Global Product Compliance Laboratory
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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-2022-0155-FCC2-27

Date Issued:
January 12, 2023

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Revisions

Date	Revision	Section	Change
1/12/2023	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):	AWHHF Airscale Micro RRH 4T4R 5G n41 4x20W
Serial Number:	EB2038R0185
FCC ID:	2AD8UAWHHF01
Hardware Version:	475181A.102
Software Version:	SBTS23R1
Frequency Range:	2496-2690 MHz
GPCL Project Number:	2022-0155
Applicant	NOKIA SOLUTIONS AND NETWORKS OY Lee Klinkenborg 2000 W. Lucent Lane, Naperville, Illinois 60563 United States
Test Requirement(s):	Title 47 CFR Parts 2 and 27
Test Standards:	• 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):	• 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
Test Date(s):	12/5/2022 – 1/4/2023
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):	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 Class II Permissive Change to add modes of operation for 30MHz 5G-NR for both single and dual carrier to the existing Grant. The AWHHF product is certified under FCC ID: 2AD8UAWHHF01.

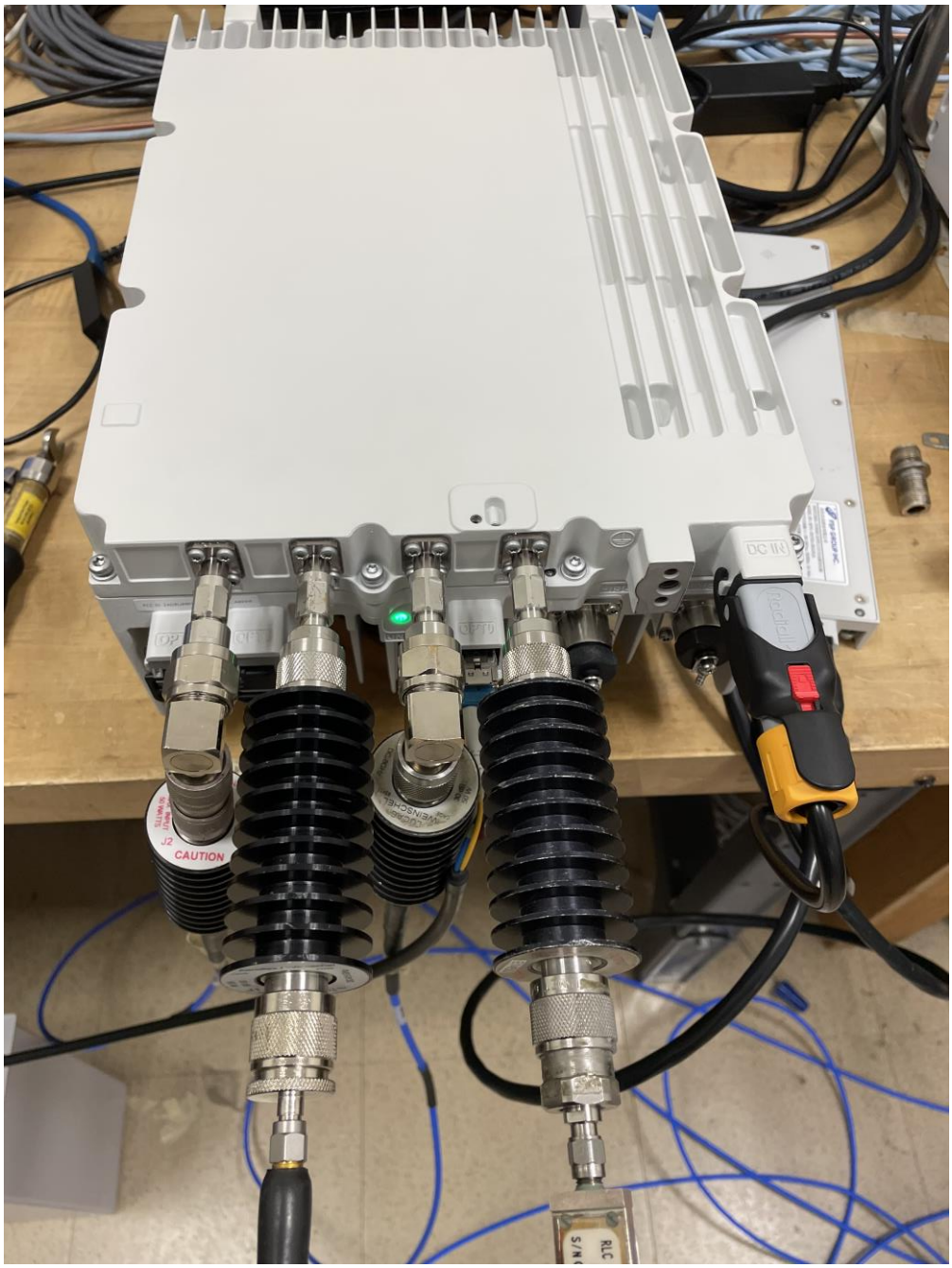
No Frequency Stability testing was considered necessary for this test program since there were no changes to the basic frequency determining and stabilizing circuitry (including clock and data rates).

1.3 EUT Details

1.3.1 Specifications

Specification Items	Description
Radio Access Technology	5G-NR
Modulation Type(s)	QPSK, 16QAM, 64QAM, 256QAM
Operation Frequency Range	2496-2690 MHz
Channel Bandwidth	30 MHz
Number of Tx Ports per Unit	4
Power	20 W/port (43.0 dBm) +/- 2.0 dBm
MIMO	MIMO 4T4R
Deployment Environment	Outdoor
Supply Voltage	-48.0 VDC

1.3.2 Photographs



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*

*Previously evaluated; 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

1.6 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, 32, *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

1.7 Executive Summary

Requirement	Description	Result
47 CFR FCC Parts 2 and 27		
2.1046, 27.50	RF Power Output Peak to Average Power Ratio	COMPLIES
2.1047	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, 27.54	Frequency Stability	NT*

*Previously evaluated; 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.

1.8 Test Configurations

Test Setup for all Antenna Port Measurements

2. FCC Section 2.1046 - 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.

2.1 Channel RF Power

1C Channel RF Power

Channel Power - 5G-NR 30MHz					
Test Model 3.1 Modulation 64QAM Channel Frequency 2511 MHz		Test Model 3.1a Modulation 256QAM Channel Frequency 2593 MHz		Test Model 3.2 Modulation QPSK/16QAM Channel Frequency 2675 MHz	
TX Port	(dBm)	TX Port	(dBm)	TX Port	(dBm)
0	**43.09**	0	**43.05**	0	42.72
1	42.96	1	42.96	1	42.59
2	43.06	2	42.94	2	**42.78**
3	43.08	3	43.03	3	42.72
Total Power (dBm)	49.07	Total Power (dBm)	49.02	Total Power (dBm)	48.72
Total Power (W)	80.69	Total Power (W)	79.72	Total Power (W)	74.54

2C Channel RF Power

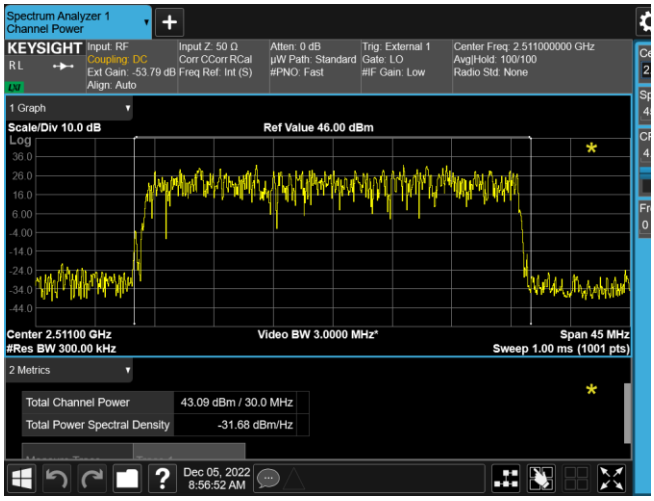
Channel Power - 5G-NR 30MHz + 30MHz					
Test Model 3.1 Modulation 64QAM Channel Frequency 2511+2641 MHz		Test Model 3.2 Modulation QPSK/16QAM Channel Frequency 2528 + 2658 MHz		Test Model 3.1a Modulation 256QAM Channel Frequency 2545 + 2675 MHz	
TX Port	(dBm)	TX Port	(dBm)	TX Port	(dBm)
0	42.75	0	43.20	0	**43.21**
1	42.63	1	43.08	1	43.09
2	42.71	2	43.15	2	43.18
3	**42.76**	3	**43.22**	3	43.16
Total Power (dBm)	48.73	Total Power (dBm)	49.18	Total Power (dBm)	49.18
Total Power (W)	74.70	Total Power (W)	82.86	Total Power (W)	82.81

2.1.1 Channel RF Power – Plots

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

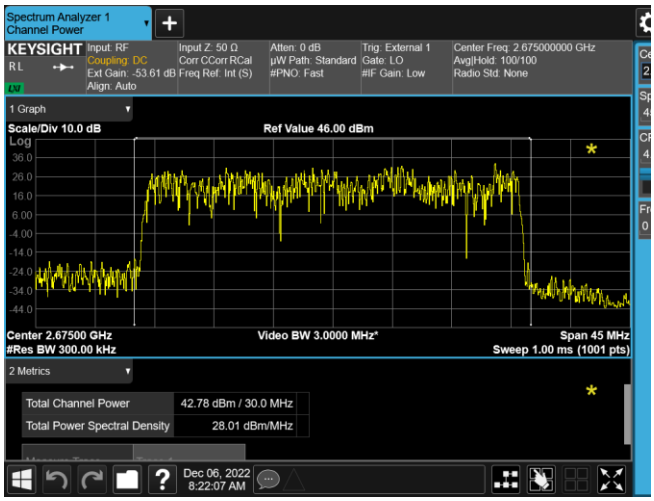
1C Channel RF Power plots – 30MHz BW

TM 3.1, 64QAM, CF 2511 MHz, TX0



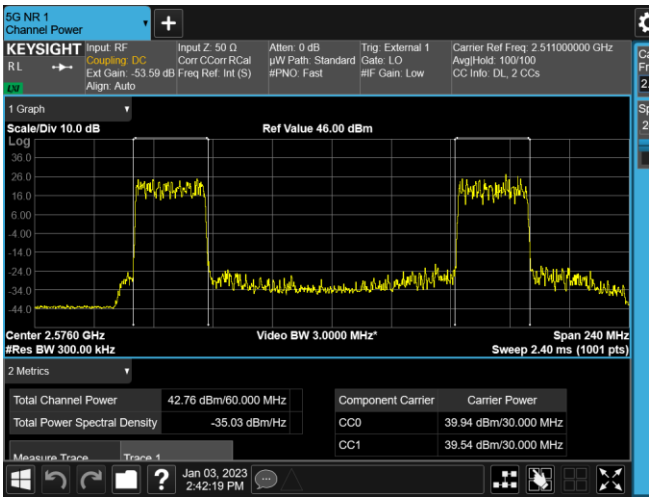
TM 3.1a, 256QAM, CF 2593 MHz, TX0

TM 3.2, QPSK/16QAM, CF 2675 MHz, TX2

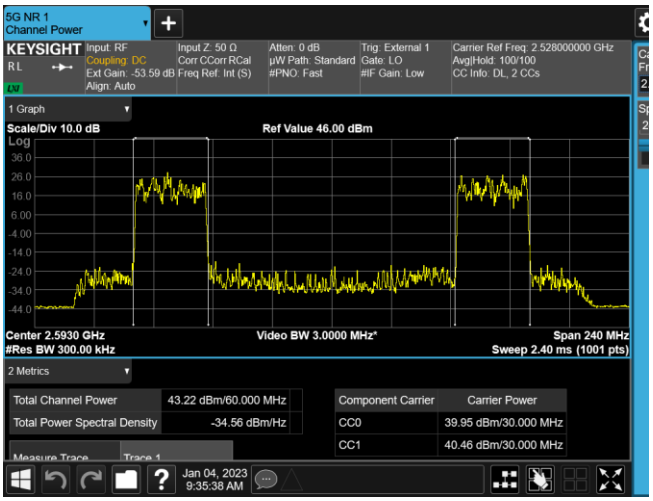


2C Channel RF Power plots – 30+30 MHz BW

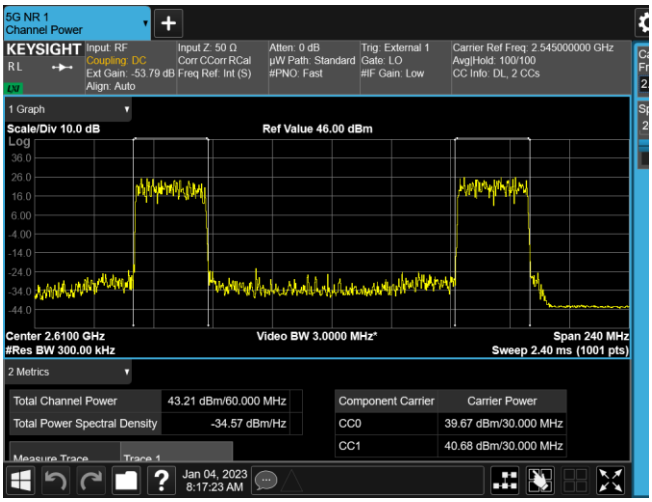
TM 3.1, 64QAM, CF 2511+2641 MHz, TX3



TM 3.2, QPSK/16QAM, CF 2528+2658 MHz, TX3



TM 3.1a, 256QAM, CF 2545+2675 MHz, TX0



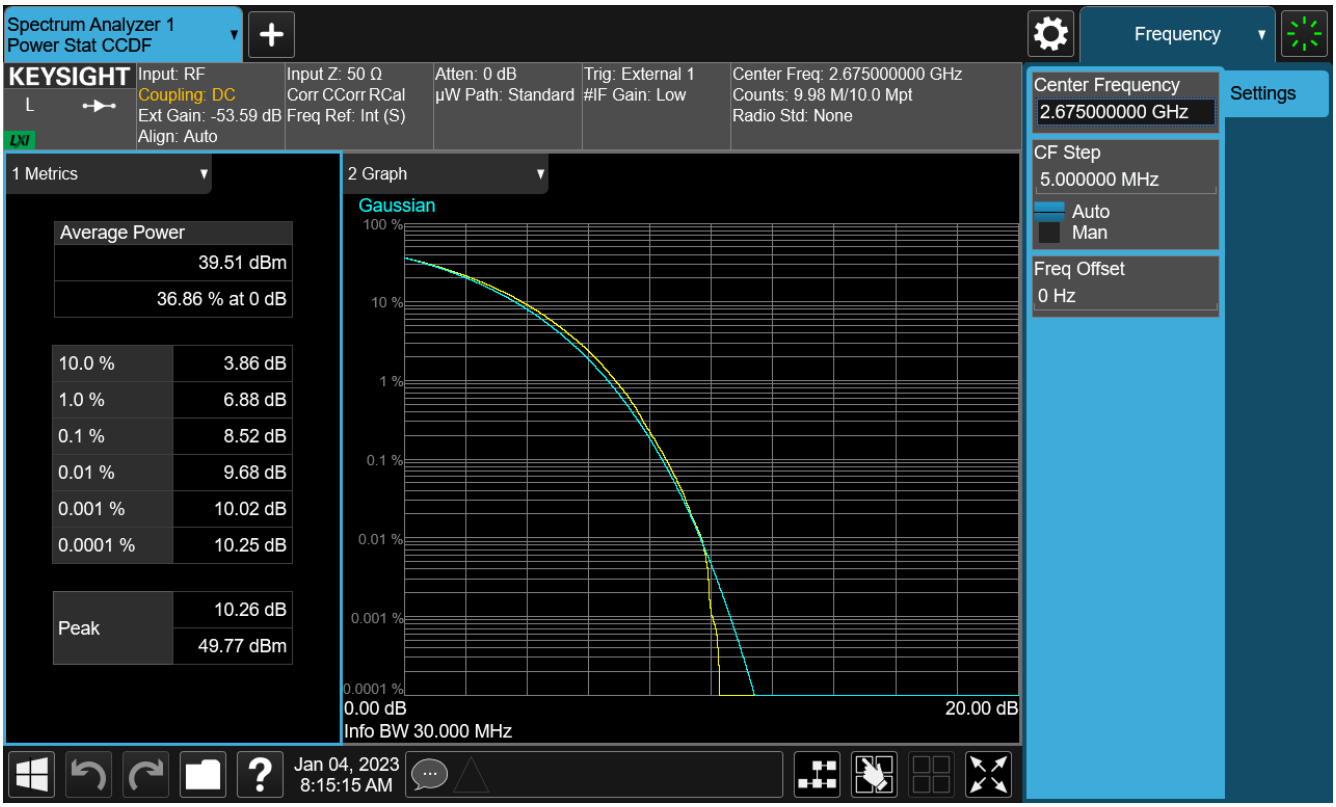
2.2 Peak-to-Average Power Ratio (PAPR)

The Peak-to-Average Power Ratio (PAPR) was evaluated per KDB 971168. The PAPR values of all carriers measured are below 13dB.

# of Carriers	Test Model	Modulation	TX Port	Channel Frequency MHz	Signal BW MHz	Radio Access Technology	PAR at 0.1% Limit - 13 dB
1	3.1	64QAM	0	2511	30	5G-NR	8.12
1	3.1a	256QAM	0	2593	30	5G-NR	8.10
1	3.2	QPSK/16QAM	2	2675	30	5G-NR	8.21
2	3.1	64QAM	3	2511+2641	30+30	5G-NR+5G-NR	8.24+8.33
2	3.2	QPSK/16QAM	3	2528+2658	30+30	5G-NR+5G-NR	8.19+8.47
2	3.1a	256QAM	0	2545+2675	30+30	5G-NR+5G-NR	8.32+**8.52**

2.2.1 Peak-to-Average Power Ratio Plot(s)

NOTE: Only worst-case plot is used in this report. The full suite of raw data resides at the MH, New Jersey location.



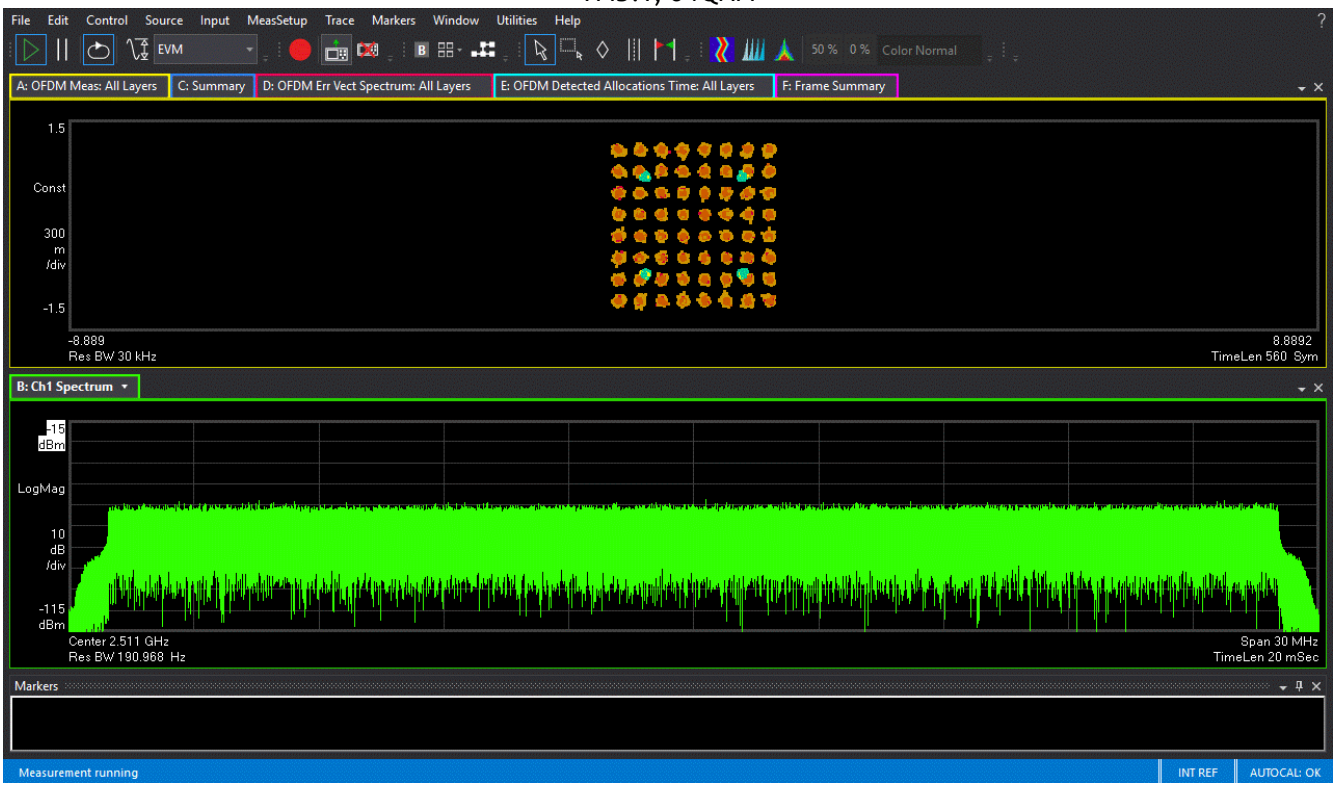
3. FCC Section 2.1047 - Modulation Characteristics

3.1 Modulation Characteristics

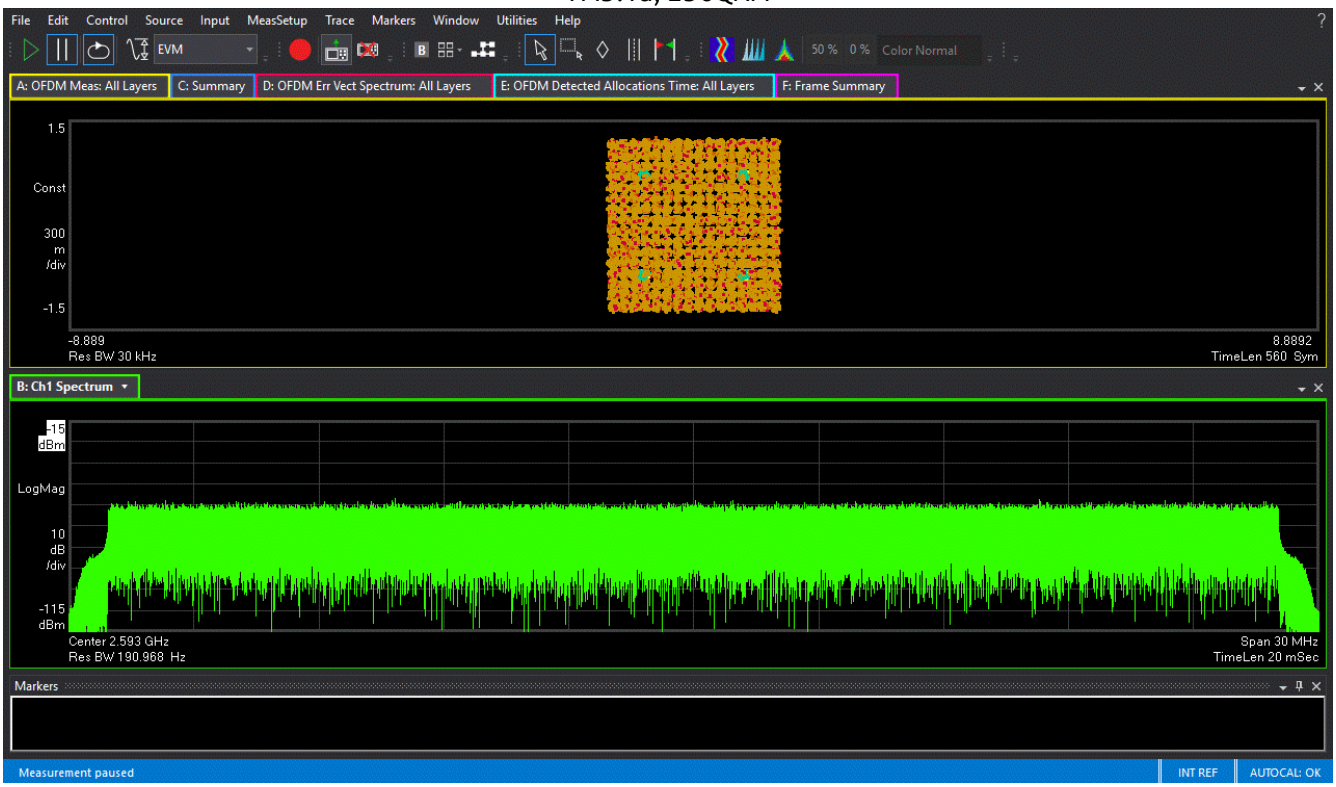
The RF signal at the antenna port was verified for correctness of the modulation signal used before each test was performed.

3.1.1 Modulation Characteristics – Sample Plot(s)

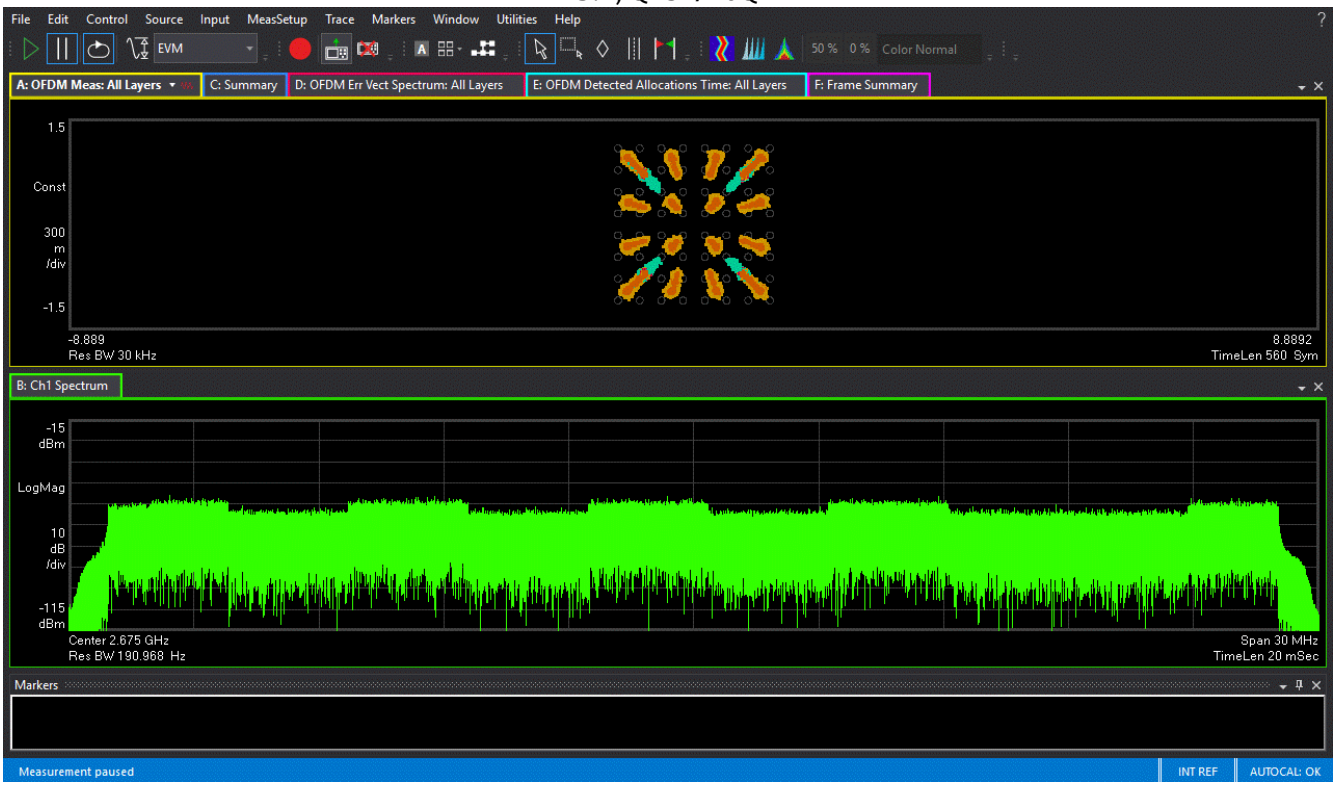
TM3.1, 64QAM



TM3.1a, 256QAM



TM3.2, 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."

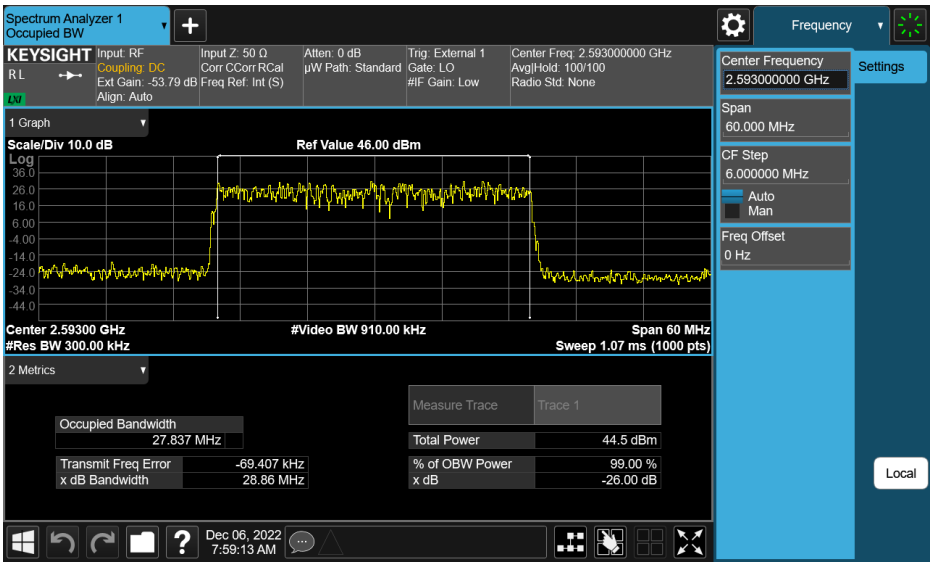
This required measurement is the 99% Occupied Bandwidth, also called the designated signal bandwidth and needs to be within the parameters of the products specified emissions designator. During these measurements it is customary to evaluate the Edge of Band emissions at block/band edges. The transmitted signal occupied bandwidth was measured using a Keysight MXA Signal Analyzer. All emissions were within the parameters as required.

Tabular Data – 99% Occupied Bandwidth

# of Carriers	Test Model	Modulation	TX Port	Channel Frequency MHz	Signal BW MHz	Radio Access Technology	99% Occupied BW MHz
1	3.1	64QAM	0	2511	30	5G-NR	27.765
1	3.1a	256QAM	0	2593	30	5G-NR	**27.837**
1	3.2	QPSK/16QAM	2	2675	30	5G-NR	27.821
2	3.1	64QAM	3	2511+2641	30+30	5G-NR+5G-NR	27.757+27.647
2	3.2	QPSK/16QAM	3	2528+2658	30+30	5G-NR+5G-NR	27.796+27.82
2	3.1a	256QAM	0	2545+2675	30+30	5G-NR+5G-NR	27.833+27.605

4.1.1 Occupied Bandwidth - 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.



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 RF Switch. 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.

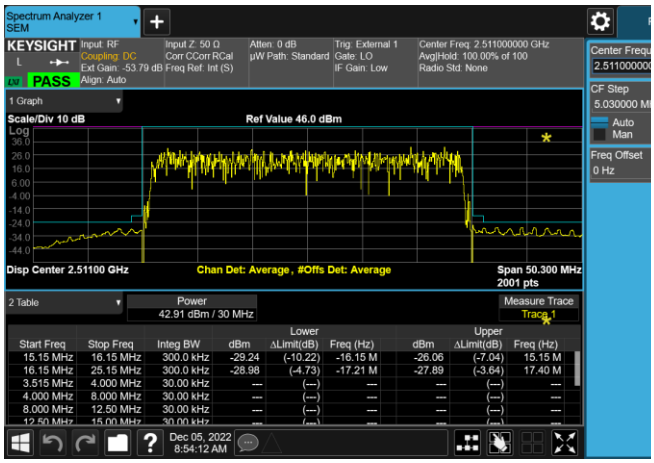
Per FCC Part 27.53 (L)(1), for base station operations in the 2496 – 2690 MHz band, the conducted power of any emission outside the licensee's authorized bandwidth shall not exceed −13 dBm/MHz. Compliance with this paragraph (L)(1) is based on the use of measurement instrumentation employing a resolution bandwidth of 1 megahertz or greater. However, in the 1 MHz bands immediately outside and adjacent to the licensee's frequency block, a resolution bandwidth of at least one percent emission bandwidth of the fundamental emission of the transmitter may be employed. Therefore, with 4TX ports, the conducted limit per port is -18.2 dBm/1% BW in the 1MHz immediately outside and adjacent to the licensee's frequency block and -24 dBm/MHz outside the 1MHz.

4.2.1 Edge of Band Emissions – Plots

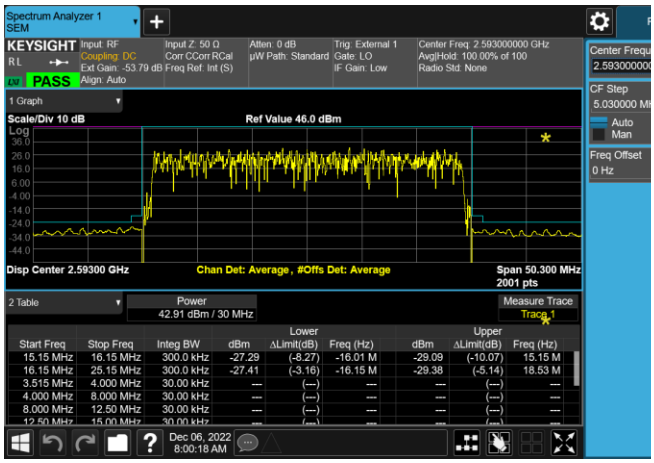
All of the measurements met the requirements of Part 27.53 when measured per Part 2.1049.

1C Channel RF Power plots – 30MHz BW

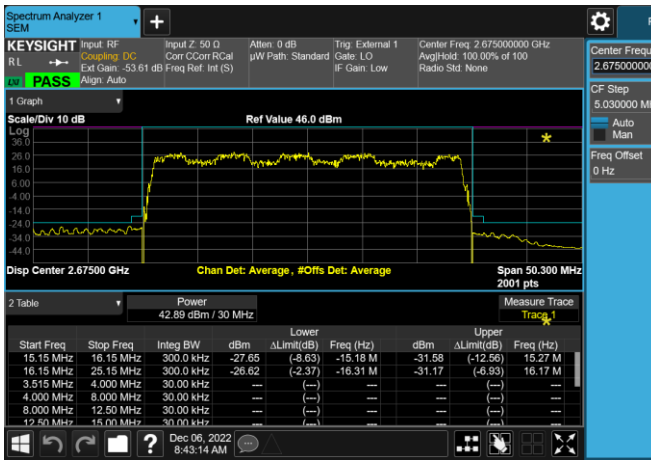
TM 3.1, 64QAM, CF 2511 MHz, TX0



TM 3.1a, 256QAM, CF 2593 MHz, TX0

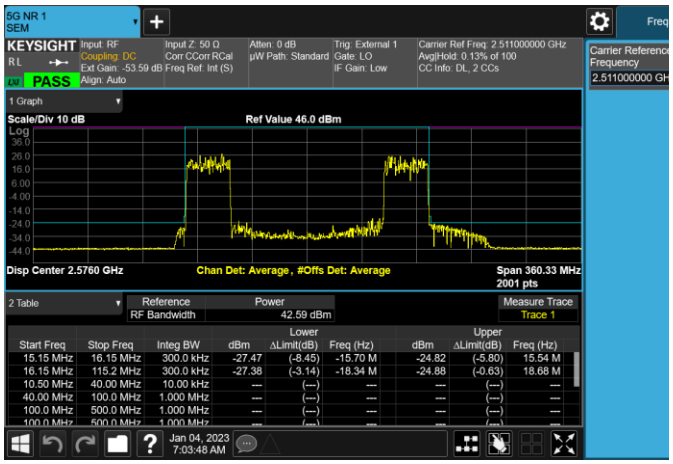


TM 3.2, QPSK/16QAM, CF 2675 MHz, TX2

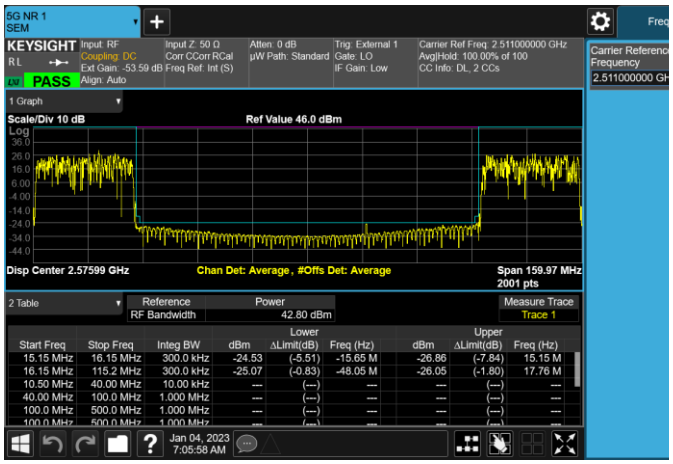


2C Channel RF Power plots – 30+30 MHz BW

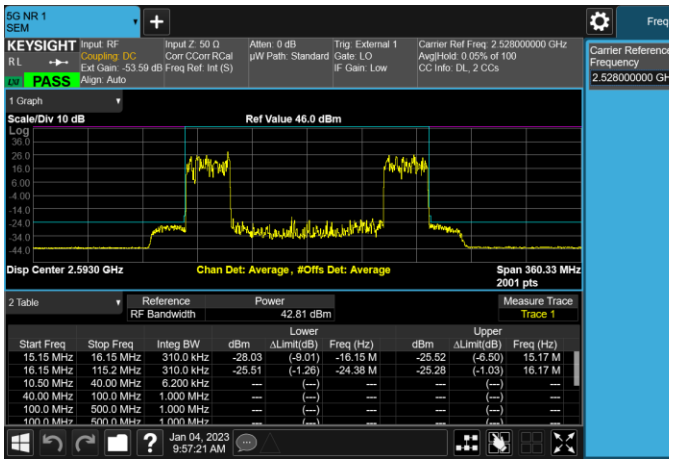
TM 3.1, 64QAM, CF 2511+2641MHz, TX3



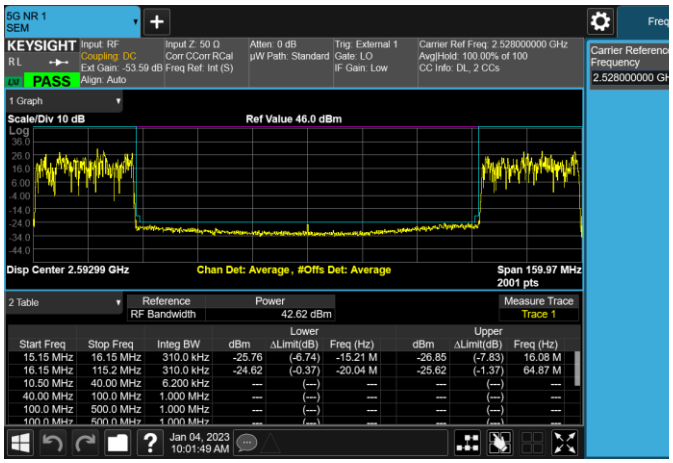
TM 3.1, 64QAM, CF 2511+2641MHz, TX3, Inner



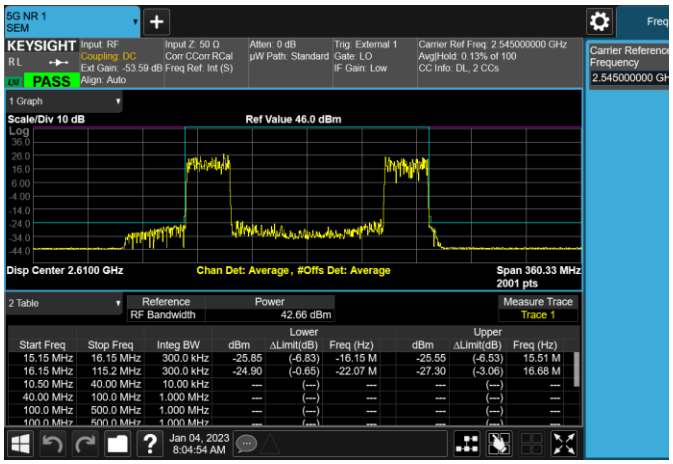
TM 3.2, QPSK/16QAM, CF 2528+2658 MHz, TX3



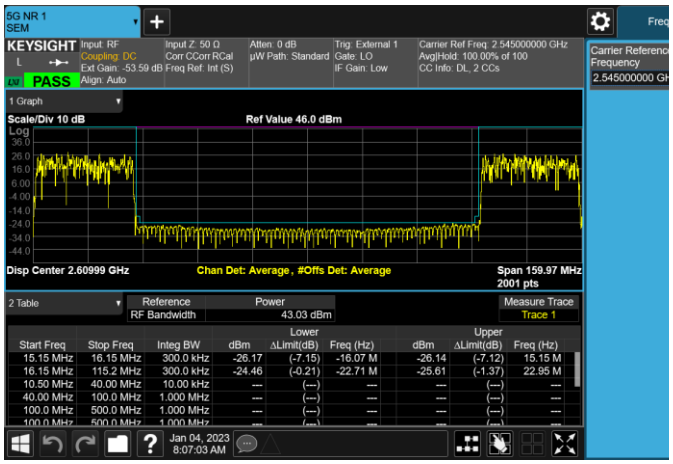
TM 3.2, QPSK/16QAM, CF 2528+2658 MHz, TX3, Inner



TM 3.1a, 256QAM, CF 2545+2675 MHz, TX0



TM 3.1a, 256QAM, CF 2545+2675 MHz, TX0, Inner



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

5.1 Measurement of Spurious Emissions at Transmit Antenna Port

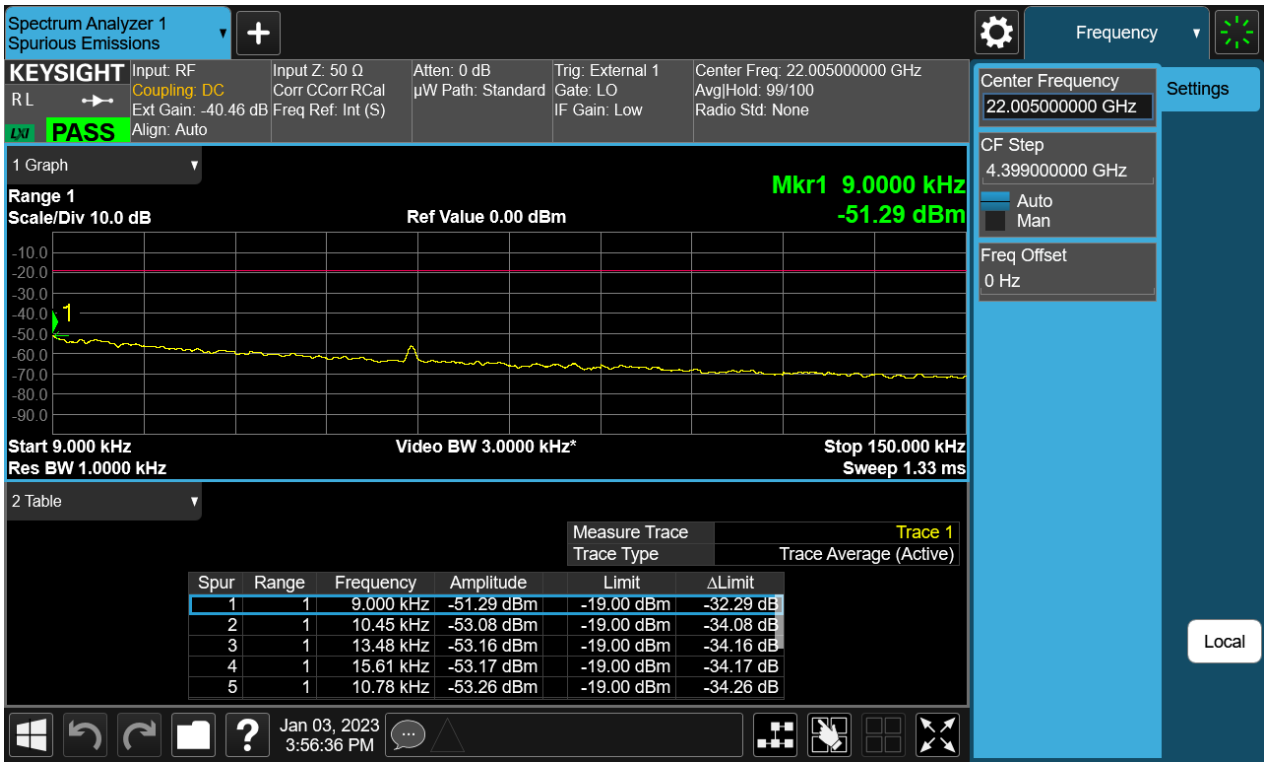
Spurious Emissions at the transmit-antenna terminals were investigated over the frequency range of 10 MHz to beyond the 10th harmonic of the specific transmit band. Carrier Bandwidth is exempt. For this band of operation, the measurements were performed up to 27 GHz. Measurements were made using a Keysight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

The 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. The limit of -13 dBm was adjusted to -19 dBm based on 10 log (4) for 4X MIMO as required in KDB 662911 D01.

NOTE: Only plots with lowest margin in each frequency range are used in this report. The full suite of raw data resides at the MH, New Jersey location.

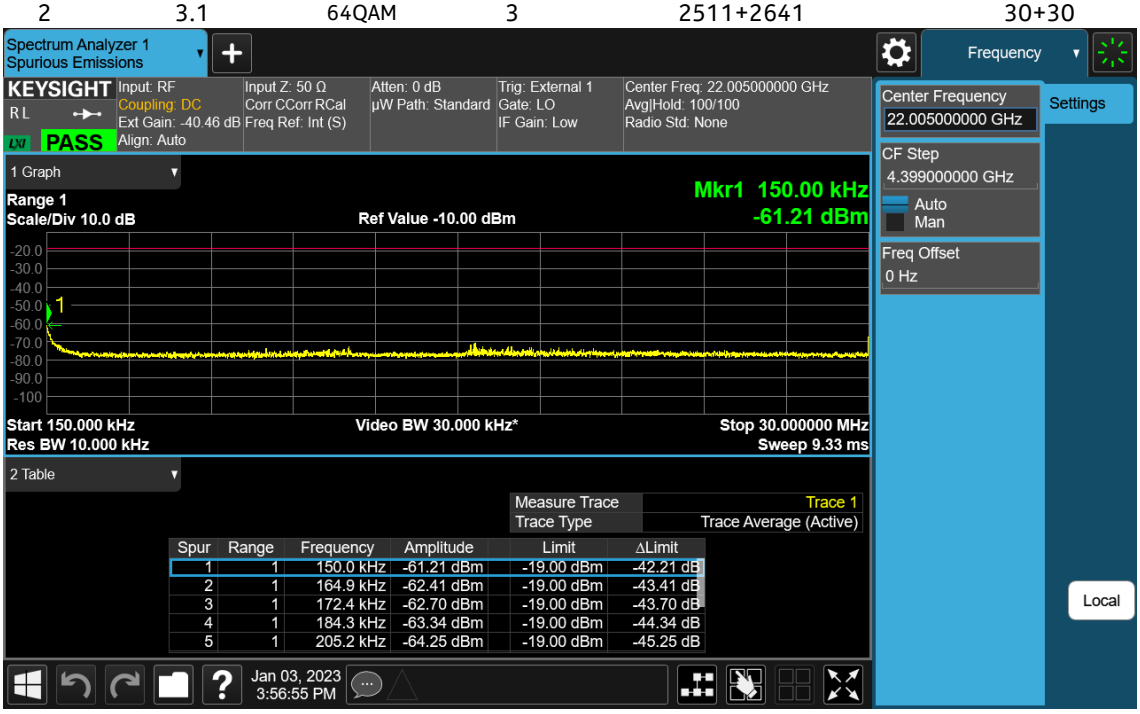
9kHz – 150kHz

# of Carriers	Test Model	Modulation	TX Port	Channel Frequency MHz	Signal BW MHz
2	3.1	64QAM	3	2511+2641	30+30



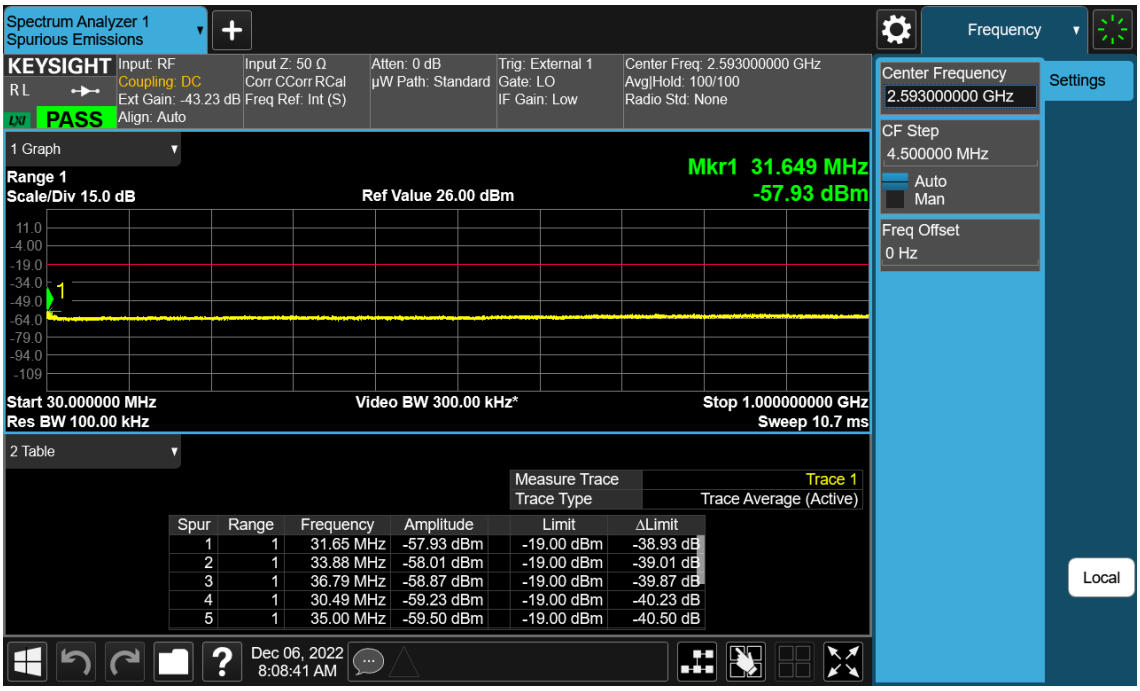
150kHz – 30MHz

# of Carriers	Test Model	Modulation	TX Port	Channel Frequency MHz	Signal BW MHz
2	3.1	64QAM	3	2511+2641	30+30



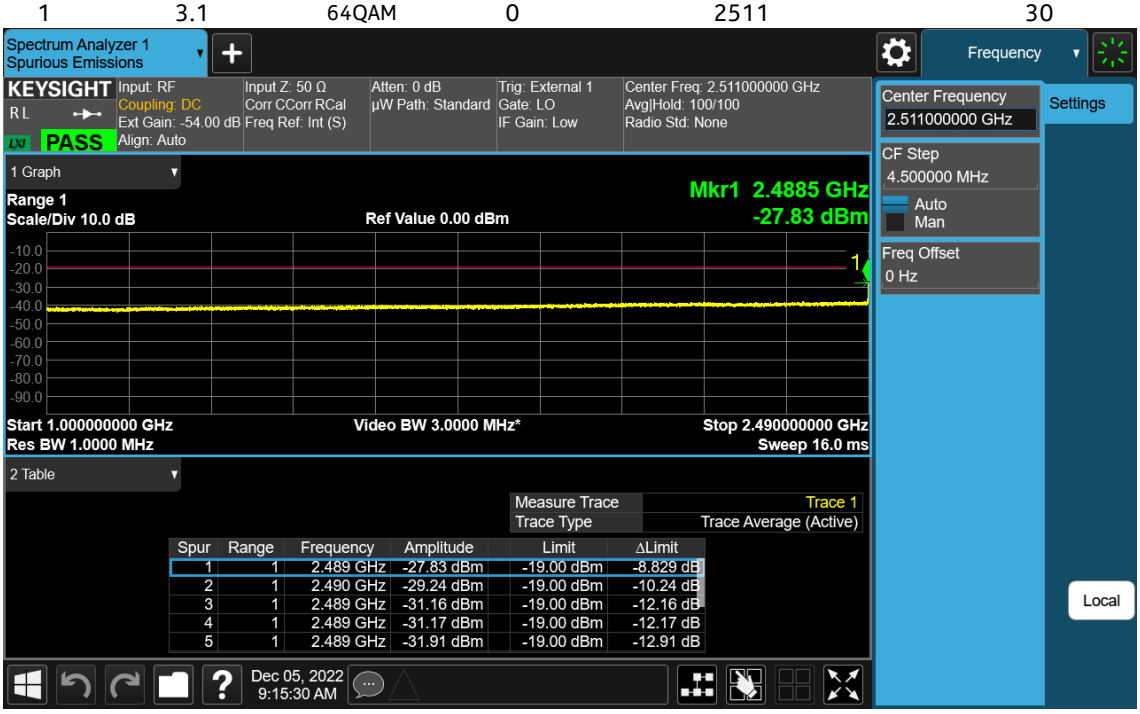
30MHz – 1GHz

# of Carriers	Test Model	Modulation	TX Port	Channel Frequency MHz	Signal BW MHz
1	3.1a	256QAM	0	2593	30



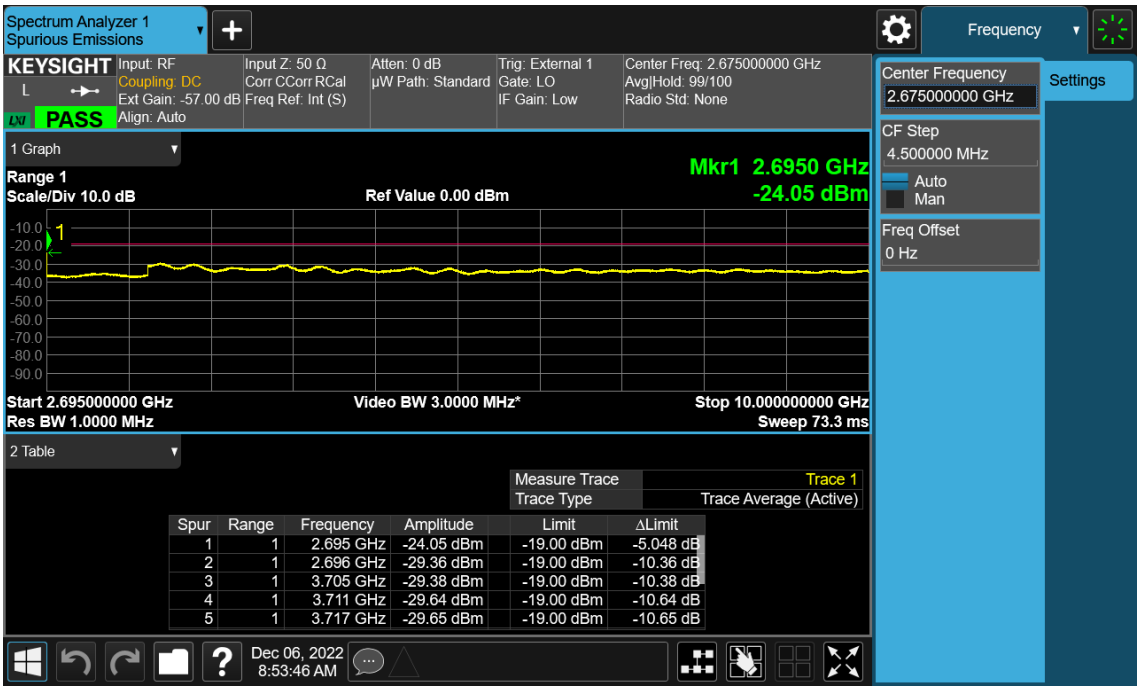
1GHz – 2.49GHz

# of Carriers	Test Model	Modulation	TX Port	Channel Frequency MHz	Signal BW MHz
1	3.1	64QAM	0	2511	30



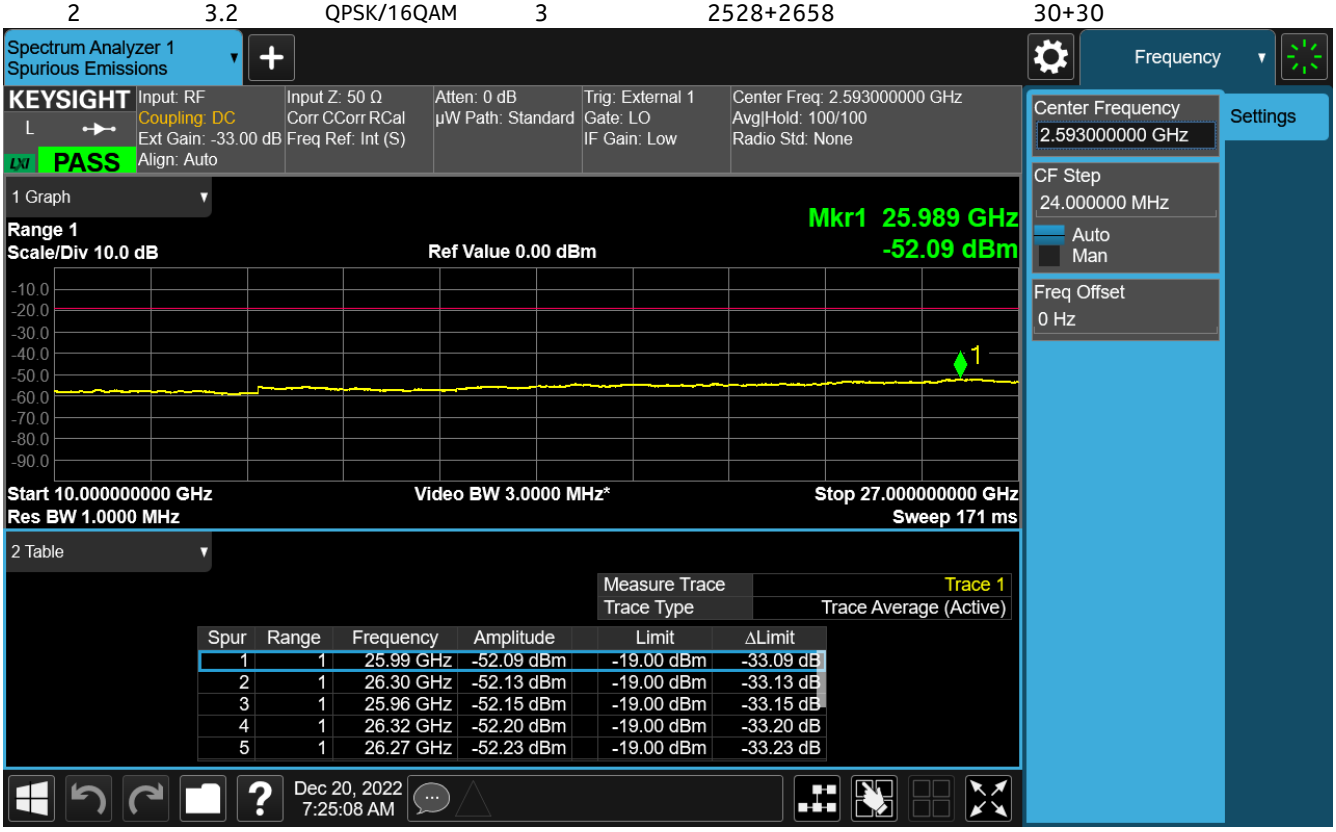
2.69GHz – 10GHz

# of Carriers	Test Model	Modulation	TX Port	Channel Frequency MHz	Signal BW MHz
1	3.2	QPSK/16QAM	2	2675	30

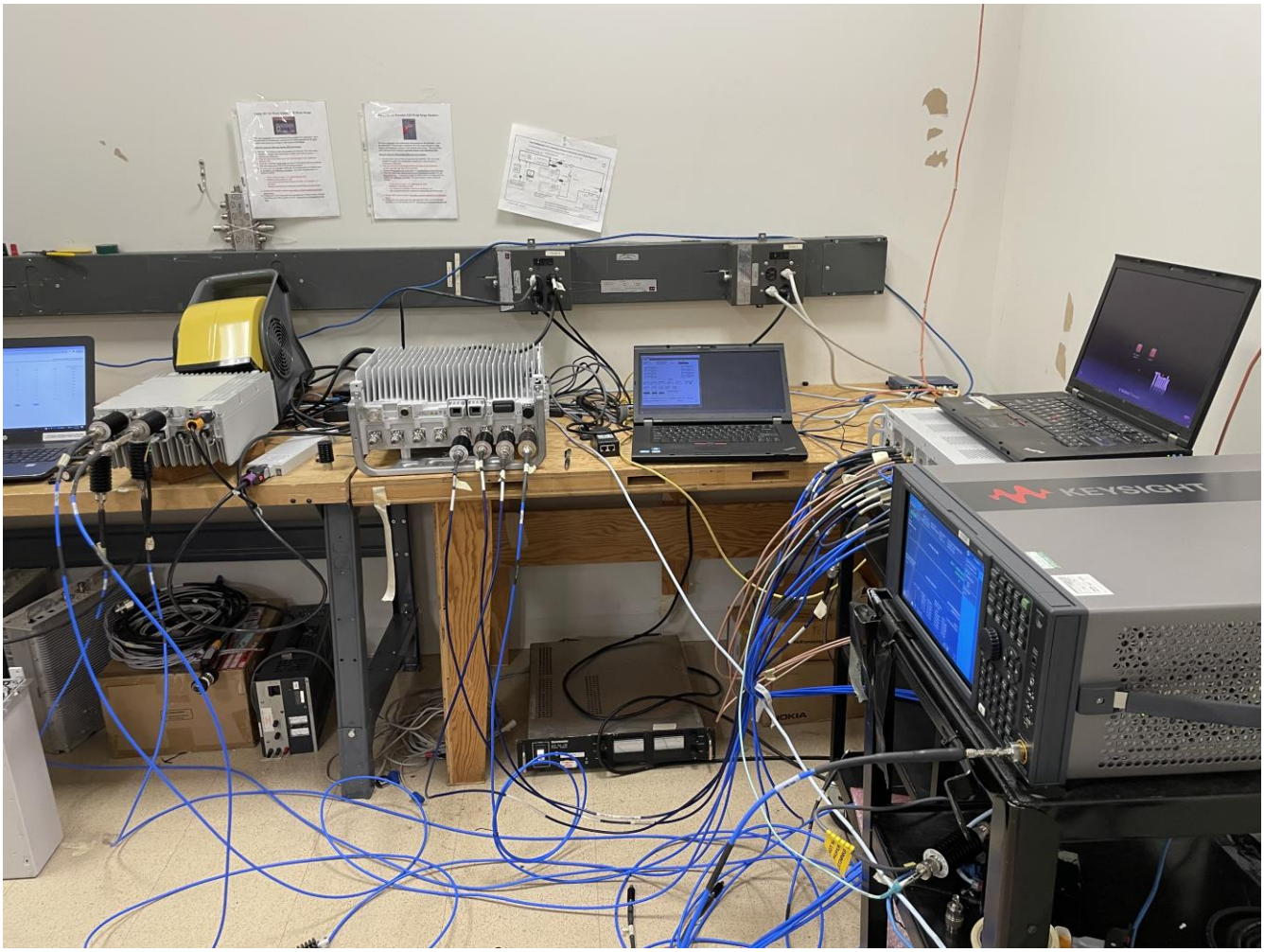


10GHz – 27GHz

# of Carriers	Test Model	Modulation	TX Port	Channel Frequency MHz	Signal BW MHz
2	3.2	QPSK/16QAM	3	2528+2658	30+30



Photographs



Test Equipment

Asset ID	Manufacturer	Type	Description	Model	Serial	Calibration Date	Calibration Due
E1217	KeySight Technologies	EMI Receiver	MXE EMI Receiver 26.5GHz	N9038A	MY54130087	2021-05-11	2023-05-11
E896	Agilent Technologies	Network Analyzer	10 MHz - 40 GHz	N5230C	MY49000897	2021-03-03	2023-03-03
E1534	Traceable	Data Logger	Barometric Humidity Temp Data Logger	6529	200648430	2020-11-21	2023-1-21
E1208	RLC Electronics Inc	Filter, High Pass	2.5 - 26 GHz	F-19391	1440-001	CNR-V	CNR-V
E1156	Weinschel	Attenuator	10dB 0.05GHz-26GHz 25W	74-10-12	1069	CNR-V	CNR-V
E1155	Weinschel	Attenuator	10dB 25Watt 0.05GHz - 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
E1347	Fairview Microwave	Attenuator	10 dB, DC - 40 GHz, 20 watt	SA4023-10	N/A	CNR-V	CNR-V

CNR-V: Calibration Not Required, Must Be Verified
Test Date: 12/5/2022 – 1/4/2023

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

NVLAP®

ilac-MRA

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).

2022-09-28 through 2023-09-30
Effective Dates

DEPARTMENT OF COMMERCE · UNITED STATES OF AMERICA

For the National Voluntary Laboratory Accreditation Program