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

TESTING
NVLAP LAB CODE: 100275-0

Title 47 Code of Federal Regulations Test Report

Regulation:
FCC Part 2 and 27

Client:
NOKIA SOLUTIONS AND NETWORKS, OY

Product Evaluated:
AWHHF Airscale Micro RRH 4T4R 5G n41 4x20W

Report Number:
TR-2020-0180-FCC2-27

Date Issued:
March 2, 2021

Table of Contents

Revisions

Date	Revision	Section	Change
03/02/2021	0		Initial Release

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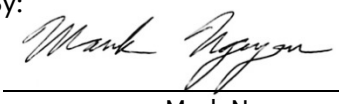
Prepared By:

Signed:  03/02/2021

Mark Nguyen
Compliance Engineer
NVLAP Signatory
mark.nguyen@nokia-bell-labs.com

Approved By:

Signed:  03/02/2021

Raymond Johnson
Technical Manager
NVLAP Signatory
ray.johnson@nokia-bell-labs.com

Reviewed By:

Signed:  03/02/2021

Nilesh Patel
EMC Engineer
NVLAP Signatory
nilesh.patel@nokia-bell-labs.com

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):	AWHHF Airscale Micro RRH 4T4R 5G n41 4x20W
Serial Number:	EB194060084
FCC ID:	2AD8UAWHHF01
Hardware Version:	475181A.101
Software Version:	5G20A
Frequency Range:	2496-2690 MHz
GPCL Project Number:	2020-0180
Manufacturer:	NOKIA SOLUTIONS AND NETWORKS OY KARAKAARI 7, FI-02610 ESPOO FINLAND
Applicant:	NOKIA SOLUTIONS AND NETWORKS OY Terry Schwenk 2000 Lucent Lane, Naperville, IL 60563
Test Requirement(s):	Title 47 CFR Parts 2 and 27
Test Standards:	See Section 1.5.1
Measurement Procedure(s):	See Section 1.5.2
Test Date(s):	1/27/2021 – 2/2/2021
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:	Nilesh Patel
Test Engineer (s):	Nilesh Patel
Test Results: The EUT, *as tested* met the above listed Test Requirements. The decision rule employed is binary (Pass/Fail) based on the measured values without accounting for Measurement Uncertainty or any Guard Band. The measured values obtained during testing were compared to a value given in the referenced regulation or normative standard. 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 AWHHF Airscale Micro RRH 4T4R 5G n41 4x20W, hereinafter referred to as the Equipment Under Test (EUT).

1.2 Purpose and Scope

The purpose of this document is to provide the 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.

This report covers the Class II Permissive change to add new 5G-NR bandwidths of 50 MHz and 90 MHz to the existing Grant. Concurrent operation was previously evaluated in project 2020-0117 and therefore only the Single Carrier operation of the new Bandwidths was tested. The AWHHF product is certified under FCC ID: 2AD8UAWHHF01.

No Frequency Stability testing was considered necessary for this test program since there were no changes to the basic frequency determining and stabilizing circuitry (including clock and data rates).

1.3 EUT Details

1.3.1 Specifications

Specification Items	Description
Radio Access Technology	5G-NR & LTE
Duplex Mode	Time Division Duplex (TDD)
Modulation Type(s)	QPSK, 16QAM, 64QAM, 256QAM
Operation Frequency Range	2496-2690 MHz
Channel Bandwidth	50 and 90 MHz
Number of Tx Ports per Unit	4
RF Power Output per Port	20 W (43.0 dBm)
MIMO	Yes
Deployment Environment	Outdoor
Supply Voltage	-48.0 VDC

1.3.2 Photographs

Front View

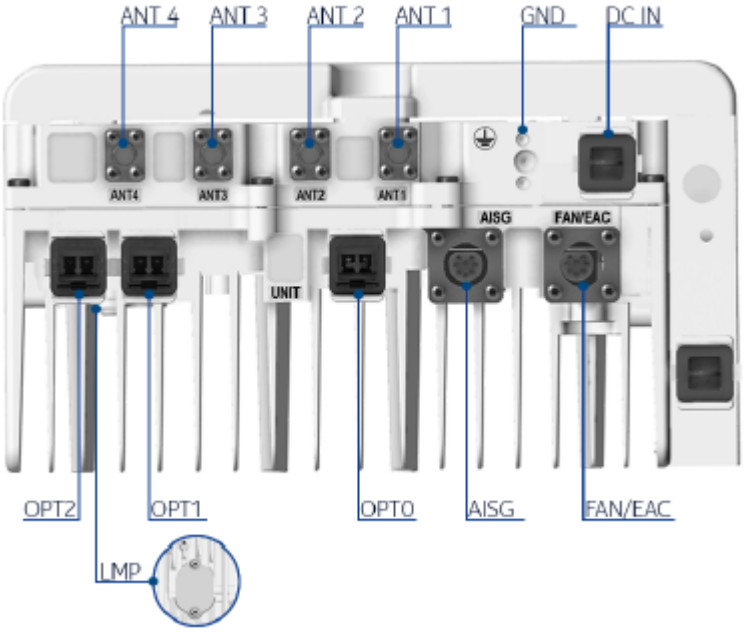
Rear View

Left View

Right View

Top View

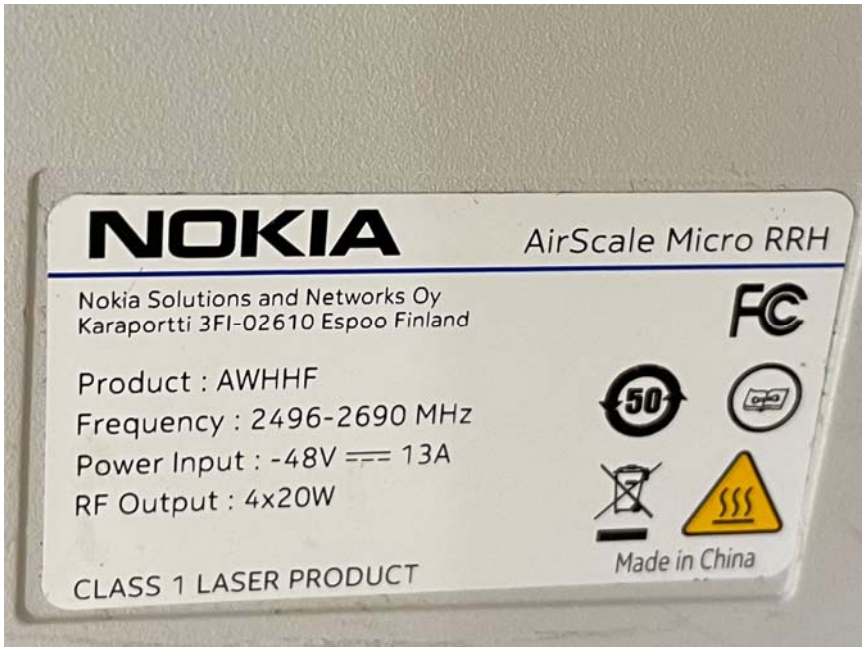
Bottom View



Interface	Label on the HW	Number of interfaces	Connector type	Additional info
Power Connector	DC IN	1	DC OCTIS Plug Kit	Hot insert not supported
Antenna connector	ANT	4	NEX 10	-
External Alarm Connection/Fan	EAC/FAN	1	CIRC 8F IP67 Flange	Two external alarms supported
Optical interface	OPT	3	OCTIS Plug Kit SFP/SFP+	9.8 Gbps, CPRI
Ethernet	RJ	1	RJ45	-
Grounding	⏚	1	M8 or dual M5 screws	-
AISG connector	AISG	1	8-pin circular	-
Local Management Port (LMP)	-	1	2x20-pin female header	-

Serial Number

Power Information



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
2.1055, 27.53	Frequency Stability	No*

*No Frequency Stability testing was considered necessary for this test program since there were no changes to the basic frequency determining and stabilizing circuitry (including clock and data rates).

1.5 Test Standards & Measurement Procedures

1.5.1 Test Standards

- Title 47 Code of Federal Regulations, Federal Communications Commission Part 2.
- Title 47 Code of Federal Regulations, Federal Communications Commission Part 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, American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services.
- ANSI C63.4-2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.

1.5.2 Measurement Procedures

- FCC-IC-OB - GPCL Power Measurement, Occupied Bandwidth & Modulation Test Procedure 6-20-2019.
- FCC-IC-SE - GPCL Spurious Emissions Test Procedure 6-20-2019.

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, (*e.g.*, ANSI C63.4, CISPR 11, 14, 22, *etc.*, using ESHS 30,	Conducted Emissions	0.009 - 30	±3.5 dB
	Radiated Emissions (AR-6 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	±5.1 dB ±5.1 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, 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

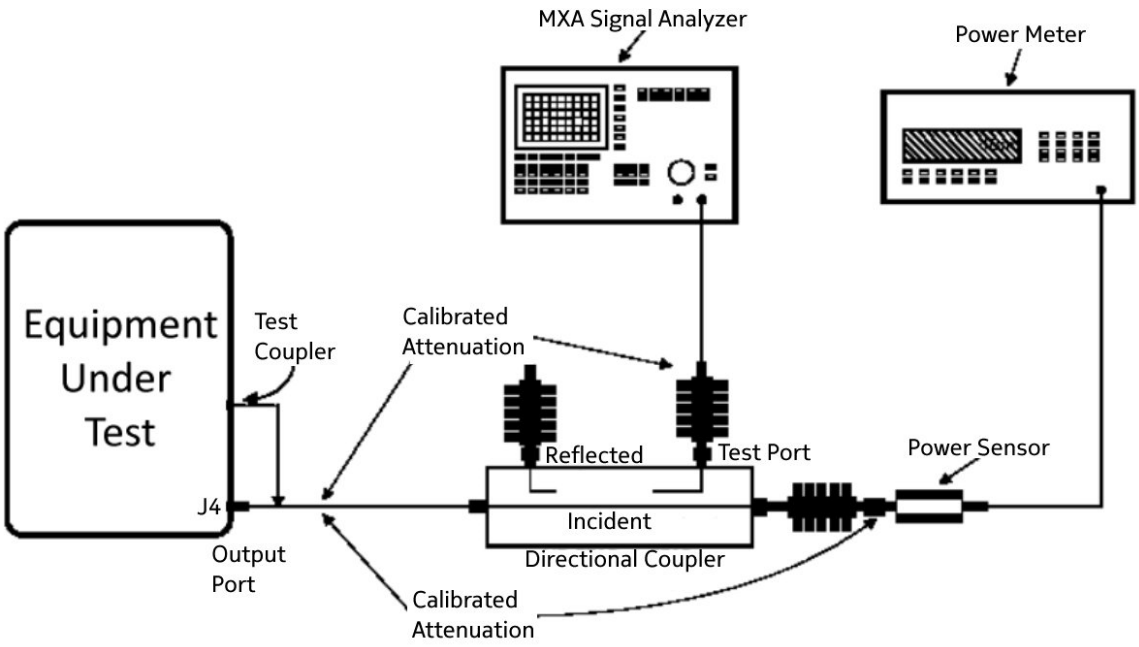
1.6 Executive Summary

Requirement	Description	Result
47 CFR FCC Parts 2 and 27		
2.1046, 27.53	RF Power Output Peak to Average Power Ratio	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
2.1055, 27.53	Frequency Stability	N/A*

*No Frequency Stability testing was considered necessary for this test program since there were no changes to the basic frequency determining and stabilizing circuitry (including clock and data rates).

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 the 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 (50MBW)

Channel Frequency MHz	Signal BW MHz	Modulation	TX Port	Channel Power dBm
2593	50	64QAM	1	42.79
			2	43.39
			3	43.52
			4	42.99
2665	50	256QAM	1	42.64
			2	43.37
			3	43.62
			4	42.90
2521	50	QPSK/16QAM	1	42.86
			2	43.47
			3	43.79
			4	43.07

Tabular Data – Channel RF Power (90MBW)

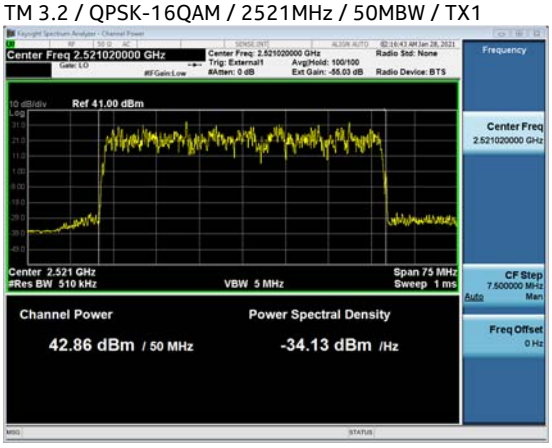
Channel Frequency MHz	Signal BW MHz	Modulation	TX Port	Channel Power dBm
2593	90	64QAM	1	42.78
			2	43.40
			3	43.55
			4	43.03
2645	90	256QAM	1	42.70
			2	43.48
			3	43.65
			4	42.95
2541	90	QPSK/16QAM	1	43.09
			2	43.74
			3	43.92
			4	43.29

2.1.1 Channel RF Power – Plots

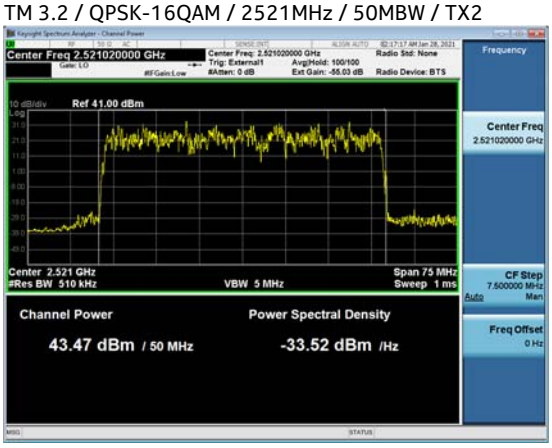
NOTE: Only a sample of the plots are used in this report. The full suite of raw data resides at the MH, New Jersey location.

2.1.1.1 50MBW Plots

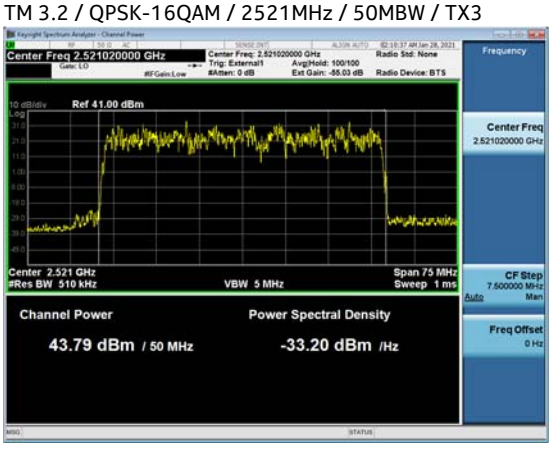
TM 3.2 / QPSK-16QAM / 2521MHz / 50MBW / TX1



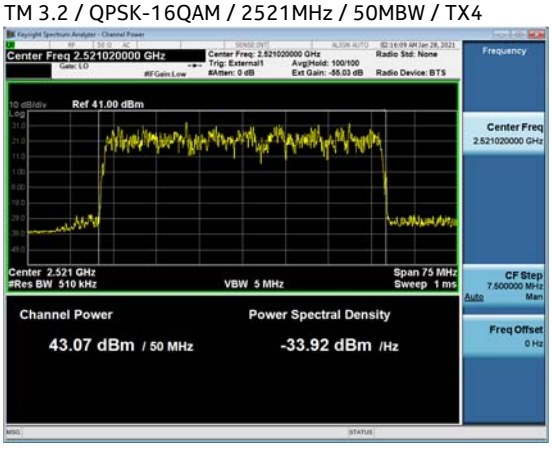
TM 3.2 / QPSK-16QAM / 2521MHz / 50MBW / TX2



TM 3.2 / QPSK-16QAM / 2521MHz / 50MBW / TX3

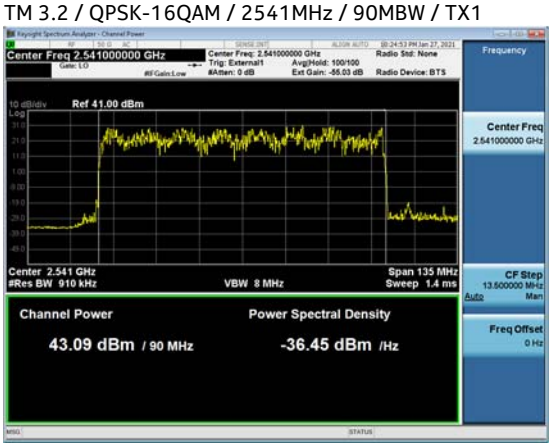


TM 3.2 / QPSK-16QAM / 2521MHz / 50MBW / TX4

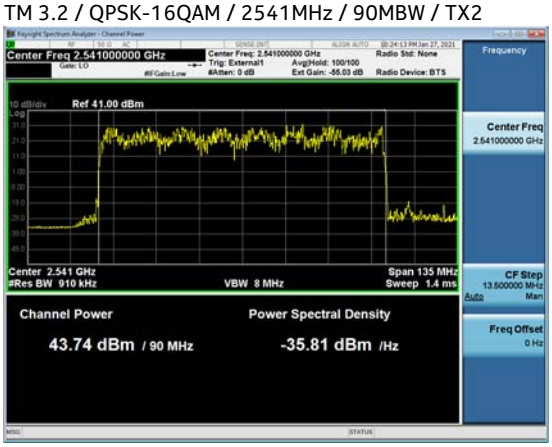


2.1.1.2 90MBW Plots

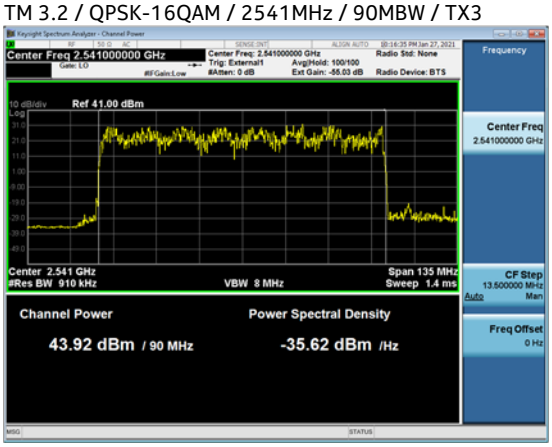
TM 3.2 / QPSK-16QAM / 2541MHz / 90MBW / TX1



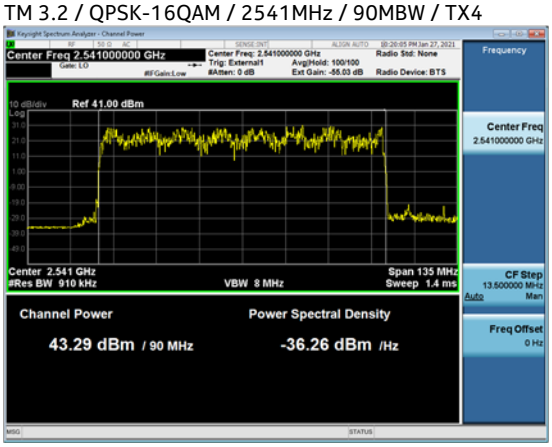
TM 3.2 / QPSK-16QAM / 2541MHz / 90MBW / TX2



TM 3.2 / QPSK-16QAM / 2541MHz / 90MBW / TX3



TM 3.2 / QPSK-16QAM / 2541MHz / 90MBW / TX4



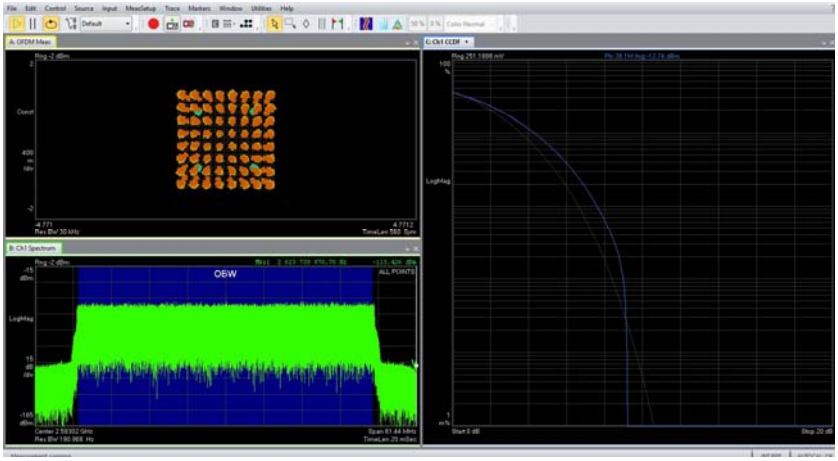
3. FCC Section 2.1047 - Modulation Characteristics

3.1 Modulation Characteristics

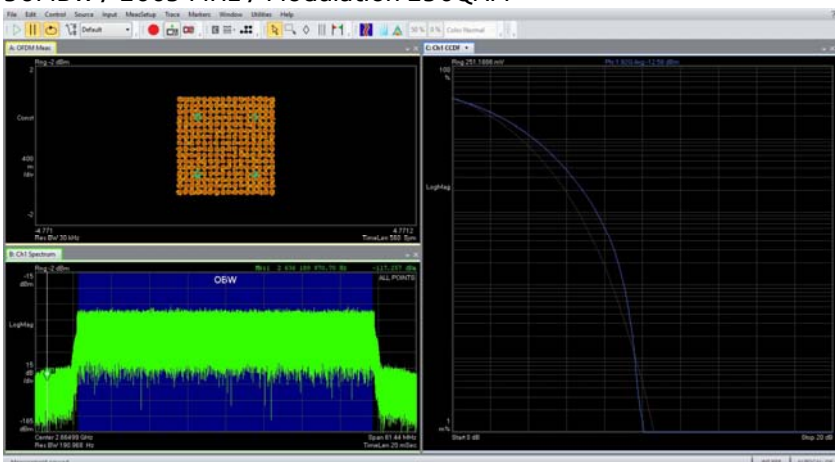
The RF signal at the antenna port was demodulated and verified for correctness of the modulation signal used before each test was performed.

3.1.1 Modulation Characteristics – Plots

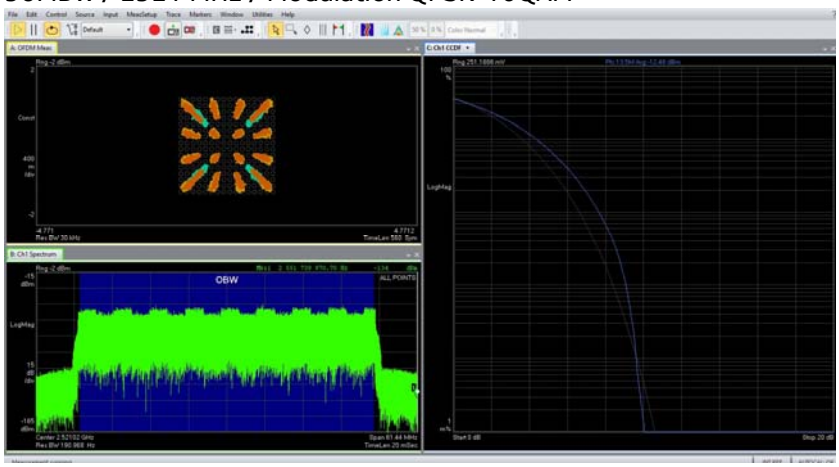
50MBW / 2593.02 MHz / Modulation 64QAM



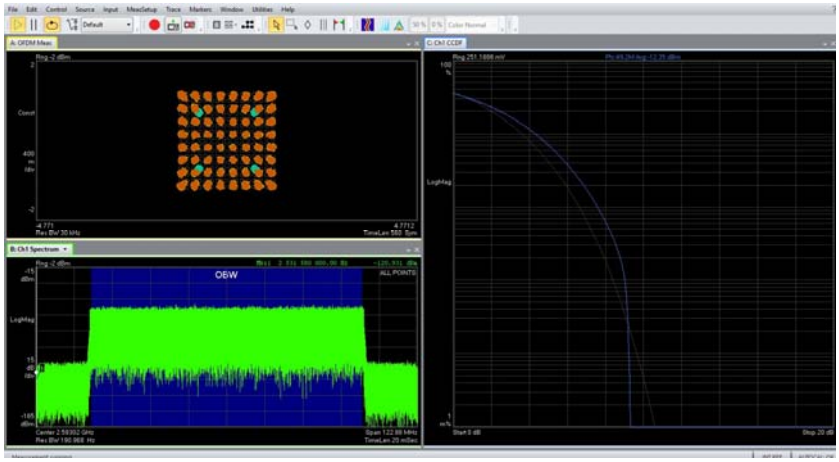
50MBW / 2665 MHz / Modulation 256QAM



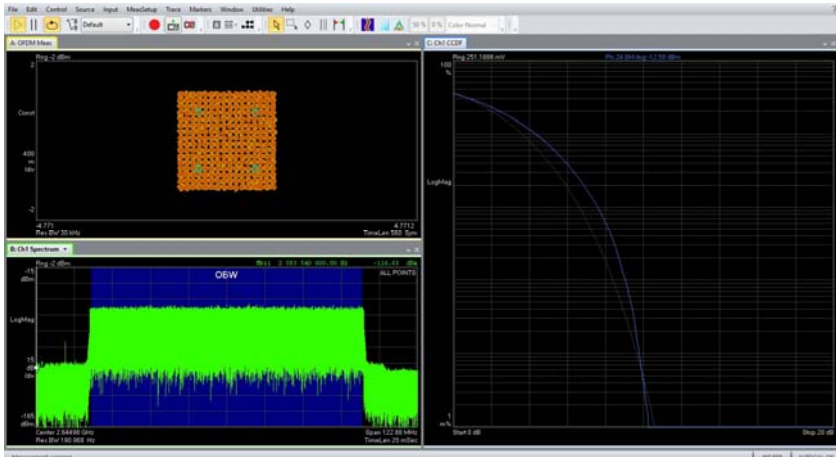
50MBW / 2521 MHz / Modulation QPSK-16QAM



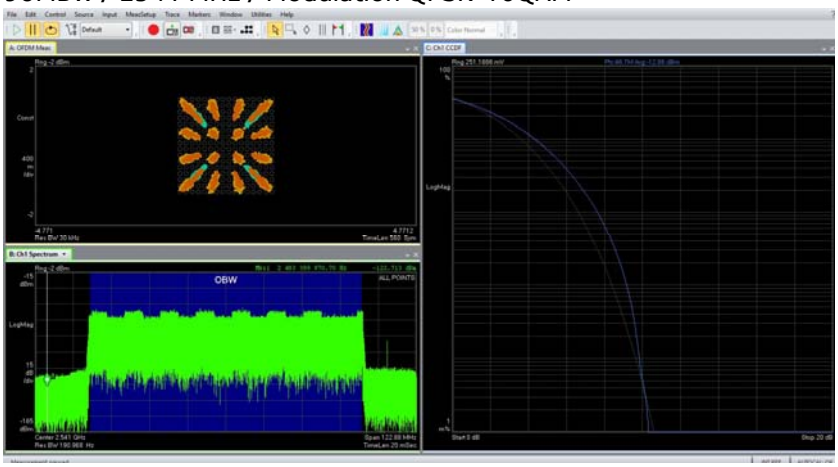
90MBW / 2593.02 MHz / Modulation 64QAM



90MBW / 2645 MHz / Modulation 256QAM



90MBW / 2541 MHz / Modulation QPSK-16QAM



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.

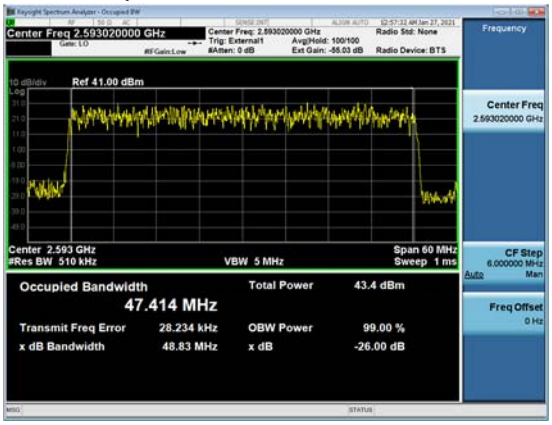
The transmitted signal occupied bandwidth was measured using a Keysight MXA Signal Analyzer. All emissions were within the parameters as required.

Tabular Data – Occupied Bandwidth

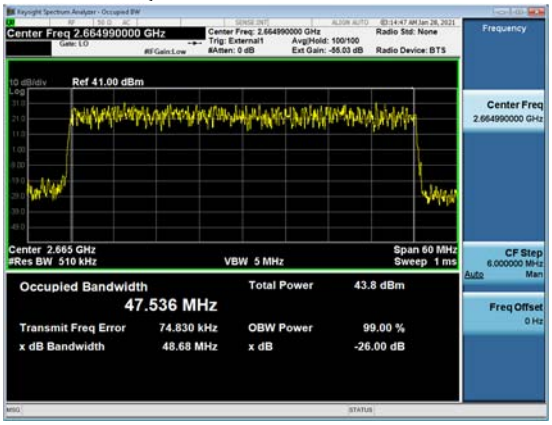
TX Port	Channel Frequency MHz	Signal BW MHz	Modulation	Occupied BW MHz
3	2593	50	64QAM	47.414
	2665		256QAM	47.536
	2521		QPSK/16QAM	47.189
3	2593	90	64QAM	87.170
	2645		256QAM	86.903
	2541		QPSK/16QAM	87.656

4.1.1 Occupied Bandwidth – Plots

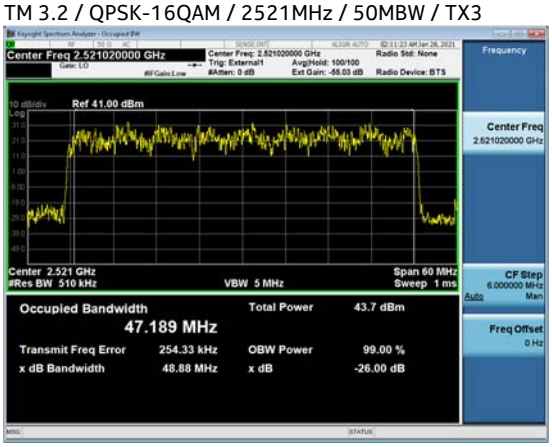
TM 3.1 / 64QAM / 2593MHz / 50MBW / TX3



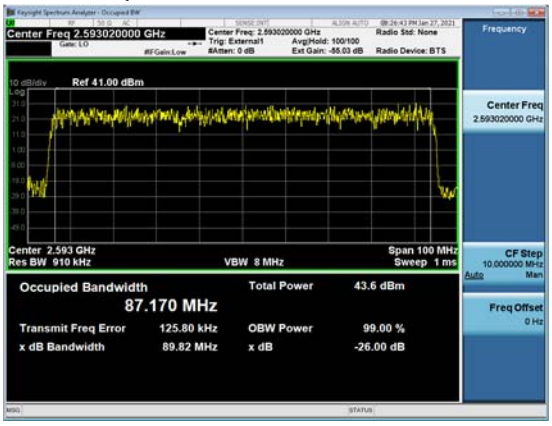
TM 3.1a / 256QAM / 2665MHz / 50MBW / TX3



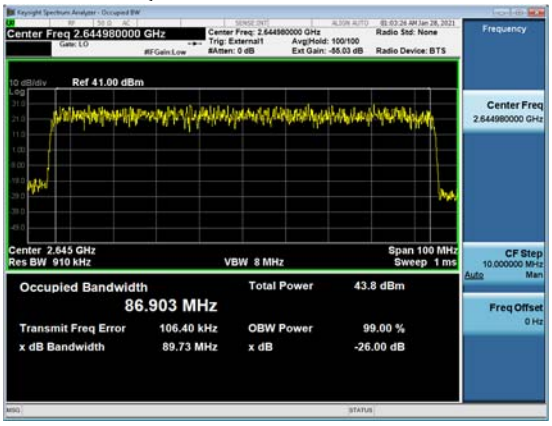
TM 3.2 / QPSK-16QAM / 2521MHz / 50MBW / TX3



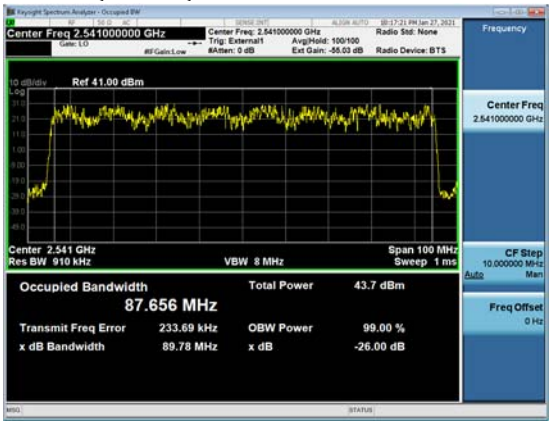
TM 3.1 / 64QAM / 2593MHz / 90MBW / TX3



TM 3.1a / 256QAM / 2645MHz / 90MBW / TX3



TM 3.2 / QPSK-16QAM / 2541MHz / 90MBW / TX3



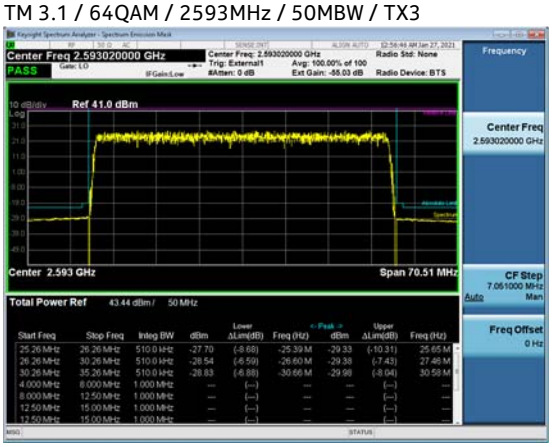
4.2 Edge of band Emissions

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 signal analyzer was reduced (to an amplitude usable by the signal analyzer) by using a calibrated attenuator and test coupler. The path attenuation was offset on the display and the signal for the 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.

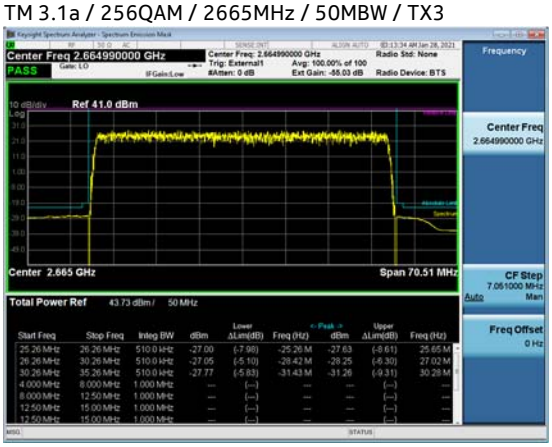
4.2.1 Edge of Band Emissions – Plots

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

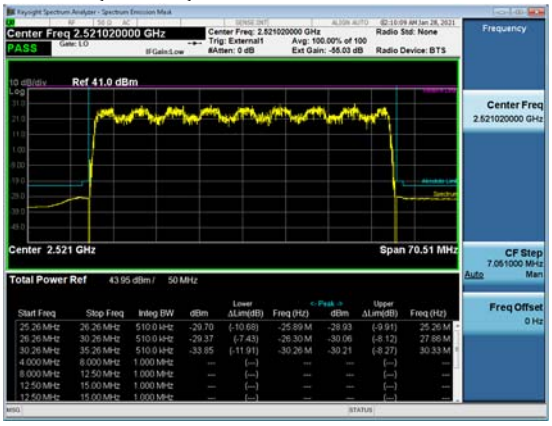
TM 3.1 / 64QAM / 2593MHz / 50MBW / TX3



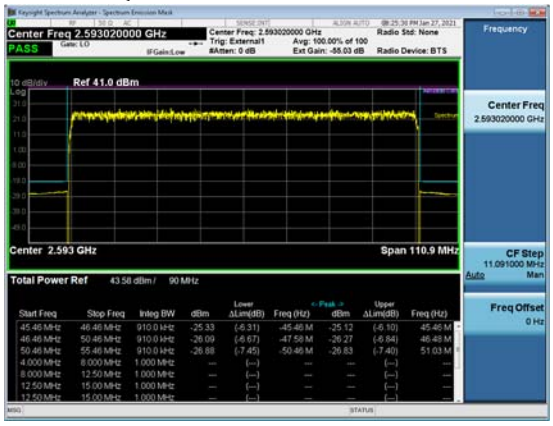
TM 3.1a / 256QAM / 2665MHz / 50MBW / TX3



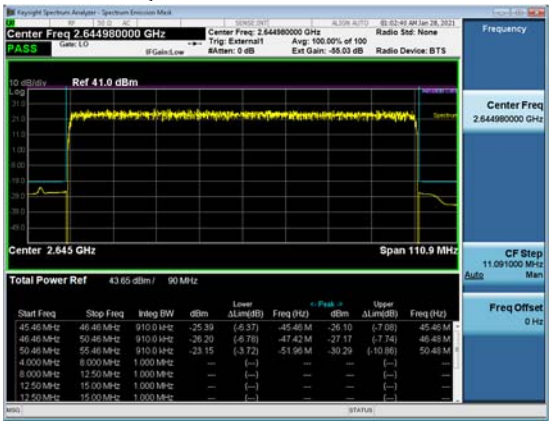
TM 3.2 / QPSK-16QAM / 2521MHz / 50MBW / TX3



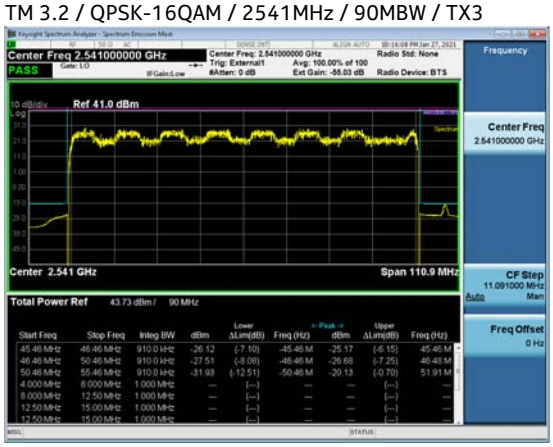
TM 3.1 / 64QAM / 2593MHz / 90MBW / TX3



TM 3.1a / 256QAM / 2645MHz / 90MBW / TX3



TM 3.2 / QPSK-16QAM / 2541MHz / 90MBW / TX3



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. Carrier Bandwidth is exempt. For this band of operation, the measurements were performed up to 10 GHz. 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.

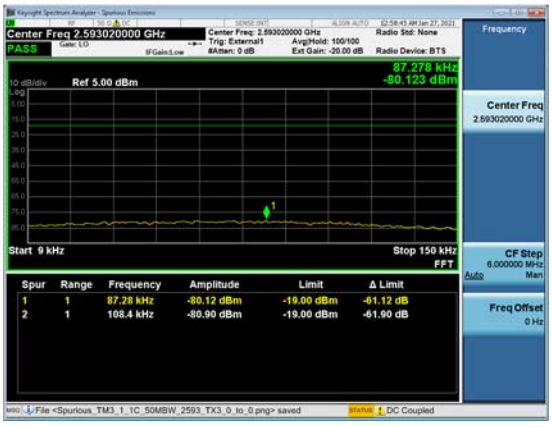
The required emission limitation is specified as appropriate in 27.53. The measured spurious emission levels were plotted for the frequency range as specified in 2.1057. There were no reportable emissions. Data below documents performance up to 27 GHz.

5.1.1 Spurious Emissions at Tx Port - Plots

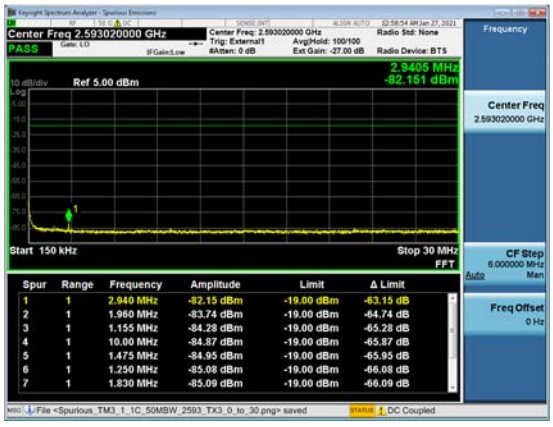
5.1.1.1 50MBW Spurious Emissions Plots

50 MHz BW
Test Model 3.1
Modulation 64QAM
Channel Frequency 2593MHz
TX3

9KHz – 150kHz



150kHz – 30MHz



30MHz – 1GHz

1GHz – 2.496GHz

2.69GHz – 10GHz

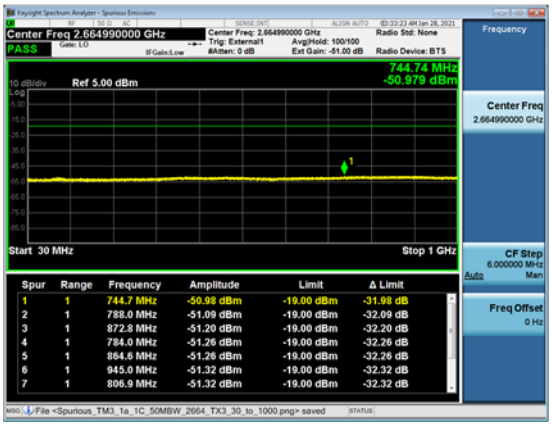
10GHz – 27GHz

50 MHz BW
Test Model 3.1a
Modulation 256QAM
Channel Frequency 2665MHz
TX3

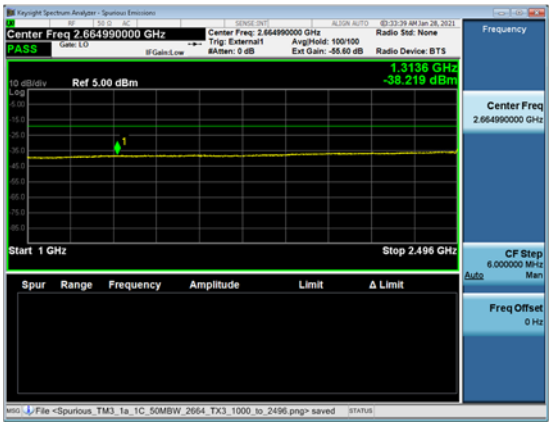
9KHz – 150kHz

150kHz – 30MHz

30MHz – 1GHz



1GHz – 2.496GHz



2.691GHz – 10GHz

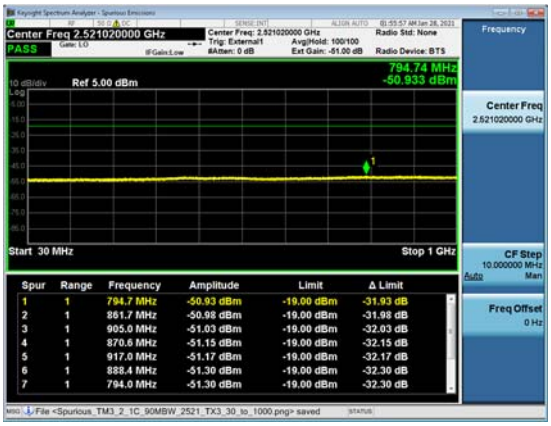
10GHz – 27GHz

50 MHz BW
Test Model 3.2
Modulation QPSK/16QAM
Channel Frequency 2521MHz
TX3

9KHz – 150kHz

150kHz – 30MHz

30MHz – 1GHz



1GHz – 2.496GHz

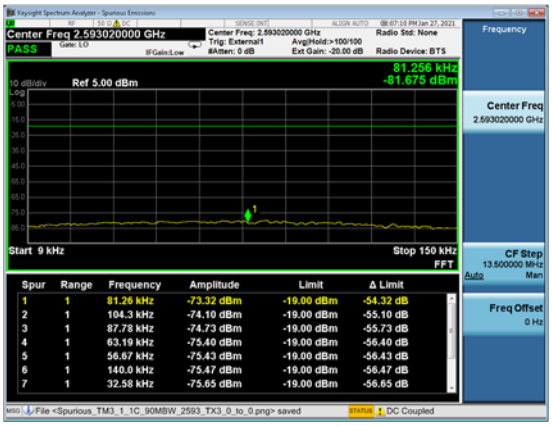
2.691GHz – 10GHz

10GHz – 27GHz

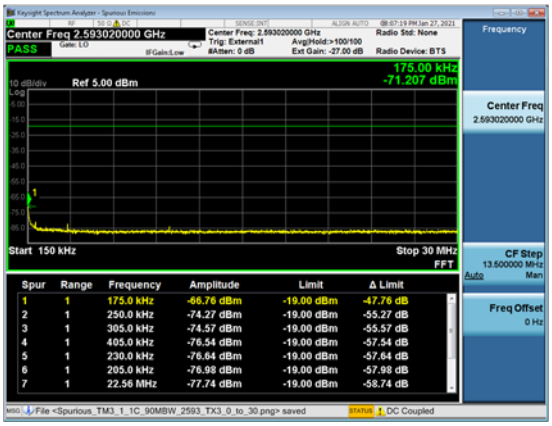
5.1.1.2 90MBW Spurious Emissions Plots

90 MHz BW
Test Model 3.1
Modulation 64QAM
Channel Frequency 2593MHz
TX3

9KHz – 150kHz

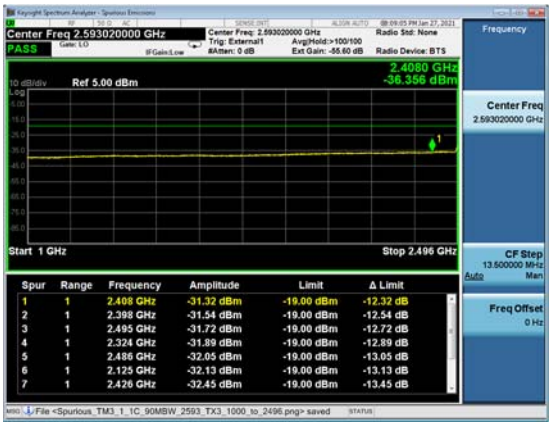


150kHz – 30MHz



30MHz – 1GHz

1GHz – 2.496GHz



2.691GHz – 10GHz

10GHz – 27GHz

90 MHz BW
Test Model 3.1a
Modulation 256QAM
Channel Frequency 2645MHz
TX3

9KHz – 150kHz

150kHz – 30MHz

30MHz – 1GHz

1GHz – 2.496GHz

2.691GHz – 10GHz

10GHz – 27GHz

90 MHz BW
Test Model 3.2
Modulation QPSK/16QAM
Channel Frequency 2541MHz
TX3

9KHz – 150kHz

150kHz – 30MHz

30MHz – 1GHz

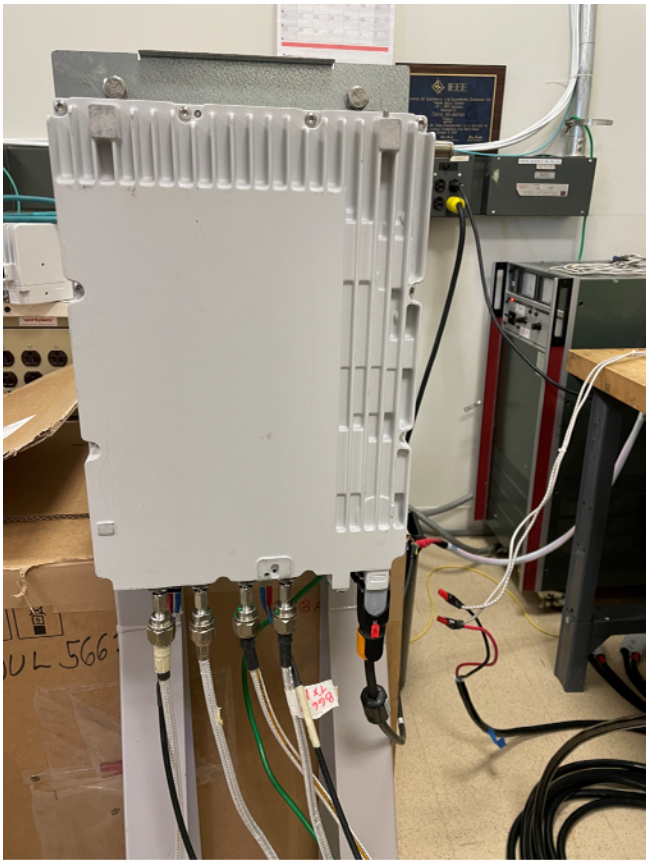
1GHz – 2.496GHz

2.691GHz – 10GHz

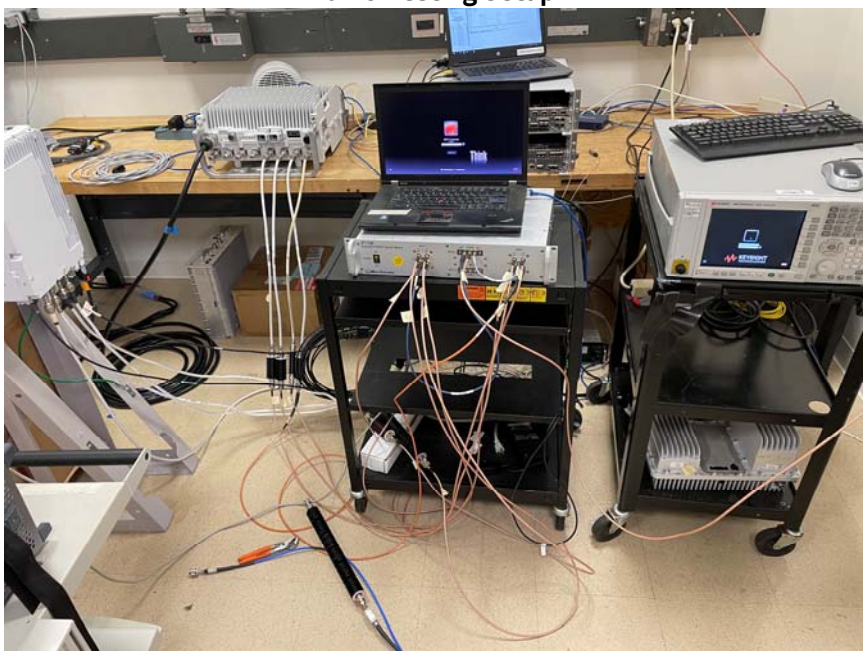
10GHz – 27GHz

Photographs

AWHHF Unit



Radio Testing Setup



Test Equipment

Asset ID	Manufacturer	Type	Description	Model	Serial	Calibration Date	Calibration Due
E831	Agilent Technologies	MXA Signal Analyzer	20Hz-26.5GHz	N9020A	MY48011791	2020-06-16	2022-06-16
E896	Agilent Technologies	Network Analyzer	10 MHz - 40 GHz	N5230C	MY49000897	2019-01-31	2021-01-31
E1022	Weinschel	Attenuator	10dB DC-18GHz 25W	46-10-34-LIM	BN3118	CNR-V	CNR-V
E1043	Weinschel	Attenuator	30dB 50W DC-8.5GHz	24-30-43	MY42140034	CNR-V	CNR-V
E1344	Macom	Attenuator	3 dB, DC - 4 GHz, 2W	2082-6171-03	N/A	CNR-V	CNR-V
E1212	RLC Electronics	Filter, High Pass	10 - 30 GHz, 2W, 5dB	F-19414	1444002	CNR-V	CNR-V
E1155	Weinschel	Attenuator	10dB 25W 0.05- 26GHz	74-10-12	1068	CNR-V	CNR-V
E1154	Weinschel	Attenuator	30dB 25W 0.05GHz-26GHz	74-30-12	1065	CNR-V	CNR-V
E1250	Weinschel	Attenuator	3dB Attenuator 100W	24-3-43	BB9072	CNR-V	CNR-V
E1251	Weinschel	Attenuator	0dB 150W DC-18GHz	66-30-33	BV1667	CNR-V	CNR-V
E1338	KeySight Technologies	MXA Signal Analyzer	MXA Signal Analyzer	N9020B	MY57430927	2019-11-14	2021-11-14
E1218	KeySight Technologies	EMI Receiver	MXE EMI Receiver 26.5GHz	N9038A	MY54130037	2020-08-28	2022-08-28
E1509	Weinschel	Attenuator	DC - 18 GHz, 30 dB, 150 W, N-Female - N-Female	66-30-34	BJ5923	CNR-V	CNR-V

CNR-V: Calibration Not Required, Must Be Verified

Tests were performed between 1/27/2021 – 2/2/2021. E896 was only used at beginning of testing for path loss calibration prior to 1/31/21.

Environmental conditions:
RH - 24.2 to 26.4%
Temp - 22.9C to 23.2C
Pressure - 30.24 to 30.08Hg

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, 27 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.

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

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

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 dBµV/m at 3m and 91.77 dBuV/m at 1m
The Part 27 non-report level is 62.23 dBµV/m at 3m.

The calculated emission levels were found by:

Measured level (dBµV) + Cable Loss(dB)+Antenna Factor(dB) = Field Strength (dBµV/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 dBµV/meter (82.23 @ 3m). Emissions equal to or less than 62.23 dBµV/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 27 GHz), no reportable spurious emissions were detected.

7. NVLAP Certificate of Accreditation

United States Department of Commerce
National Institute of Standards and Technology

Certificate of Accreditation to ISO/IEC 17025:2017

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 17025:2017. 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).

2020-09-25 through 2021-09-30
Effective Dates

For the National Voluntary Laboratory Accreditation Program