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Title 47 Code of Federal Regulations Test Report

Regulation:
FCC Part 2 and 27

Client:
Nokia Solutions and Networks

Product Evaluated:
AAHF Full Band
40MHz 5G at 120W

Report Number:
TR-2019-0172-FCC2-27

Date Issued:
November 13, 2019

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Revisions

Date	Revision	Section	Change
11/13/2019	0		Initial Release

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1. System Information and Requirements

Report copies and other information not contained in this report are held by either the product engineer or in an identified file at the Global Product Compliance Laboratory in Murray-Hill, NJ.

Equipment Under Test (EUT):	AAHF Full Band 40MHz
FCC ID:	VBNAAHF-01
Serial Number:	See Section 1.3
Hardware Version:	See Section 1.3
Software Version:	FL19A
Frequency Range:	2496 – 2690 MHz
GPCL Project Number:	2019-0172
Manufacturer:	NOKIA SOLUTIONS AND NETWORKS OY KARAPORTTI 3, FI-02610 ESPOO FINLAND
Test Requirement(s):	Title 47 CFR Parts 2 and 27
Test Standards:	<ul style="list-style-type: none"> • Title 47 CFR Parts 2 and 27 • KDB 971168 D01 Power Measurement License Digital Systems v03r01 April 9, 2018. • KDB 662911 D01 Multiple Transmitter Output v02r01 Oct 2013 • ANSI C63.26 (2015) • ANSI C63.4 (2014)
Measurement Procedure(s):	<ul style="list-style-type: none"> • FCC-IC-OB - GPCL Occupied Bandwidth and Power Measurement Test Procedure 12-4-2017 • FCC-IC-SE - GPCL Spurious Emissions Test Procedure 12-4-2017
Test Date(s):	October 2019
Test Performed By:	Nokia Global Product Compliance Laboratory 600-700 Mountain Ave. P.O. Box 636 Murray Hill, NJ 07974-0636
Product Engineer(s):	Ron Remy
Lead Engineer:	Steve Gordon
Test Engineer (s):	Jaideep Yadav, Eugene Mitchell, Mike Soli
Test Results: The EUT, <i>as tested</i> /met the above listed requirements. Report copies and other information not contained in this report are held by either the product engineer or in an identified file at the Global Product Compliance Laboratory in New Providence, NJ.	

1.1 Introduction

This Conformity test report applies to the AAHF Full Band 40MHz, hereinafter referred to as the Equipment Under Test (EUT).

1.2 Purpose and Scope

The purpose of this testing is to demonstrate compliance for the 40MHz 5G-NR Carrier. A Class II Permissive Change will be submitted to add 60 W for 40 MHz 5G-NR (G7W) operation in 32T32R mode and 60 W LTE (F9W) in 32T32R mode.

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The product operates with a 40 MHz 32T32R 5G-NR carrier (1.875 W/port, two port arrays at 120W) or 64T64R 5G-NR carrier (1.875 W/port at 120W).

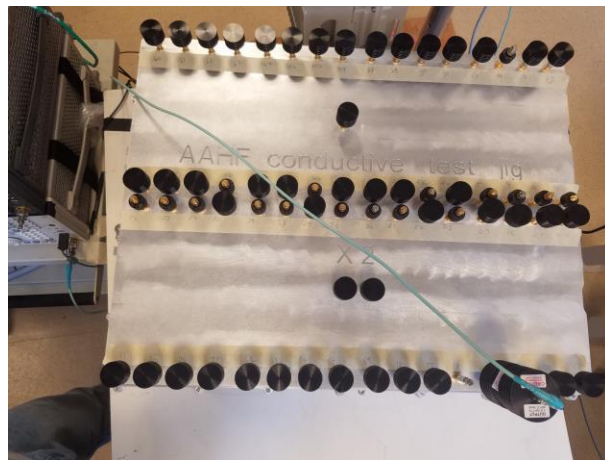
This report documents testing data required for qualifying the EUT in compliance with FCC Parts 2 and 27 measured in accordance with the procedures set out in Section 2.1033 (c) (14) of the Rules.

1.3 EUT Details

The Nokia AirScale AAHF mMIMO Radio Head is a 64 port radio head over the Band 41 spectrum of 2496 - 2690 MHz. Each of the 64 transmit ports generates 32.73dBm/1.875W for a total of 120W.

Nokia's AirScale massive MIMO Adaptive Antenna deploys 64 transmit and 64 receive streams, 16-layer Massive MIMO, and Carrier Aggregation with broad range of customized variants to deliver up to five times more network capacity, high peak downlink throughput, significantly improved uplink, and greater coverage.

Specification Items	Description
Radio Access Technology	E-UTRA
Duplex Mode	Frequency Division Duplex (FDD)
Modulation Type(s)	QPSK, 16QAM, 64QAM, 256QAM
Operation Frequency Range	2496-2690MHz
Channel Bandwidth	5, 10, 15, 20, 40 and 60MHz
Supply Voltage	-48.0 VDC
Number of Antenna Ports	64Tx/64Rx
MiMo	Yes



1.4 Test Requirements

Each required measurement is listed below:

47 CFR FCC Sections	Description of Tests	Test Required
2.1046, 27.53	RF Power Output	Yes
2.1047, 27.53	Modulation Characteristics	Yes
2.1049, 27.53	(a) Occupied Bandwidth (b) Out-of-Band Emissions	Yes
2.1051, 27.53	Spurious Emissions at Antenna Terminals	Yes
2.1053, 27.53	Field Strength of Spurious Radiation	Yes

1.5 Standards & Procedures

1.5.1 Standards

- Title 47 Code of Federal Regulations, Federal Communications Commission Part 2.
- Title 47 Code of Federal Regulations, Federal Communications Commission Part 27.
- ANSI C63.26, American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services

1.5.2 Procedures

1. FCC-IC-OB and FCC-IC-SE
2. ANSI C63.4 (2014) entitled: "American National Standard for Methods of Measurement of Radio-Noise Emissions from Low Voltage Electrical and Electronic Equipment in the Range of 9kHz to 40 GHz", American National Standards Institute, Institute of Electrical and Electronic Engineers, Inc., New York, NY 10017-2394, USA.
3. FCC KDB 971168 D01 Power Measurement License Digital Systems v03r01 April 9, 2018.
FCC KDB 662911 D01 Multiple Transmitter Output v02r01 Oct 2013

1.5.3 MEASUREMENT UNCERTAINTY

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

Worst-Case Estimated Measurement Uncertainties

Standard, Method or Procedure	Condition	Frequency MHz	Expanded Uncertainty (k=2)
a. Classical Emissions, (<i>e.g.</i> , ANSI C63.4, CISPR 11, 14, 22, <i>etc.</i> , using ESHS 30,	Conducted Emissions	0.009 - 30	±3.5 dB
	Radiated Emissions (AR-6 Semi-Anechoic Chamber)	30 MHz – 200MHz H	±5.1 dB
		30 MHz – 200 MHz V	±5.1 dB
		200 MHz – 1000 MHz H	±4.7 dB
		200 MHz – 1000 MHz V	±4.7 dB
		1 GHz - 18 GHz	±3.3 dB

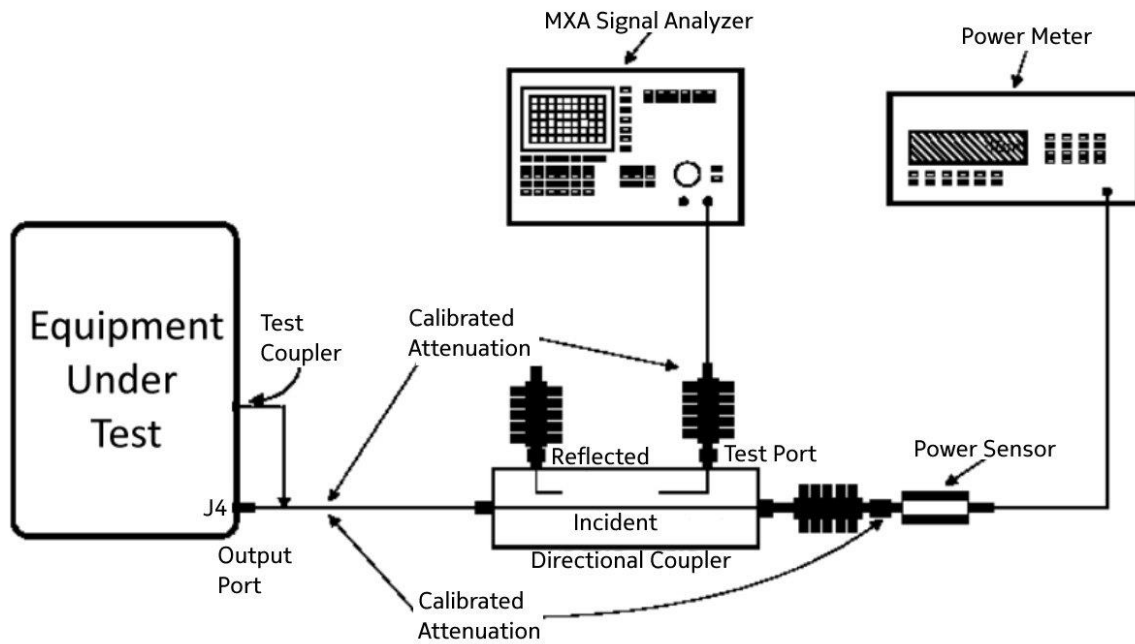
Antenna Port Test	Signal Bandwidth	Frequency Range	Expanded Uncertainty (k=2), Amplitude
Occupied Bandwidth, Edge of Band, Conducted Spurious Emissions	10 Hz 100 Hz 10 kHz to 1 MHz 1MHz	9 kHz to 20 MHz 20 MHz to 1 GHz 1 GHz to 10 GHz 10 GHz to 40 GHz:	1.78 dB
RF Power	10 Hz to 20 MHz	50 MHz to 18 GHz	0.5 dB

1.6 Executive Summary

Requirement	Description	Result
47 CFR FCC Parts 2 and 27		
2.1046, 27.53	RF Power Output	COMPLIES
2.1047, 27.53	Modulation Characteristics	COMPLIES
2.1049, 27.53	(a) Occupied Bandwidth (b) Edge of Band Emissions	COMPLIES
2.1051, 27.53	Spurious Emissions at Antenna Terminals	COMPLIES
2.1053, 27.53	Field Strength of Spurious Radiation	COMPLIES

1. **COMPLIES** - Passed all applicable tests.
2. **N/A** – Not Applicable.
3. **NT** – Not Tested.

1.7 Test Configuration for all Antenna Port Measurements.



2. FCC Section 2.1046 - RF Power Output

2.1 RF Power Output

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

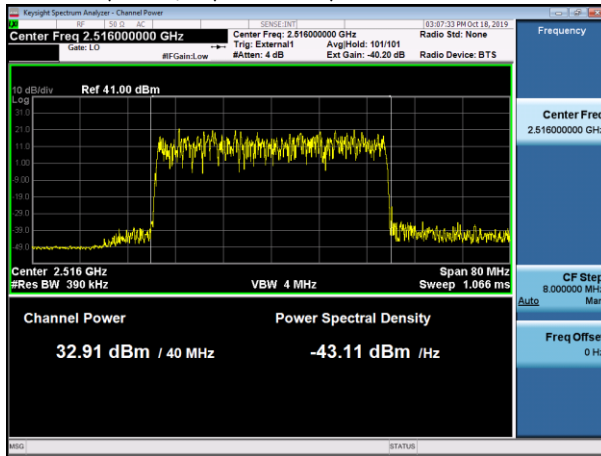
Power measurements were made with an MXA Signal Analyzer.

Tabular Data – Channel RF Power, 40MHz BW

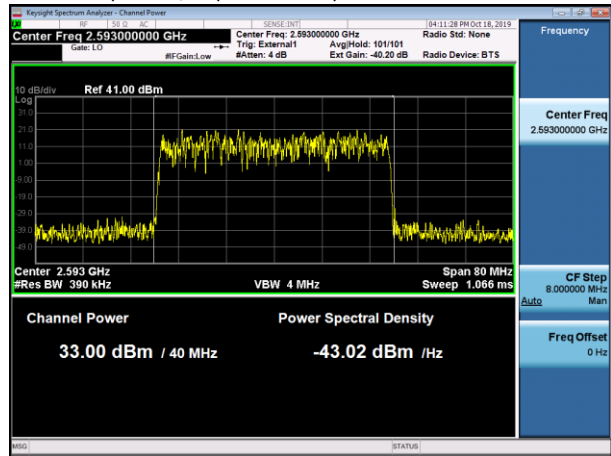
Modulation	Channel Frequency MHz	Channel Power dBm
256QAM	2516	32.91
	2593	33.00
	2670	32.98
QPSK+16QAM	2670	32.58
64QAM	2593	32.64
	2670	32.88

2.1.1 Channel RF Power - Plots.

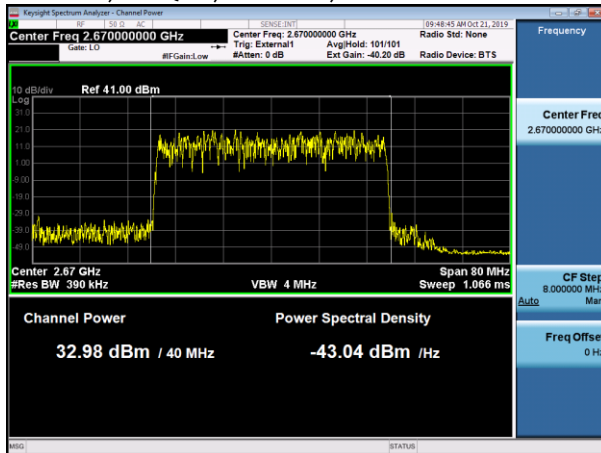
Ch Power, 256QAM, 2516MHz, TX1



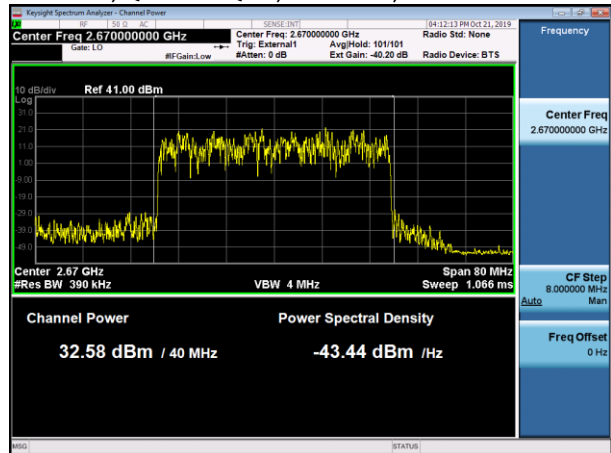
Ch Power, 256QAM, 2593MHz, TX1



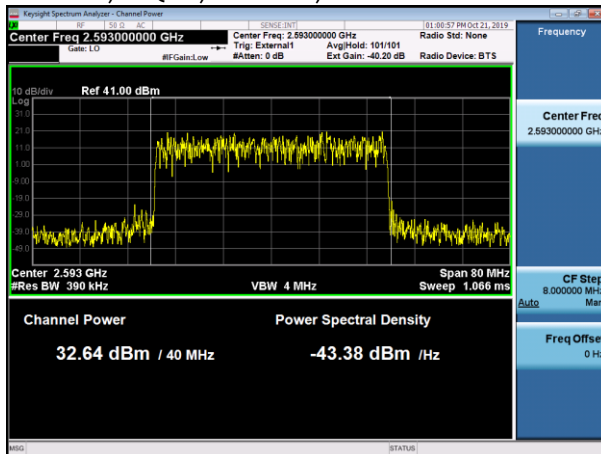
Ch Power, 256QAM, 2670MHz, TX1



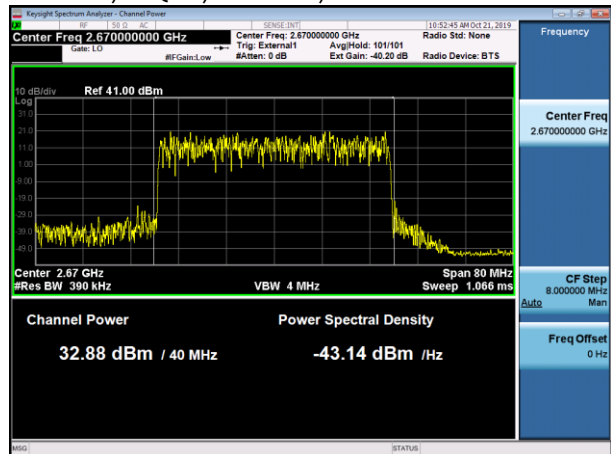
Ch Power, QPSK+16QAM, 2670MHz, TX1



Ch Power, 64QAM, 2593MHz, TX1



Ch Power, 64QAM, 2670MHz, TX1



3. FCC Section 2.1047 - Modulation Characteristics

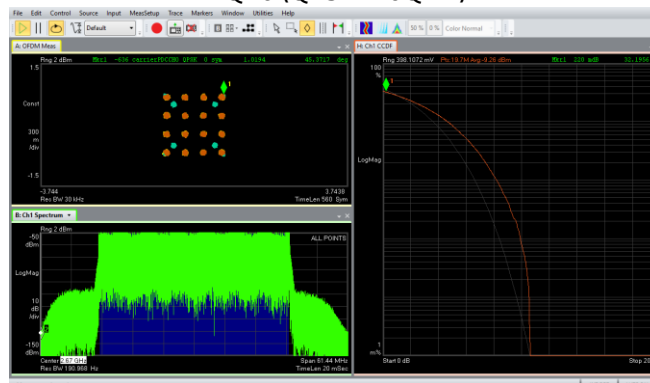
3.1 Modulation Characteristics

The RF signal at the antenna port was demodulated and verified for correctness of the modulation signal used before each test was performed. For these products the operation with QPSK, 16QAM, 64QAM and 256QAM modulation was evaluated and verified to demonstrate proper operation before testing.

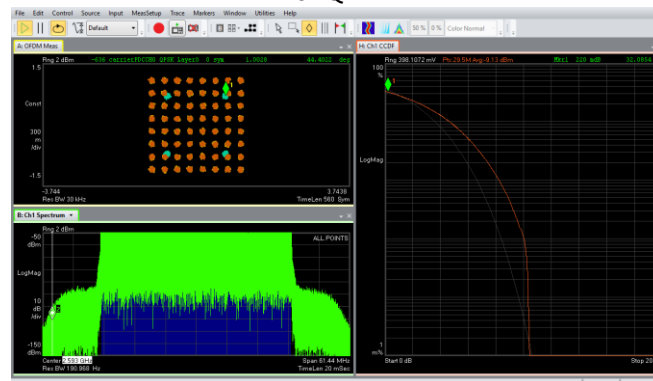
3.1.1 Modulation Characteristics – Plots.

NOTE: Only a sample of the plots are used in this report. The full suite of raw data resides at the MH, New Jersey location.

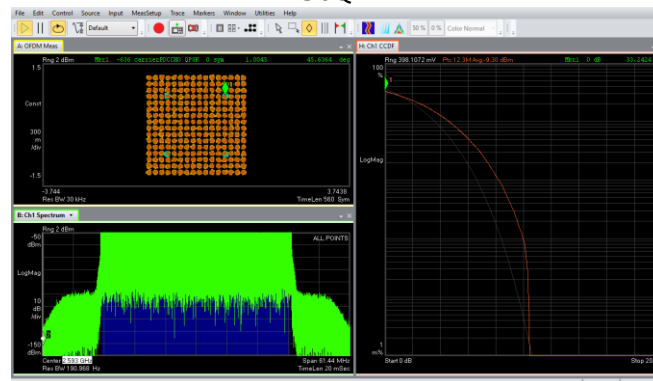
Q16 (QPSK+16QAM)



64QAM



256QAM



4. FCC Section 2.1049 – Occupied Bandwidth/Edge of Band Emissions

4.1 Occupied Bandwidth

In 47CFR 2.1049 the FCC requires:

“The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured under the following conditions as applicable.”

This required measurement is the 99% Occupied Bandwidth, also called the designated signal bandwidth and needs to be within the parameters of the products specified emissions designator. During these measurements it is customary to evaluate the Edge of Band emissions at block/band edges.

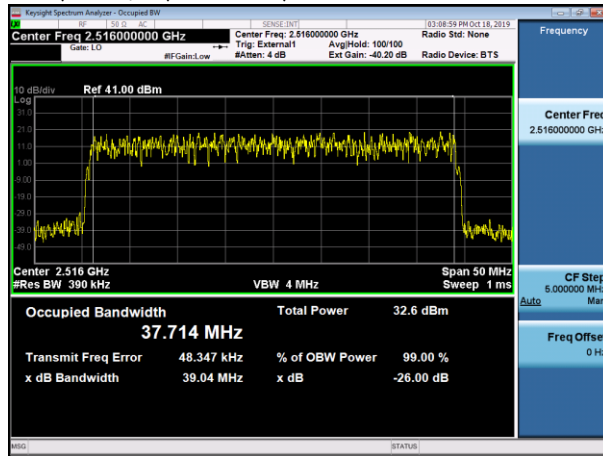
The transmitted signal occupied bandwidth was measured using a Keysight MXA Signal Analyzer. All emissions were within the parameters as required.

Tabular Data – Occupied Bandwidth, 40MHz BW

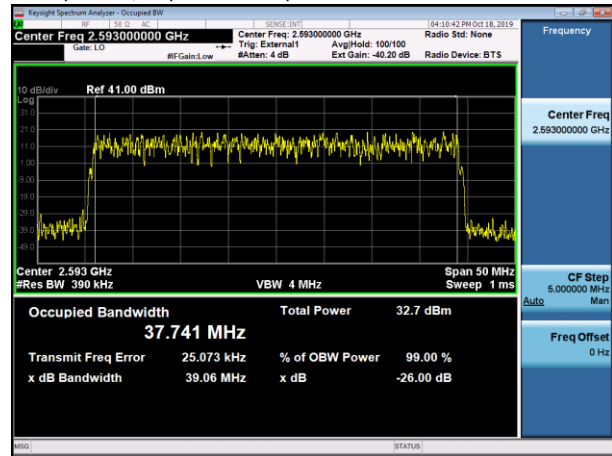
Modulation	Channel Frequency MHz	Occupied BW MHz
256QAM	2516	37.714
	2593	37.741
	2670	37.719
QPSK+16QAM	2670	37.464
64QAM	2593	37.830
	2670	37.813

4.1.1 Occupied Bandwidth – Plots.

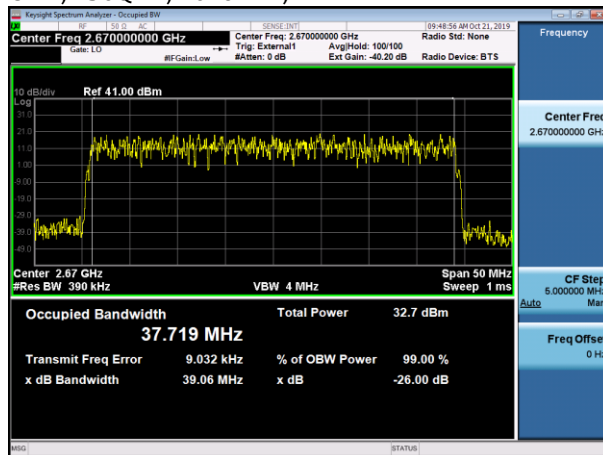
OBW, 256QAM, 2516MHz, TX1



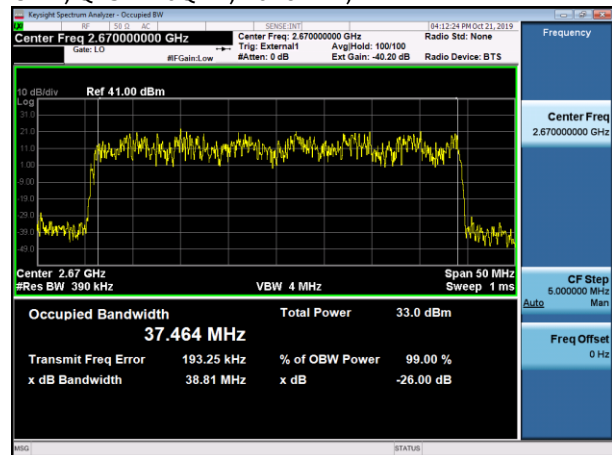
OBW, 256QAM, 2593MHz, TX1



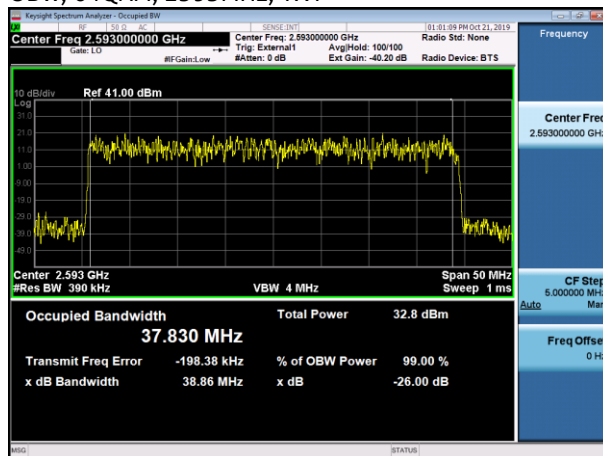
OBW, 256QAM, 2670MHz, TX1



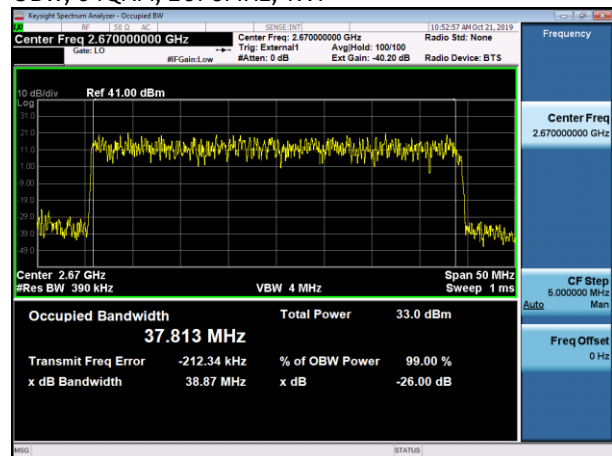
OBW, QPSK+16QAM, 2670MHz, TX1



OBW, 64QAM, 2593MHz, TX1



OBW, 64QAM, 2670MHz, TX1



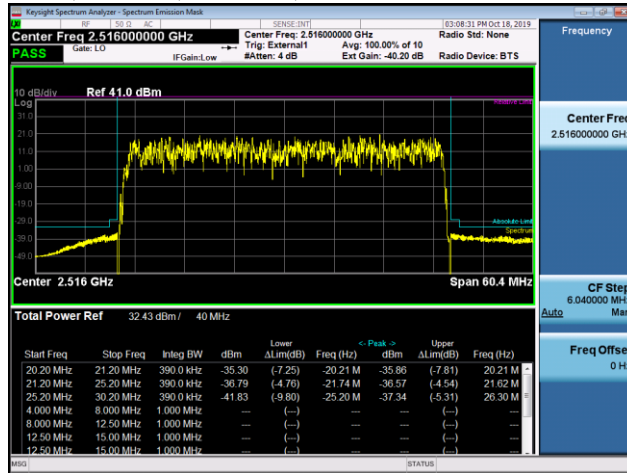
4.2 Edge of band Emissions

The Edge of Band emissions of the EUT at the external antenna connector (EAC) were measured using a Keysight MXA Signal Analyzer. The RF power level was continuously measured using a RF broadband power meter. The RF output from the EAC port to spectrum analyzer was reduced (to an amplitude usable by the spectrum analyzer) by using a calibrated attenuator and test coupler. The path attenuation was offset on the display and the signal for single carrier was adjusted to the corrected RF power level for the resolution bandwidth used for the transmit signal. All mask values were adjusted based upon the designated signal bandwidth and measurement bandwidths. The Top of Mask corresponds to the set rated power level as confirmed by the RF power meter.

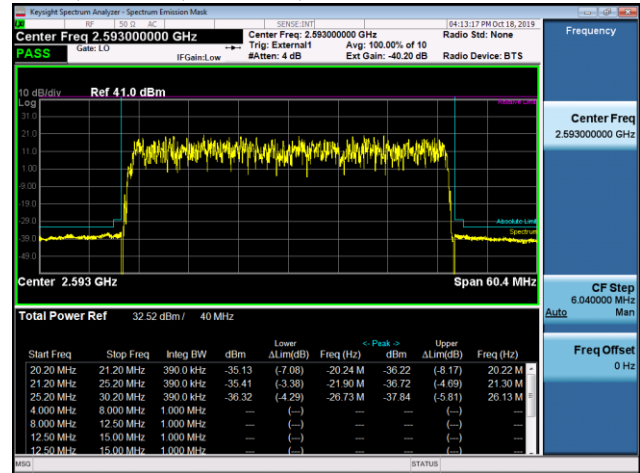
4.2.1 Edge of Band Emissions - Plots.

All of the measurements met the requirements of Part 27.53 when measured per Part 2.1049.

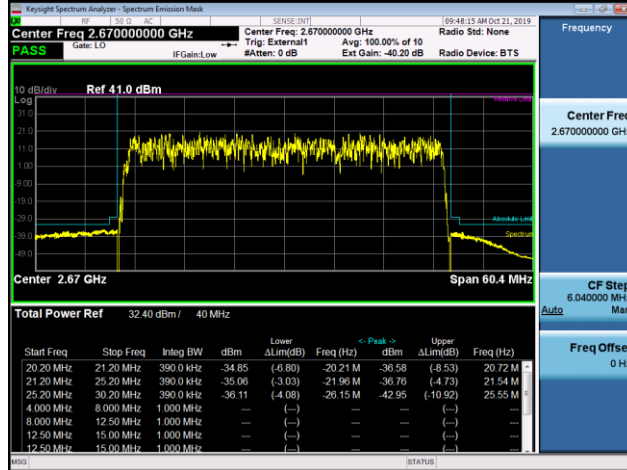
OOBE, 256QAM, 2516MHz, TX1



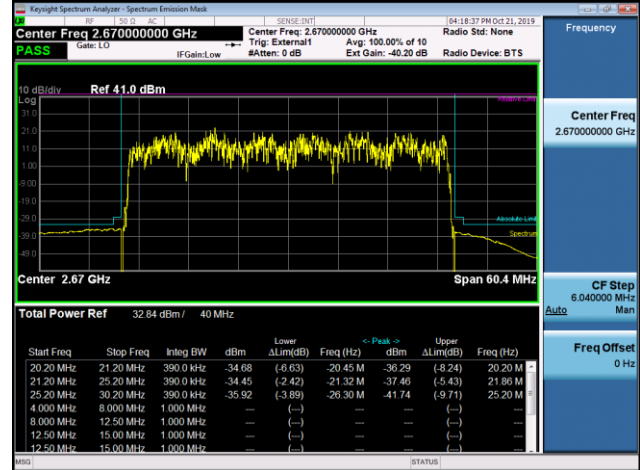
OOBE, 256QAM, 2593MHz, TX1



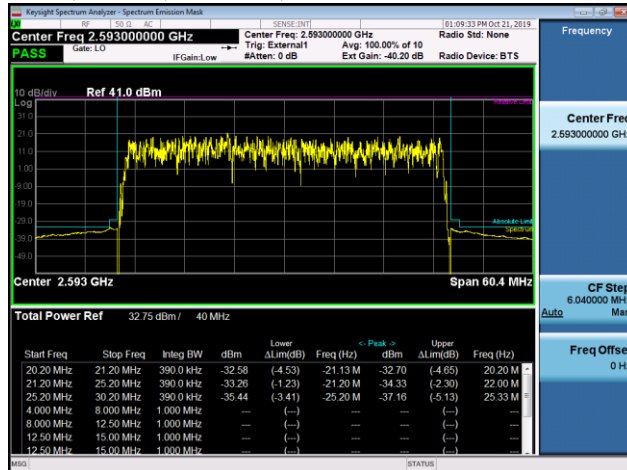
OOBE, 256QAM, 2670MHz, TX1



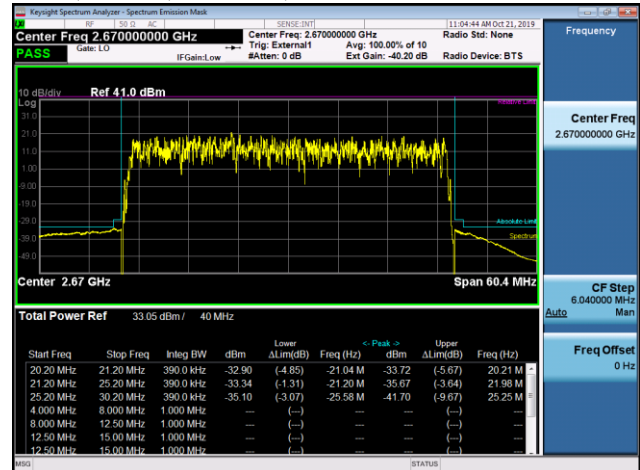
OOBE, QPSK+16QAM, 2670MHz, TX1



OOBE, 64QAM, 2593MHz, TX1



OOBE, 64QAM, 2670MHz, TX1



5. FCC Section 2.1051 - Spurious Emissions at Transmit Antenna Port

5.1 Measurement of Spurious Emissions at Transmit Antenna Port

Spurious Emissions at the transmit-antenna terminals were investigated over the frequency range of 10 MHz to beyond the 10th harmonic of the specific transmit band. For this band of operation, the measurements were performed up to 27GHz. Measurements were made using a Keysight MXA Signal Analyzer. The RF output from the transmitter was reduced (to an amplitude usable by the receivers) using calibrated attenuators. The RF power level was continuously monitored via a coupled RF Power Meter.

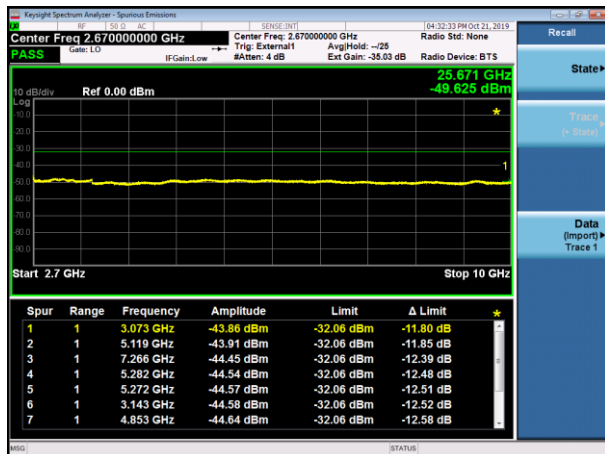
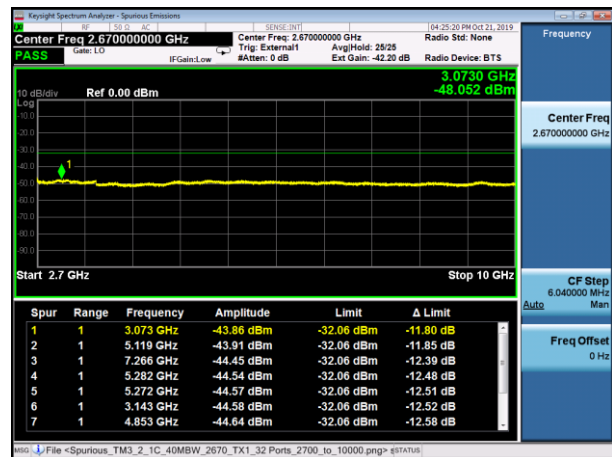
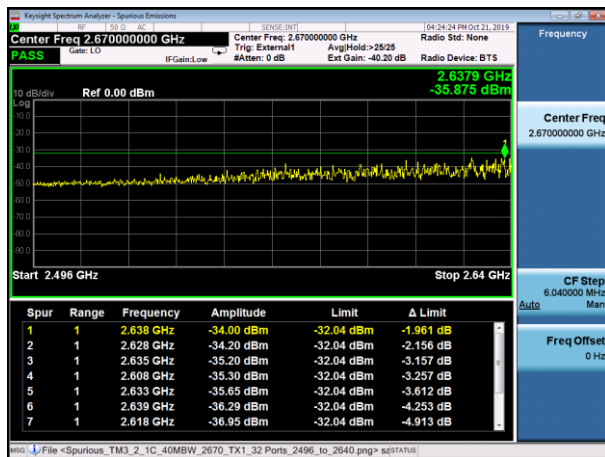
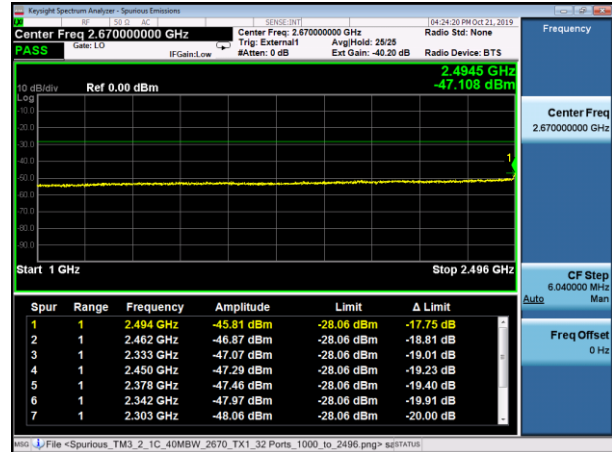
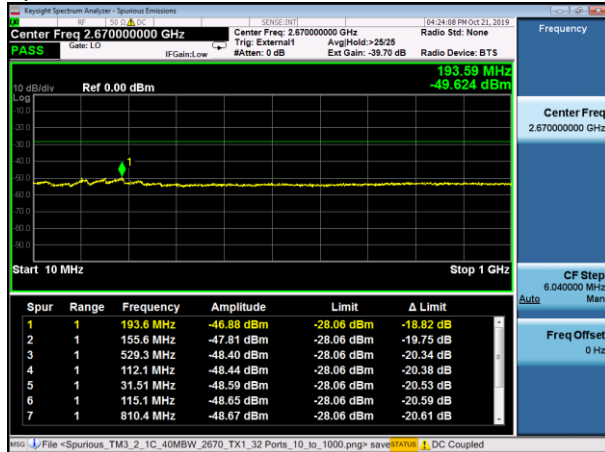
The required emission limitation is specified as appropriate in 27.53. The measured spurious emission levels were plotted for the frequency range as specified in 2.1057. There were no reportable emissions. Data below documents performance up to 27 GHz.

Note: The limit is set to -31 dBm, which is 18 dBm below the -13 dBm limit due to the 64X mMIMO based on $10 \log(64)$ for mMIMO.

5.1.1 Spurious Emissions at Tx Port - Plots

NOTE: Only a sample of the plots are used in this report. The full suite of raw data resides at the MH, New Jersey location.

Spurious, QPSK+16QAM, 40MHz BW, 2670MHz, TX1



Photographs



Test Equipment

Asset ID	Manufacturer	Type	Description	Model	Serial	Calibration Date	Calibration Due	Calibration Type	Status
E831	Agilent Technologies	MXA Signal Analyzer	20Hz-26.5GHz	N9020A	MY48011791	2018-02-15	2020-02-15	Requires Calibration	Active
E896	Agilent Technologies	Network Analyzer	10 MHz - 40 GHz	N5230C	MY49000897	2019-01-31	2021-01-31	Requires Calibration	Active
E1235	RLC Electronics Inc	High Pass Filter	High Pass filter 5GHz to 26GHz	F-19413	1446-006			Calibration Not Required, Must Be Verified	Active
E1155	Weinschel	Attenuator	10dB 25Watt 0.05GHz - 26GHz	74-10-12	1068			Calibration Not Required, Must Be Verified	Active
E1120	Extech	Data Logger	Pressure Humidity Temp Data Logger	SD700	Q673552	2019-01-16	2021-01-16	Requires Calibration	Active
E1154	Weinschel	Attenuator	30dB 25W 0.05GHz-26GHz	74-30-12	1065			Calibration Not Required, Must Be Verified	Active

Environmental Conditions: RH= 43.1%, Temp=24°C, Pressure=1006.5hPa

6. FCC Section 2.1053 - Field strength of spurious radiation.

6.1 Section 2.1053 Field Strength of Spurious Emissions

Field strength measurements of radiated spurious emissions were made in an FCC registered 3m Semi-Anechoic Chamber which is maintained by Nokia Bell Labs in Murray Hill, New Jersey. A complete description and full measurement data for the site is on file with the Commission (Site Registration Number: 515091).

The spectrum from 30 MHz to beyond the tenth harmonic of the carrier, 26 GHz, was searched for spurious radiation. Measurements were made using both horizontally and vertically polarized broadband antennas. Per FCC regulations, the comparison of out of band spurious emissions directly to the limit is appropriately made using the substitution method. However, when the emissions are more than 20 dB below the specification limit, the use of field strength measurements for compliance determination is acceptable and those emissions are considered not reportable (Section 2.1053 and the FCC Interpretive database for 2.1053). For this case the evaluation of acceptable radiated field strength is as follows.

6.2 Field Strength of Spurious Emissions - Limits

Sections 2.1053 and 27.53 contain the requirements for the levels of spurious radiation as a function of the level of the unmodulated carrier. The reference level for the unmodulated carrier is calculated as the field produced by an ideal dipole excited by the transmitter output power according to the following relation taken from Reference Data for Radio Engineers, page 676, 4th edition, IT&T Corp.

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

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

Where:

E = Field Intensity in Volts/meter

P = Transmitted Power in Watts

R = Measurement distance in meters = 3 m

The Part 27 Limit is 82.23 dBuV/m at 3m and 91.77 dBuV/m at 1m

The Part 27 non-report level is 62.23 dBuV/m at 3m.

The calculated emission levels were found by:

$$\text{Measured level (dB}\mu\text{V)} + \text{Cable Loss(dB)} + \text{Antenna Factor(dB)} = \text{Field Strength (dB}\mu\text{V}/\text{m)}$$

RESULTS:

For compliance with 47CFR Parts 2 and 27, the field strength of any spurious radiation, measured at 3m, is required to be less than 82.23 dBuV/meter (82.23 @ 3m). Emissions equal to or less than 62.23 dBuV/meter at 3m are not reportable and may be verified using field strength measurements and broadband antennas. Over the out of band spectrum investigated from 30 MHz to beyond the tenth harmonic of the carrier (up to 26GHz), no reportable spurious emissions were detected.

7. NVLAP Certificate of Accreditation

<p>United States Department of Commerce National Institute of Standards and Technology</p> <p>NVLAP[®]</p> <hr/> <p>Certificate of Accreditation to ISO/IEC 17025:2005</p> <hr/> <p>NVLAP LAB CODE: 100275-0</p> <p>Nokia, Global Product Compliance Lab Murray Hill, NJ</p> <p><i>is accredited by the National Voluntary Laboratory Accreditation Program for specific services, listed on the Scope of Accreditation, for:</i></p> <p>Electromagnetic Compatibility & Telecommunications</p> <p><i>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).</i></p> <table><tr><td><hr/><p>2019-09-20 through 2020-09-30 <i>Effective Dates</i></p></td><td></td><td><hr/><p><i>[Signature]</i> For the National Voluntary Laboratory Accreditation Program</p></td></tr></table>		<hr/> <p>2019-09-20 through 2020-09-30 <i>Effective Dates</i></p>		<hr/> <p><i>[Signature]</i> For the National Voluntary Laboratory Accreditation Program</p>
<hr/> <p>2019-09-20 through 2020-09-30 <i>Effective Dates</i></p>		<hr/> <p><i>[Signature]</i> For the National Voluntary Laboratory Accreditation Program</p>		