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 90

Client:
Nokia Solutions and Networks, US LLC

Product Evaluated:
AHCF AirScale RRH 4T4R 200W

Report Number:
TR-2023-0061-FCC2-90

Date Issued:
June 20, 2023

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Revisions

Date	Revision	Section	Change
6/20/2023	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):	AHCF AirScale RRH 4T4R 200W
FCC ID:	VBNAHCF-01
Serial Number:	6Q201003945
Hardware Version:	475313A.101
Software Version:	SBTS23R3_ENB
Frequency Range:	860-869MHz
GPCL Project Number:	2023-0061
Applicant	Nokia Solutions and Networks, US LLC 3201 Olympus Blvd Dallas, Texas 75019 Steve Mitchell
Test Requirement(s):	Title 47 CFR Parts 2 and 90
Test Standards:	Refer to Section 1.5.1
Measurement Procedure(s):	Refer to Section 1.5.2
Test Date(s):	6/8/2023 – 6/15/2023
Test Performed By:	Nokia Global Product Compliance Laboratory 600-700 Mountain Ave. P.O. Box 636 Murray Hill, NJ 07974-0636 Test Site Number: US5302
Product Engineer(s):	Ron Remy
Lead Engineer:	Nilesh Patel
Test Engineer (s):	Nilesh Patel, Mike Soli, Norberto Batista, Hussain Saifnijat
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 **AHCF AirScale RRH 4T4R 200W**, 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 90 measured in accordance with the procedures set out in Section 2.1033 (c) (14) of the Rules.

The Nokia AHCF AirScale RRH 4T4R 200W (RRH) (hereinafter referred to as "AHCF") is a higher power RRH that supports 5G-NR and Long-Term Evolution - Frequency Division Duplex (LTE FDD) technology, 4 MIMO ports configured for 2x60W + 2x40W or 4x40 MIMO. The AHCF also supports single and multiple carriers, with combinations of LTE + NBIoT (Guardband and Inband), NBIoT Standalone, and 5G-NR, as well as single and multiple carrier operations.

The original AHCF FCC Part 22 (869-894MHz) certification was done for the following LTE and 5G-NR carrier configurations:

- 200kHz – Standalone NB-IoT
- 1.4 MHz – Single LTE carrier
- 3 MHz – Single LTE carrier
- 5 MHz – Single LTE carrier, 5 MHz LTE + NB-IoT Standalone, 5+5 MHz LTE + NB-IoT Standalone
- 10 MHz – Single LTE carrier, 10 MHz LTE with NB-IoT Inband or NB-IoT Guardband
- 5 MHz – Single 5G-NR carrier
- 10 MHz – Single 5G-NR carrier

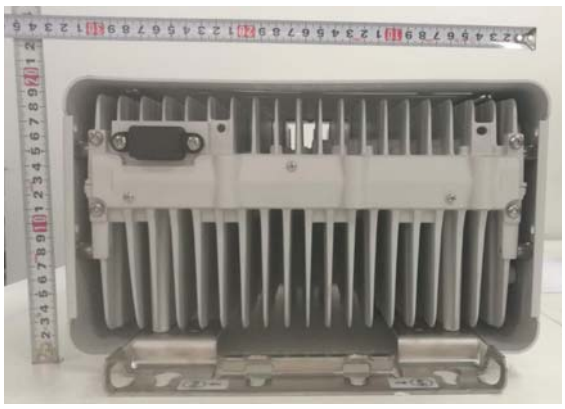
RF Conducted testing was performed at the antenna port for two power levels 60W (TX1 and TX3) and at 40W (TX2 and TX4) for all four ports.

This Class II Permissive Change is to add 5MHz LTE and 5G-NR emissions designators for FCC part 90 (860-869MHz) to the existing Grant. Nokia Bell Labs, part of the Nokia family of companies, hereby requests this certification for addition of 5MHz LTE and 5G-NR carrier operation.

1.3 Specification

Specification Items	**Description**		
Radio Access Technology	LTE, 5G-NR		
Duplex Mode	FDD		
Modulation Type(s)	QPSK, 16QAM, 64QAM, 256QAM		
Channel Bandwidth	5 MHz		
Number of Tx Ports per Unit	4		
MIMO	Yes		
Max Conducted Power	2 x 47.8 dBm (60 W) + 2 x 46.0 dBm (40 W) or 4 x 46.0 dBm (40 W)		
Max Number of Carriers per Port	4		
Deployment Environment	Outdoor		
Environment Temperature Range	-40 °C to 55 °C		
Power Source	Voltage Ranges (VDC)		
	Minimum	Nominal	Maximum
	-40.0	-48.0	-57.0
Antenna	Detachable Directional Panel		
Maxi Antenna Gain Allowed for Urban (dBi)	6.13 dBi		
Maxi Antenna Gain Allowed for non-Urban (dBi)	9.15 dBi		

1.3.1 Photographs



Serial Number

1.4 Test Requirements

Each required measurement is listed below:

47 CFR FCC Sections	Description of Tests	Test Required
2.1046, 90.1321	RF Power Output	Yes
2.1047, 90.1323	Modulation Characteristics	Yes
2.1049, 90.1323	(a) Occupied Bandwidth (b) Out-of-Band Emissions	Yes
2.1051, 90.1323	Spurious Emissions at Antenna Terminals	Yes
2.1053, 90.1323	Field Strength of Spurious Radiation	Yes
2.1055, 90.1323	Measurement of Frequency Stability	No*

*Previous tested and documented under GPCL Project 2020-0085

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 90.
- ANSI C63.26, American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services.
- ANSI C63.4 (2009) 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.
- FCC KDB 971168 D01 Power Measurement License Digital Systems v03r01 April 9, 2018.
- FCC KDB 662911 D01 Multiple Transmitter Output v02r01 Oct 2013

1.5.2 Procedures

- 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

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

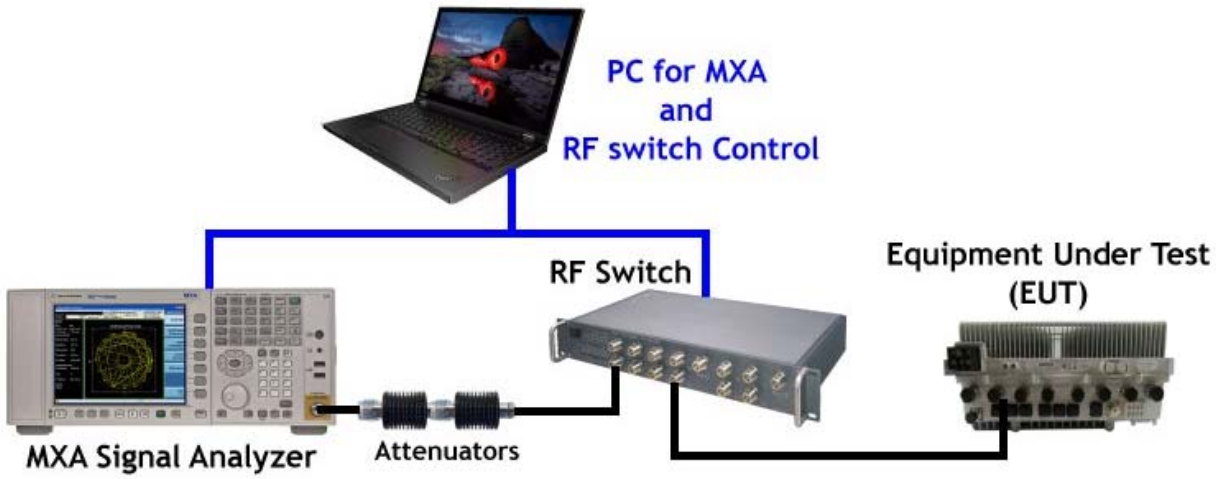
1.6 Executive Summary

47 CFR FCC Sections	Description	Result
2.1046, 90.1321	RF Power Output	COMPLIES
2.1047, 90.1323	Modulation Characteristics	COMPLIES
2.1049, 90.1323	(a) Occupied Bandwidth (b) Out-of-Band Emissions	COMPLIES
2.1051, 90.1323	Spurious Emissions at Antenna Terminals	COMPLIES
2.1053, 90.1323	Field Strength of Spurious Radiation	COMPLIES
2.1055, 90.1323	Measurement of Frequency Stability	NT

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

1.7 Test Configuration for all Antenna Port Measurements.

Test Setup 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 and the procedure of ANSI C63.26:2015 Section 5.4.2.2 was observed. The maximum output is bolded in each case.

Tabular Data – Channel RF Power

Channel Power - Signal BW 5MHz (5G-NR)			
Test Model 3.2 Modulation QPSK/16QAM Channel Frequency 862.5MHz		Test Model 1.1 Modulation QPSK Channel Frequency 866.5MHz	
TX Port	(dBm)	TX Port	(dBm)
0	**47.89**	0	**47.63**
1	46.85	1	46.66
2	47.65	2	47.44
3	46.62	3	46.36
Total Power (dBm)	53.31	Total Power (dBm)	53.07
Total Power (W)	214.07	Total Power (W)	203.00

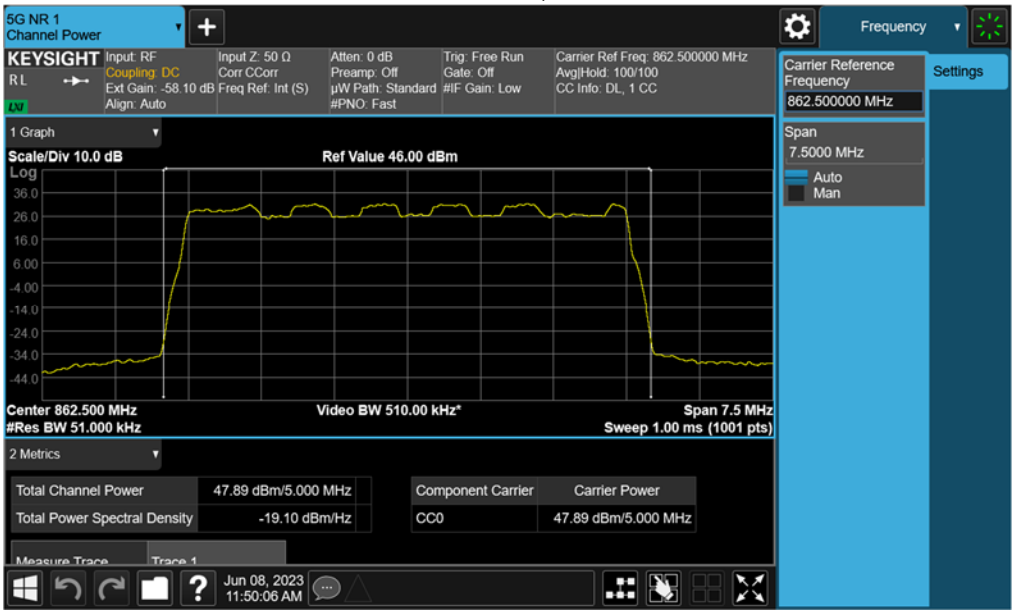
Channel Power - Signal BW 5MHz (LTE)			
Test Model 3.1 Modulation 64QAM Channel Frequency 862.5MHz		Test Model 3.1a Modulation 256QAM Channel Frequency 866.5MHz	
TX Port	(dBm)	TX Port	(dBm)
0	**48.05**	0	**48.38**
1	46.51	1	46.91
2	47.85	2	48.07
3	46.37	3	46.64
Total Power (dBm)	53.28	Total Power (dBm)	53.58
Total Power (W)	212.90	Total Power (W)	228.21

2.1.1 Channel RF Power - Plots.

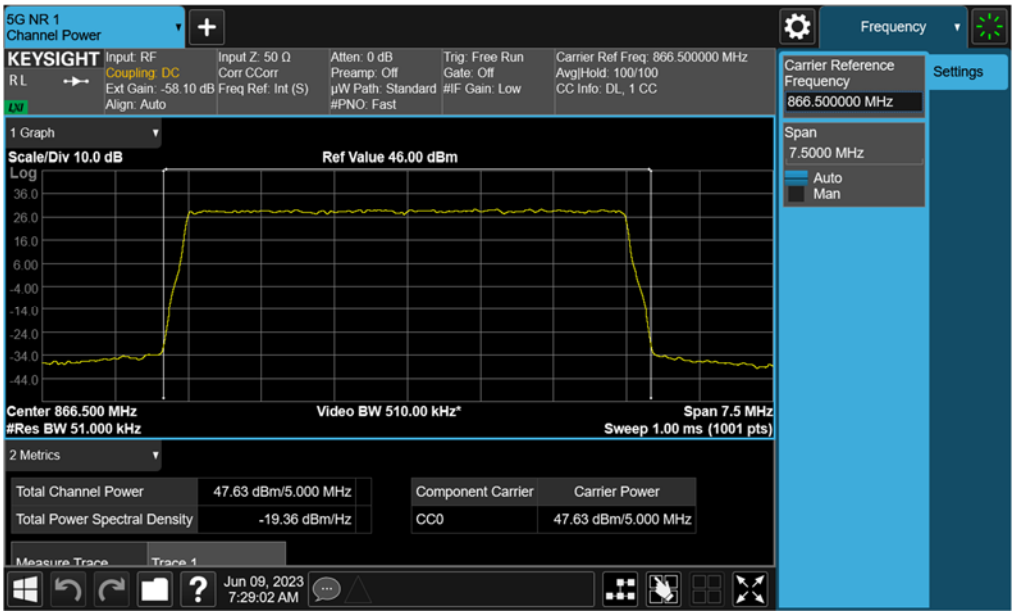
NOTE: Only a sample of the plots are used in this report. The full suite of raw data resides at the MH, New Jersey location.

5G-NR

862.5 MHz, TX0

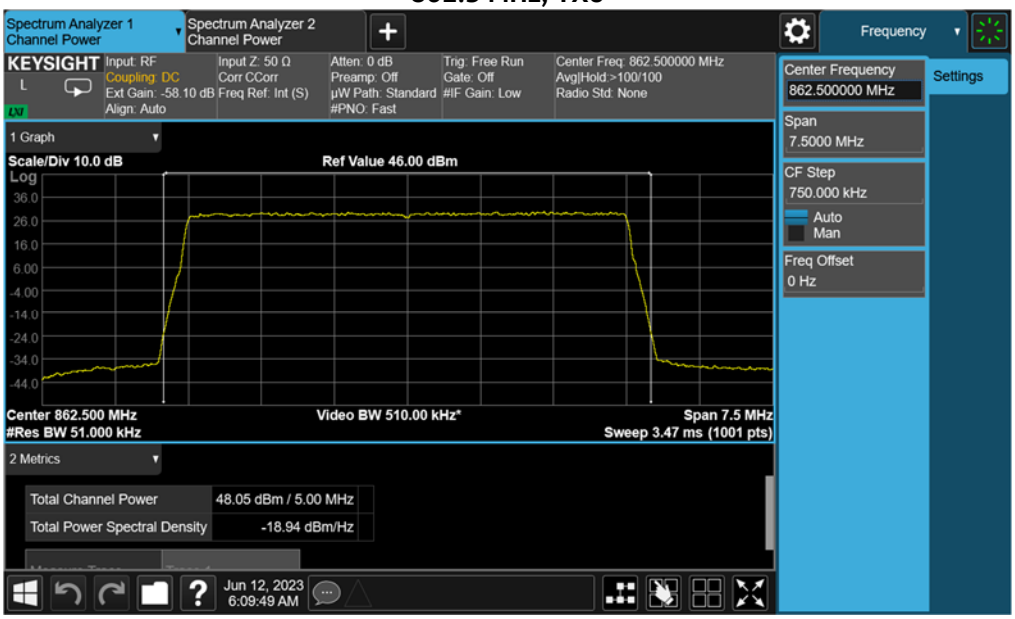


866.5 MHz, TX0

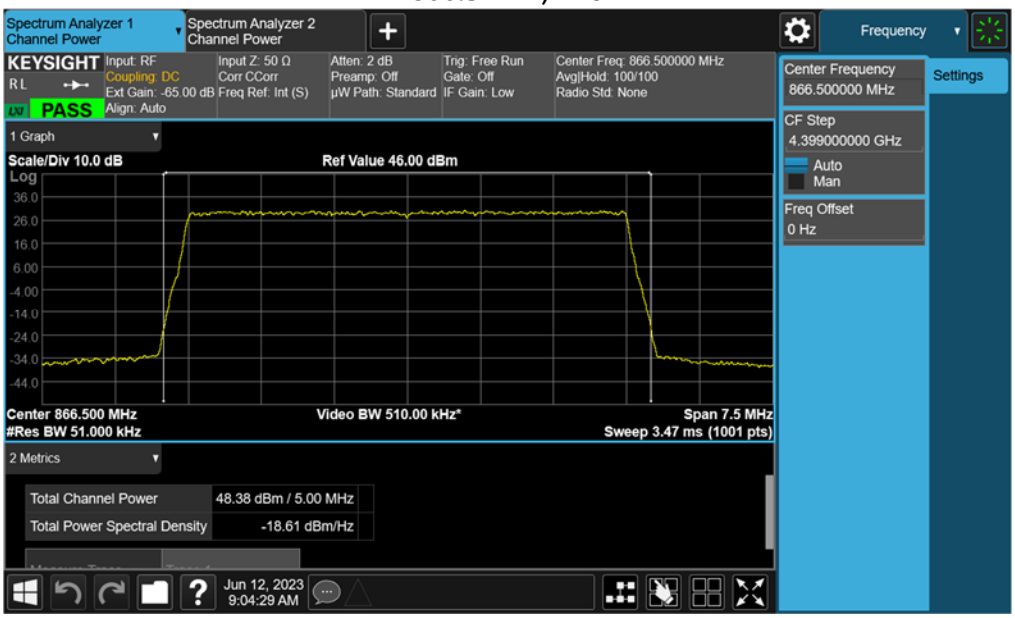


LTE

862.5 MHz, TX0



866.5 MHz, TX0



2.1.2 Peak-to-Average Power Ratio (PAPR)

The Peak-to-Average Power Ratio (PAPR) was evaluated per KDB 971168 for 5MHz bandwidths. The PAPR values of all carriers measured are below 13dB.

PAPR Tabular Data

Radio Technology	# of Carrier	Signal BW MHz	Test Model	Modulation	TX Port	Channel Frequency MHz	PAR at 0.1% Limit - 13 dB
5G-NR	1	5	3.2	QPSK/16QAM	0	862.5	7.05
5G-NR	1	5	1.1	QPSK	0	866.5	**7.25**
LTE	1	5	3.1	64QAM	0	862.5	**6.87**
LTE	1	5	3.1a	256QAM	0	866.5	6.74

5G-NR, 5MHz, TM1.1, QPSK, TX0, 866.5 MHz

LTE, 5MHz, TM3.1, 64QAM, TX1, 862.5 MHz

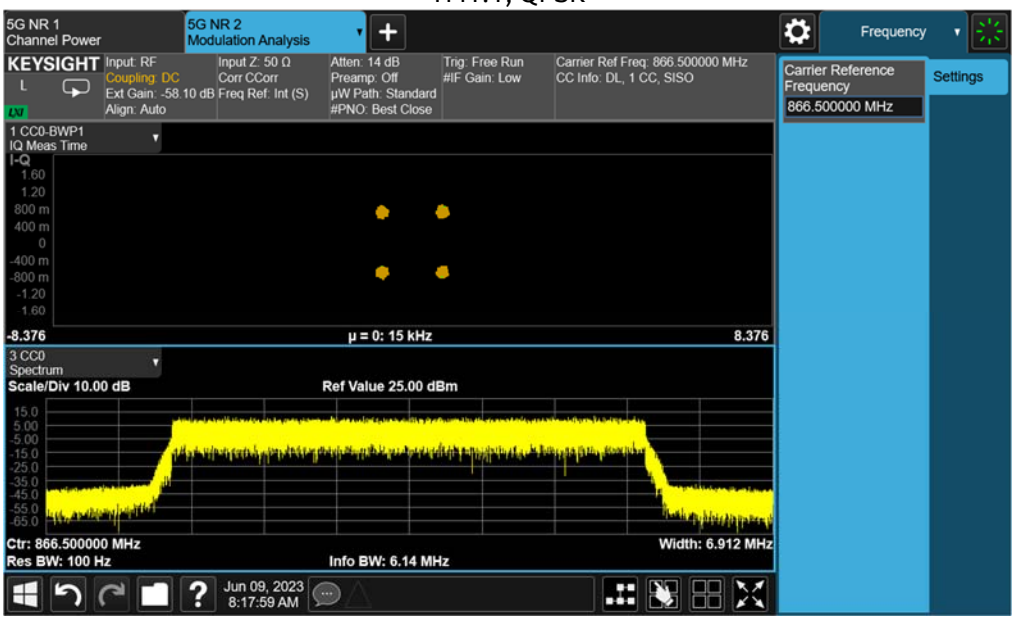
3. FCC Section 2.1047 - Modulation Characteristics

3.1 Modulation Characteristics

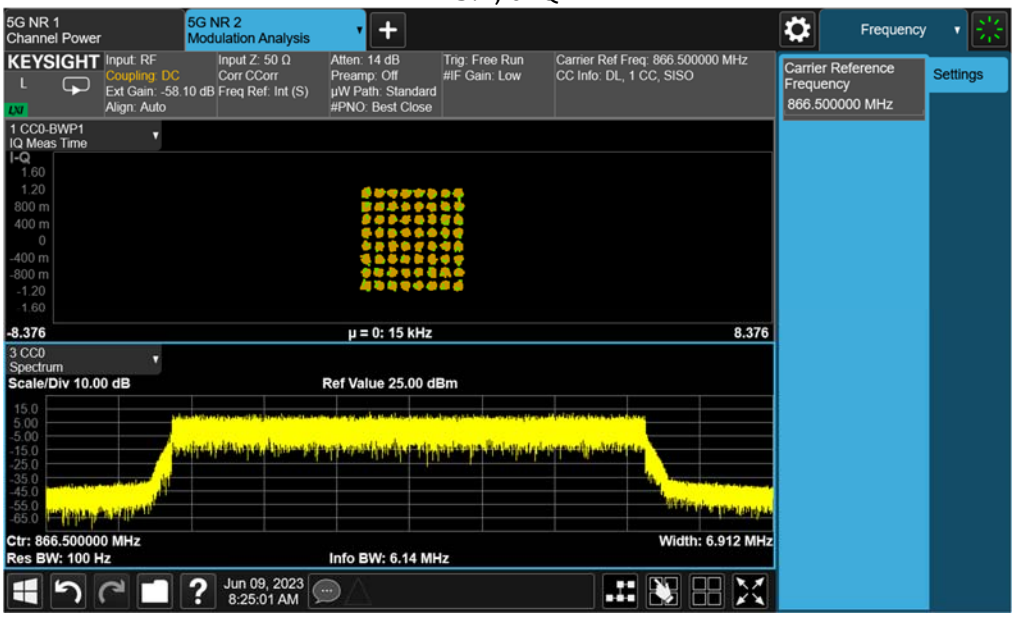
The RF signal at the antenna port was demodulated and verified for correctness of the modulation signal used before each test was performed. For these products the operation with, 64QAM and 256QAM modulation was evaluated for both LTE and 5G-NR and verified to demonstrate proper operation before testing.

3.1.1 Modulation Characteristics – Plots.

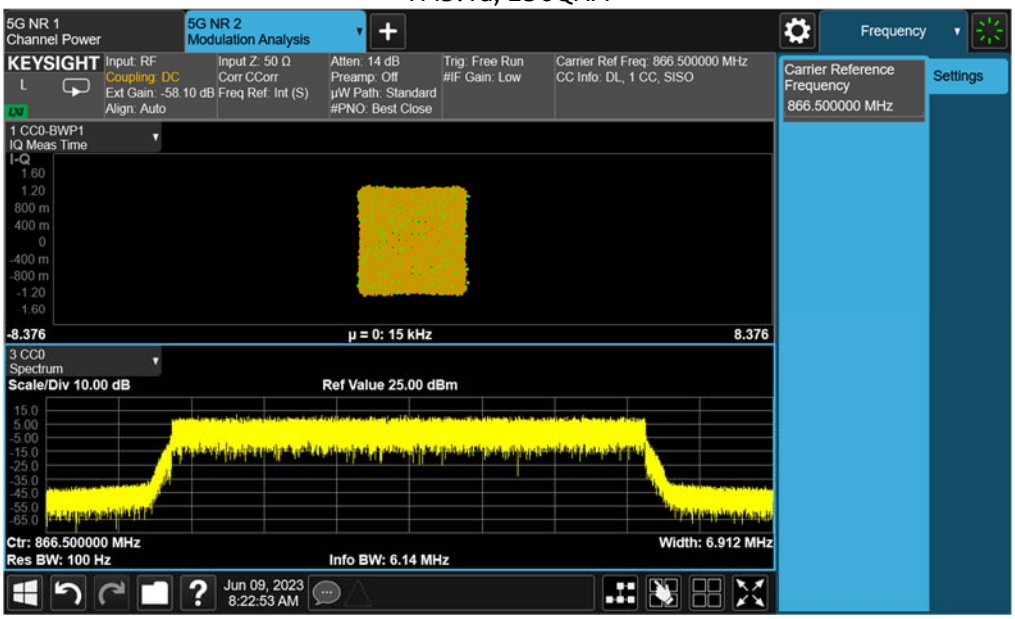
5G-NR
TM1.1, QPSK



TM3.1, 64QAM



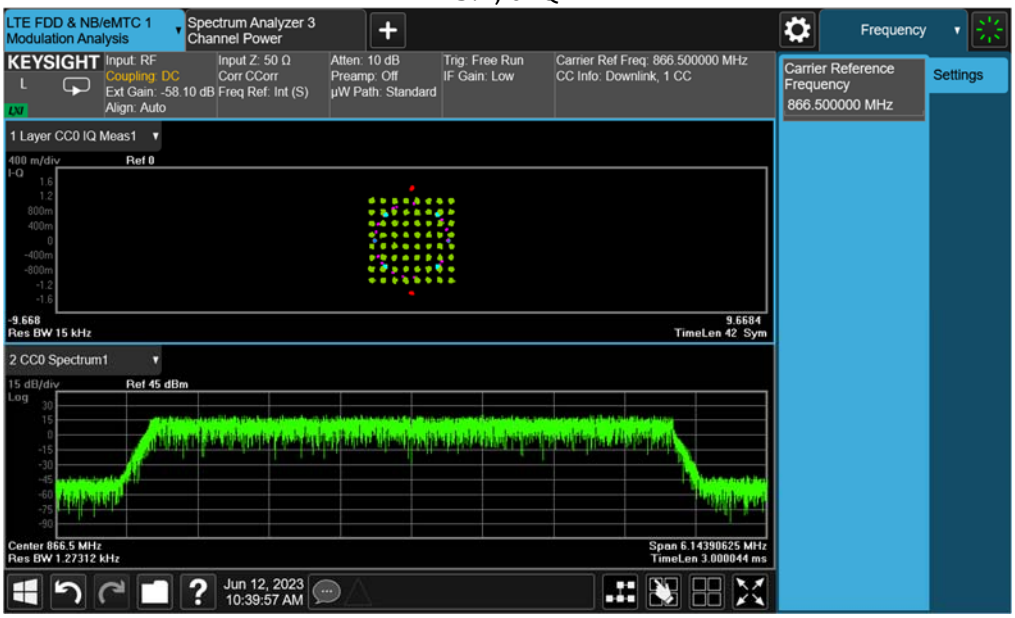
TM3.1a, 256QAM



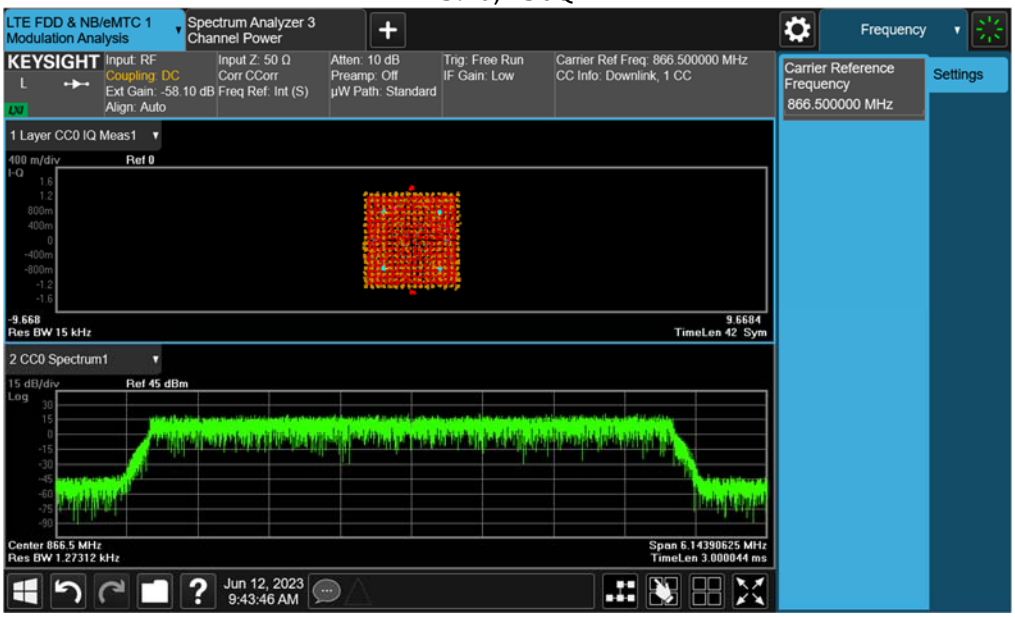
TM3.2, QPSK/16QAM

LTE

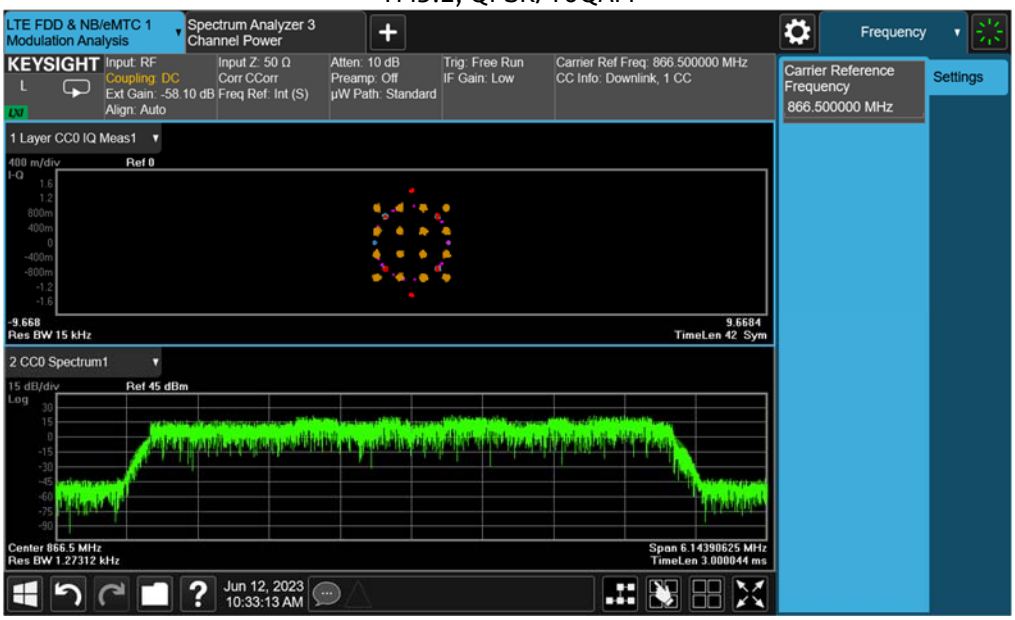
TM3.1, 64QAM



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.

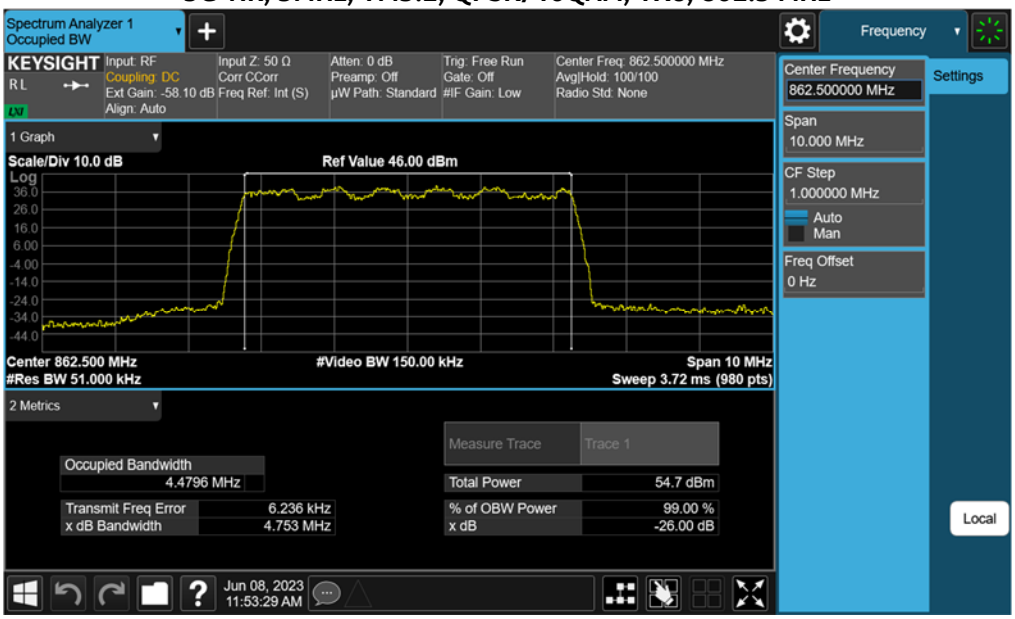
Tabular Data – Occupied Bandwidth

Radio Technology	# of Carrier	Signal BW MHz	Test Model	Modulation	TX Port	Channel Frequency MHz	99% OBW MHz
5G-NR	1	5	3.2	QPSK/16QAM	0	862.5	**4.4796**
5G-NR	1	5	1.1	QPSK	0	866.5	4.4575
LTE	1	5	3.1	64QAM	0	862.5	4.4747
LTE	1	5	3.1a	256QAM	0	866.5	**4.4773**

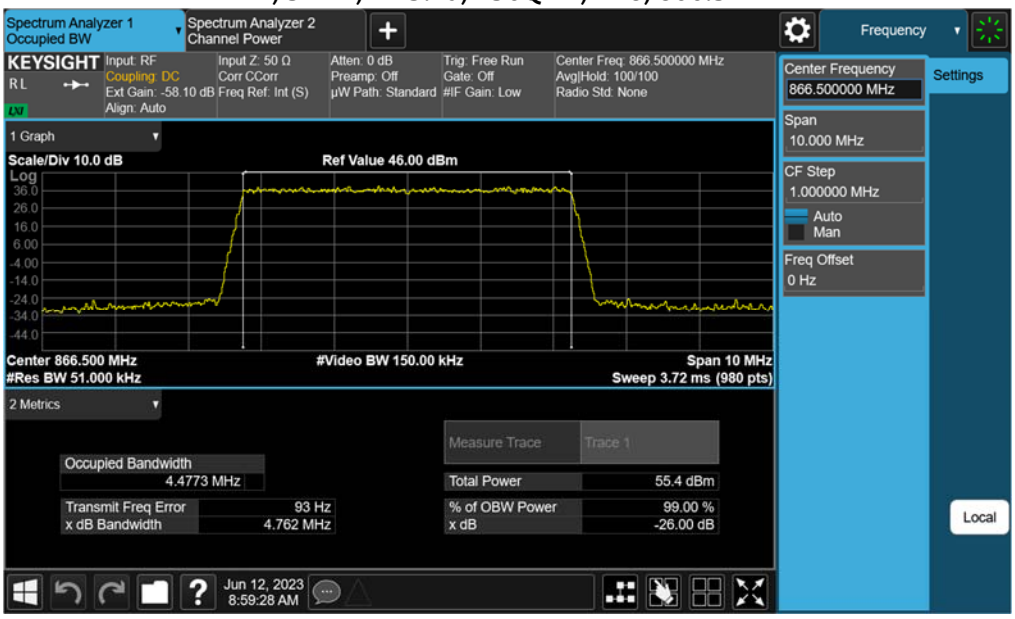
4.1.1 Occupied Bandwidth – Plots.

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.

5G-NR, 5MHz, TM3.2, QPSK/16QAM, TX0, 862.5 MHz



LTE, 5MHz, TM3.1a, 256QAM, TX0, 866.5 MHz



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. Before measuring the Edge of Band emissions, the RF power level was confirmed with the Keysight MXA Signal Analyzer. 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.

Note that the RF Switch is used only for units with a large number of ports and coincides with the photo and diagram, otherwise is removed.

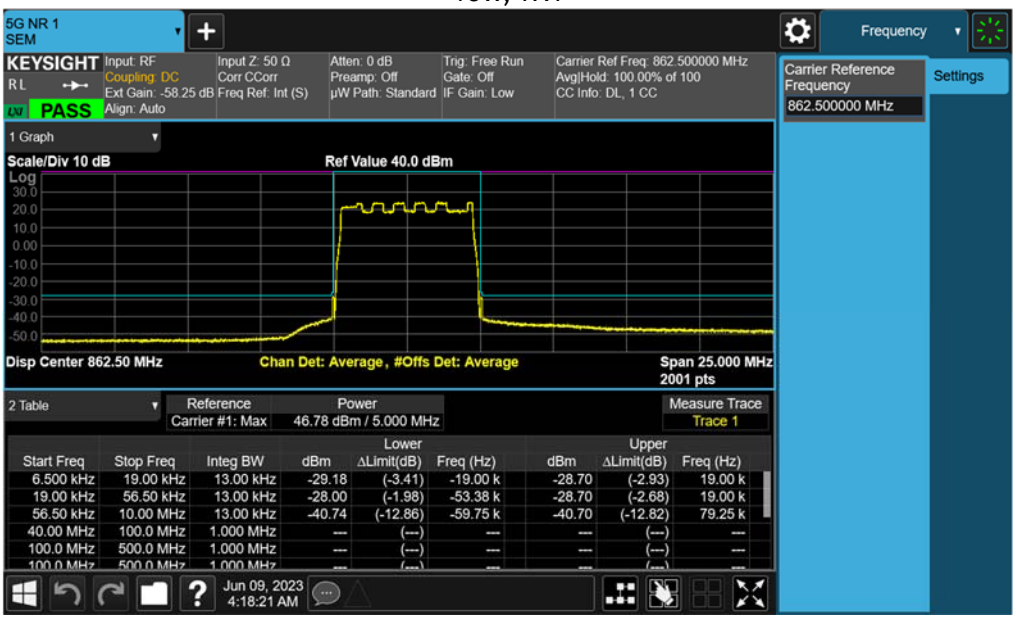
In accordance with KDB 662911 D01 Multiple Transmitter Output, the limit of -13 dBm has been adjusted to -19 dBm to reflect 10 log(n) where n=4 for the 4x4 MIMO operation, then adjusted for the 1 MHz bands immediately outside and adjacent to the frequency block where a smaller RBW than the required 100 kHz stated in 47 CFR Parts 90.669 & 90.691 were used.

4.2.1 Edge of Band Emissions - Plots.

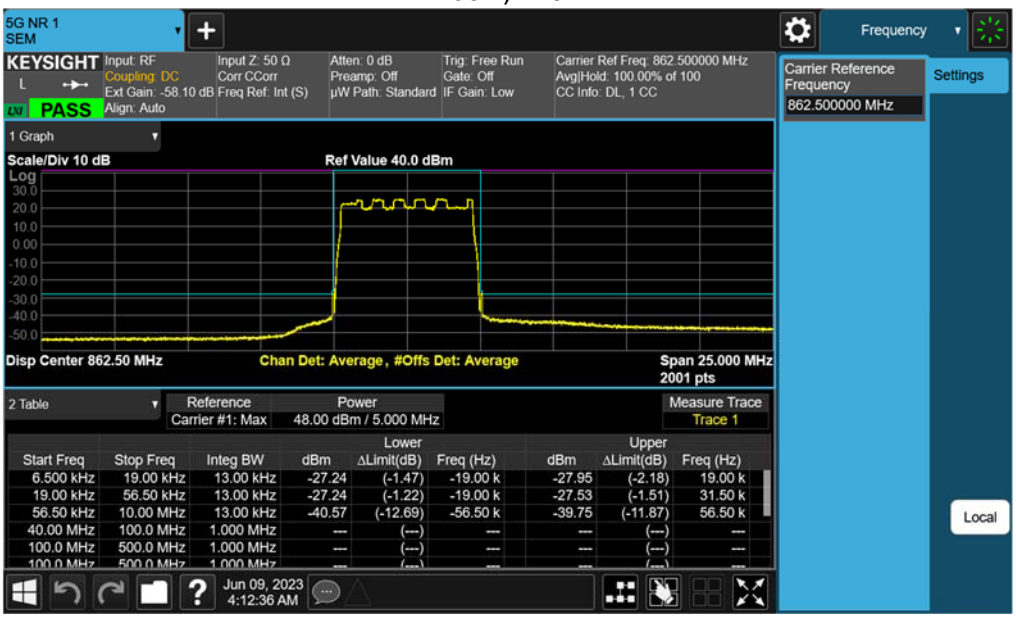
All of the measurements met the requirements of Part 2.1049 and 90.

5G-NR, 5MHz, TM3.2, QPSL/16QAM, 862.5 MHz

40W, TX1

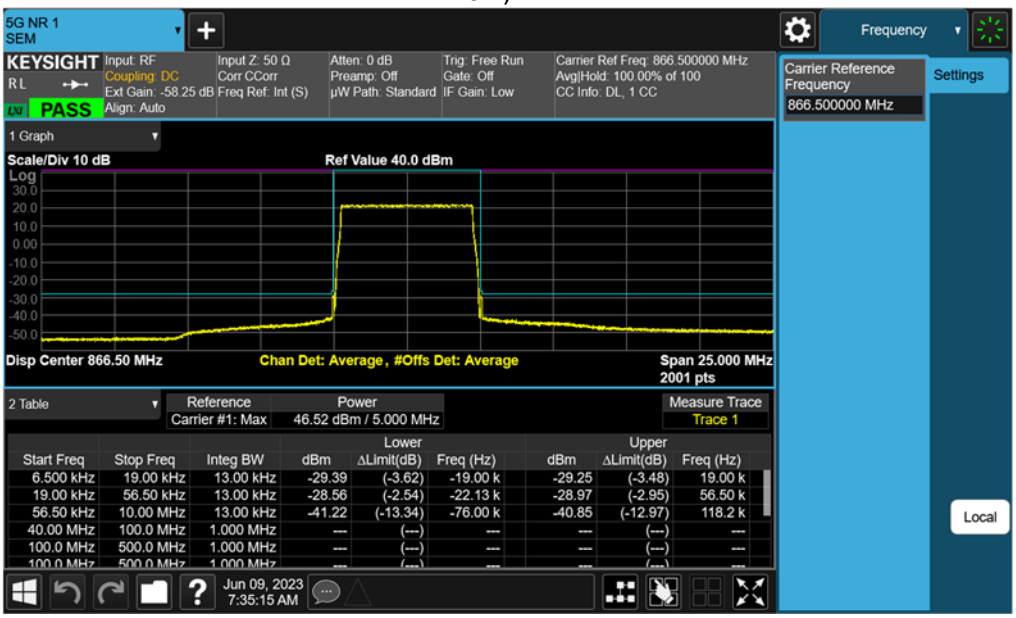


60W, TX0

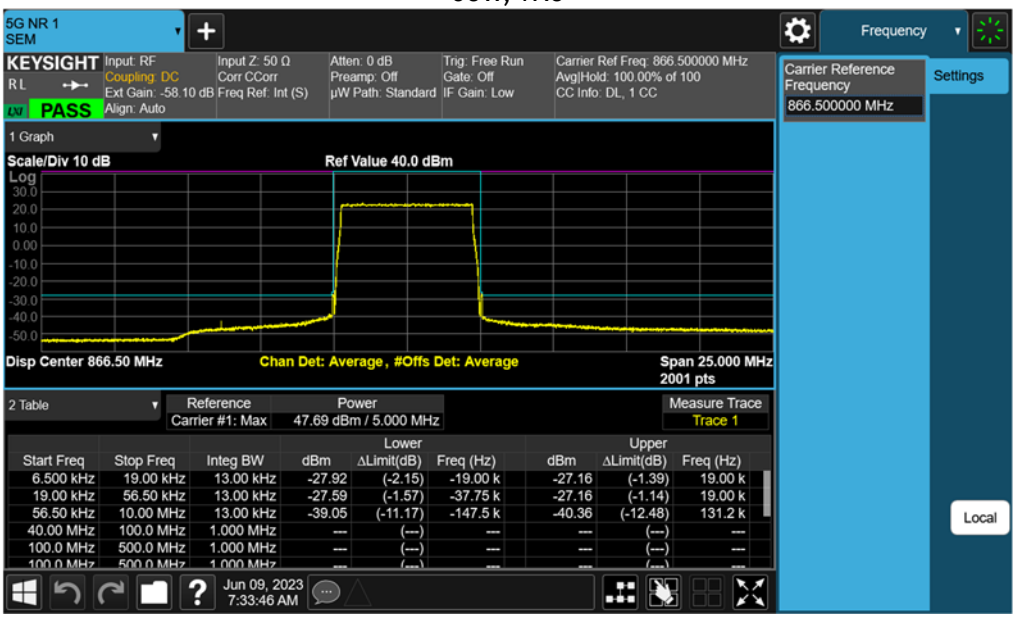


5G-NR, 5MHz, TM1.1, QPSK, 866.5 MHz

40W, TX1

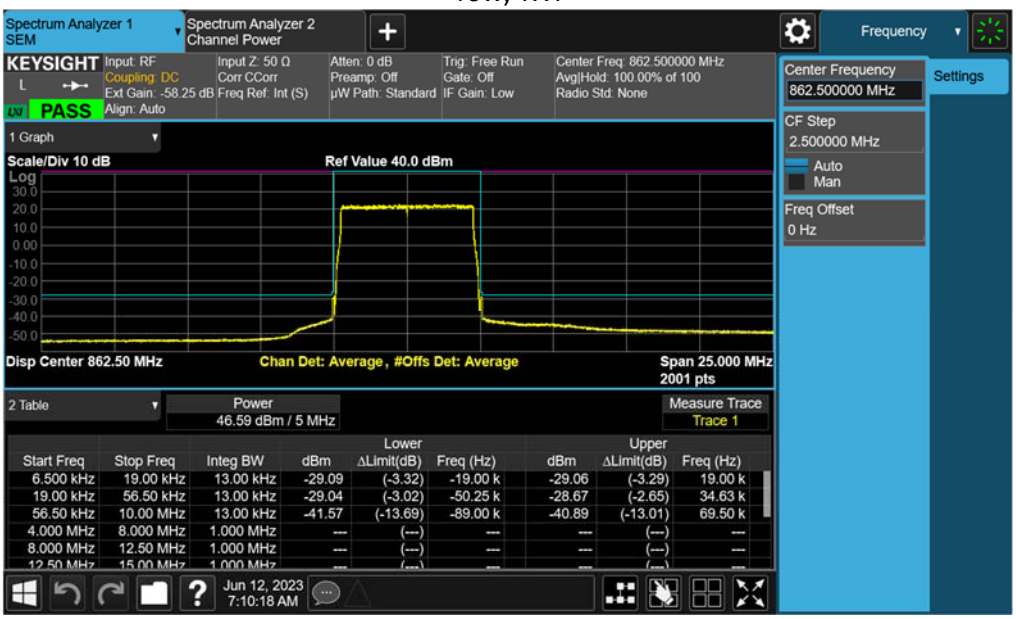


60W, TX0

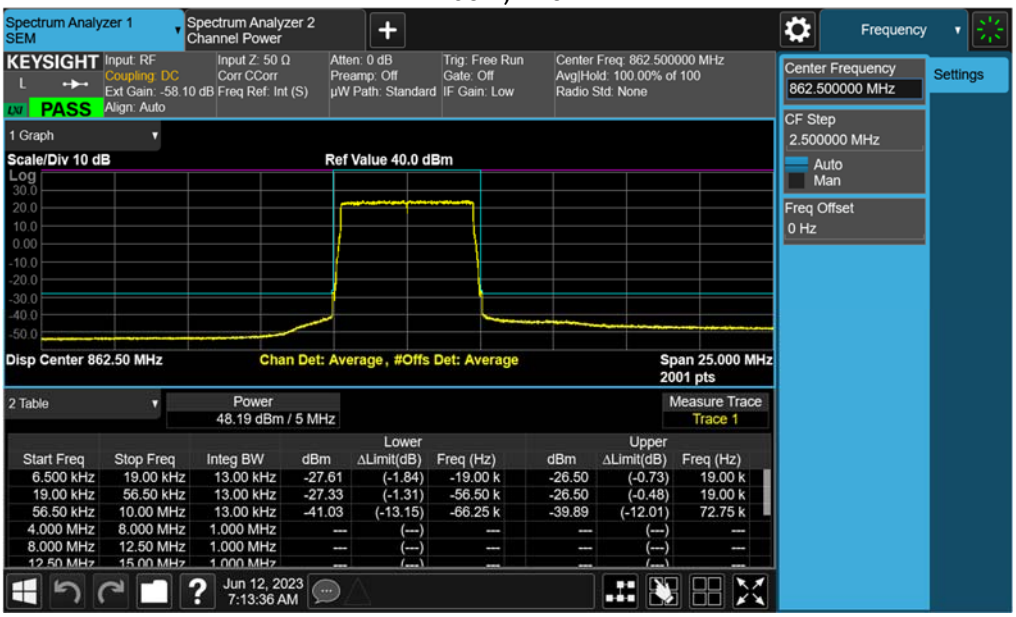


LTE, 5MHz, TM3.1, 64QAM, 862.5 MHz

40W, TX1

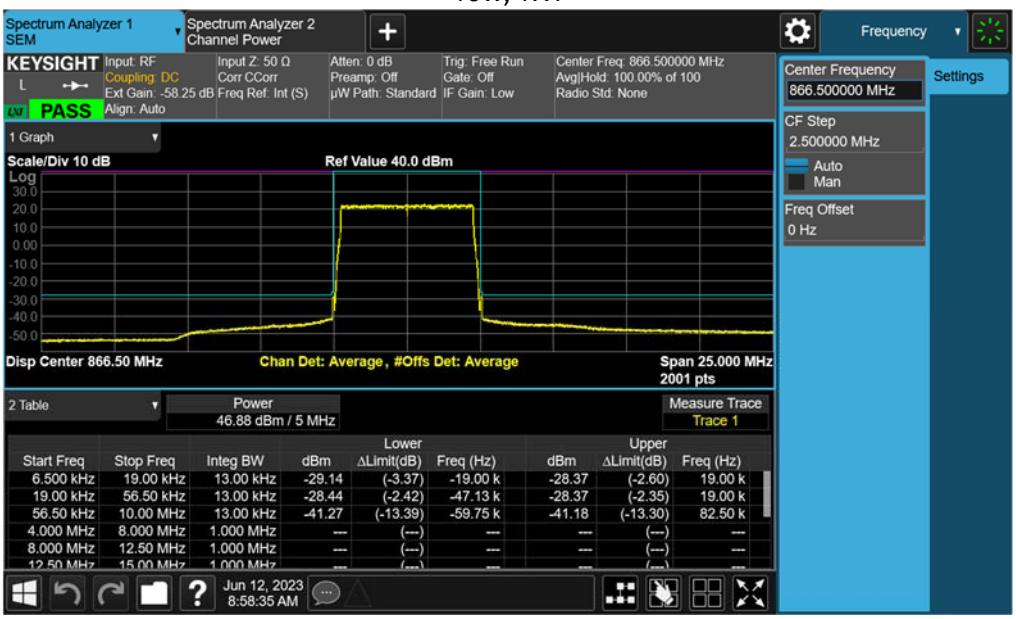


60W, TX0

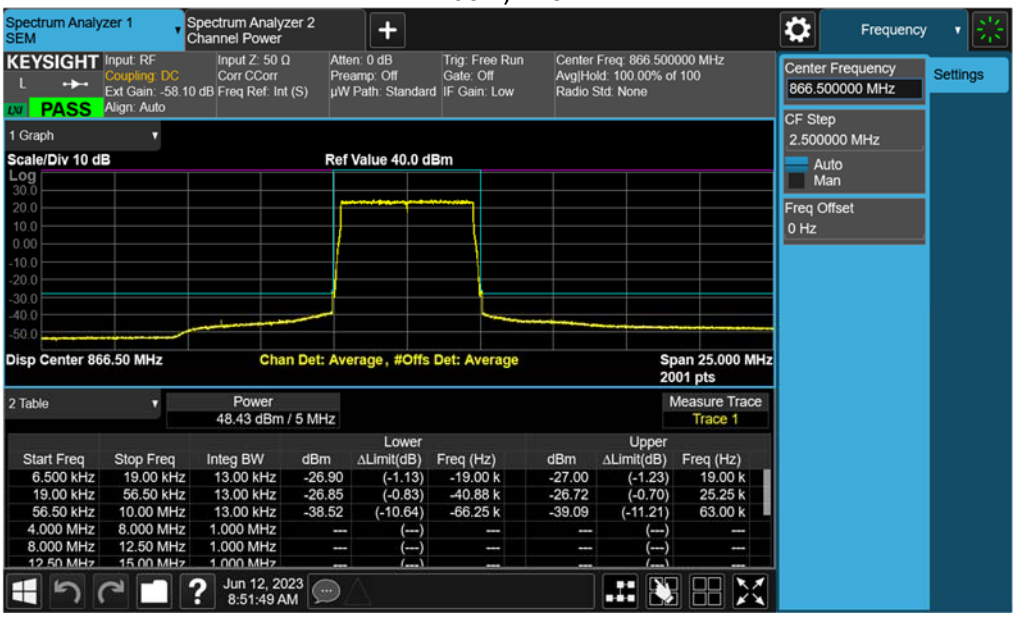


LET, 5MHz, TM3.1a, 256QAM, 866.5 MHz

40W, TX1



60W, TX0



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 10GHz. 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.

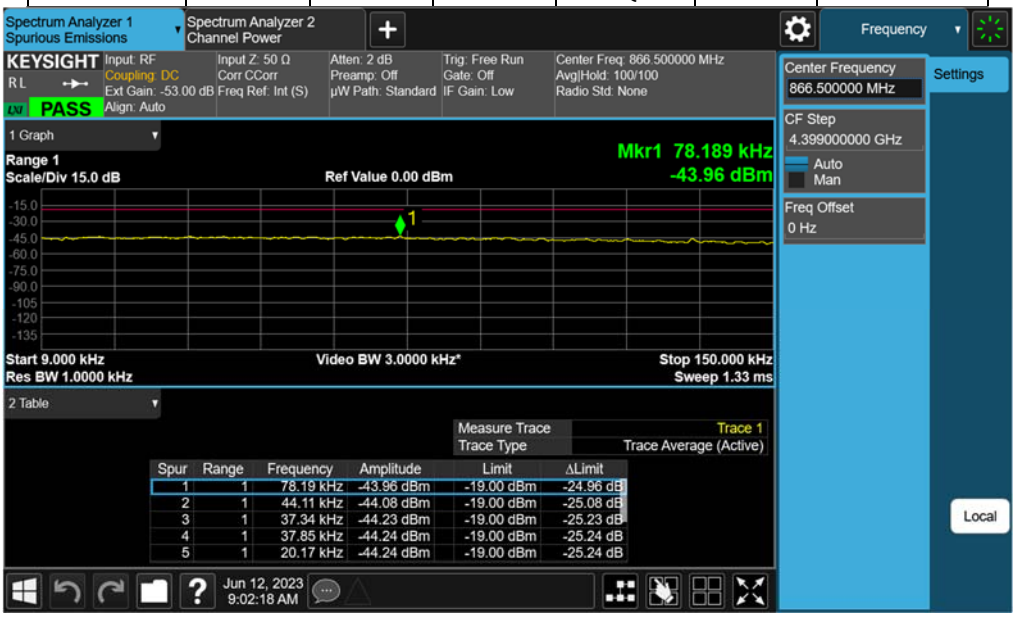
The measured spurious emission levels were plotted for the frequency range as specified in 2.1057. There were no reportable emissions. Data below documents performance up to 10 GHz. In accordance with KDB 662911 D01 Multiple Transmitter Output, the limit of -13 dBm has been adjusted to -19 dBm to reflect 10 log(n) where n=4 for the 4x4 MIMO operation.

NOTES: Only the emissions plots which give the minimum emission margin in each frequency range and with the emissions margin less than 20dB were used in this report. The full suite of raw data resides at the MH, New Jersey location.

5.1.1 Spurious Emissions at Tx Port - Plots

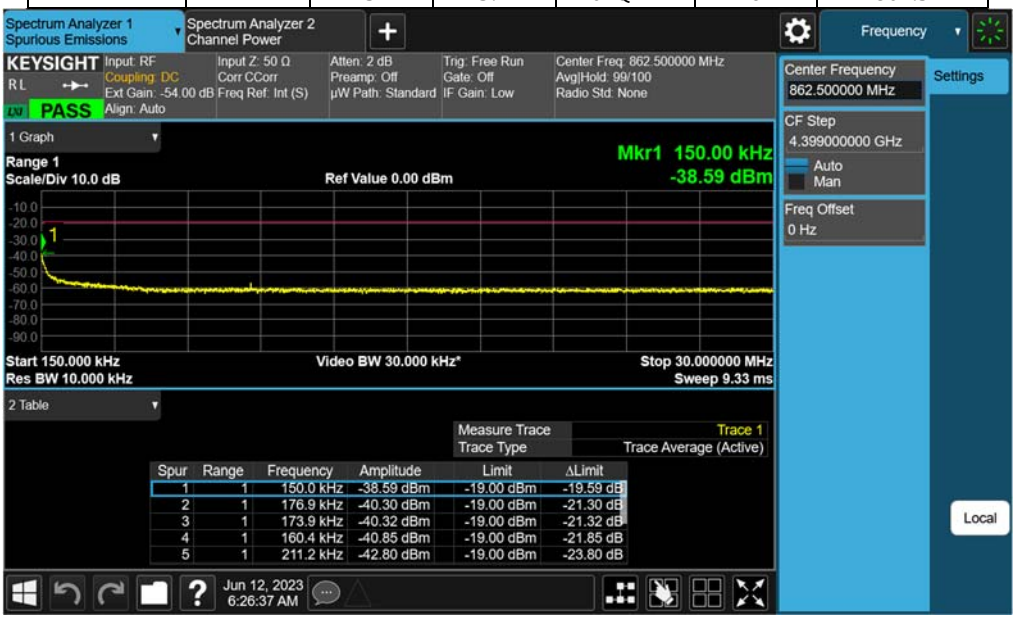
90 kHz – 150kHz

Radio Technology	# of Carrier	Signal BW MHz	Test Model	Modulation	TX Port	Channel Frequency MHz
LTE	1	5	3.1a	256QAM	0	866.5



150 kHz – 30MHz

Radio Technology	# of Carrier	Signal BW MHz	Test Model	Modulation	TX Port	Channel Frequency MHz
LTE	1	5	3.1	64QAM	0	862.5

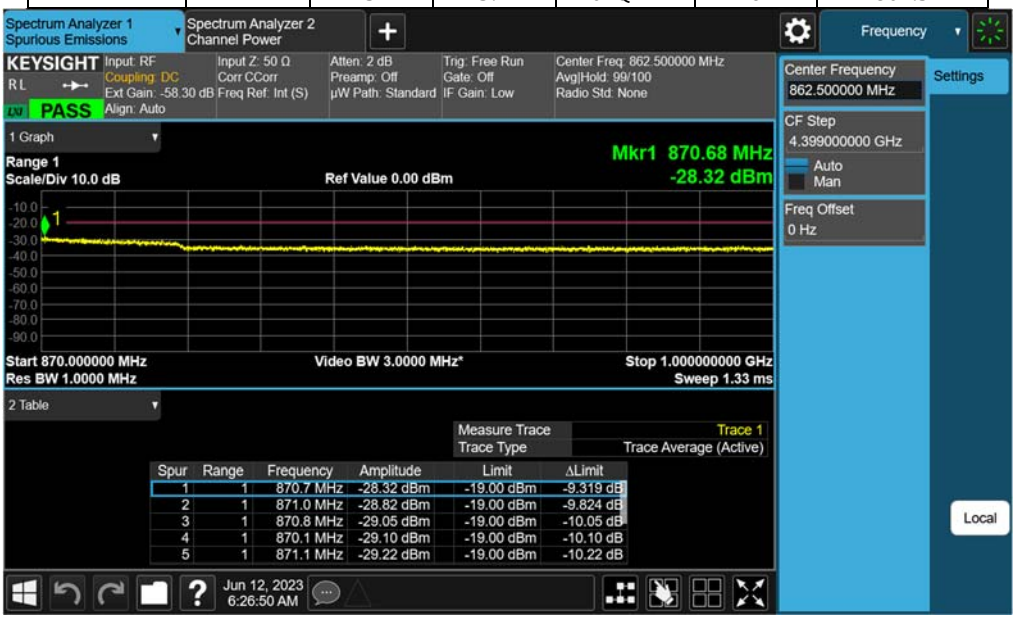


30MHz – 859 MHz

Radio Technology	# of Carrier	Signal BW MHz	Test Model	Modulation	TX Port	Channel Frequency MHz
LTE	1	5	3.1	64QAM	0	862.5

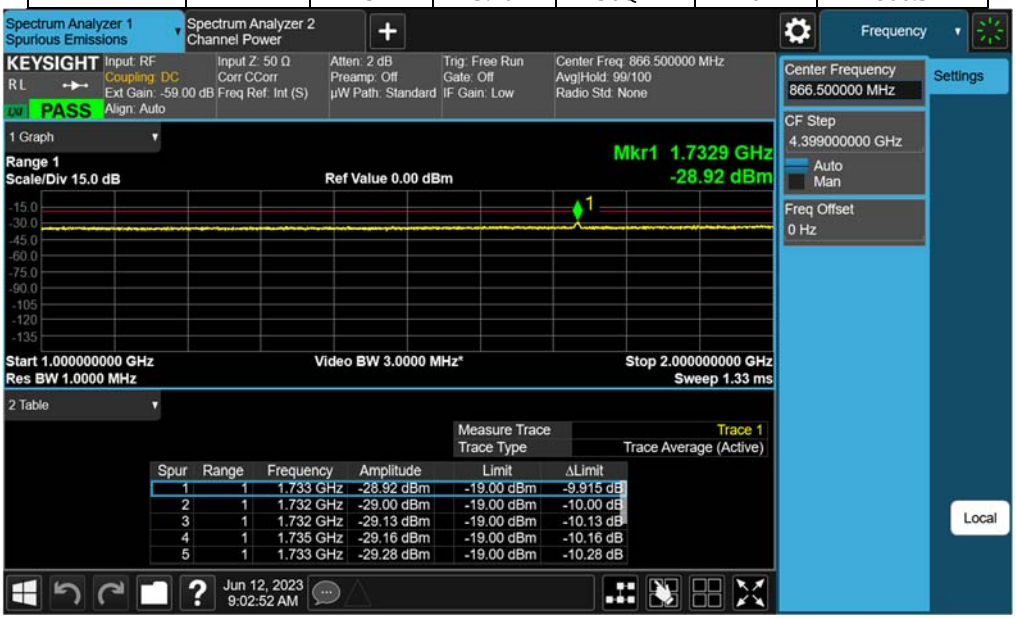
870MHz – 1 GHz

Radio Technology	# of Carrier	Signal BW MHz	Test Model	Modulation	TX Port	Channel Frequency MHz
LTE	1	5	3.1	64QAM	0	862.5



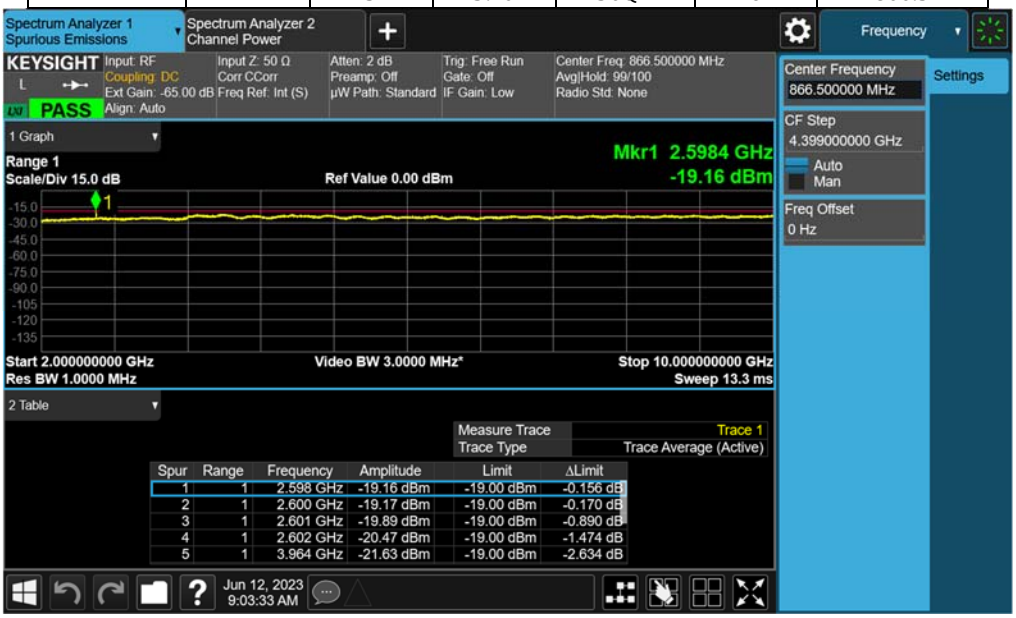
1GHz – 2 GHz

Radio Technology	# of Carrier	Signal BW MHz	Test Model	Modulation	TX Port	Channel Frequency MHz
LTE	1	5	3.1a	256QAM	0	866.5

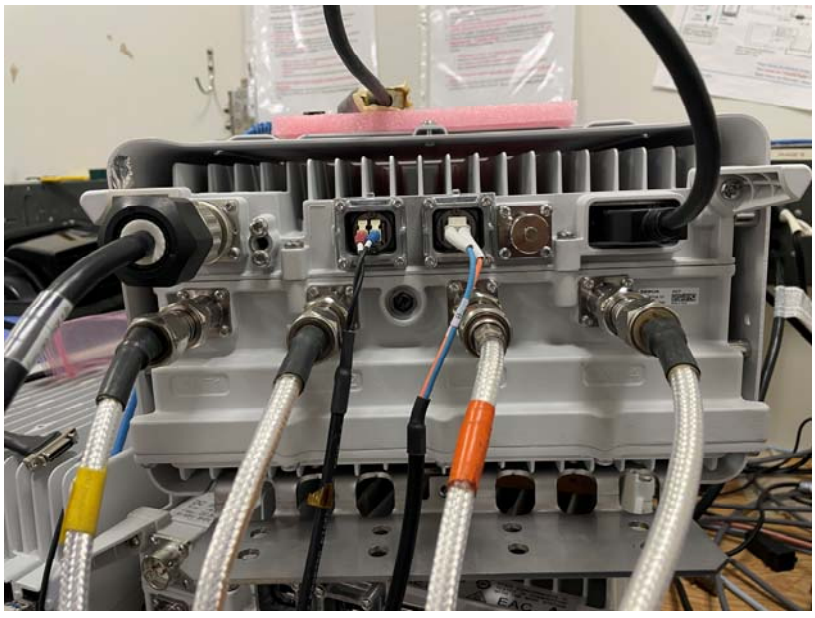


2GHz – 10GHz

Radio Technology	# of Carrier	Signal BW MHz	Test Model	Modulation	TX Port	Channel Frequency MHz
LTE	1	5	3.1a	256QAM	0	866.5



Photographs



Test Equipment

Asset ID	Manufacturer	Type	Description	Model	Serial	Calibration Date	Calibration Due
E1338	KeySight Technologies	MXA Signal Analyzer	20 Hz-44 GHz (Analysis Bandwidth 125 MHz)	N9020B	MY57430927	2023-05-06	2025-05-06
E896	Agilent Technologies	Network Analyzer	10 MHz - 40 GHz	N5230C	MY49000897	2023-02-08	2025-02-08
1609	Traceable	Data Logger	Barometric Humidity Temp Data Logger	6453,98767-15	221743404	2022-08-25	2024-08-25

Test Date: 6/8/23 – 6/12/23

Customer Provided Equipment

Manufacturer	Type	Description	Model	Serial	Calibration Type
Weinschel	Attenuator	20dB/50W DC-8.5GHz	24-20-12-LIM	CE5786	CNR-V
Weinschel	Attenuator	6dB/25W DC - 18GHz	6530-6-34-LIM	BN3225	CNR-V
Weinschel	Attenuator	30dB 25W DC - 18GHz	66-30-33	BV2473	CNR-V
Fairview Microwave	Attenuator	30dB/150W, DC – 18GHz	66-30-34	BJ5920	CNR-V
Weinschel	Attenuator	30dB/150W DC-18GHz	6528-30-34-LIM	BN4177	CNR-V
Weinschel	Attenuator	30dB/150W DC-18GHz	6528-30-34-LIM	BN4181	CNR-V
Weinschel	Attenuator	30dB/50W DC-18GHz	6528-30-34-LIM	BN4177	CNR-V

CNR-V: Calibration Not Required, Must Be Verified

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, 10 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.

Section 2.1053 contains 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 2.1053 Limit is 82.23 dBuV/m at 3m and 91.77 dBuV/m at 1m
The Part 2.1053 non-report level is 62.23 dBuV/m at 3m.

The calculated emission levels were found by:

Measured level (dBμV) + Cable Loss(dB)+Antenna Factor(dB) = Field Strength (dBμV/m)

6.2 Field Strength of Spurious Radiation Results:

For compliance with 47CFR Part 2.1053, 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 10 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