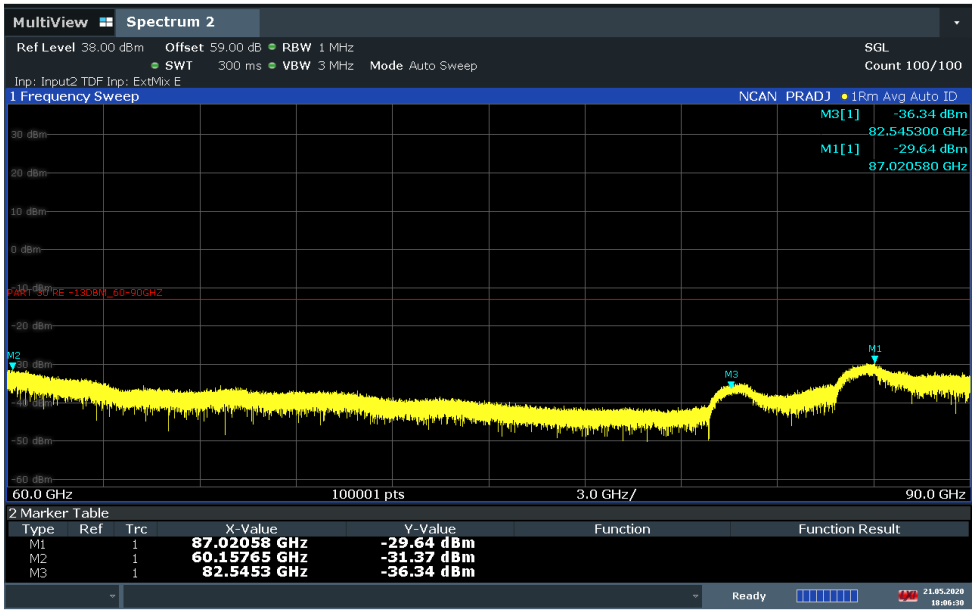


21:41:54 21.05.2020

Maximum Measured Radiated Emissions -U Band 60GHz-90GHz FCC B Part 30

Vertical Polarization - 1 MHz RBW

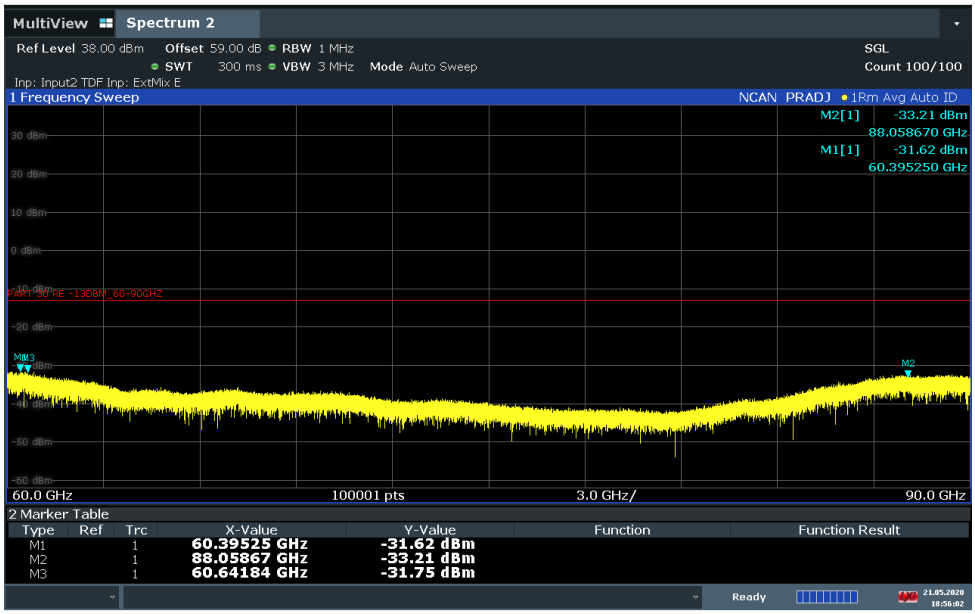
2020-0063 28 GHz AEUA-F SNL1182710698



18:06:30 21.05.2020

Horizontal Polarization - 1 MHz RBW

2020-0063 28 GHz AEUA-F SNL1182710698

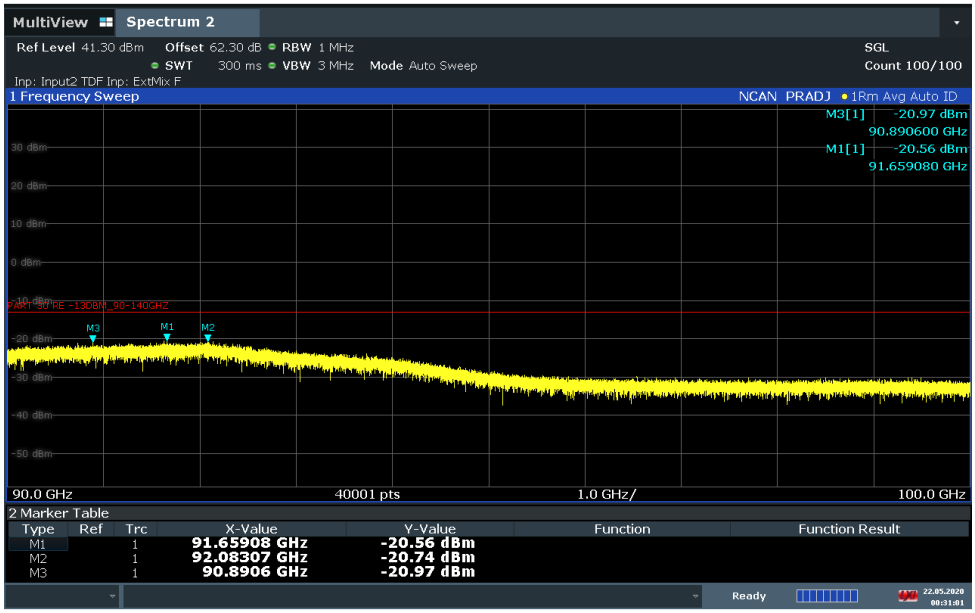


18:56:02 21.05.2020

Maximum Measured Radiated Emissions -U Band 90GHz-100GHz FCC B Part 30

Vertical Polarization - 1 MHz RBW

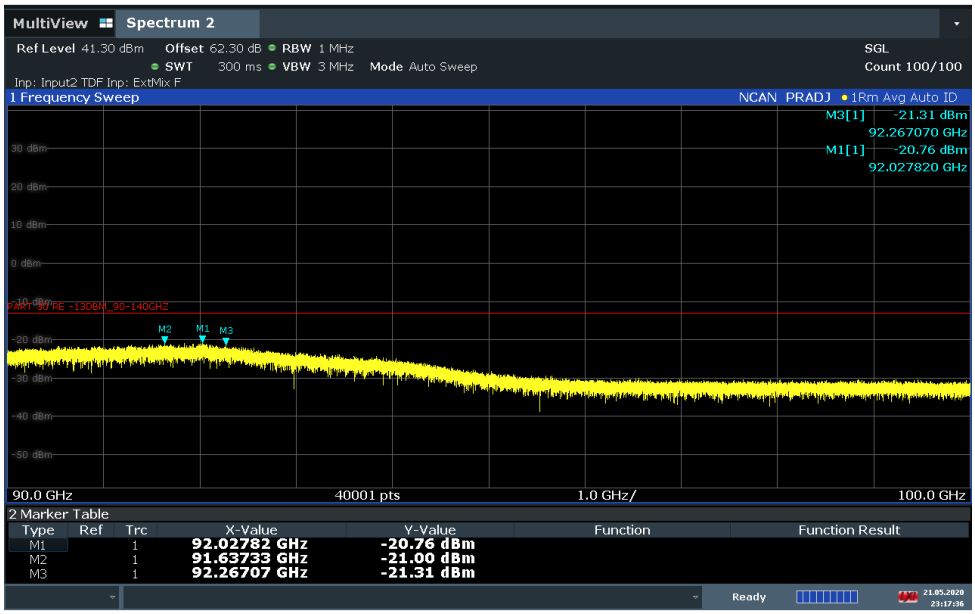
2020-0063 28 GHz AEUA-F SN L1182710698



00:31:02 22.05.2020

Horizontal Polarization - 1 MHz RBW

2020-0063 28 GHz AEUA-F SN L1182710698



23:17:37 21.05.2020

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 Radio Measurements and Radiated Emissions Test Equipment

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

Asset ID	Manufacturer	Type	Description	Model	Serial	Calibration Date	Calibration Due
E1373	A-Info	Horn Antenna	26.5-40GHz WR28 25 dB	LB-28-25-C2-KF	J202062735	2018-12-05	2021-12-05
E1321	Extech	Data Logger	Barometric Pressure/Humidity/Temp.	SD700	A075782	2018-11-07	2020-11-07
E1384	Rohde & Schwarz	Spectrum Analyzer	2 Hz to 85 GHz (with R&S®FSW-B90G option: 2 Hz to 90 GHz)	FSW85	101537	2018-12-17	2019-12-17[1]
EIH69	Rohde & Schwarz	Test Receiver	EMI 20Hz - 40GHz	ESU40	100247	2018-05-22	2020-05-22
E588	Sunol Sciences	Controller	Measurement Tower Controller	SC99V	32802-1	CNR	CNR
E766	A.H. Systems Inc.	Bilogical Antenna	25 - 2000 MHz	SAS-521-2	457	2019-02-13	2021-02-13
E513	EMC Test Systems	Horn Antenna	Double Ridged Horn 18-40 GHz	3116	2539	2019-08-26	2021-08-26
E1074	ETS Lindgren	Horn Antenna	Double Ridged Horn 1-18 GHz	3117	00135194	2019-05-01	2021-05-01
E447	Hewlett Packard	Pre-Amplifier	Preamplifier 1-26.5 GHz	8449B	3008A01384	2018-04-10	2020-06-10
E1387	Miteq	Pre-Amplifier	18 GHz-40 GHz, 45dB	TTA1840-35-HG	2034	2018-08-08	2020-08-08
E1469	A.H. Systems Inc.	Pre-Amplifier	18 GHz-40 GHz, 37 dB	PAM-1840VH	185	2020-06-01	2021-06-01
E1315	RS Microwave Company, Inc.	Filter, Microwave	DC - 40 GHz, 20W, 2.5dB	P/N 60733A	007	CNR-V	CNR-V
EIH69	Rohde & Schwarz	Test Receiver	EMI 20Hz - 40GHz	ESU40	100247	2018-05-22	2020-05-22
E1338	KeySight	Analyzer	MXA Signal Analyzer	N9020B	MY57430927	2019-11-14	2021-11-14
E1308	Rohde & Schwarz	Harmonic Mixer	Harmonic Down Converter 90-140GHz	FS-Z140	101008	2017-04-06 in Service 2018-07-01	
E1311	Rohde & Schwarz	Harmonic Mixer	Harmonic Down Converter 40-60GHz	FS-Z60	100977	2017-12-21 in Service 2018-07-01	
E1312	Rohde & Schwarz	Harmonic Mixer	Harmonic Down Converter 60-90GHz	FS-Z90	101719	2017-08-09 in Service 2018-07-01	
E1332	Sage Millimeter, Inc.	Horn Antenna	E-band pyramidal horn antenna - 60 to 90 GHz.	SAR-2309-12-S2	14853-01		
E1335	Sage Millimeter, Inc.	Horn Antenna	F-band pyramidal horn antenna - 90 to 140 GHz	SAR-2309-08-S2	14853-02		
E1330	Sage Millimeter, Inc.	Horn Antenna	U-band pyramidal horn antenna - 40 to 60 GHz	SAR-2309-19-S2	14853-01		
E980	Trilithic	Low Pass Filter	PCS 0.01-2 GHz	10LC1790-3-AA	PCS-LPF-12	CNR-V	CNR-V

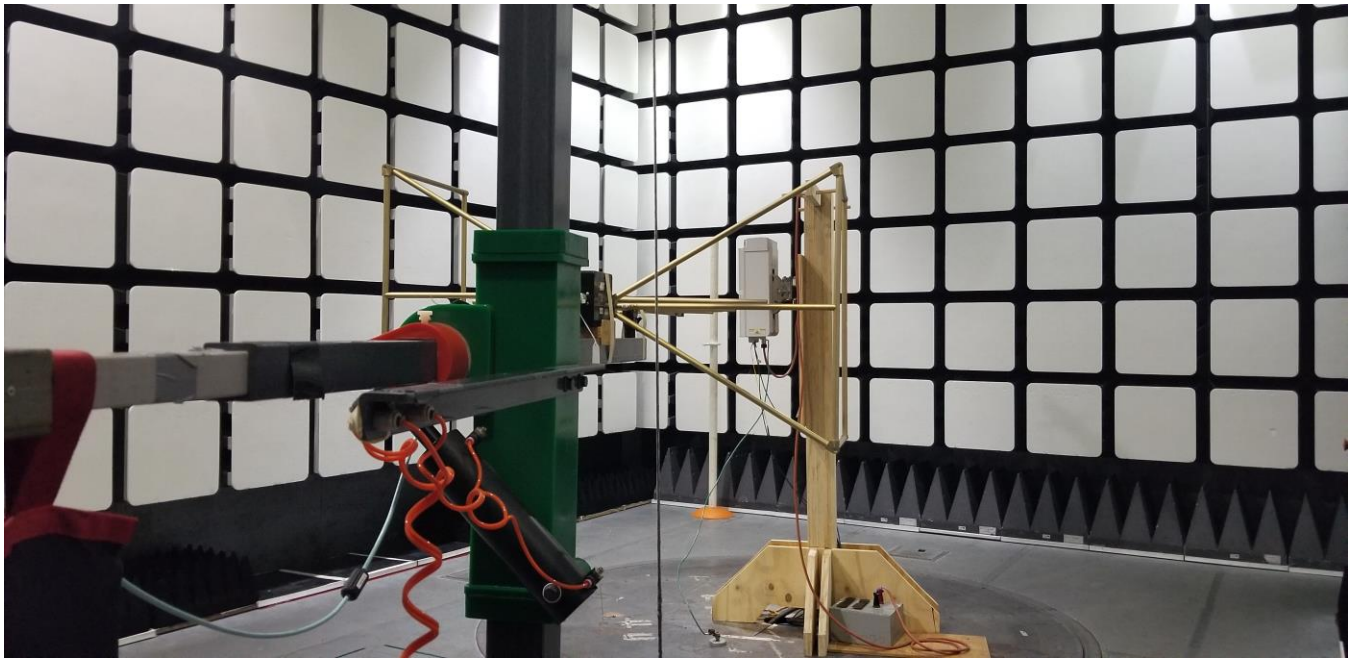
CNR: Calibration Not Required, CNR-V: Calibration Not Required, Must Be Verified, [1] Processing for Calibration

4.8 PHOTOGRAPHS OF THE TEST SETUPS

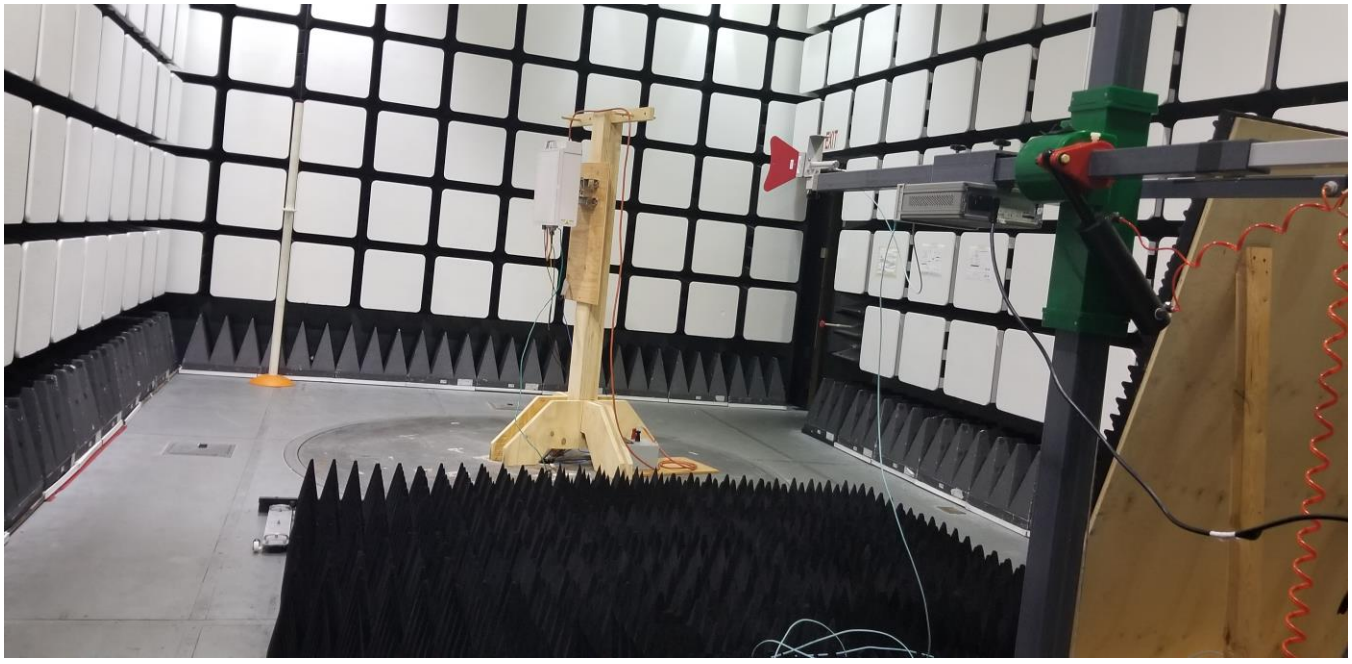
Response:

The photographs of the test setups for the **VBNAEUA-01 Band 25, FCC ID: VBNAEUA-01** are provided in the Filing exhibits.

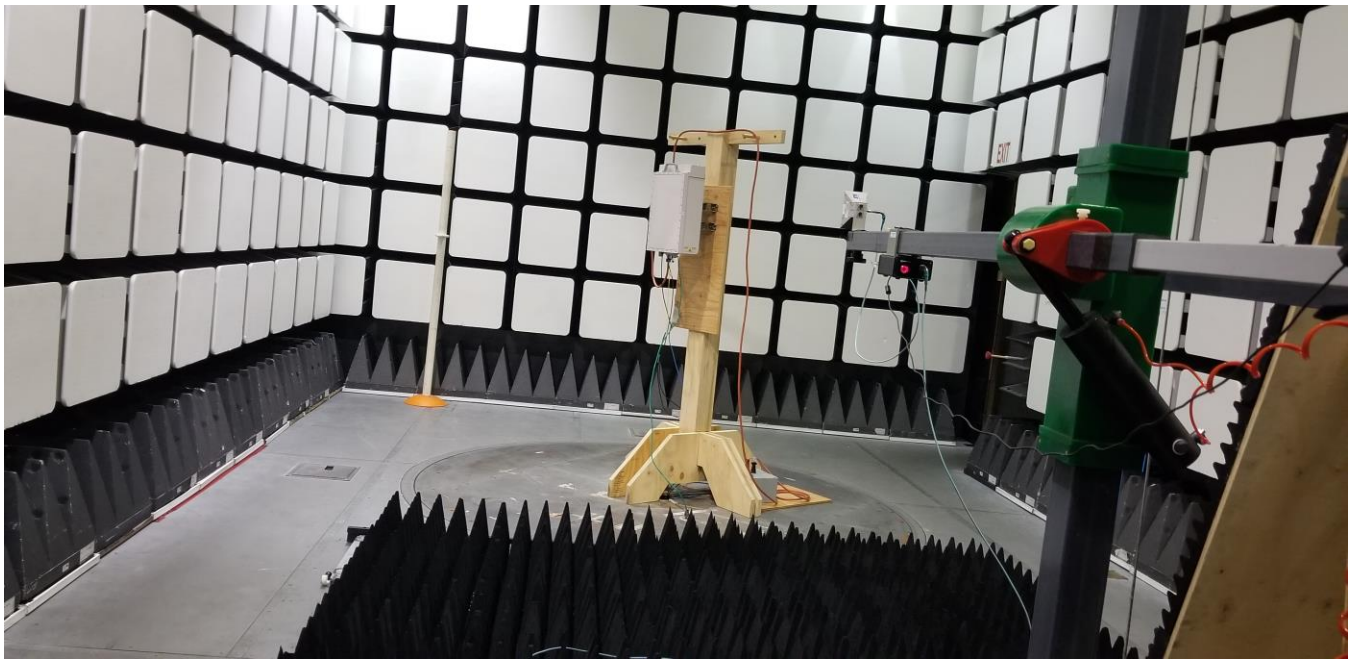
30 MHz- 1 GHz



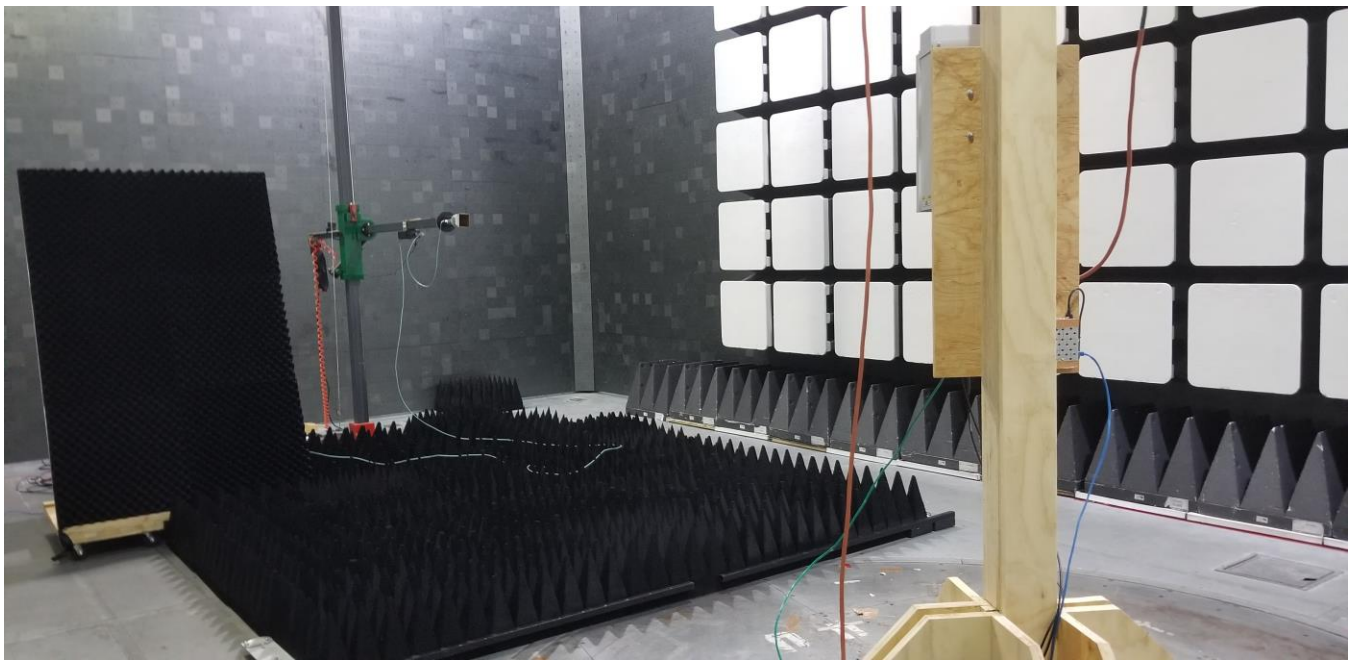
1 GHz- 18 GHz



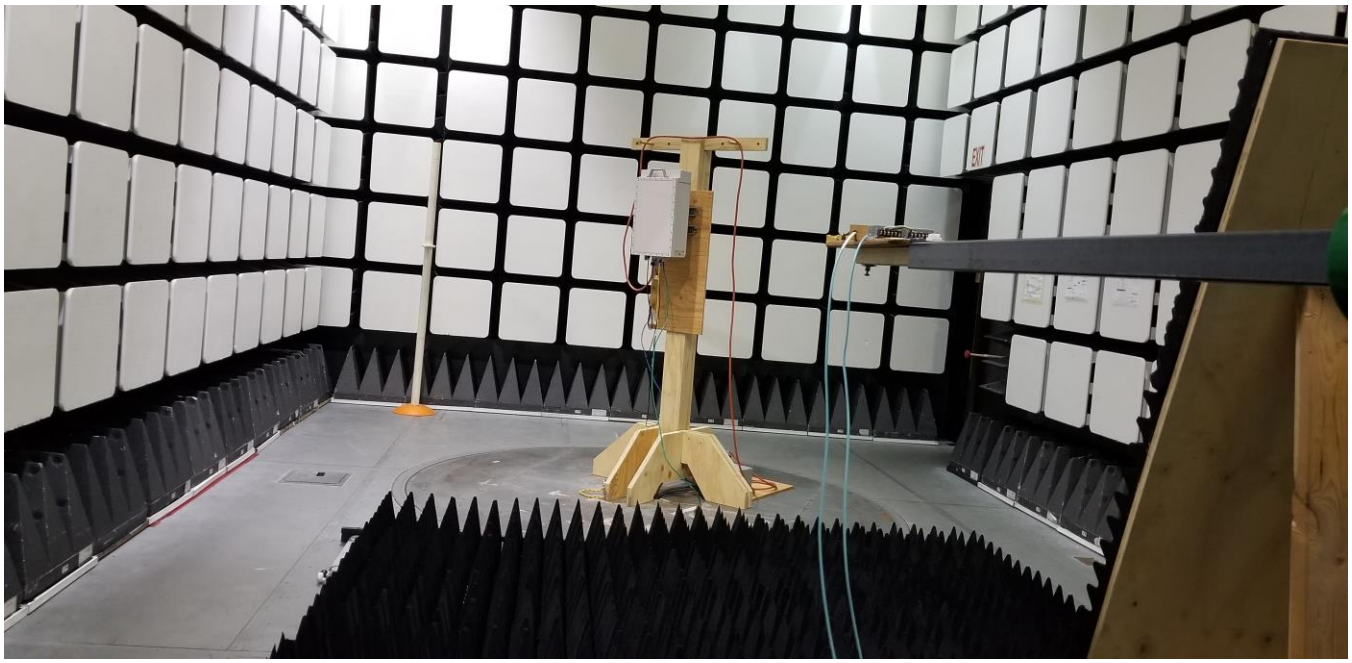
18 GHz- 26.5 GHz



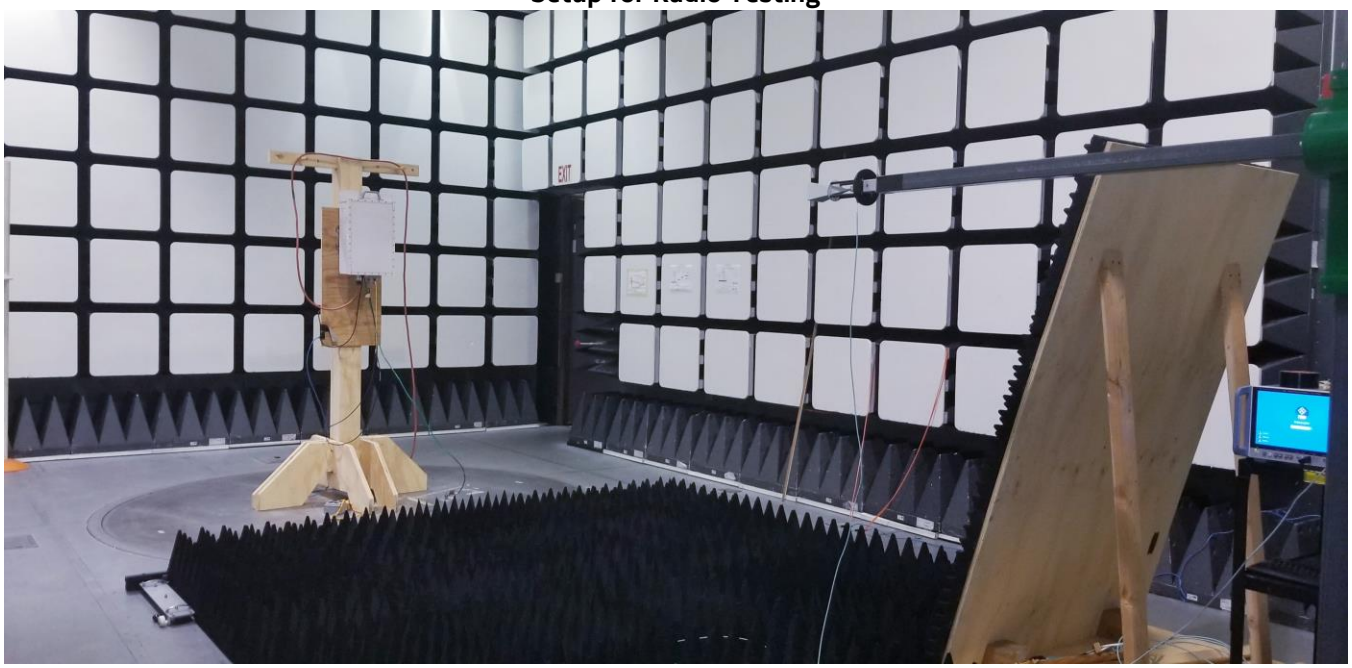
29 GHz- 40 GHz



40 GHz- 100 GHz



Setup for Radio Testing



Equipment Label

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 five meter semi-anechoic chamber AR-5, (FCC Registration Number: 395774) **NVLAP** Lab Code: 100275-0 and IC (Filing Number: 6933F-5) which is maintained by Nokia Bell Labs in Murray Hill, New Jersey. The sites were constructed and are continuously in conformance with the requirements of ANSI C63.4 and CISPR Publication 22.

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

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

and is as listed in the Table below.

OET Accredited Test Firm Scope List

Test Firm: Nokia, Global Product Compliance Lab

Scope	FCC Rule Parts	Maximum Assessed Frequency, MHz	Status	Expiration Date	Recognition Date
Unintentional Radiators	FCC Part15, Subpart B	40000	Approved	9/30/2020	7/6/2017
Intentional Radiators	FCC Part 15 Subpart C	40000	Approved	9/30/2020	6/5/2018
U-NII without DFS Intentional Radiators	FCC Part 15, Subpart E	40000	Approved	9/30/2020	6/5/2018
U-NII with DFS Intentional Radiators	FCC Part 15, Subpart E	40000	Approved	9/30/2020	6/5/2018
Commercial Mobile Services	Part 22 (cellular), Part 24, Part 25 (below 3 GHz), Part 27	40000	Approved	9/30/2020	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	9/30/2020	6/5/2018
Citizens Broadband Radio Services	Part 30	40000	Approved	9/30/2020	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	9/30/2020	7/6/2017

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

United States Department of Commerce
National Institute of Standards and Technology

NVLAP®

Certificate of Accreditation to ISO/IEC 17025:2005

NVLAP LAB CODE: 100275-0

Nokia, Global Product Compliance Lab
Murray Hill, NJ

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

Electromagnetic Compatibility & Telecommunications

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

2019-09-20 through 2020-09-30
Effective Dates

DEPARTMENT OF COMMERCE * UNITED STATES OF AMERICA *

For the National Voluntary Laboratory Accreditation Program

5. APPENDIX A - CALIBRATION CERTIFICATES.

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

Radiometer Physics
A Rohde & Schwarz Company

Calibration Certificate
Kalibrierschein

Certificate Number 24-0060-100977-01
Zertifikatsnummer

Unit Data

Item
Gegenstand
Harmonic Mixer, 40 GHz to 60 GHz

Manufacturer
Hersteller
RPG

Type
Typ
RPG FS-Z60

Material Number
Materialnummer
1048.0171.02

Serial Number
Seriennummer
100977

Asset Number
Inventarnummer

Order Data

Customer
Auftraggeber

Order Number
Bestellnummer

Date of Receipt
Eingangsdatum

Performance

Place and Date of Calibration
Ort und Datum der Kalibrierung
Meckenheim, 2017-12-21

Scope of Calibration
Umfang der Kalibrierung
Standard Calibration

Statement of Compliance (Incoming)
Konformitätsaussage (Anlieferung)
New device

Statement of Compliance (Outgoing)
Konformitätsaussage (Auslieferung)
All measured values are within the data sheet specifications.

Extend of Calibration Documents
Umfang des Kalibrierdokuments
2 pages Calibration Certificate
5 pages Outgoing Results

This calibration certificate documents, that the named item is tested and measured against defined specifications. Measurement results are located usually in the corresponding interval with a probability of approx. 95% (coverage factor k = 2). Calibration is performed with test equipment and standards directly or indirectly traceable by means of approved calibration techniques to the PTB/DKD or other national/international standards, which realize the physical units of measurement according to the International System of Units (SI). In all cases where no standards are available, measurements are referenced to standards of the R&S laboratories. Principles and methods of calibration correspond with EN ISO/IEC 17025. This calibration certificate may not be reproduced other than in full. Calibration certificates without signatures are not valid. The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein dokumentiert, dass der genannte Gegenstand nach festgelegten Vorgaben geprüft und gemessen wurde. Die Messwerte lagen im Regelfall mit einer Wahrscheinlichkeit von annähernd 95% im zugeordneten Werteintervall (Erweiterte Messunsicherheit mit k = 2). Die Kalibrierung erfolgte mit Messmitteln und Normalen, die direkt oder indirekt durch Ableitung mittels anerkannter Kalibriertechniken rückgeführt sind auf Normale der PTB/DKD oder anderer nationaler/internationaler Standards zur Darstellung der physikalischen Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI). Wenn keine Normale existieren, erfolgt die Rückführung auf Bezugsnormale der R&S-Laboratorien. Grundsätze und Verfahren der Kalibrierung beziehen sich auf EN ISO/IEC 17025. Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Kalibrierscheine ohne Unterschriften sind ungültig. Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.

Radiometer Physics GmbH; Meckenheim

Date of Issue
Ausstellungsdatum
2017-12-21

Head of Laboratory
Laborleitung
Schulze

Person Responsible
Bearbeiter
Wildfang

Radiometer Physics GmbH ● Werner-von-Siemens-Str. 4 ● 53340 Meckenheim ● Telephone national: 02225/99981-0 international: 0049 2225-99981-0
Fax: 02225/99981-99 ● Managing Director: Achim Walber, Dr. Thomas Rose ● Company's Place of Business: Meckenheim
Commercial Register No.: Bonn, HRB 10291 ● VAT Identification No.: DE 123 377 395

Calibration Method
Kalibrieranweisung

RPG-PAQA-TN-2014-002

Relative Humidity **20 % - 80 %**
Relative Luftfeuchte

Ambient Temperature
Umgebungstemperatur

(23 $^{+7}_{-3}$) °C

Working standards used (having a significant effect on the accuracy)
Verwendete Gebrauchsnormale (mit signifikantem Einfluss auf die Genauigkeit)

Item Gegenstand	**Type** Typ	**Serial Number** Seriennummer	**Calibration Certificate Number** Kalibrierscheinnummer	**Cal. Due** Kalibr. bis
Vector Network Analyzer	R&S® ZVA67	101097	20-300432406	2020-07-21
Powersensor	R&S® NRP-Z55	140093	20-300426315	2018-05-17
Powersensor	R&S® NRP-Z57	101423	20-541799	2019-04-27

UGB1 **A compliance statement may be possible where a confidence level of less than 95 % is acceptable.**
Die Bestätigung der Konformität ist möglich, sofern ein Grad des Vertrauens von weniger als 95 % akzeptabel ist.

UGB2 **A non-compliance statement may be possible where a confidence level of less than 95 % is acceptable.**
Die Bestätigung der Nicht-Konformität ist möglich, sofern ein Grad des Vertrauens von weniger als 95 % akzeptabel ist.

Ref.: ILAC-G8:03/2009 'Guidelines on the Reporting of Compliance with Specification'.

Notes
Anmerkungen

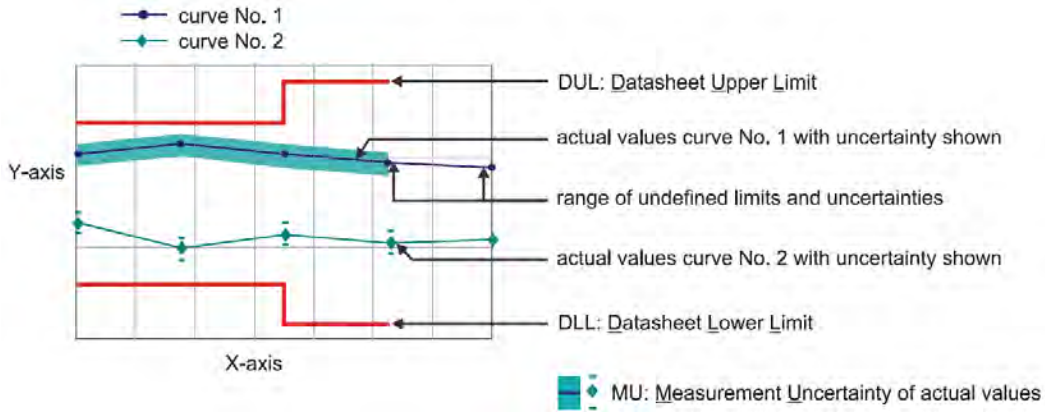
If the new product is stored under the climate conditions as specified in the data sheet upon delivery, the product's accuracy is not significantly affected within 12 month after its calibration in our factory. In this case, the recommended calibration interval starts on the date when the product is actually put into operation.

Outgoing Results

The following abbreviations may be used in this document

{a}	No measurement uncertainty stated because the errors always add together. So it is sure that a measurement result evaluated as "PASS" is pass.
{b}	The measurement uncertainty depends on the measurement result. The stated measurement uncertainty is valid for the close area around the specification. Measurement results outside the close area have a higher measurement uncertainty but are within the specification.
{c}	Functional test, therefore no measurement uncertainty is stated.
{d}	Typical value, refer to performance test.
{e}	The measurement uncertainty is taken into account when setting the measuring system.
DL or DT	Data Limit for symmetrical tolerance limits
DLL	Datasheet Lower Limit
DUL	Datasheet Upper Limit
MU	Measurement Uncertainty
MLL or MLV	Measurement Uncertainty Lower Value
MUL or MUV	Measurement Uncertainty Upper Value
Nom.	Nominal Value
Dev.	Deviation
MErr.	Measurement Error
Act.	Actual Value
UGB	Uncertainty Guard Band: Measuring uncertainty violates the data (spec.) limit.
UGB1	Measurement results marked as UGB1 show conformity with a probability of >50 %and <95 %.
UGB2	Measurement results marked as UGB2 show non-conformity with a probability of >50 %and <95 %.
DU	Datasheet Uncertainty

Explanation of charts

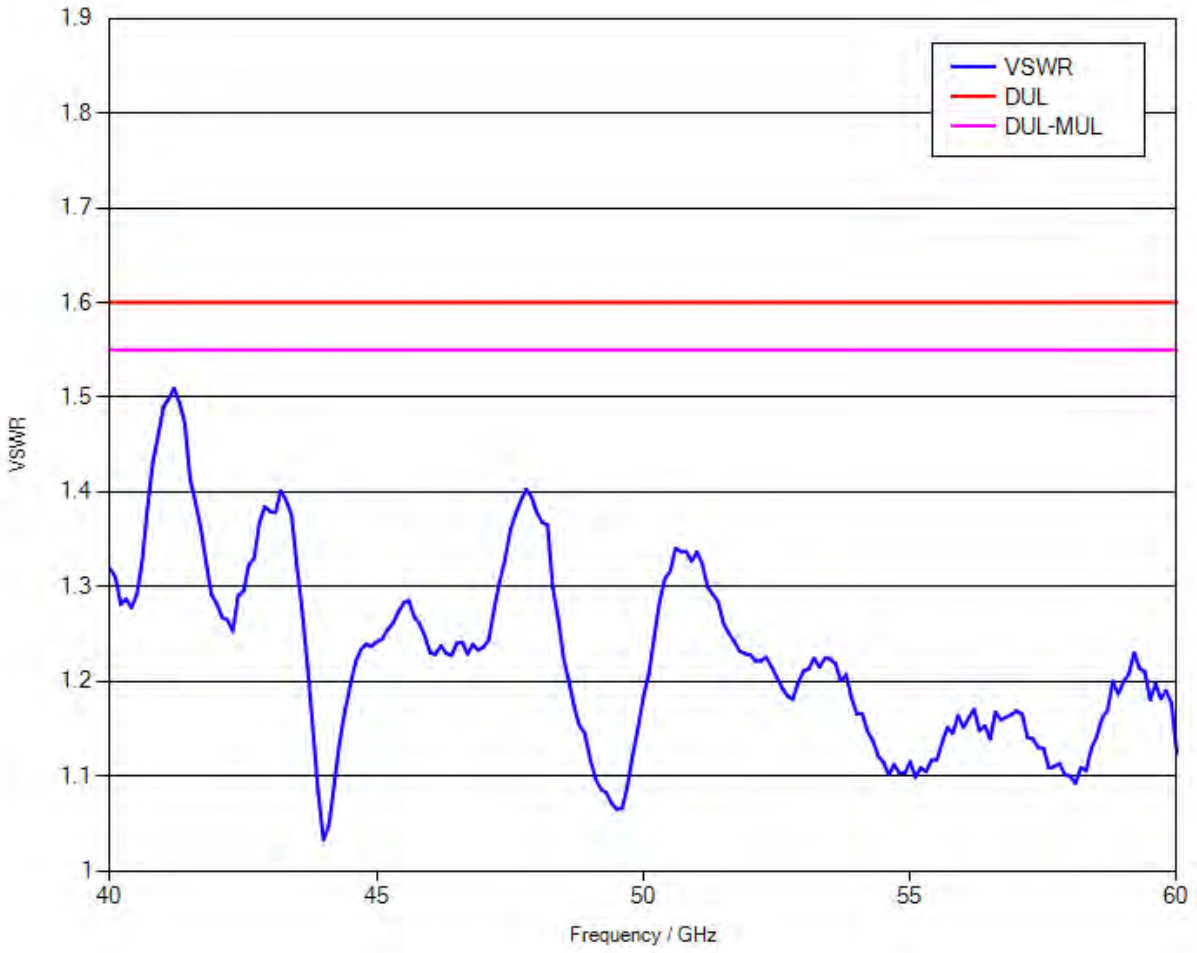


Software used for measurement

Item Type	Version	Remark
Measurement Studio Professional Edition	2013	
MixerCertification	7_07	

1.1 RF Input – VSWR

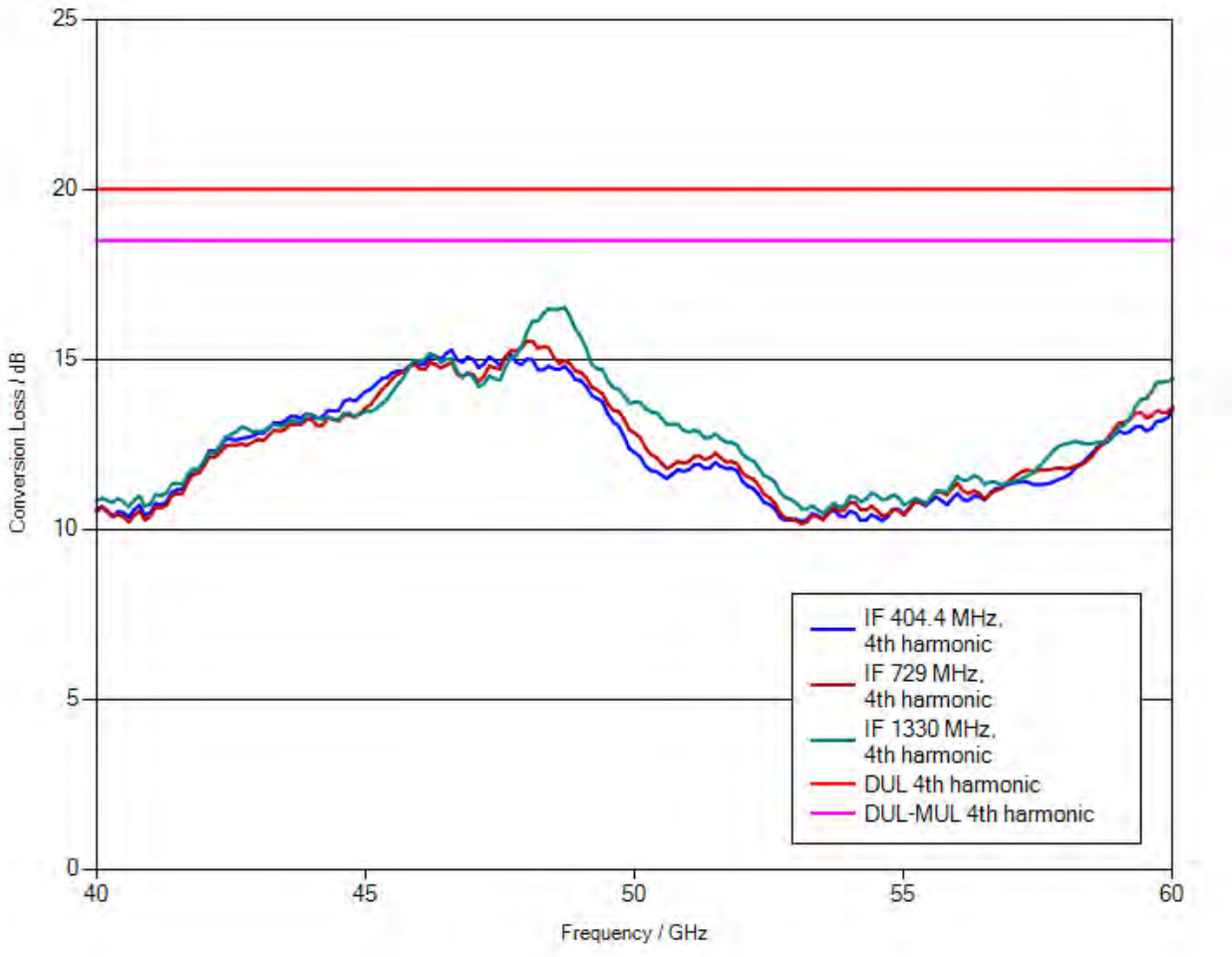
Measurement uncertainty: 0.05 (VSWR)



1.2 Conversion loss

LO level +13 dBm nominal
Bias 0 A

Measurement uncertainty: 1.5 dB



Note: Numeric calibration data can be found attached to the PDF file of the calibration certificate. Click the "paper clip" symbol to display the file.

The file has been renamed for safety reasons.
When downloading the file onto your PC, please delete the ".file" extension and unzip the data.

1.3 Frequency response within 1 GHz

	DUL	Actual (worst case)	Evaluation
IF = 404.4 MHz, 4th harmonic	4 dB	2.02 dB	PASS
IF = 729 MHz, 4th harmonic	4 dB	1.78 dB	PASS
IF = 1330 MHz, 4th harmonic	4 dB	2.35 dB	PASS

ROHDE&SCHWARZ

Calibration Certificate
Kalibrierschein

Certificate Number 24-0090-101719-01
Zertifikatsnummer

Unit Data

Item
Gegenstand
Harmonic Mixer, 60 GHz to 90 GHz

Manufacturer
Hersteller
ROHDE & SCHWARZ

Type
Typ
R&S® FS-Z90

Material Number
Materialnummer
1048.0371.02

Serial Number
Seriennummer
101719

Asset Number
Inventarnummer

Order Data

Customer
Auftraggeber

Order Number
Bestellnummer

Date of Receipt
Eingangsdatum

Performance

Place and Date of Calibration
Ort und Datum der Kalibrierung
Meckenheim, 2017-08-09

Scope of Calibration
Umfang der Kalibrierung
Standard Calibration

Statement of Compliance (Incoming)
Konformitätsaussage (Anlieferung)
New device

Statement of Compliance (Outgoing)
Konformitätsaussage (Auslieferung)
All measured values are within the data sheet specifications.

Extend of Calibration Documents
Umfang des Kalibrierdokuments
2 pages Calibration Certificate
5 pages Outgoing Results

This calibration certificate documents, that the named item is tested and measured against defined specifications. Measurement results are located usually in the corresponding interval with a probability of approx. 95% (coverage factor k = 2). Calibration is performed with test equipment and standards directly or indirectly traceable by means of approved calibration techniques to the PTB/DKD or other national/international standards, which realize the physical units of measurement according to the International System of Units (SI). In all cases where no standards are available, measurements are referenced to standards of the R&S laboratories. Principles and methods of calibration correspond with EN ISO/IEC 17025. This calibration certificate may not be reproduced other than in full. Calibration certificates without signatures are not valid. The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein dokumentiert, dass der genannte Gegenstand nach festgelegten Vorgaben geprüft und gemessen wurde. Die Messwerte lagen im Regelfall mit einer Wahrscheinlichkeit von annähernd 95% im zugeordneten Werteintervall (Erweiterte Messunsicherheit mit k = 2). Die Kalibrierung erfolgte mit Messmitteln und Normalen, die direkt oder indirekt durch Ableitung mittels anerkannter Kalibriertechniken rückgeführt sind auf Normale der PTB/DKD oder anderer nationaler/internationaler Standards zur Darstellung der physikalischen Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI). Wenn keine Normale existieren, erfolgt die Rückführung auf Bezugsnormale der R&S-Laboratorien. Grundsätze und Verfahren der Kalibrierung beziehen sich auf EN ISO/IEC 17025. Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Kalibrierscheine ohne Unterschriften sind ungültig. Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.

Radiometer Physics GmbH; Meckenheim

Date of Issue
Ausstellungsdatum
2017-08-11

Head of Laboratory
Laborleitung
Ceru

Person Responsible
Bearbeiter
Heinze

Vers2010-05-05/
RPG2014-02-28

Radiometer Physics GmbH ● Werner-von-Siemens-Str. 4 ● 53340 Meckenheim ● Telephone national: 02225/99981-0 international: 0049 2225-99981-0
Fax: 02225/99981-99 ● Managing Director: Achim Walber, Dr. Thomas Rose ● Company's Place of Business: Meckenheim
Commercial Register No.: Bonn, HRB 10291 ● VAT Identification No.: DE 123 377 395

Calibration Method
Kalibrieranweisung

RPG-PAQA-TN-2014-002

Relative Humidity **20 % - 80 %**
Relative Luftfeuchte

Ambient Temperature
Umgebungstemperatur

(23 $^{+7}_{-3}$) °C

Working standards used (having a significant effect on the accuracy)
Verwendete Gebrauchsnormale (mit signifikantem Einfluss auf die Genauigkeit)

Item Gegenstand	**Type** Typ	**Serial Number** Seriennummer	**Calibration Certificate Number** Kalibrierscheinnummer	**Cal. Due** Kalibr. bis
Vector Network Analyzer	R&S® ZVA67	101097	20-300432406	2020-07-21
Powersensor	R&S® NRP-Z55	140093	20-300426315	2018-05-17
Powersensor	R&S® NRP-Z58	101063	20-611482	2018-07-21
Calibration kit	WR12	E10001	RPG-PAQA-TN-2014-005	2019-02-01

UGB1 **A compliance statement may be possible where a confidence level of less than 95 % is acceptable.**
Die Bestätigung der Konformität ist möglich, sofern ein Grad des Vertrauens von weniger als 95 % akzeptabel ist.

UGB2 **A non-compliance statement may be possible where a confidence level of less than 95 % is acceptable.**
Die Bestätigung der Nicht-Konformität ist möglich, sofern ein Grad des Vertrauens von weniger als 95 % akzeptabel ist.

Ref.: ILAC-G8:03/2009 'Guidelines on the Reporting of Compliance with Specification'.

Notes
Anmerkungen

If the new product is stored under the climate conditions as specified in the data sheet upon delivery, the product's accuracy is not significantly affected within 12 month after its calibration in our factory. In this case, the recommended calibration interval starts on the date when the product is actually put into operation.

Outgoing Results

The following abbreviations may be used in this document

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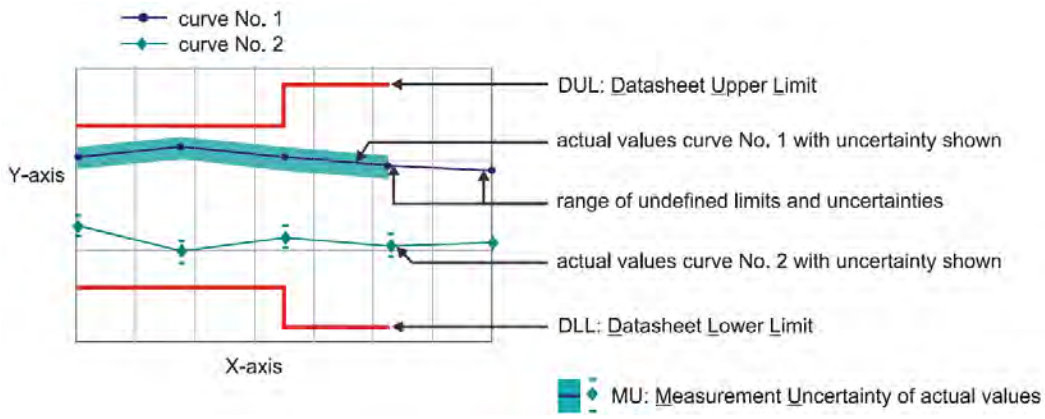
DL or DT	Data Limit for symmetrical tolerance limits
DLL	Datasheet Lower Limit
DUL	Datasheet Upper Limit
MU	Measurement Uncertainty
MLL or MLV	Measurement Uncertainty Lower Value
MUL or MUV	Measurement Uncertainty Upper Value
Nom.	Nominal Value
Dev.	Deviation
MErr.	Measurement Error
Act.	Actual Value
UGB	Uncertainty Guard Band: Measuring uncertainty violates the data (spec.) limit.
UGB1	Measurement results marked as UGB1 show conformity with a probability of >50 %and <95 %.
UGB2	Measurement results marked as UGB2 show non-conformity with a probability of >50 %and <95 %.
DU	Datasheet Uncertainty

Explanation of charts

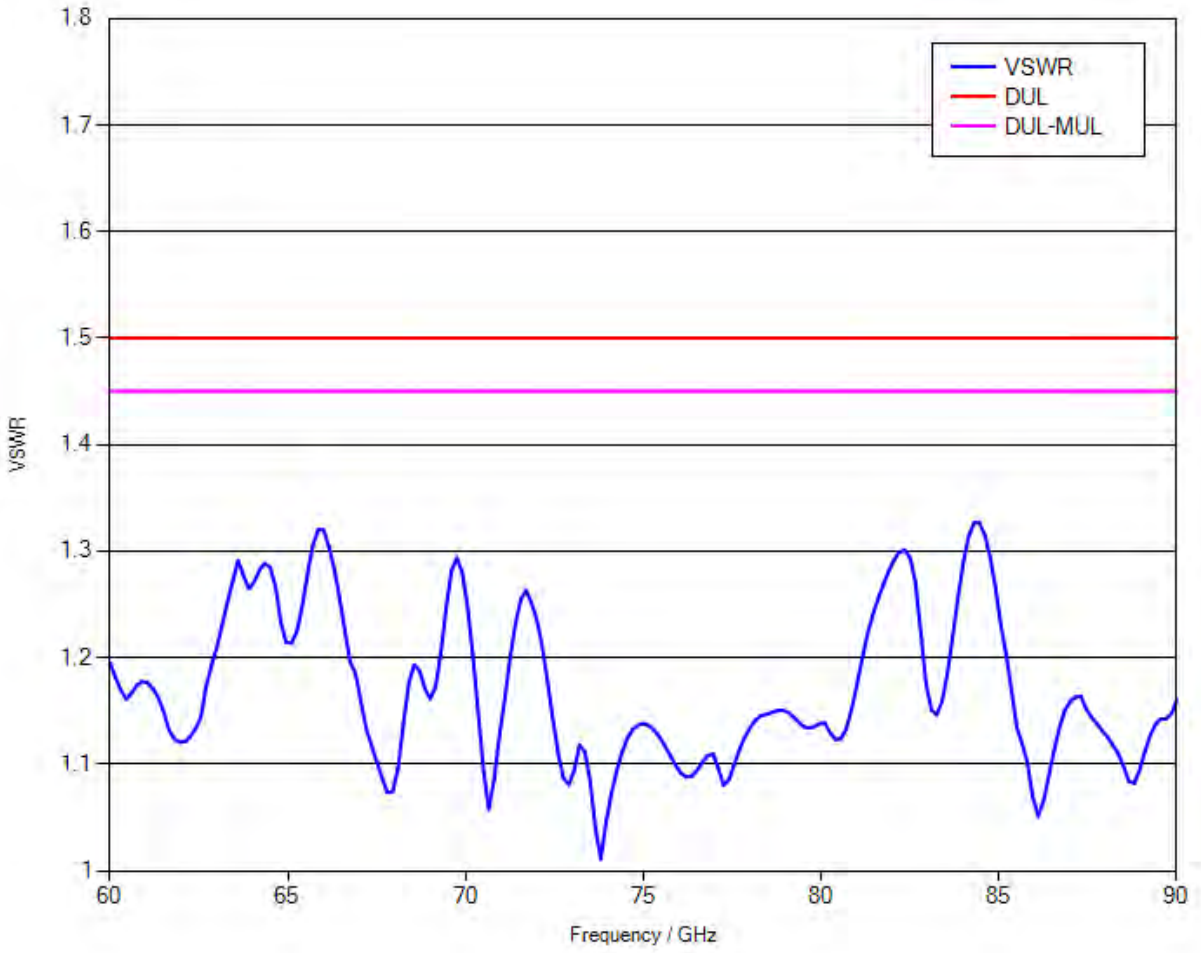


Software used for measurement

Item Type	Version	Remark
Measurement Studio Professional Edition	2013	
MixerCertification	only	

1.1 RF Input – VSWR

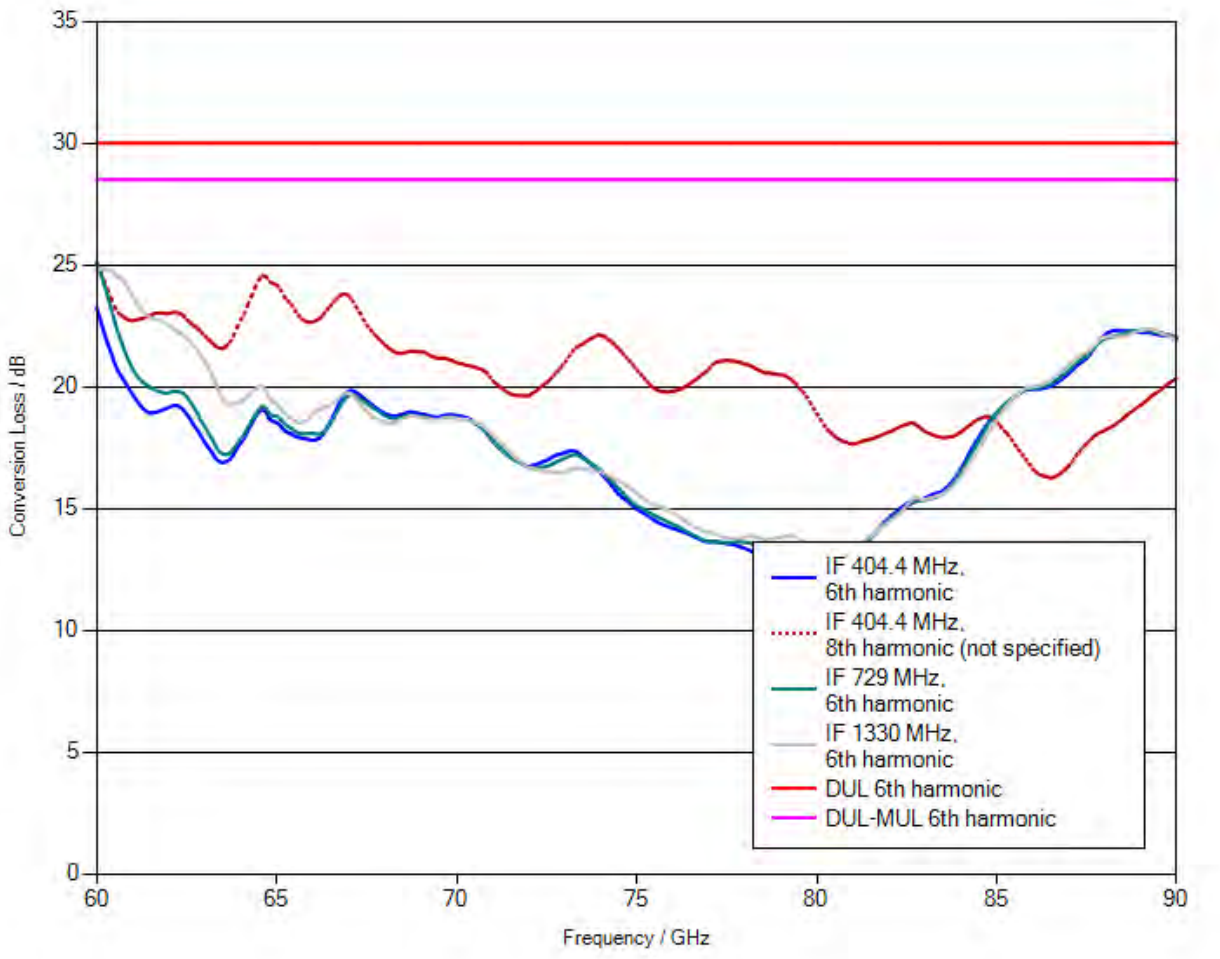
Measurement uncertainty: 0.05 (VSWR)



1.2 Conversion loss

LO level +14 dBm nominal
Bias 0 A

Measurement uncertainty: 1.5 dB



Note: Numeric calibration data can be found attached to the PDF file of the calibration certificate. Click the "paper clip" symbol to display the file.

The file has been renamed for safety reasons.
When downloading the file onto your PC, please delete the ".file" extension and unzip the data.

1.3 Frequency response within 1 GHz

	DUL	Actual (worst case)	Evaluation
IF = 404.4 MHz, 6th harmonic	6 dB	3.33 dB	PASS
IF = 404.4 MHz, 8th harmonic	not specified	2.73 dB	not specified
IF = 729 MHz, 6th harmonic	6 dB	4.12 dB	PASS
IF = 1330 MHz, 6th harmonic	6 dB	2.32 dB	PASS

Radiometer Physics
A Rohde & Schwarz Company

Calibration Certificate
Kalibrierschein

Certificate Number 24-0140-101008-01
Zertifikatsnummer

Unit Data

Item
Gegenstand
Harmonic Mixer, 90 GHz to 140 GHz

Manufacturer
Hersteller
RPG

Type
Typ
RPG FS-Z140

Material Number
Materialnummer
3622.0708.02

Serial Number
Seriennummer
101008

Asset Number
Inventarnummer

Order Data

Customer
Auftraggeber

Order Number
Bestellnummer

Date of Receipt
Eingangsdatum

Performance

Place and Date of Calibration
Ort und Datum der Kalibrierung
Meckenheim, 2017-04-06

Scope of Calibration
Umfang der Kalibrierung
Standard Calibration

Statement of Compliance (Incoming)
Konformitätsaussage (Anlieferung)
New device

Statement of Compliance (Outgoing)
Konformitätsaussage (Auslieferung)
All measured values are within the data sheet specifications.

Extend of Calibration Documents
Umfang des Kalibrierdokuments
2 pages Calibration Certificate
5 pages Outgoing Results

This calibration certificate documents, that the named item is tested and measured against defined specifications. Measurement results are located usually in the corresponding interval with a probability of approx. 95% (coverage factor k = 2). Calibration is performed with test equipment and standards directly or indirectly traceable by means of approved calibration techniques to the PTB/DKD or other national/international standards, which realize the physical units of measurement according to the International System of Units (SI). In all cases where no standards are available, measurements are referenced to standards of the R&S laboratories. Principles and methods of calibration correspond with EN ISO/IEC 17025. This calibration certificate may not be reproduced other than in full. Calibration certificates without signatures are not valid. The user is obliged to have the object recalibrated at appropriate intervals.

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Radiometer Physics GmbH; Meckenheim

Date of Issue
Ausstellungsdatum
2017-04-07

Head of Laboratory
Laborleitung
Ceru

Person Responsible
Bearbeiter
Heinze

Vers2010-05-05/
RPG2014-02-28

Radiometer Physics GmbH ● Werner-von-Siemens-Str. 4 ● 53340 Meckenheim ● Telephone national: 02225/99981-0 international: 0049 2225-99981-0
Fax: 02225/99981-99 ● Managing Director: Achim Walber, Dr. Thomas Rose ● Company's Place of Business: Meckenheim
Commercial Register No.: Bonn, HRB 10291 ● VAT Identification No.: DE 123 377 395

Calibration Method
Kalibrieranweisung

RPG-PAQA-TN-2014-002

Relative Humidity **20 % - 80 %**
Relative Luftfeuchte

Ambient Temperature
Umgebungstemperatur

(23 $^{+7}_{-3}$) °C

Working standards used (having a significant effect on the accuracy)
Verwendete Gebrauchsnormale (mit signifikantem Einfluss auf die Genauigkeit)

Item Gegenstand	**Type** Typ	**Serial Number** Seriennummer	**Calibration Certificate Number** Kalibrierscheinnummer	**Cal. Due** Kalibr. bis
Vector Network Analyzer	R&S® ZVA67	101097	10-300319061	2017-08-06
Powersensor	R&S® NRP-Z55	140093	20-541556	2017-05-12

UGB1 **A compliance statement may be possible where a confidence level of less than 95 % is acceptable.**
Die Bestätigung der Konformität ist möglich, sofern ein Grad des Vertrauens von weniger als 95 % akzeptabel ist.

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Notes
Anmerkungen

Outgoing Results

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DUL	Datasheet Upper Limit
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MLL or MLV	Measurement Uncertainty Lower Value
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Nom.	Nominal Value
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MErr.	Measurement Error
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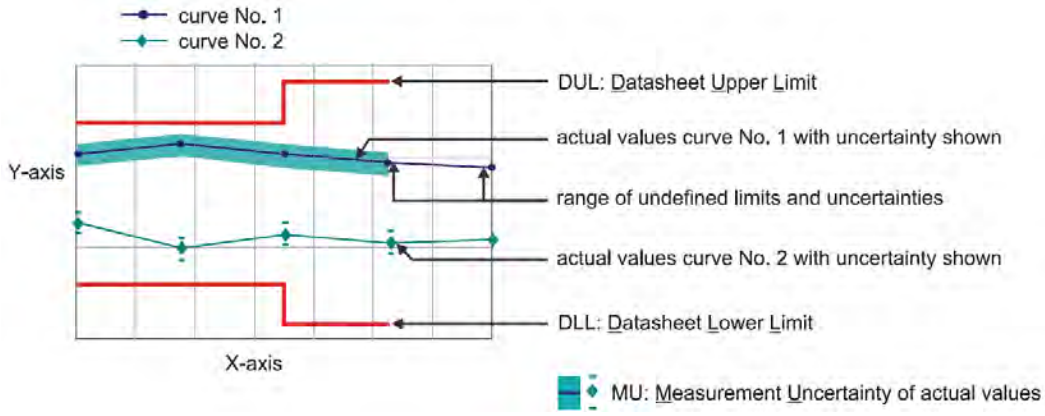
DU	Datasheet Uncertainty

Explanation of charts

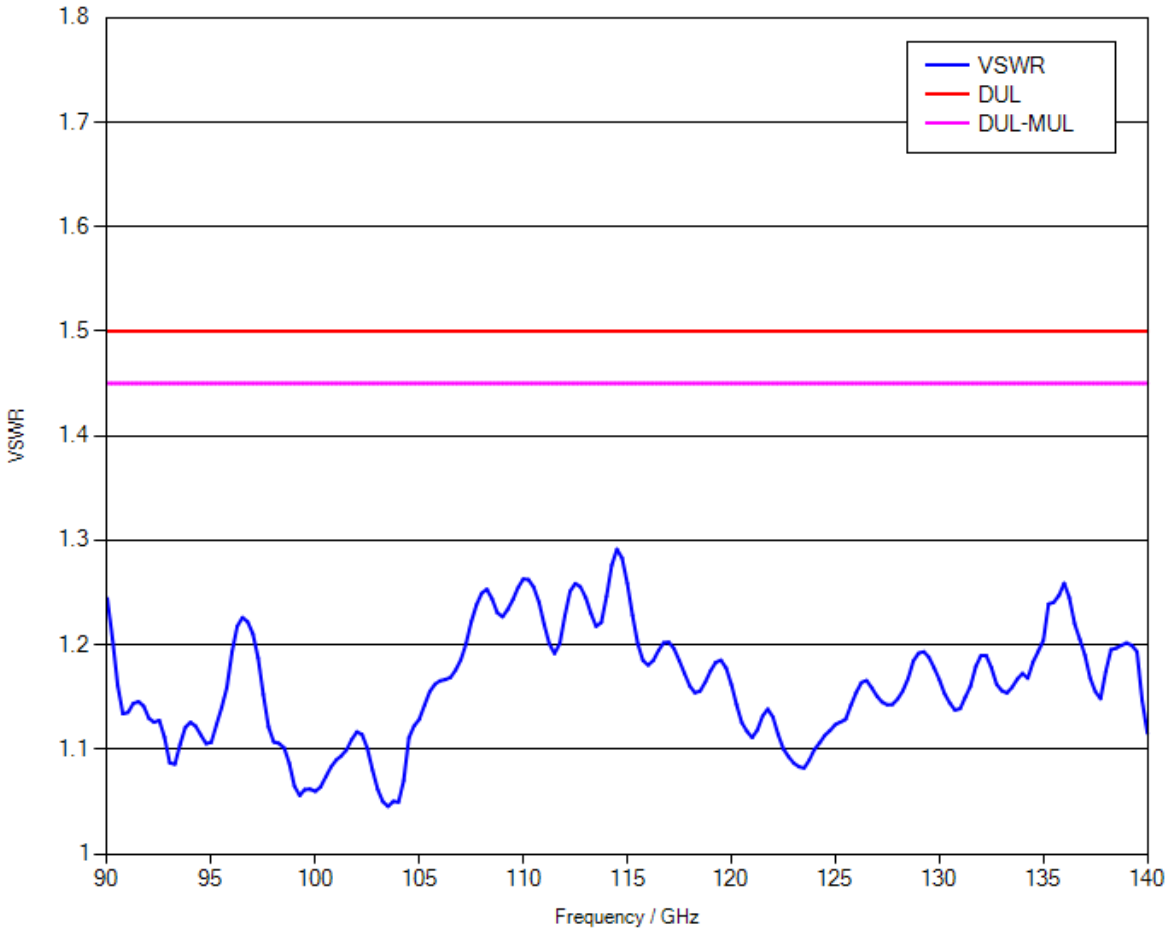


Software used for measurement

Item Type	Version	Remark
Measurement Studio Professional Edition	2013	
MixerCertification	7_04	

1.1 RF Input – VSWR

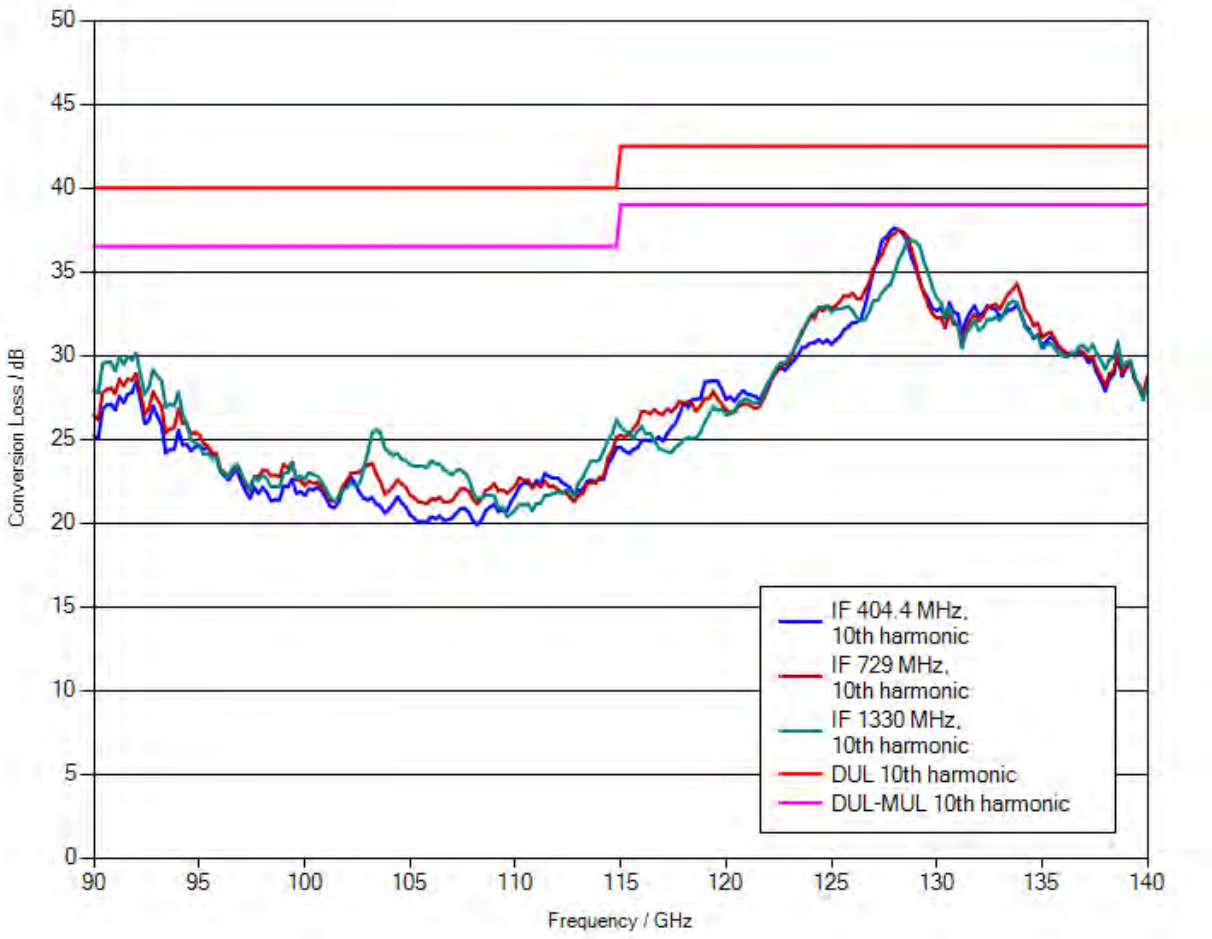
Measurement uncertainty: 0.05 (VSWR)



1.2 Conversion loss

LO level +14 dBm nominal
Bias 0 A

Measurement uncertainty: 3.5 dB



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1.3 Frequency response within 1 GHz

	DUL	Actual (worst case)	Evaluation
IF = 404.4 MHz, 10th harmonic	6 dB	3.86 dB	PASS
IF = 729 MHz, 10th harmonic	6 dB	3.48 dB	PASS
IF = 1330 MHz, 10th harmonic	6 dB	3.19 dB	PASS

Radiometer Physics
A Rohde & Schwarz Company

Calibration Certificate
Kalibrierschein

Certificate Number 24-0220-100960-01
Zertifikatsnummer

Unit Data

Item
Gegenstand
Harmonic Mixer, 140 GHz to 220 GHz

Manufacturer
Hersteller
RPG

Type
Typ
RPG FS-Z220

Material Number
Materialnummer
3593.3250.02

Serial Number
Seriennummer
100960

Asset Number
Inventarnummer

Order Data

Customer
Auftraggeber

Order Number
Bestellnummer

Date of Receipt
Eingangsdatum

Performance

Place and Date of Calibration
Ort und Datum der Kalibrierung
Meckenheim, 2018-01-17

Scope of Calibration
Umfang der Kalibrierung
Standard Calibration

Statement of Compliance (Incoming)
Konformitätsaussage (Anlieferung)
New device

Statement of Compliance (Outgoing)
Konformitätsaussage (Auslieferung)
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Umfang des Kalibrierdokuments
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Radiometer Physics GmbH; Meckenheim

Date of Issue
Ausstellungsdatum
2018-01-19

Head of Laboratory
Laborleitung
Ceru

Person Responsible
Bearbeiter
Dick

Radiometer Physics GmbH ● Werner-von-Siemens-Str. 4 ● 53340 Meckenheim ● Telephone national: 02225/99981-0 international: 0049 2225-99981-0
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Commercial Register No.: Bonn, HRB 10291 ● VAT Identification No.: DE 123 377 395

Calibration Method
Kalibrieranweisung

RPG-PAQA-TN-2014-002

Relative Humidity **20 % - 80 %**
Relative Luftfeuchte

Ambient Temperature
Umgebungstemperatur

(23 $^{+7}_{-3}$) °C

Working standards used (having a significant effect on the accuracy)
Verwendete Gebrauchsnormale (mit signifikantem Einfluss auf die Genauigkeit)

Item Gegenstand	**Type** Typ	**Serial Number** Seriennummer	**Calibration Certificate Number** Kalibrierscheinnummer	**Cal. Due** Kalibr. bis
Vector Network Analyzer	R&S® ZVA67	101097	20-300432406	2020-07-21
Powersensor	R&S® NRP-Z55	140093	20-300426315	2018-05-17

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Notes
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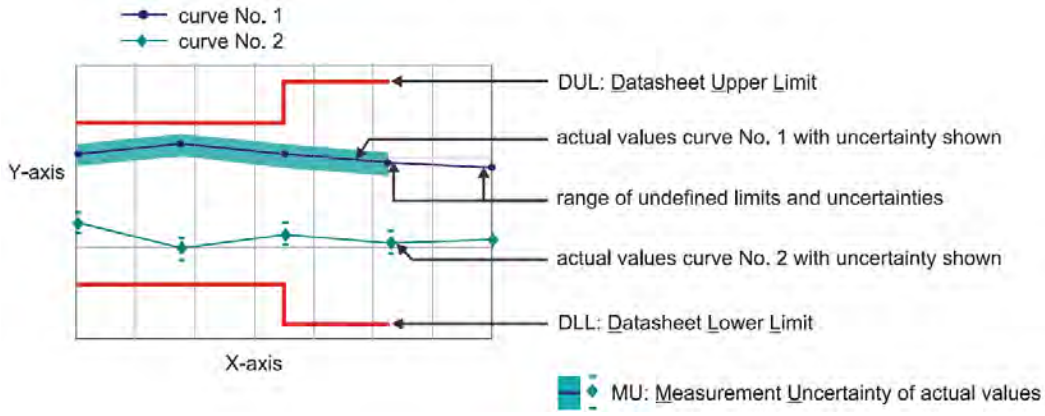
Explanation of charts

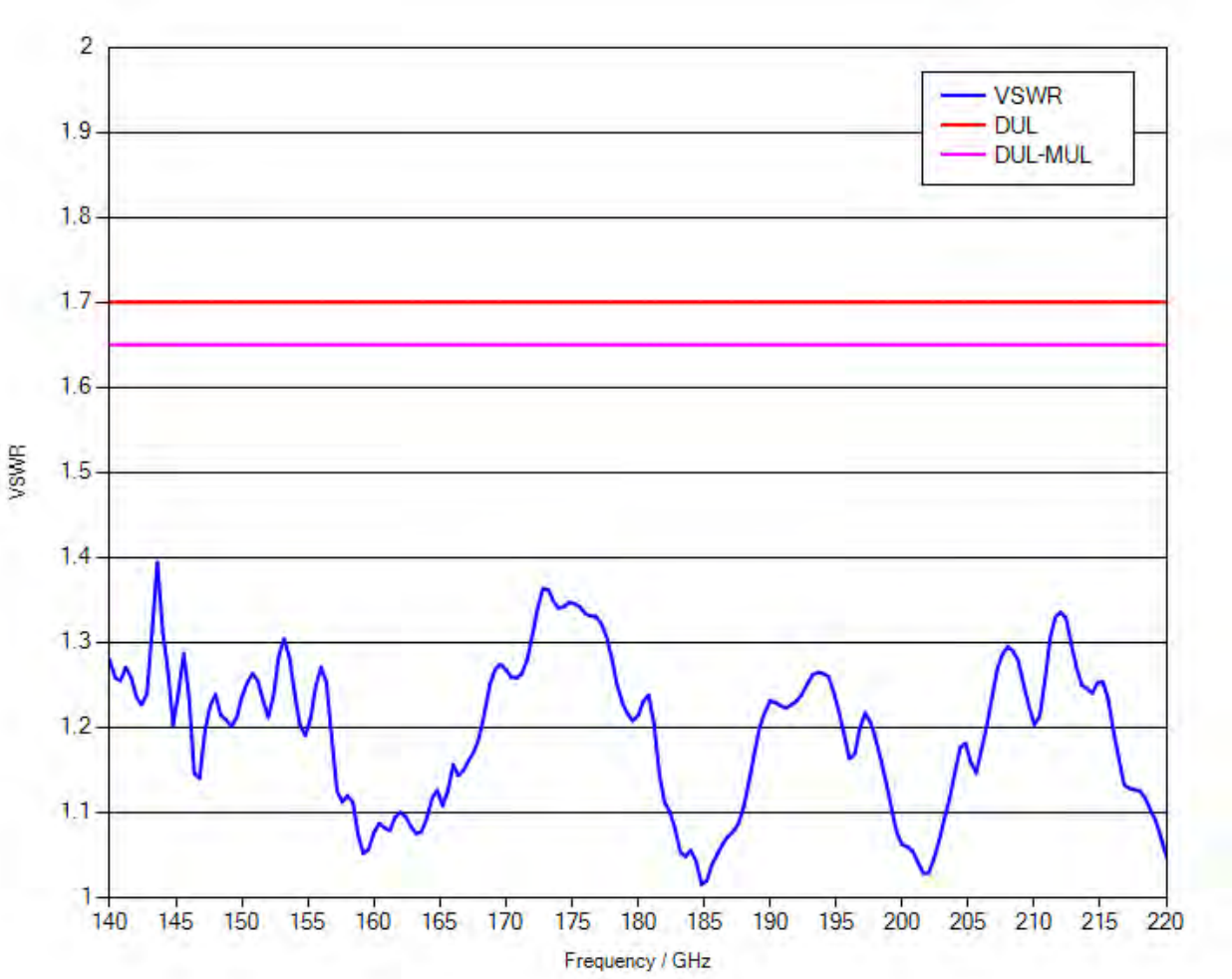


Software used for measurement

Item Type	Version	Remark
Measurement Studio Professional Edition	2013	
MixerCertification	7_08	

1.1 RF Input – VSWR

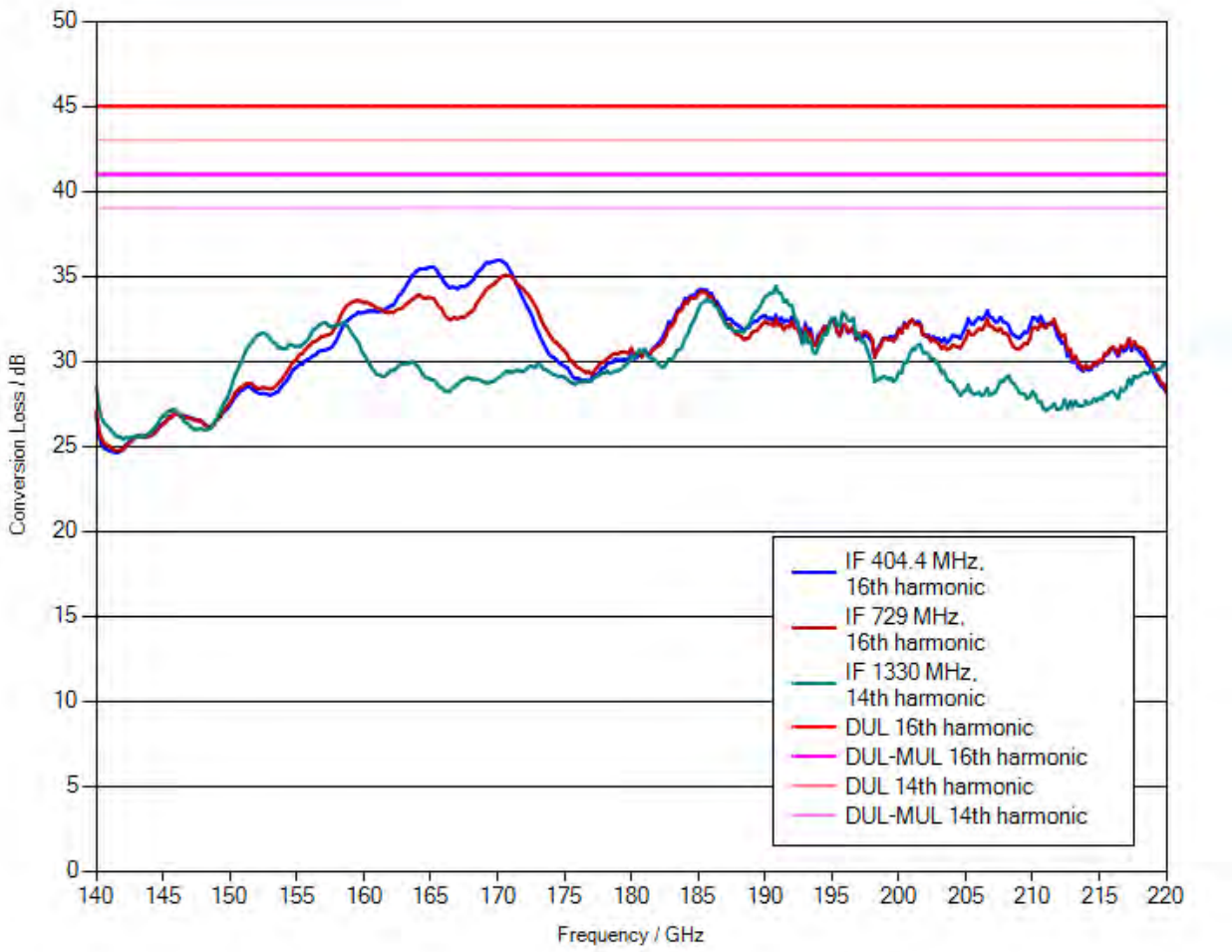
Measurement uncertainty: 0.05 (VSWR)



1.2 Conversion loss

LO level +13 dBm nominal
Bias 0 A

Measurement uncertainty: 4 dB



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1.3 Frequency response within 1 GHz

	DUL	Actual (worst case)	Evaluation
IF = 404.4 MHz, 16th harmonic	6 dB	2.1 dB	PASS
IF = 729 MHz, 16th harmonic	6 dB	2.05 dB	PASS
IF = 1330 MHz, 14th harmonic	6 dB	2.48 dB	PASS