NOKIA

Bell Labs

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NVLAP®

TESTING
NVLAP LAB CODE: 100275-0

Title 47 Code of Federal Regulations Test Report

Regulation:
FCC Part 2 and 22

Client:
NOKIA SOLUTIONS AND NETWORKS

Product Evaluated:
AHBCD AirScale Dual RRH 4T4R 240W

Report Number:
TR-2022-0010-FCC2-22

Date Issued:
March 31, 2022

Table of Contents

Revisions

Date	Revision	Section	Change
3/31/2022	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):	AHBCD AirScale Dual RRH 4T4R 240W
FCC ID:	VBNAHBCD-01
Serial Number:	RW220100009 (Radio), RW220100010 (Frequency Stability)
Hardware Version:	476021A.X21
Software Version:	SBTS22R2
Frequency Range:	869-894MHz
GPCL Project Number:	2022-0010
Applicant	Nokia Solutions and Networks 3201 Olympus Blvd Dallas, Texas 75019 Steve Mitchell
Manufacturer:	NOKIA SOLUTIONS AND NETWORKS OY KARAKAARI 7, FI-02610 ESPOO FINLAND
Test Requirement(s):	Title 47 CFR Parts 2 and 22
Test Standards:	• Title 47 CFR Parts 2 and 22 • 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 Occupied Bandwidth and Power Measurement Test Procedure 12-4-2017 • FCC-IC-SE - GPCL Spurious Emissions Test Procedure 12-4-2017
Test Date(s):	2/9/2022 – 3/9/2022
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:	Steve Gordon
Test Engineer (s):	Nilesh Patel, Chris Polanco, Mike Soli, Joe Bordonaro
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 **AHBCD AirScale Dual RRH 4T4R 240W**, 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 22, measured in accordance with the procedures set out in Section 2.1033 (c) (14) of the Rules.

The current test program is to demonstrate the following operation of the AHBCD:

- 5G-NR: 5, 10, 15, 20, 5+5, 5+20 MHz
- LTE: 5, 10,15 MHz

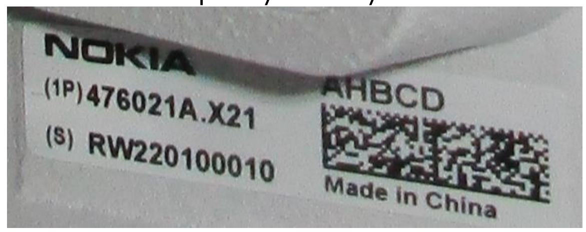
1.3 Specifications

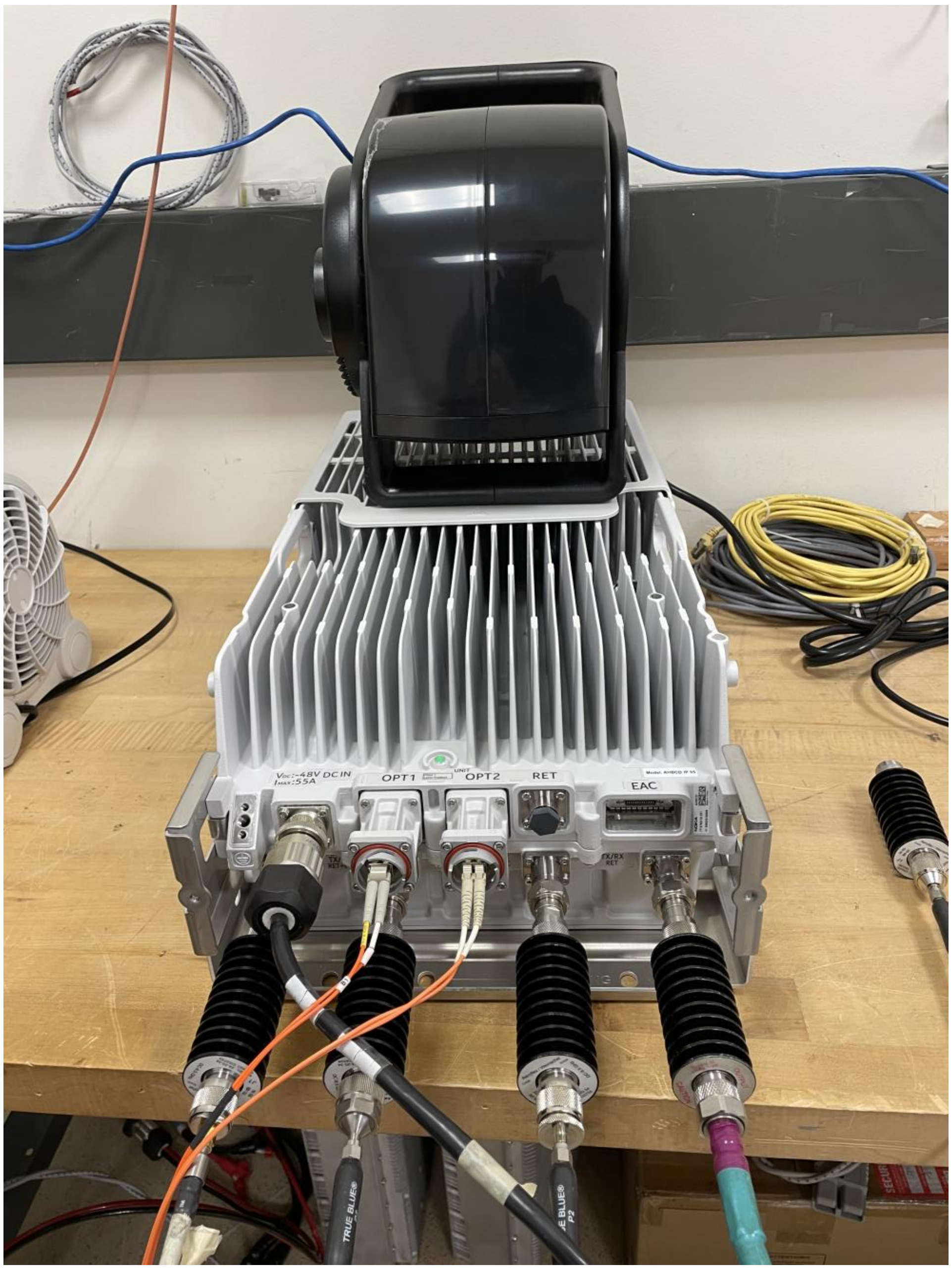
Specification Items	Description
Radio Access Technology	5G-NR, LTE
Modulation Type(s)	QPSK, 16QAM, 64QAM, 256QAM
Operation Frequency Range	869-894MHz
Channel Bandwidths	5G-NR: 5, 10, 15, 20, 5+5, 5+20 MHz LTE: 5, 10,15 MHz
Tx/Rx	4T4R
MIMO	Yes
Deployment Environment	Outdoor
Supply Voltage	DC
Max RF Output Power	4X40 W (47.78 dBm +/- 2.0dBm)

1.3.1 Photographs

Radio Test

Frequency Stability Test





1.4 Test Requirements

Each required measurement is listed below:

47 CFR FCC Sections	Description of Tests	Test Required
2.1046	RF Power Output	Yes
2.1047	Modulation Characteristics	Yes
2.1049	(a) Occupied Bandwidth (b) Out-of-Band Emissions	Yes
2.1051	Conducted Out-of-Band Emissions Spurious Emissions at Antenna Terminals	Yes
2.1053, 22.917	Field Strength of Spurious Radiation	Yes
2.1055	Frequency Stability	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 22.
- FCC KDB 971168 D01 Power Measurement License Digital Systems v03r01 April 9, 2018.
- FCC KDB 662911 D01 Multiple Transmitter Output v02r01 Oct 2013.
- ANSI C63.26, American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services
- 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.

1.5.2 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

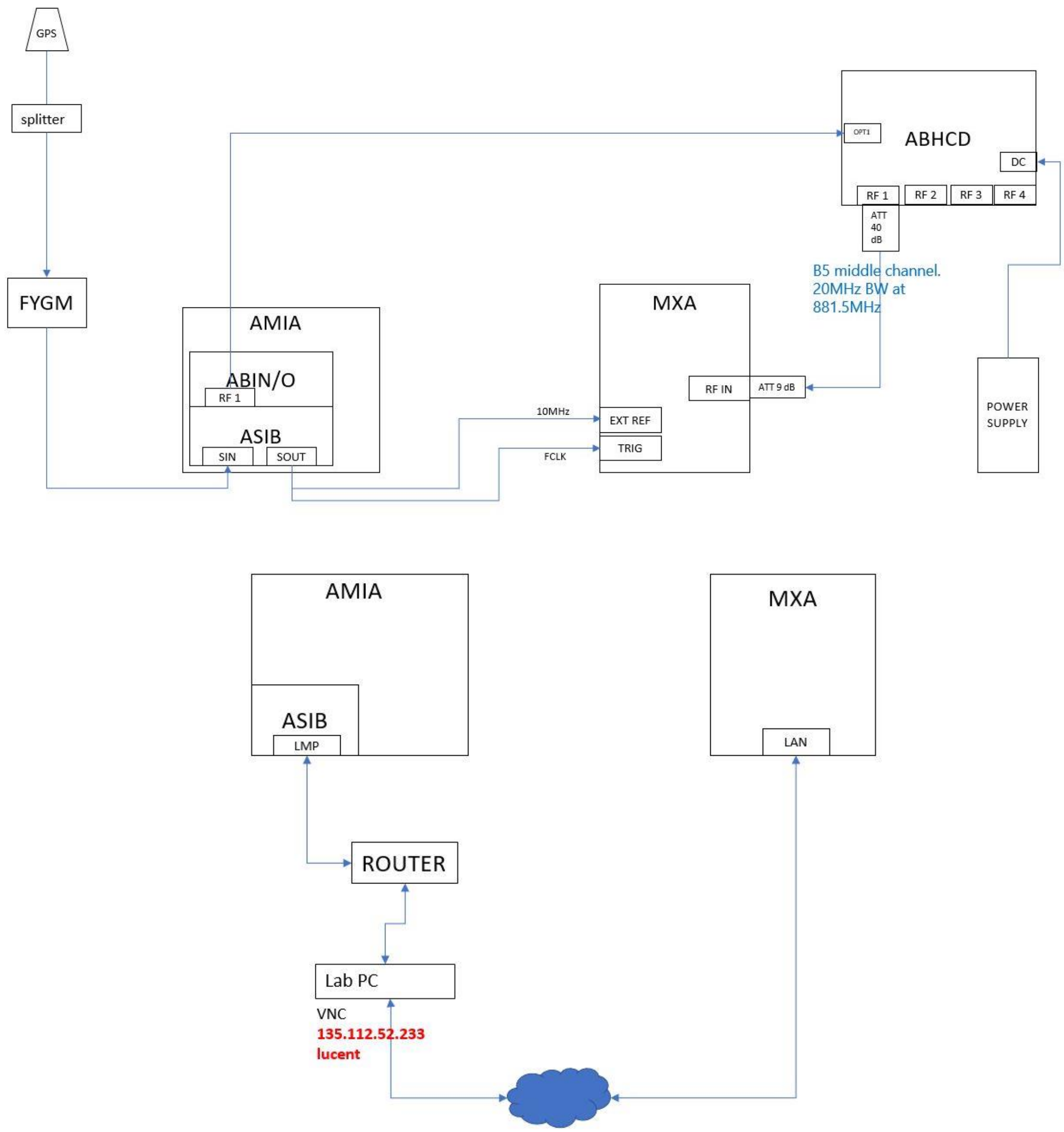
Requirement	Description	Result
47 CFR FCC Parts 2 and 22		
2.1046	RF Power Output Peak to Average Power Ratio	COMPLIES
2.1047	Modulation Characteristics	COMPLIES
2.1049	(a) Occupied Bandwidth (b) Edge of Band Emissions	COMPLIES
2.1051	Spurious Emissions at Antenna Terminals	COMPLIES
2.1053, 22.917	Field Strength of Spurious Radiation	COMPLIES
2.1055	Frequency Stability	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.

Test Setup for all Antenna Port Measurements

Test Setup for Frequency Stability



Customer Provided Equipment

Module	part number	serial number
ASIB	473764A.M02	L1190510494
ABIO	475266A.M02	L1204600898
FYGM	473394A.102	1721800035

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. The product is rated for 40 W (47.78 dBm +/- 2.0 dBm) per port for each of the four transmit ports. 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.

Power measurements were made with an MXA Signal Analyzer. The maximum output is bolded in each case. The product's maximum emission for 160 W (52.0 dBm) conducted power is less than the ERP of 500 W (57.0 dBm) per emission specified in Part 22.913 when coupled with an antenna that does not exceed 5.0 dBi.

2.1.1 5G-NR

Channel RF Power – 1C, 5MHz BW

Channel Power - Signal BW 5MHz (5G-NR)					
Test Model 3.1 Modulation 64QAM Channel Frequency 871.5MHz		Test Model 3.2 Modulation QPSK/16QAM Channel Frequency 881.5MHz		Test Model 3.1a Modulation 256QAM Channel Frequency 891.5MHz	
TX Port	(dBm)	TX Port	(dBm)	TX Port	(dBm)
1	46.30	1	45.72	1	45.78
2	46.04	2	45.60	2	45.50
3	46.44	3	45.91	3	45.87
4	**46.68**	4	**46.07**	4	**46.06**
Total Power (dBm)	52.39	Total Power (dBm)	51.85	Total Power (dBm)	51.83
Total Power (W)	173.45	Total Power (W)	153.08	Total Power (W)	152.33

Channel RF Power – 1C, 10MHz BW

Channel Power - Signal BW 10MHz (5G-NR)					
Test Model 3.1 Modulation 64QAM Channel Frequency 874MHz		Test Model 3.2 Modulation QPSK/16QAM Channel Frequency 881.5MHz		Test Model 3.1a Modulation 256QAM Channel Frequency 889MHz	
TX Port	(dBm)	TX Port	(dBm)	TX Port	(dBm)
1	46.33	1	45.83	1	45.80
2	46.11	2	45.58	2	45.60
3	46.43	3	46.01	3	45.97
4	**46.63**	4	**46.26**	4	**46.20**
Total Power (dBm)	52.40	Total Power (dBm)	51.95	Total Power (dBm)	51.92
Total Power (W)	173.77	Total Power (W)	156.59	Total Power (W)	155.55

Channel RF Power – 1C, 15MHz BW

Channel Power - Signal BW 15MHz (5G-NR)					
Test Model 3.1 Modulation 64QAM Channel Frequency 876.5MHz		Test Model 3.2 Modulation QPSK/16QAM Channel Frequency 881.5MHz		Test Model 3.1a Modulation 256QAM Channel Frequency 886.5MHz	
TX Port	(dBm)	TX Port	(dBm)	TX Port	(dBm)
1	46.15	1	46.01	1	45.96
2	45.93	2	45.80	2	45.61
3	46.27	3	46.23	3	46.06
4	**46.58**	4	**46.41**	4	**46.42**
Total Power (dBm)	52.26	Total Power (dBm)	52.14	Total Power (dBm)	52.04
Total Power (W)	168.25	Total Power (W)	163.65	Total Power (W)	160.05

Channel RF Power – 1C, 20MHz BW

Channel Power - Signal BW 20MHz (5G-NR)					
Test Model 3.1 Modulation 64QAM Channel Frequency 879MHz		Test Model 3.2 Modulation QPSK/16QAM Channel Frequency 881.5MHz		Test Model 3.1a Modulation 256QAM Channel Frequency 884MHz	
TX Port	(dBm)	TX Port	(dBm)	TX Port	(dBm)
1	46.44	1	45.99	1	45.98
2	46.26	2	45.92	2	45.81
3	46.40	3	46.21	3	46.18
4	**46.66**	4	**46.43**	4	**46.42**
Total Power (dBm)	52.46	Total Power (dBm)	52.16	Total Power (dBm)	52.12
Total Power (W)	176.32	Total Power (W)	164.54	Total Power (W)	163.08

Channel RF Power – 2C, 5+5MHz & 5+20MHz BW

Channel Power - 2C (5G-NR)			
Signal BW 5+5 MHz		Signal BW 5+20 MHz	
Test Model 3.1 Modulation 64QAM Channel Frequency 871+891MHz		Test Model 3.1 Modulation 64QAM Channel Frequency 871+884MHz	
TX Port	(dBm)	TX Port	(dBm)
1	45.80	1	46.22
2	45.52	2	46.05
3	45.89	3	46.46
4	**46.12**	4	**46.88**
Total Power (dBm)	51.86	Total Power (dBm)	52.43
Total Power (W)	153.41	Total Power (W)	175.16

2.1.2 LTE

Channel RF Power – 1C, 5MHz BW

Channel Power - Signal BW 5MHz (LTE)					
Test Model 3.1 Modulation 64QAM Channel Frequency 871.5MHz		Test Model 3.2 Modulation QPSK/16QAM Channel Frequency 881.5MHz		Test Model 3.1a Modulation 256QAM Channel Frequency 891.5MHz	
TX Port	(dBm)	TX Port	(dBm)	TX Port	(dBm)
1	**46.34**	1	46.13	1	**45.95**
2	46.10	2	45.93	2	45.67
3	46.10	3	45.95	3	45.63
4	46.32	4	**46.18**	4	45.87
Total Power (dBm)	52.24	Total Power (dBm)	52.07	Total Power (dBm)	51.8
Total Power (W)	167.38	Total Power (W)	161.05	Total Power (W)	151.45

Channel RF Power – 1C, 10MHz BW

Channel Power - Signal BW 10MHz (LTE)					
Test Model 3.1 Modulation 64QAM Channel Frequency 874MHz		Test Model 3.2 Modulation QPSK/16QAM Channel Frequency 881.5MHz		Test Model 3.1a Modulation 256QAM Channel Frequency 889MHz	
TX Port	(dBm)	TX Port	(dBm)	TX Port	(dBm)
1	**46.27**	1	**46.21**	1	**46.04**
2	45.98	2	45.92	2	45.81
3	45.93	3	45.96	3	45.77
4	46.17	4	46.15	4	46.01
Total Power (dBm)	52.11	Total Power (dBm)	52.08	Total Power (dBm)	51.93
Total Power (W)	162.57	Total Power (W)	161.52	Total Power (W)	155.95

Channel RF Power – 1C, 15MHz BW

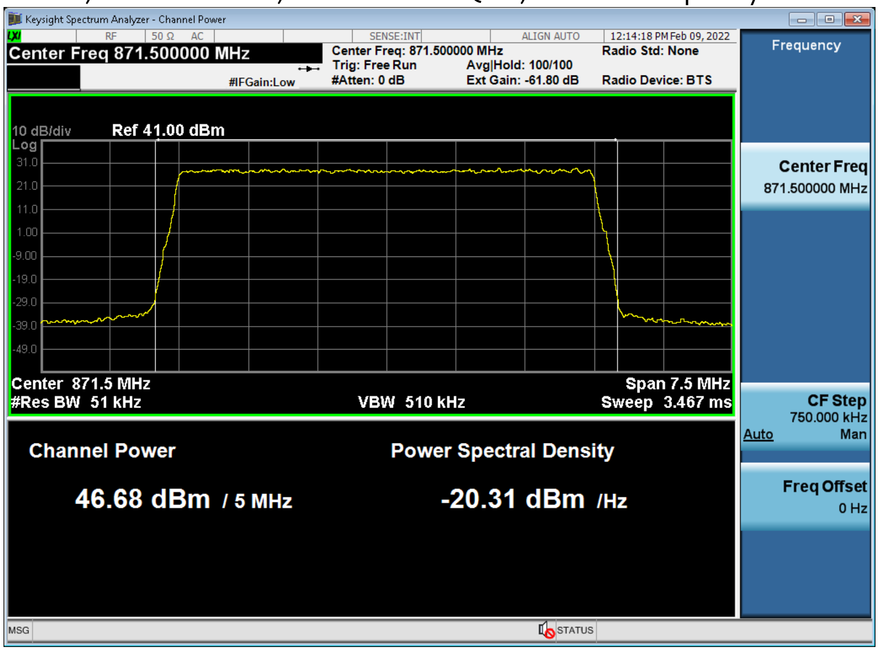
Channel Power - Signal BW 15MHz (LTE)					
Test Model 3.1 Modulation 64QAM Channel Frequency 876.5MHz		Test Model 3.2 Modulation QPSK/16QAM Channel Frequency 881.5MHz		Test Model 3.1a Modulation 256QAM Channel Frequency 886.5MHz	
TX Port	(dBm)	TX Port	(dBm)	TX Port	(dBm)
1	**46.22**	1	**46.18**	1	**46.16**
2	45.90	2	46.00	2	45.88
3	45.91	3	45.89	3	45.79
4	46.09	4	46.17	4	46.06
Total Power (dBm)	52.05	Total Power (dBm)	52.08	Total Power (dBm)	52.00
Total Power (W)	160.42	Total Power (W)	161.52	Total Power (W)	158.33

2.2 Channel RF Power – Plots

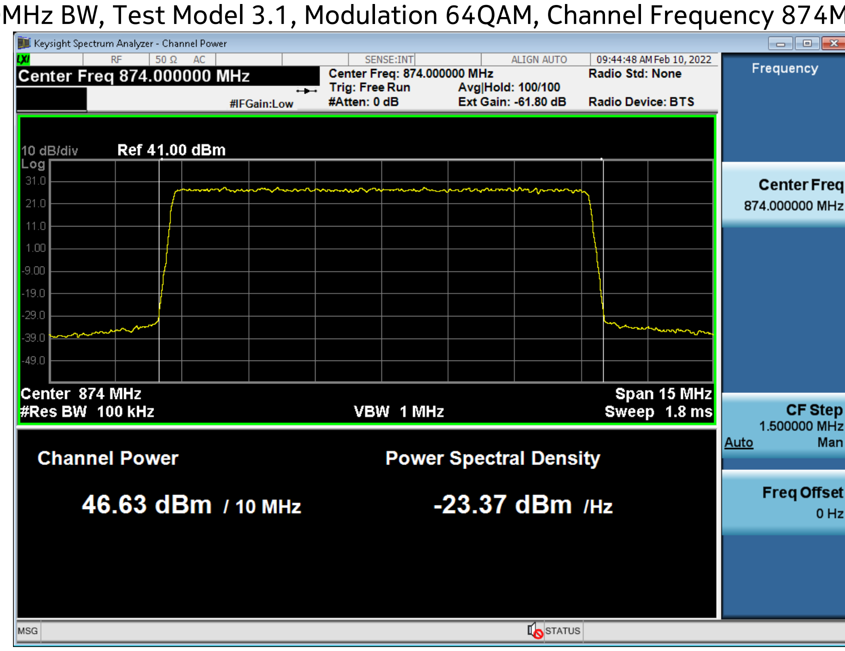
NOTE: Only a sample of the plots are used in this report. The full suite of raw data resides at the MH, New Jersey location.

2.2.1 5G-NR

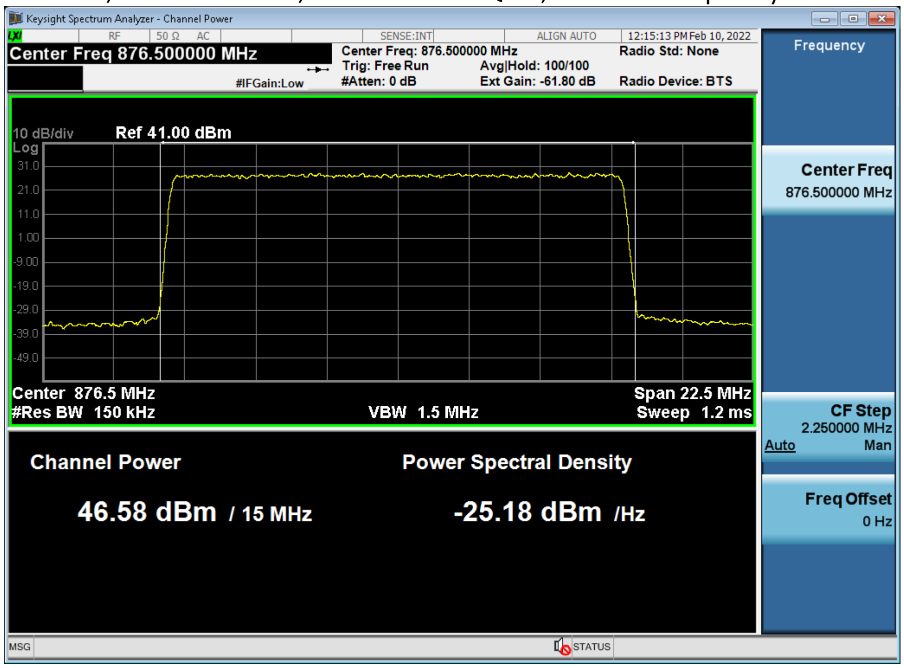
1C, 5MHz BW, Test Model 3.1, Modulation 64QAM, Channel Frequency 871.5MHz, TX4



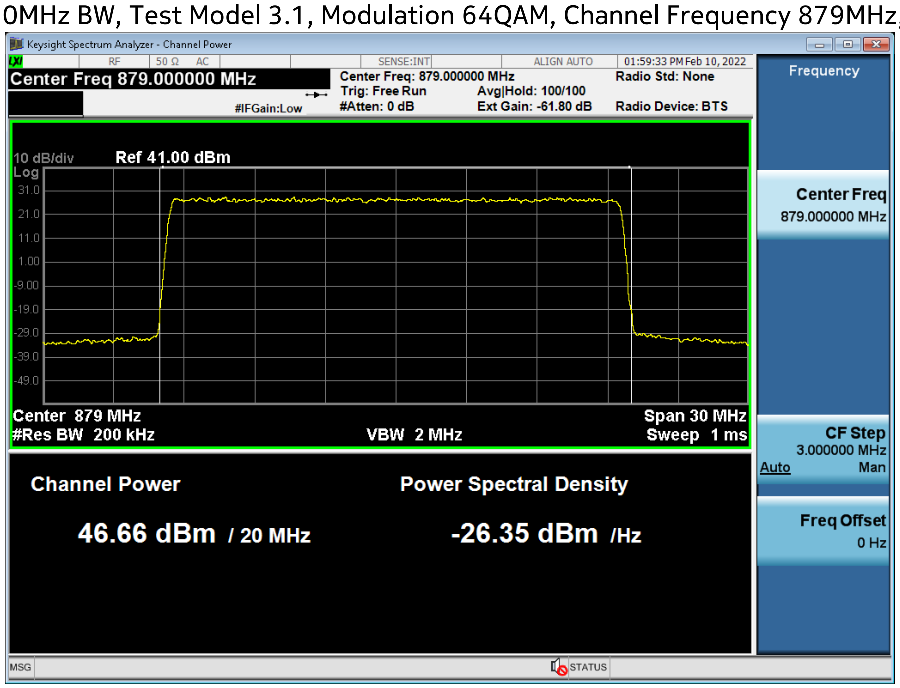
1C, 10MHz BW, Test Model 3.1, Modulation 64QAM, Channel Frequency 874MHz, TX4



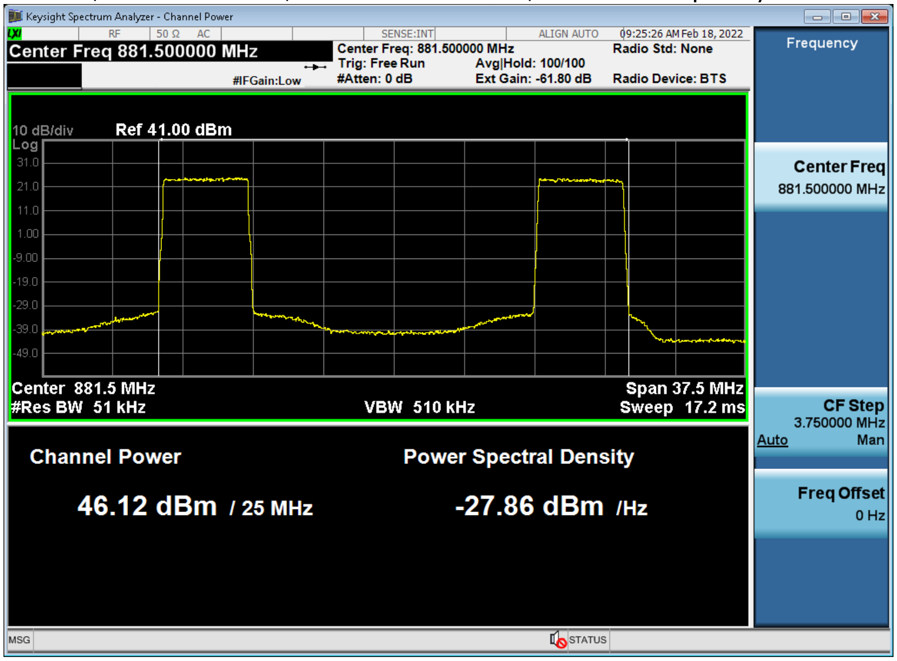
1C, 15MHz BW, Test Model 3.1, Modulation 64QAM, Channel Frequency 876.5MHz, TX4



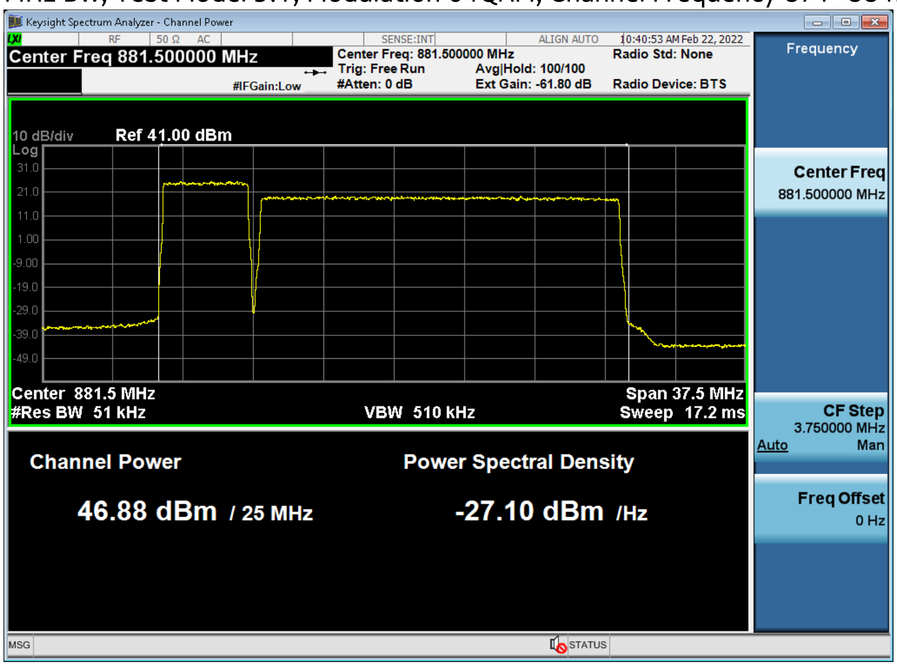
1C, 20MHz BW, Test Model 3.1, Modulation 64QAM, Channel Frequency 879MHz, TX4



2C, 5+5 MHz BW, Test Model 3.1, Modulation 64QAM, Channel Frequency 871+891MHz, TX4

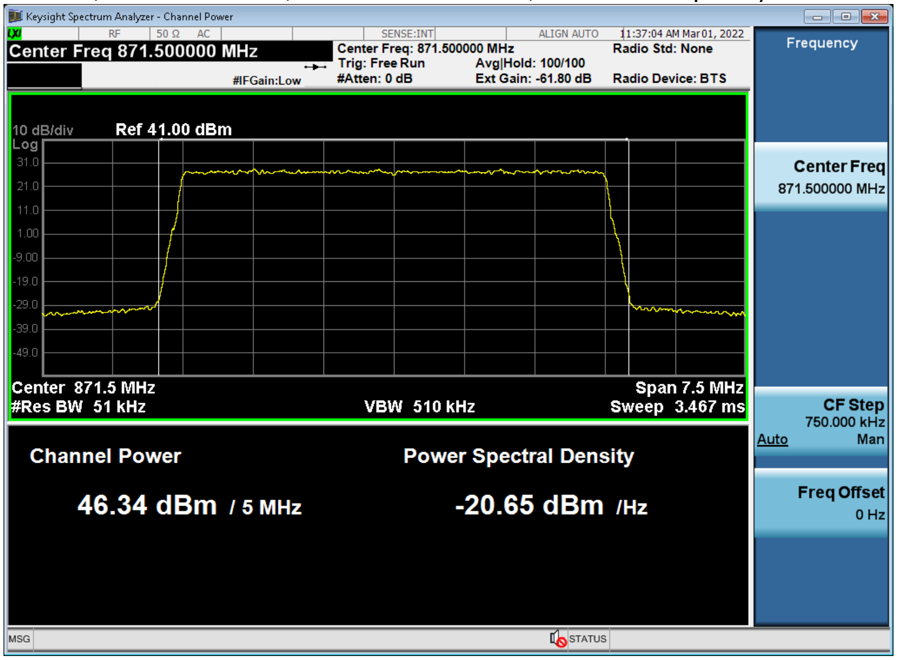


2C, 5+20 MHz BW, Test Model 3.1, Modulation 64QAM, Channel Frequency 871+884MHz, TX4

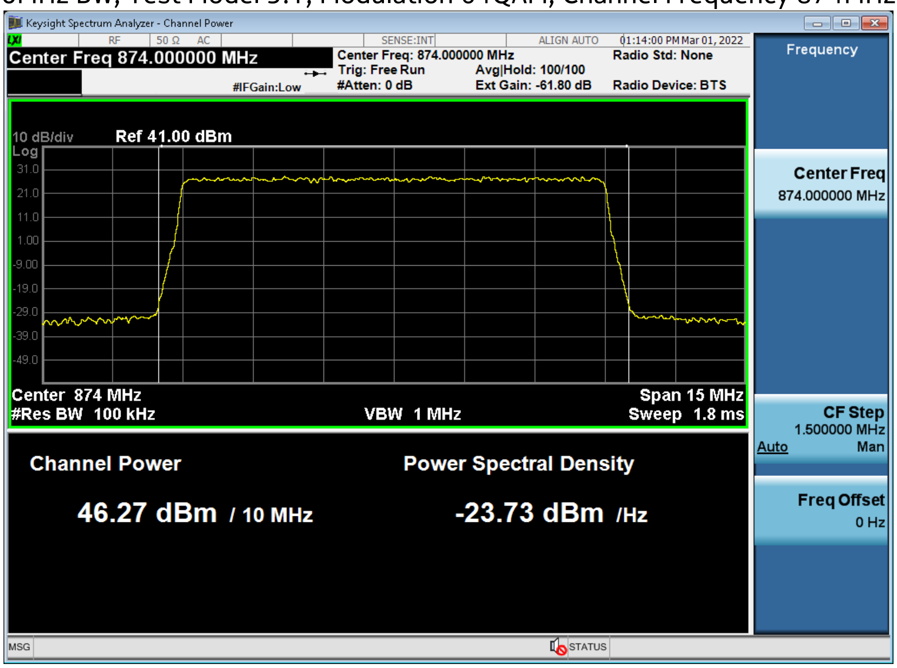


2.2.2 LTE

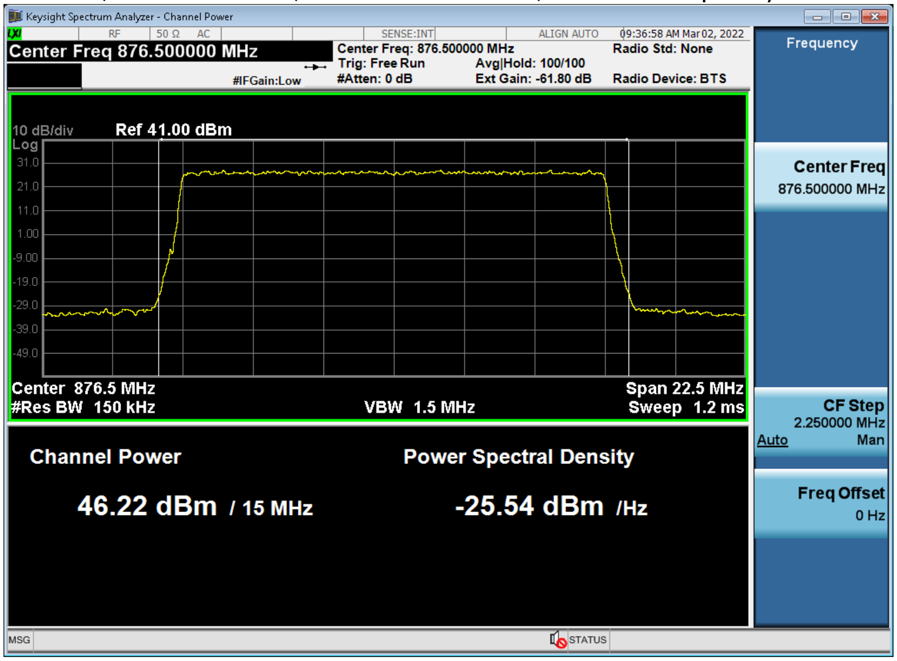
1C, 5MHz BW, Test Model 3.1, Modulation 64QAM, Channel Frequency 871.5MHz, TX1



1C, 10MHz BW, Test Model 3.1, Modulation 64QAM, Channel Frequency 874MHz, TX1



1C, 15MHz BW, Test Model 3.1, Modulation 64QAM, Channel Frequency 876.5MHz, TX1



2.3 Peak-to-Average Power Ratio (PAPR)

The Peak-to-Average Power Ratio (PAPR) was evaluated per KDB 971168 for 5,10, 15, 20, 5+5 and 5+20MHz bandwidths. The PAPR values of all carriers measured are below 13dB.

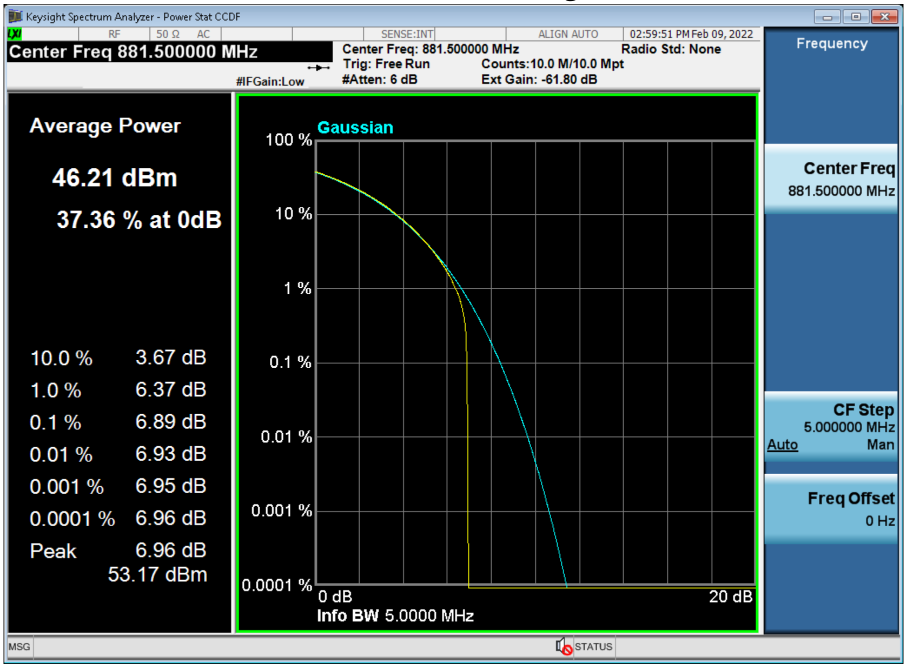
PAPR Tabular Data

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	3.1	64QAM	4	871.5	6.69
5G-NR	1	5	3.2	QPSK/16QAM	4	881.5	**6.89**
5G-NR	1	5	3.1a	256QAM	4	891.5	6.84
5G-NR	1	10	3.1	64QAM	4	874	6.77
5G-NR	1	10	3.2	QPSK/16QAM	4	881.5	6.87
5G-NR	1	10	3.1a	256QAM	4	889	**6.96**
5G-NR	1	15	3.1	64QAM	4	876.5	6.75
5G-NR	1	15	3.2	QPSK/16QAM	4	881.5	6.80
5G-NR	1	15	3.1a	256QAM	4	886.5	**7.05**
5G-NR	1	20	3.1	64QAM	4	879	6.66
5G-NR	1	20	3.2	QPSK/16QAM	4	881.5	6.80
5G-NR	1	20	3.1a	256QAM	4	884	**6.98**
5G-NR	2	5+5	3.1	64QAM	4	871+891.5	7.62 / 7.63
5G-NR	2	5+20	3.1	64QAM	4	871+884	6.84
LTE	1	5	3.1	64QAM	1	871.5	7.32
LTE	1	5	3.2	QPSK/16QAM	4	881.5	7.34
LTE	1	5	3.1a	256QAM	1	891.5	**7.42**
LTE	1	10	3.1	64QAM	1	874	7.34
LTE	1	10	3.2	QPSK/16QAM	1	881.5	7.33
LTE	1	10	3.1a	256QAM	1	889	**7.43**
LTE	1	15	3.1	64QAM	1	876.5	7.32
LTE	1	15	3.2	QPSK/16QAM	1	881.5	7.31
LTE	1	15	3.1a	256QAM	1	886.5	**7.47**

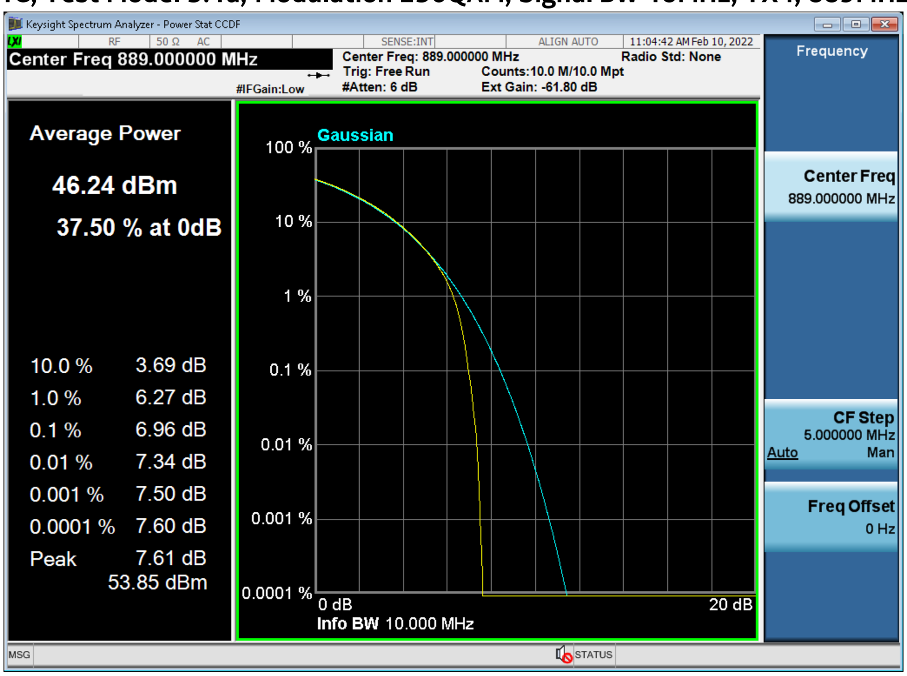
2.3.1 Peak-to-Average Power Ratio Plots – 5G-NR

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.

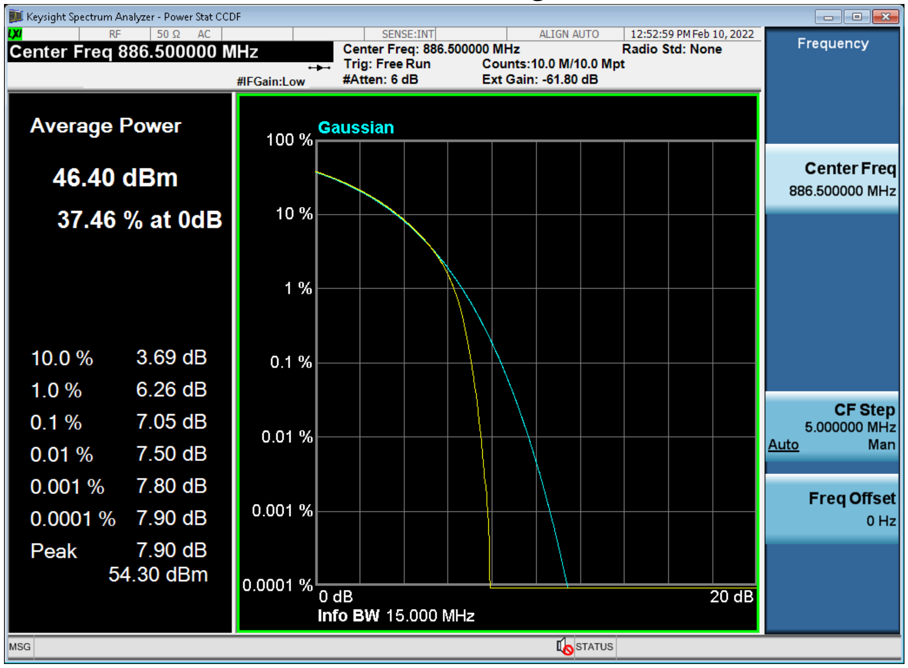
1C, Test Model 3.2, Modulation QPSK/16QAM, Signal BW 5MHz, TX4, 881.5MHz



1C, Test Model 3.1a, Modulation 256QAM, Signal BW 10MHz, TX4, 889MHz

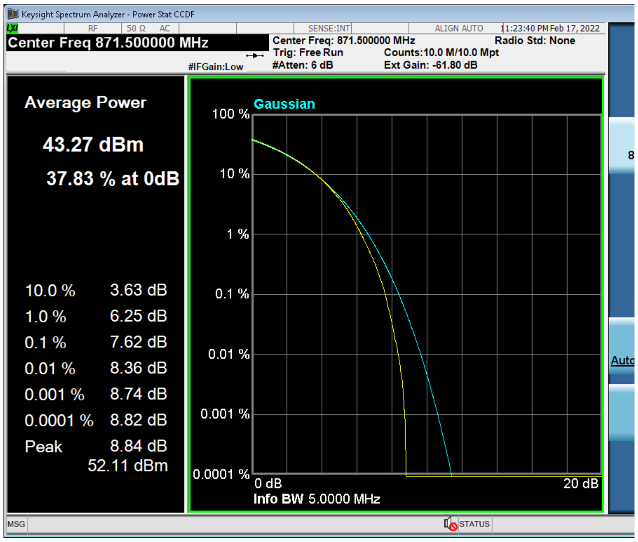


1C, Test Model 3.1a, Modulation 256QAM, Signal BW 15MHz, TX4, 886.5MHz

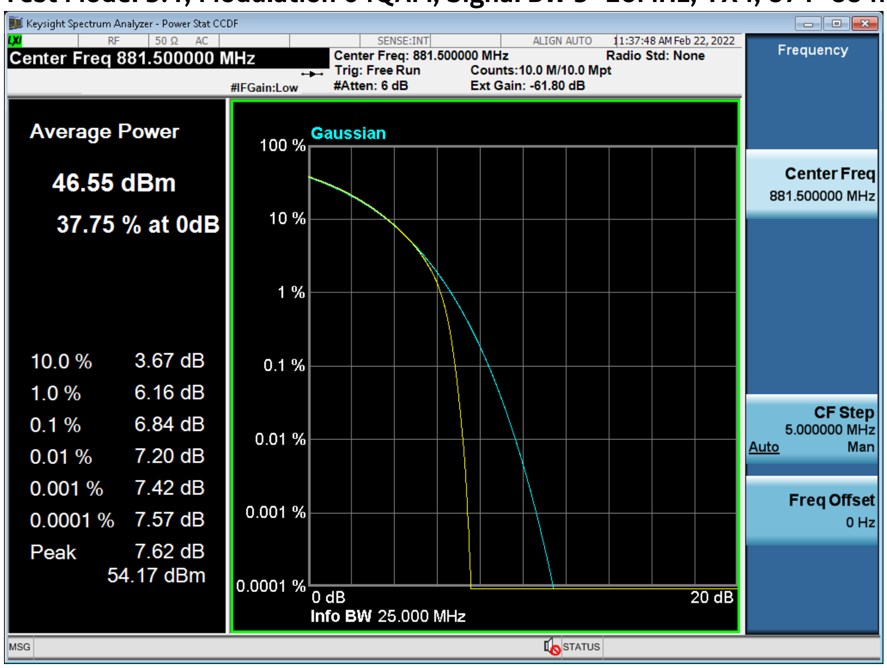


1C, Test Model 3.1a, Modulation 256QAM, Signal BW 20MHz, TX4, 884MHz

2C, Test Model 3.1, Modulation 64QAM, Signal BW 5+5MHz, TX4, 871+891.5MHz



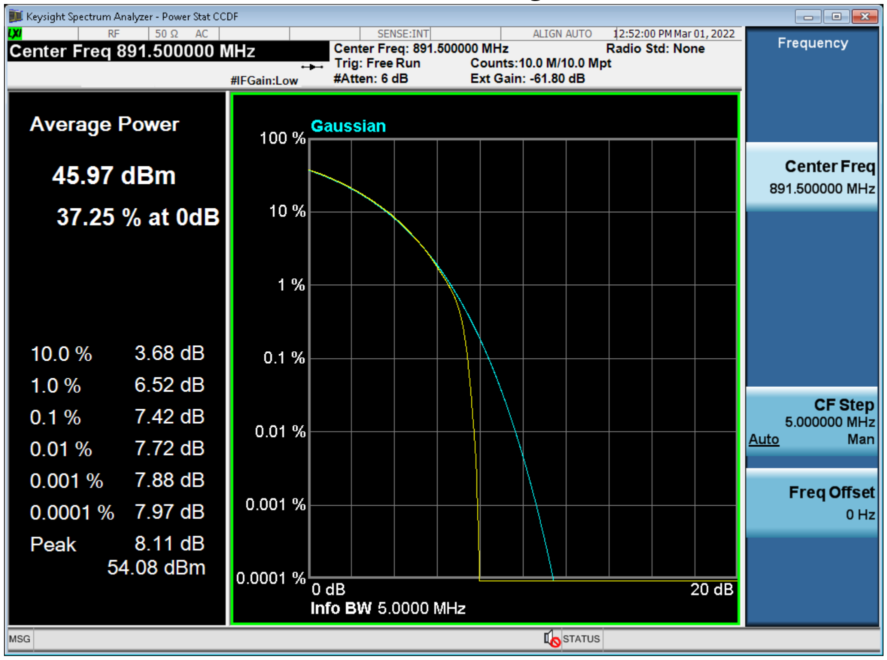
2C, Test Model 3.1, Modulation 64QAM, Signal BW 5+20MHz, TX4, 871+884MHz



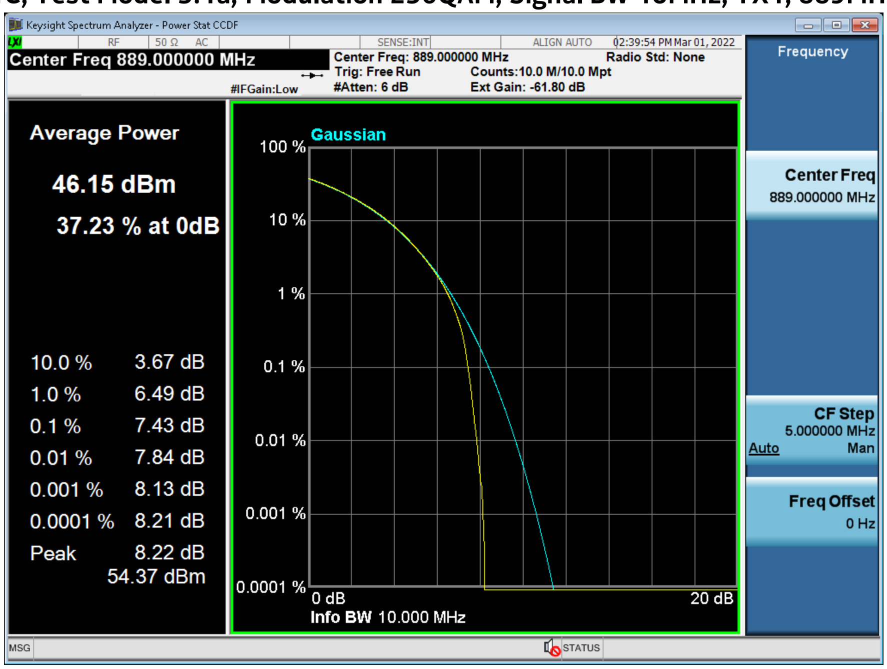
2.3.2 Peak-to-Average Power Ratio Plots – LTE

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.

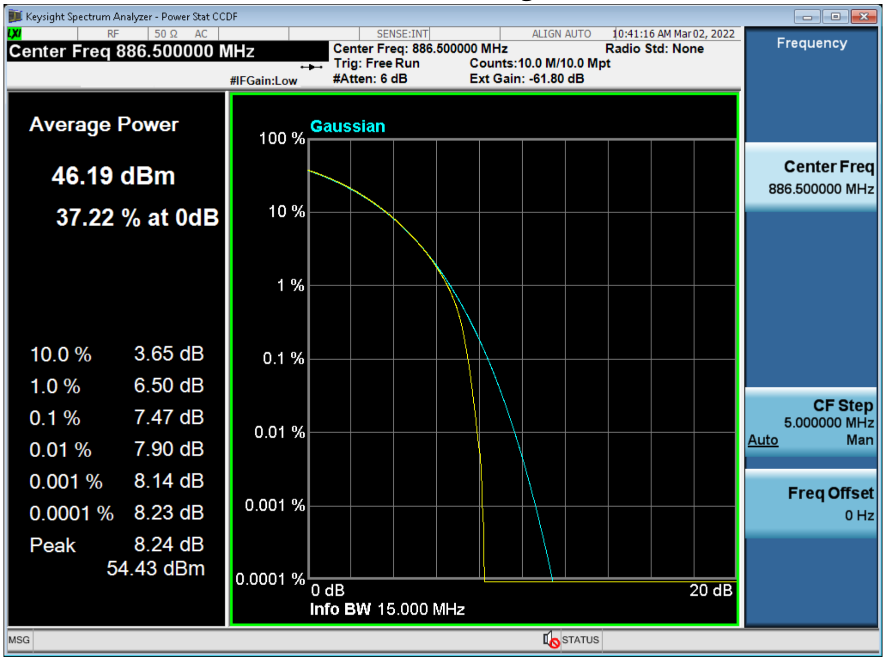
1C, Test Model 3.1a, Modulation 256QAM, Signal BW 5MHz, TX1, 891.5MHz



1C, Test Model 3.1a, Modulation 256QAM, Signal BW 10MHz, TX1, 889MHz



1C, Test Model 3.1a, Modulation 256QAM, Signal BW 15MHz, TX1, 886.5MHz



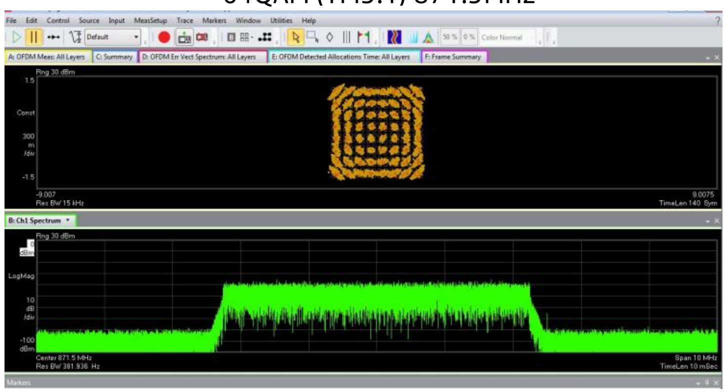
3. FCC Section 2.1047 - Modulation Characteristics

3.1 Modulation Characteristics

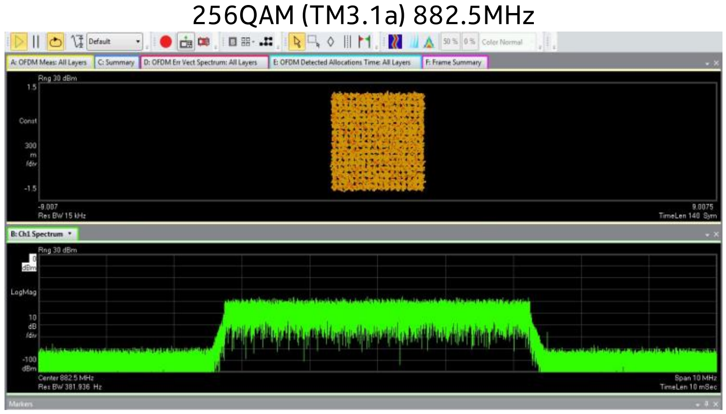
The RF signal at the antenna port was demodulated and verified for correctness of the modulation signal used before each test was performed. NOTE: Only a sample of the plots are used in this report. The full suite of raw data resides at the MH, New Jersey location.

3.1.1 Modulation Characteristics Plots – 5G-NR

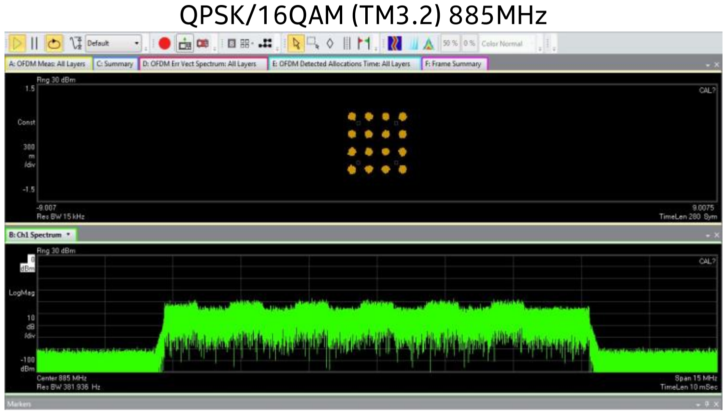
64QAM (TM3.1) 871.5MHz



256QAM (TM3.1a) 882.5MHz

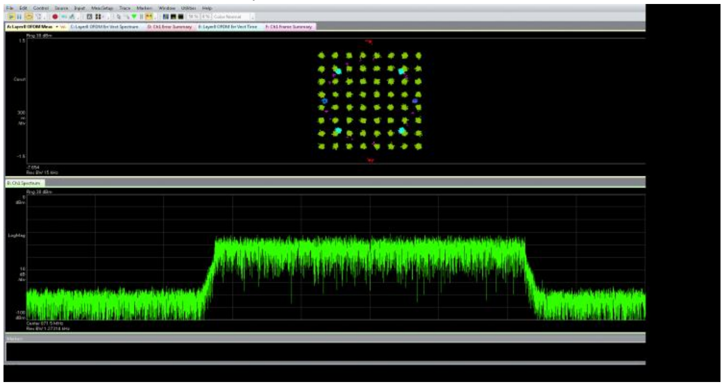


QPSK/16QAM (TM3.2) 885MHz

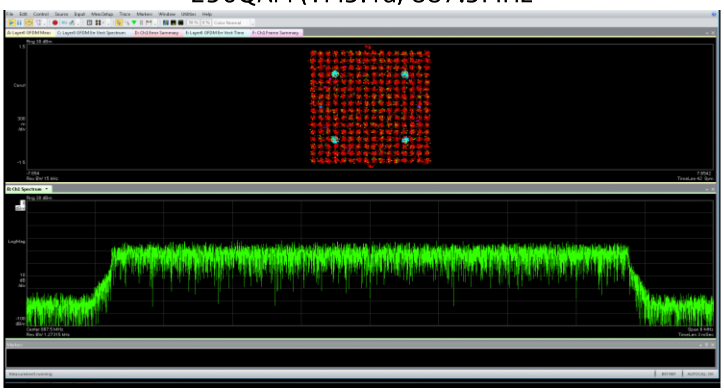


3.1.2 Modulation Characteristics Plots – LTE

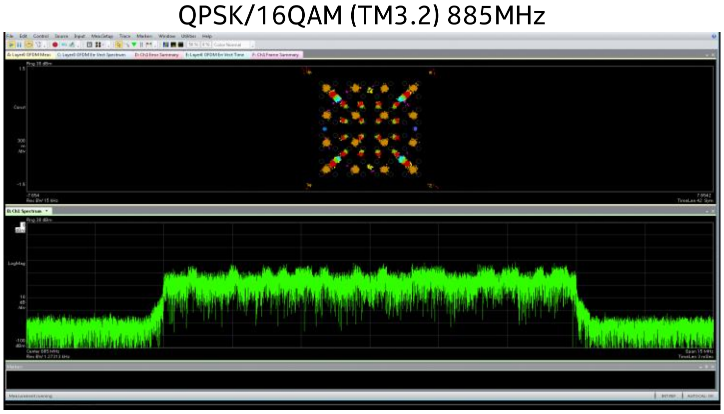
64QAM (TM3.1) 871.5MHz



256QAM (TM3.1a) 887.5MHz



QPSK/16QAM (TM3.2) 885MHz



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.

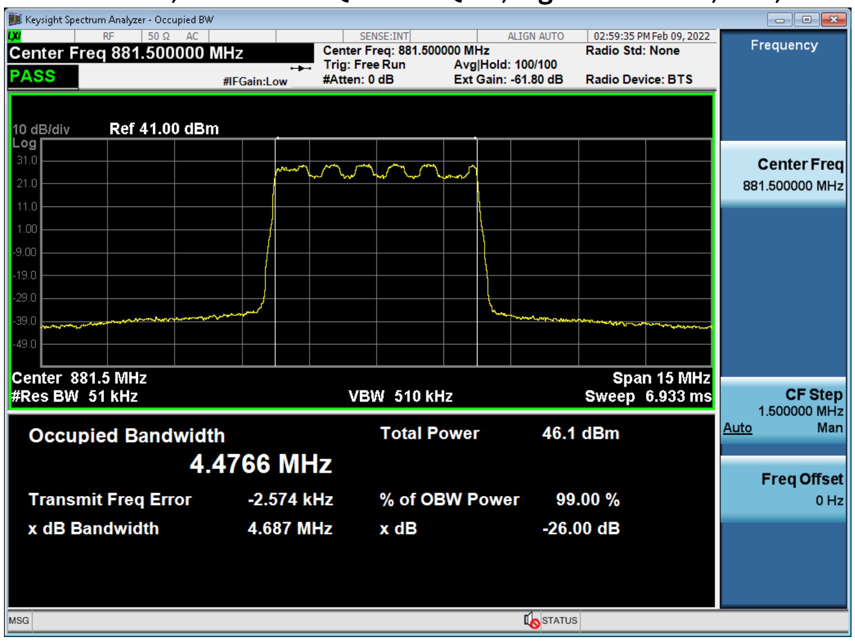
Tabular Data – Occupied Bandwidth

Radio Technology	# of Carrier	Signal BW MHz	Test Model	Modulation	TX Port	Channel Frequency MHz	99% OBW MHz
5G-NR	1	5	3.1	64QAM	4	871.5	4.4679
5G-NR	1	5	3.2	QPSK/16QAM	4	881.5	**4.4766**
5G-NR	1	5	3.1a	256QAM	4	891.5	4.4628
5G-NR	1	10	3.1	64QAM	4	874	**9.2766**
5G-NR	1	10	3.2	QPSK/16QAM	4	881.5	9.2435
5G-NR	1	10	3.1a	256QAM	4	889	9.2649
5G-NR	1	15	3.1	64QAM	4	876.5	14.085
5G-NR	1	15	3.2	QPSK/16QAM	4	881.5	**14.124**
5G-NR	1	15	3.1a	256QAM	4	886.5	14.079
5G-NR	1	20	3.1	64QAM	4	879	18.918
5G-NR	1	20	3.2	QPSK/16QAM	4	881.5	**18.935**
5G-NR	1	20	3.1a	256QAM	4	884	18.900
5G-NR	2	5+5	3.1	64QAM	4	871+891.5	4.4598+4.4619
5G-NR	2	5+20	3.1	64QAM	4	871+884	24.026
LTE	1	5	3.1	64QAM	1	871.5	**4.4779**
LTE	1	5	3.2	QPSK/16QAM	4	881.5	4.4502
LTE	1	5	3.1a	256QAM	1	891.5	4.4747
LTE	1	10	3.1	64QAM	1	874	8.9361
LTE	1	10	3.2	QPSK/16QAM	1	881.5	**8.9366**
LTE	1	10	3.1a	256QAM	1	889	8.9339
LTE	1	15	3.1	64QAM	1	876.5	13.392
LTE	1	15	3.2	QPSK/16QAM	1	881.5	**13.394**
LTE	1	15	3.1a	256QAM	1	886.5	13.389

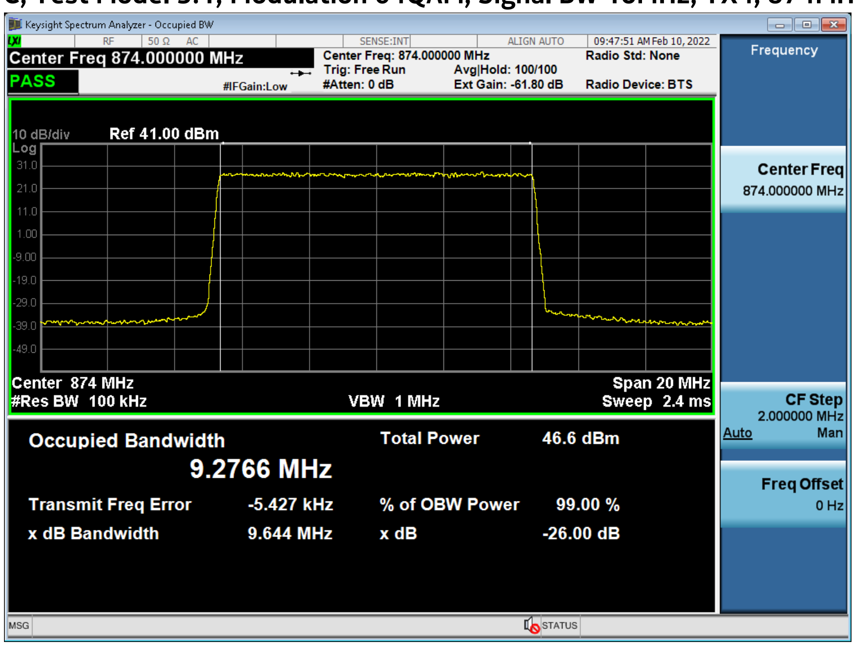
4.1.1 Occupied Bandwidth Plots – 5G-NR

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.

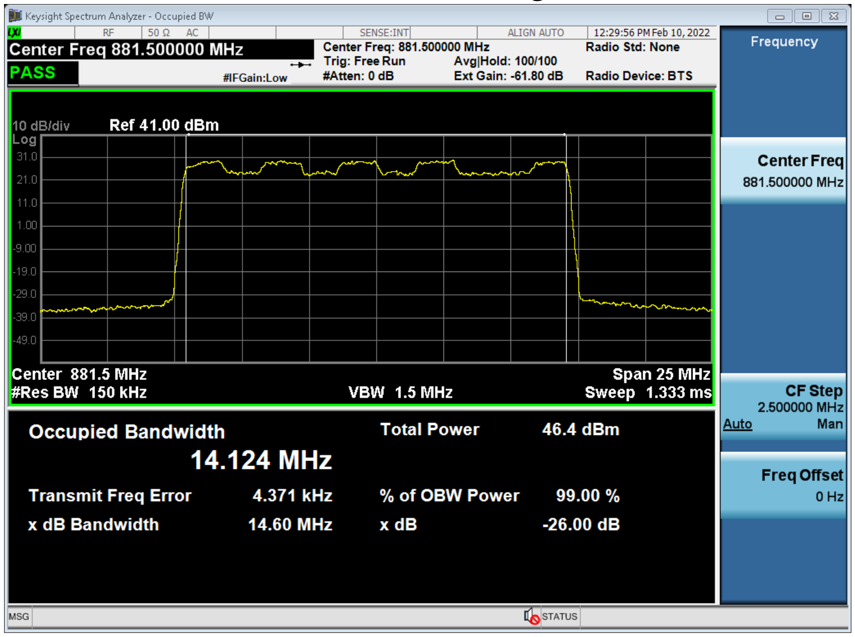
1C, Test Model 3.2, Modulation QPSK/16QAM, Signal BW 5MHz, TX4, 881.5MHz



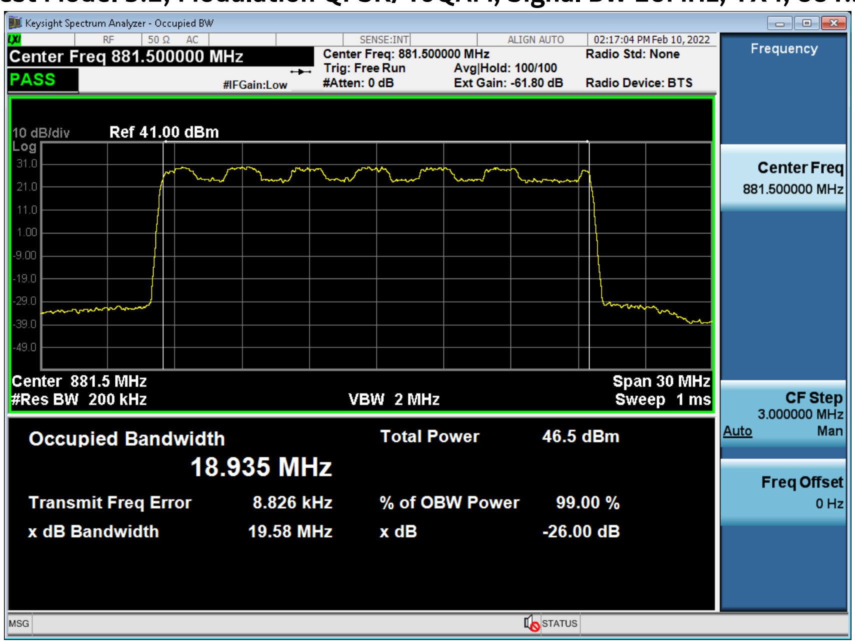
1C, Test Model 3.1, Modulation 64QAM, Signal BW 10MHz, TX4, 874MHz



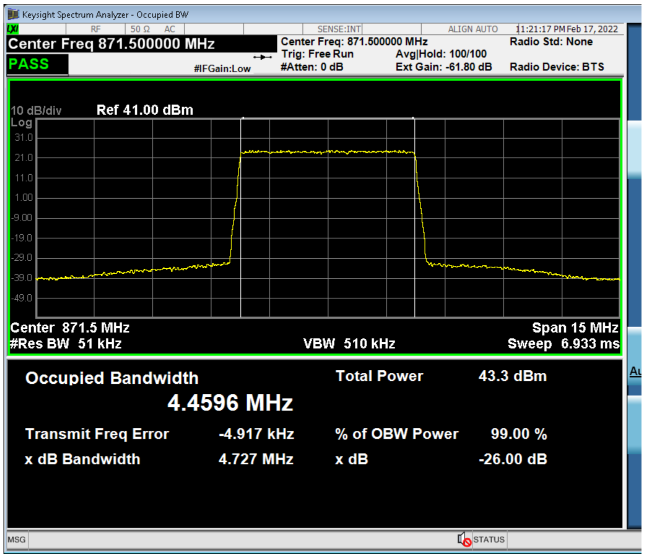
1C, Test Model 3.2, Modulation QPSK/16QAM, Signal BW 15MHz, TX4, 881.5MHz

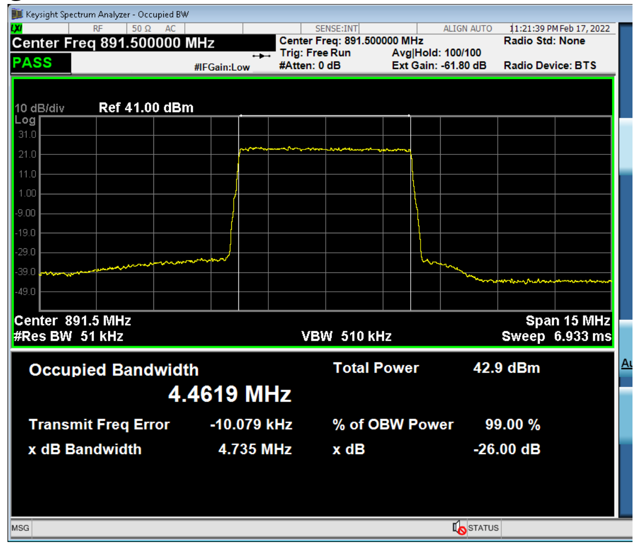


1C, Test Model 3.2, Modulation QPSK/16QAM, Signal BW 20MHz, TX4, 881.5MHz

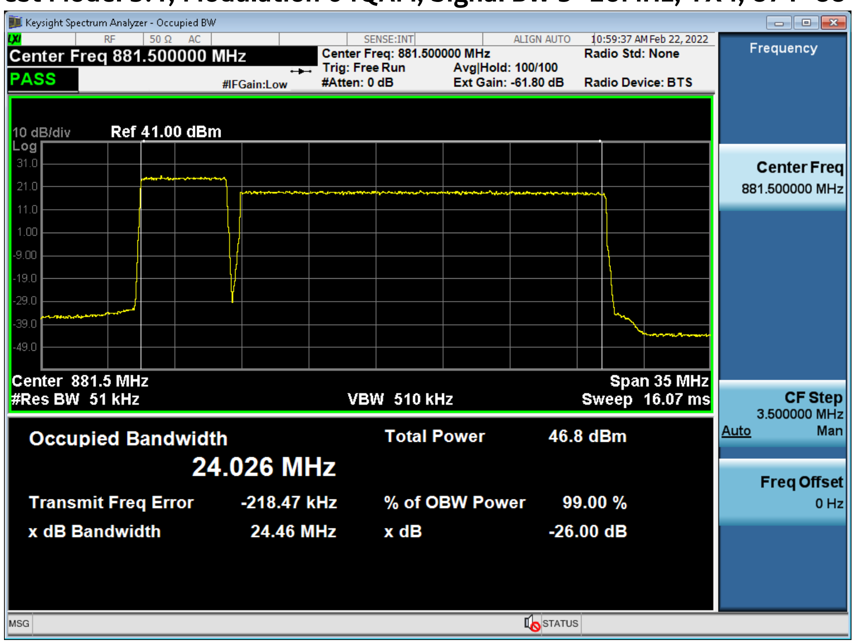


2C, Test Model 3.1, Modulation 64QAM, Signal BW 5+5MHz, TX4, 871+891.5MHz





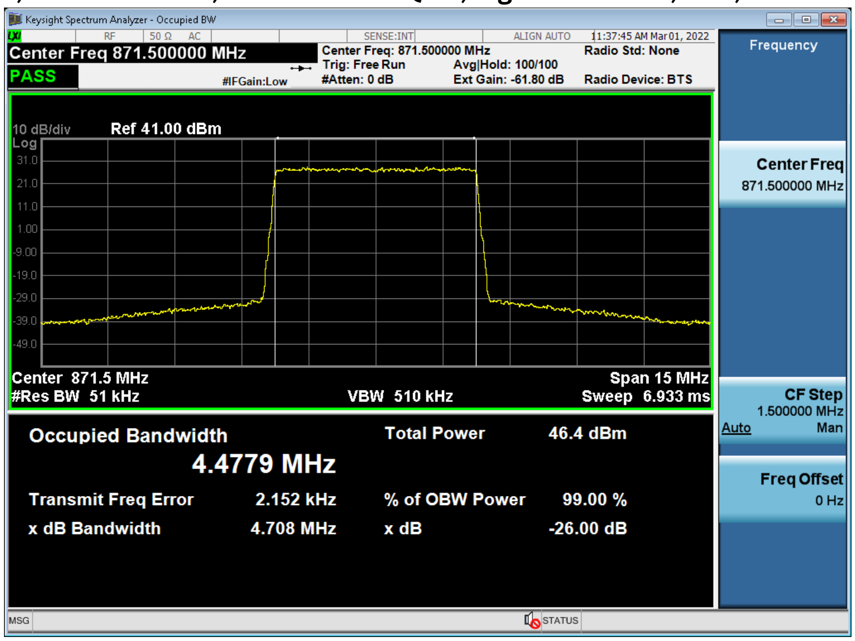
2C, Test Model 3.1, Modulation 64QAM, Signal BW 5+20MHz, TX4, 871+884MHz



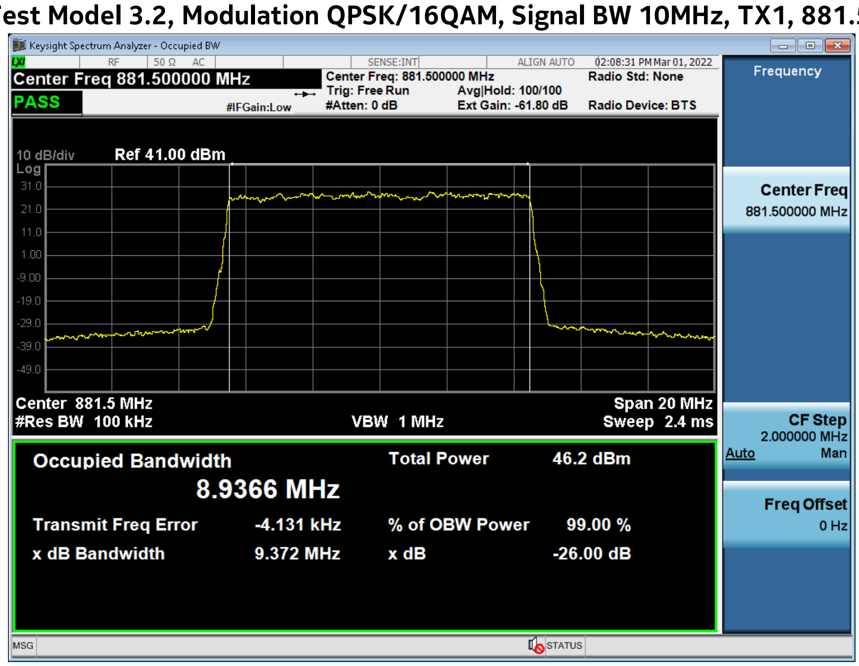
4.1.2 Occupied Bandwidth Plots – LTE

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.

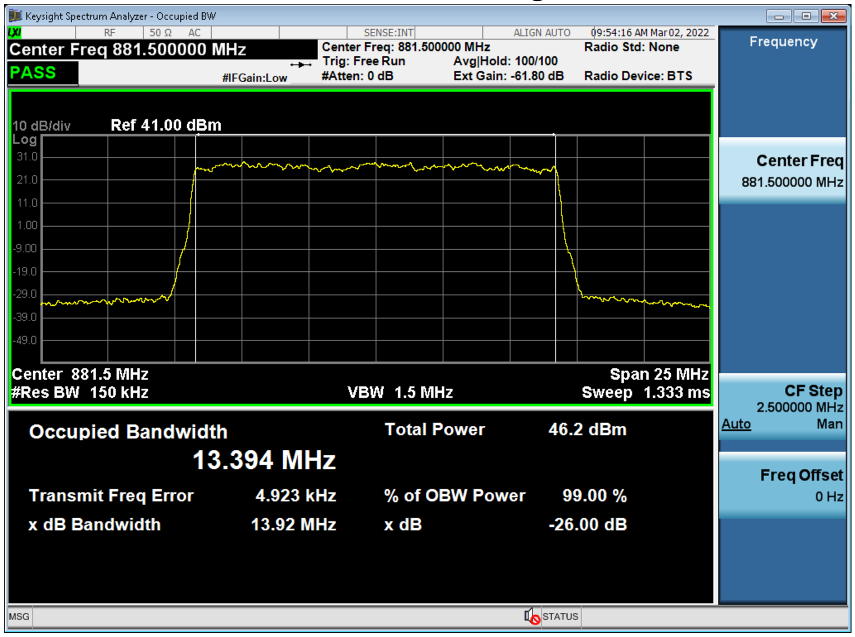
1C, Test Model 3.1, Modulation 64QAM, Signal BW 5MHz, TX1, 871.5MHz



1C, Test Model 3.2, Modulation QPSK/16QAM, Signal BW 10MHz, TX1, 881.5MHz



1C, Test Model 3.2, Modulation QPSK/16QAM, Signal BW 15MHz, TX1, 881.5MHz



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.

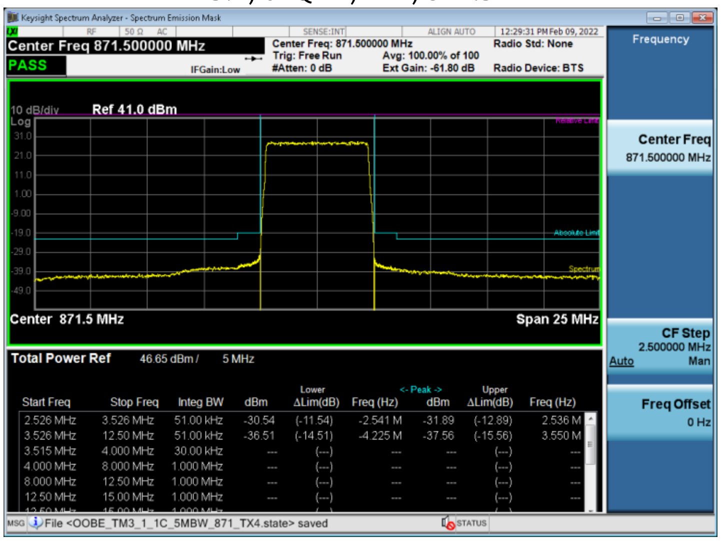
In accordance with KDB 662911 D01 Multiple Transmitter Output, the limit of -13 dBm has been adjusted to -19 dBm to reflect 10 log(n) where n=4 for the 4x4 MIMO operation, then adjusted for the 1 MHz bands immediately outside and adjacent to the frequency block where a smaller RBW than the required 100 kHz stated in 47 CFR Part 22.917 was used.

4.2.1 Edge of Band Emissions Plots – 5G-NR

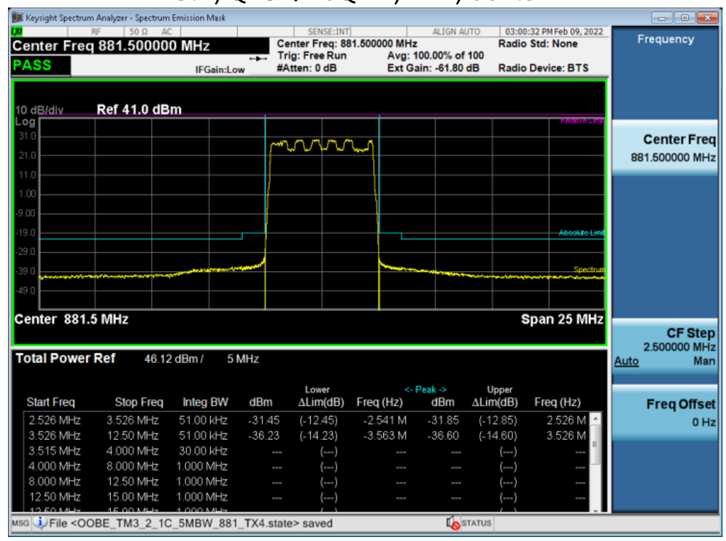
All of the measurements met the requirements of Part 2.1049.

5MHz BW

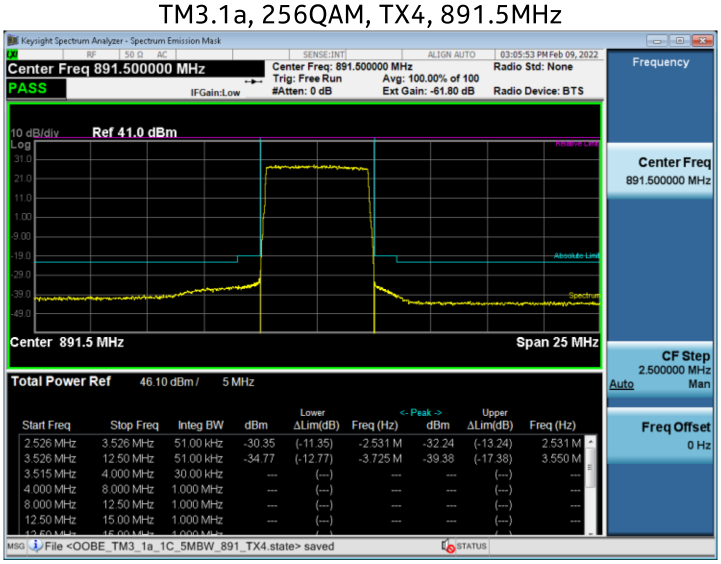
TM3.1, 64QAM, TX4, 871.5MHz



TM3.2, QPSK/16QAM, TX4, 881.5MHz

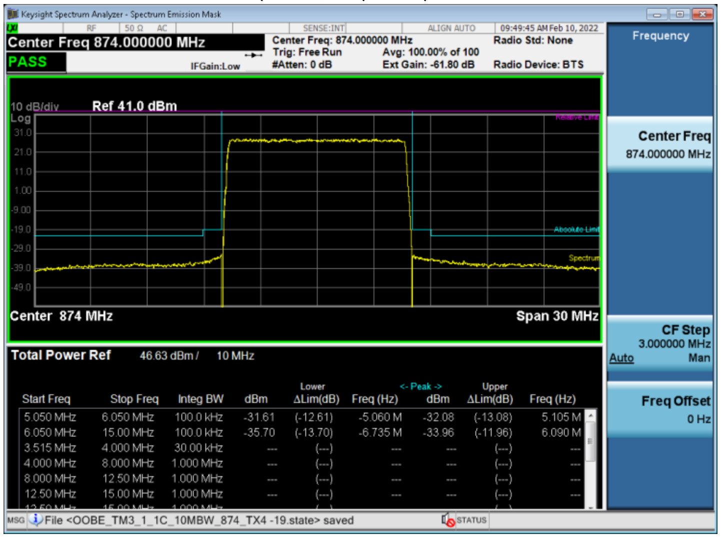


TM3.1a, 256QAM, TX4, 891.5MHz

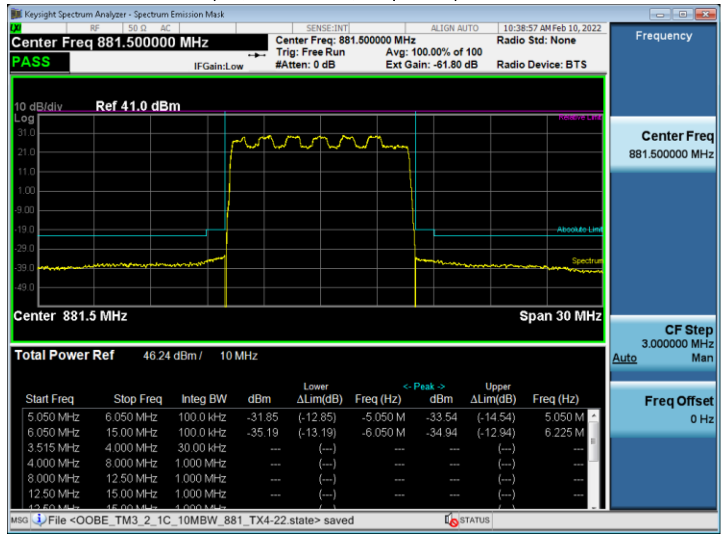


10MHz BW

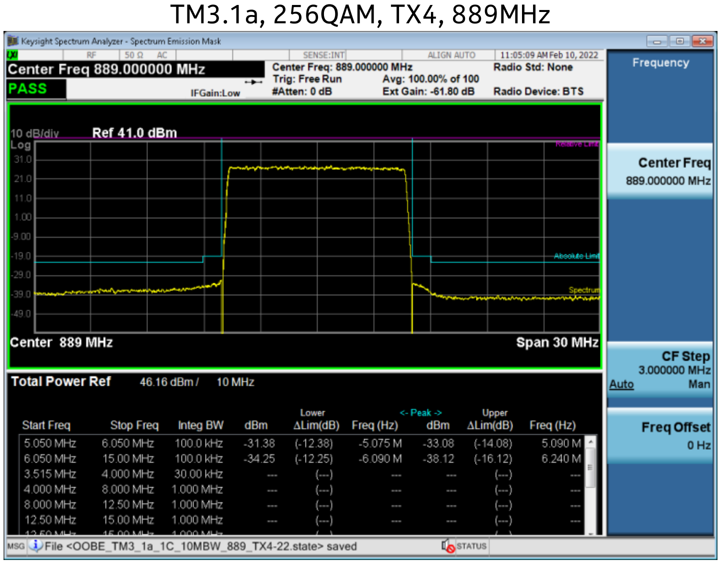
TM3.1, 64QAM, TX4, 874MHz



TM3.2, QPSK/16QAM, TX4, 881.5MHz

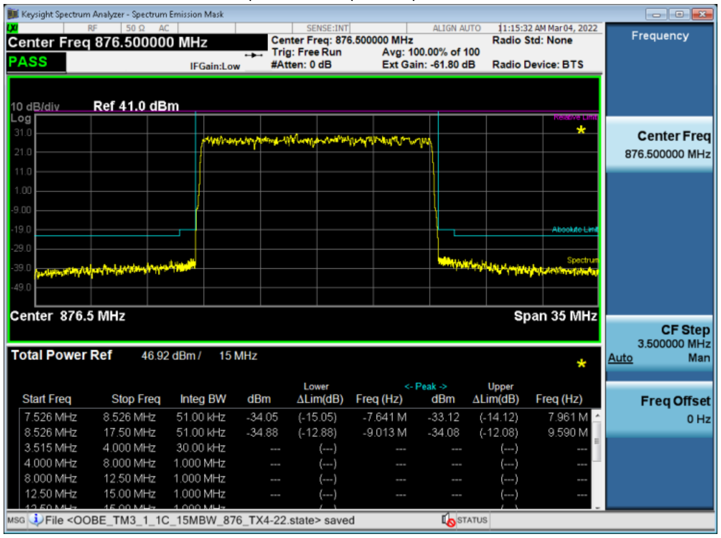


TM3.1a, 256QAM, TX4, 889MHz

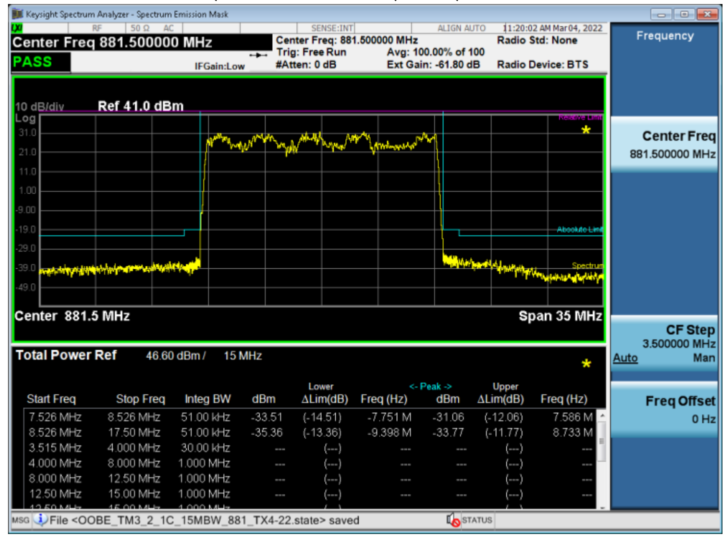


15MHz BW

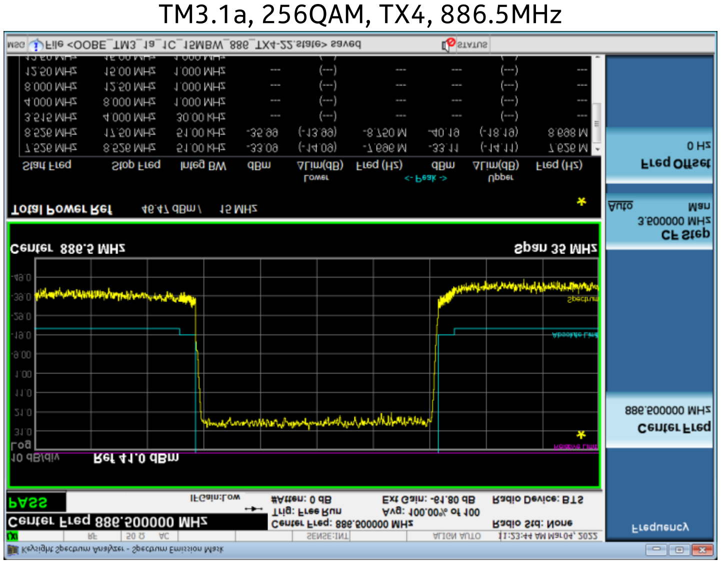
TM3.1, 64QAM, TX4, 876.5MHz



TM3.2, QPSK/16QAM, TX4, 881.5MHz

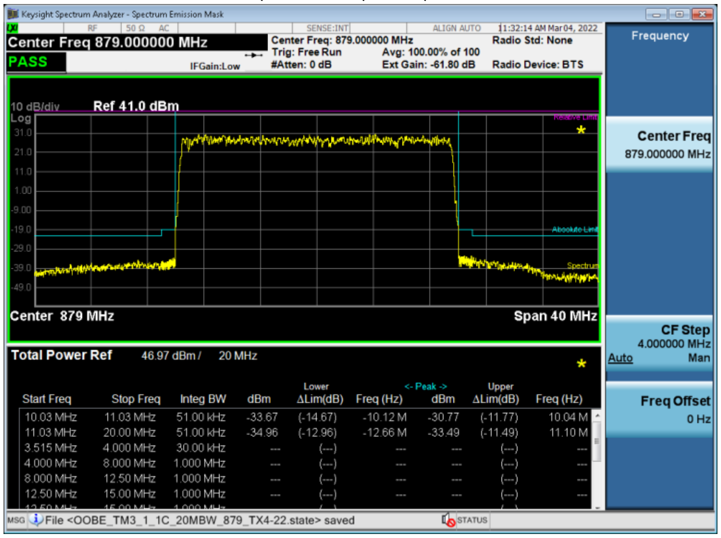


TM3.1a, 256QAM, TX4, 886.5MHz

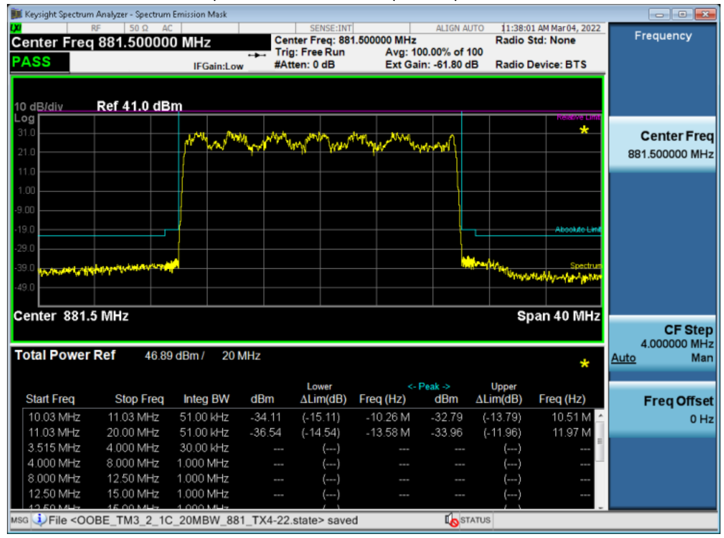


20MHz BW

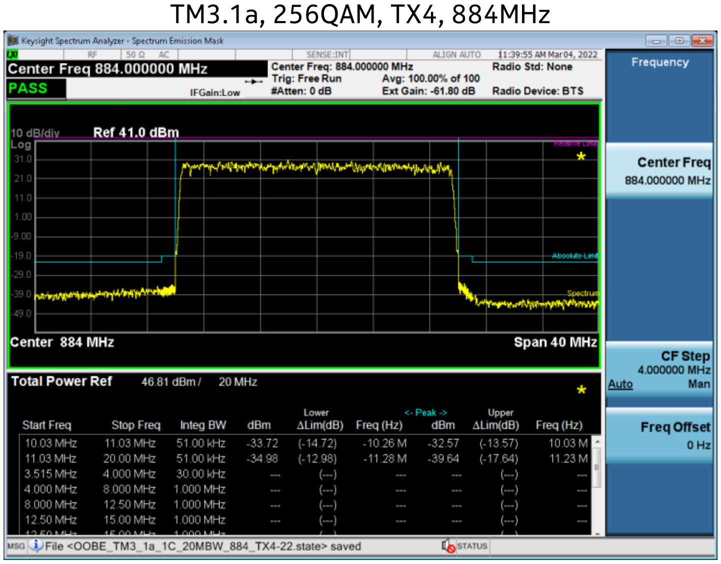
TM3.1, 64QAM, TX4, 879MHz



TM3.2, QPSK/16QAM, TX4, 881.5MHz

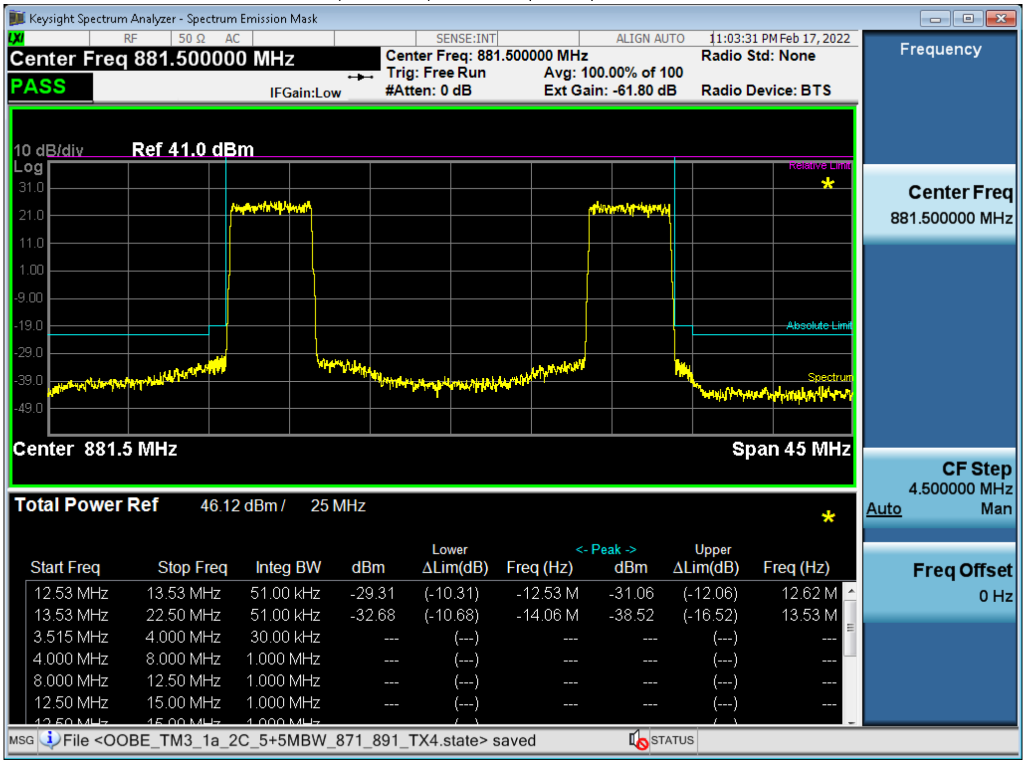


TM3.1a, 256QAM, TX4, 884MHz



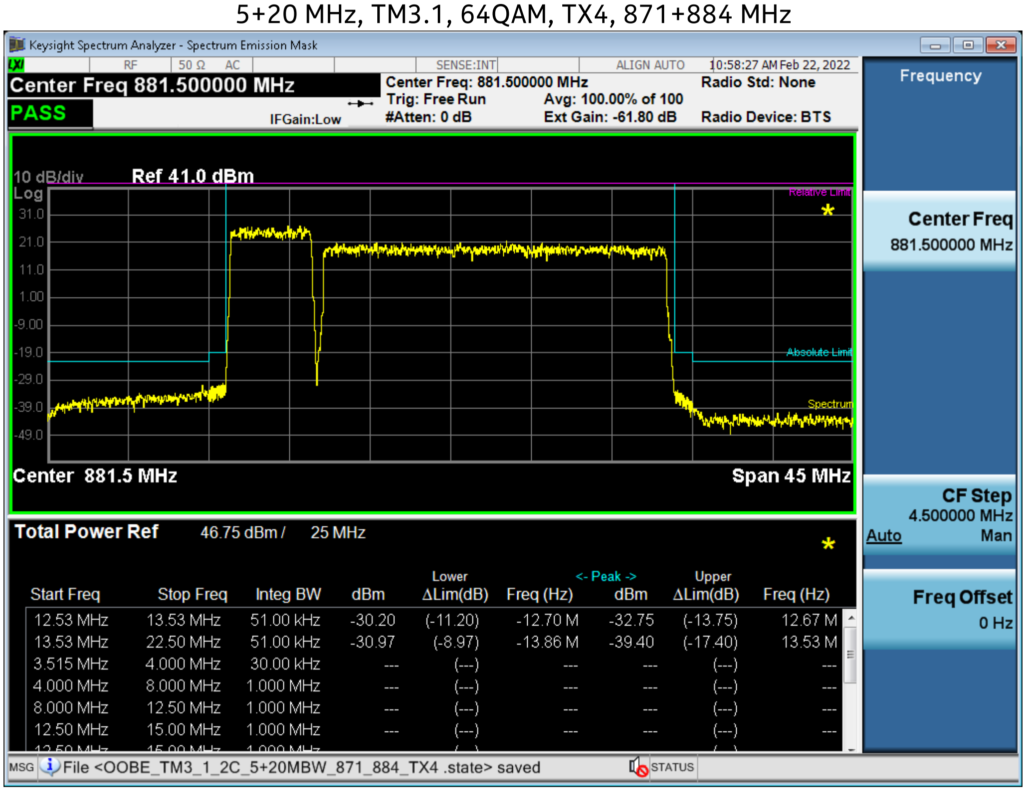
2C

5+5 MHz, TM3.1, 64QAM, TX4, 871+891.5 MHz



Start Freq	Stop Freq	Integ BW	dBm	Lower ΔLim(dB)	Freq (Hz)	dBm	Upper ΔLim(dB)	Freq (Hz)
12.53 MHz	13.53 MHz	51.00 kHz	-29.31	(-10.31)	-12.53 M	-31.06	(-12.06)	12.62 M
13.53 MHz	22.50 MHz	51.00 kHz	-32.68	(-10.68)	-14.06 M	-38.52	(-16.52)	13.53 M
3.515 MHz	4.000 MHz	30.00 kHz	---	(---)	---	---	(---)	---
4.000 MHz	8.000 MHz	1.000 MHz	---	(---)	---	---	(---)	---
8.000 MHz	12.50 MHz	1.000 MHz	---	(---)	---	---	(---)	---
12.50 MHz	15.00 MHz	1.000 MHz	---	(---)	---	---	(---)	---

5+20 MHz, TM3.1, 64QAM, TX4, 871+884 MHz



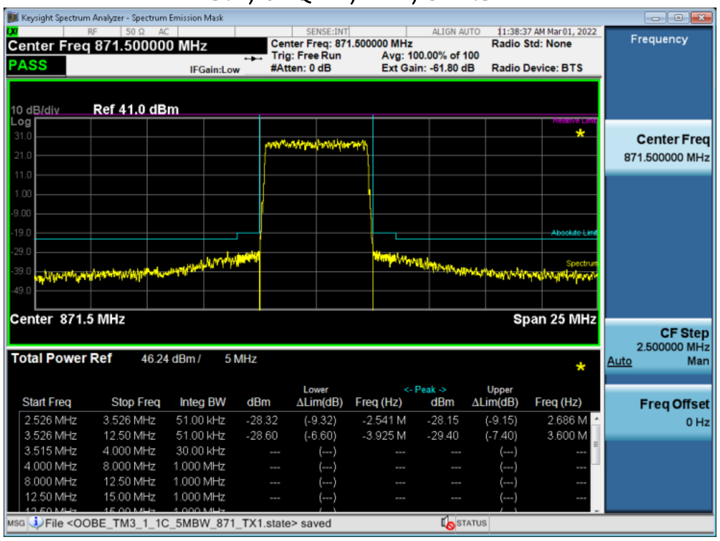
Start Freq	Stop Freq	Integ BW	dBm	Lower ΔLim(dB)	Freq (Hz)	dBm	Upper ΔLim(dB)	Freq (Hz)
12.53 MHz	13.53 MHz	51.00 kHz	-30.20	(-11.20)	-12.70 M	-32.75	(-13.75)	12.67 M
13.53 MHz	22.50 MHz	51.00 kHz	-30.97	(-8.97)	-13.86 M	-39.40	(-17.40)	13.53 M
3.515 MHz	4.000 MHz	30.00 kHz	---	(---)	---	---	(---)	---
4.000 MHz	8.000 MHz	1.000 MHz	---	(---)	---	---	(---)	---
8.000 MHz	12.50 MHz	1.000 MHz	---	(---)	---	---	(---)	---
12.50 MHz	15.00 MHz	1.000 MHz	---	(---)	---	---	(---)	---

4.2.2 Edge of Band Emissions Plots – LTE

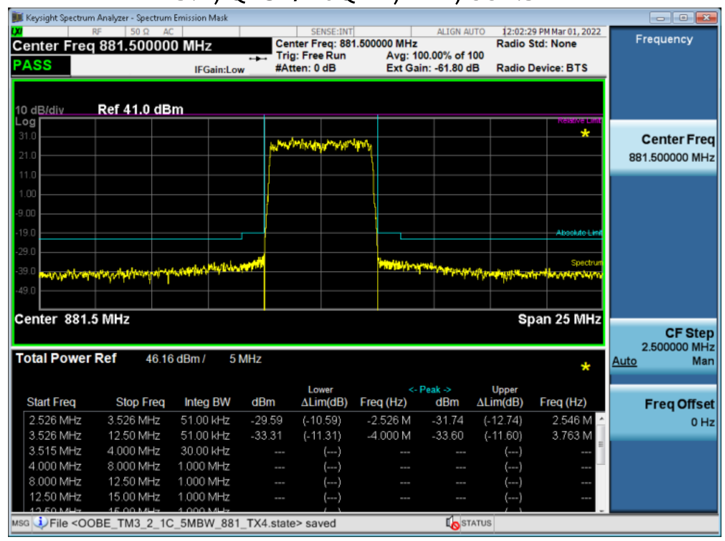
All of the measurements met the requirements of Part 2.1049.

5MHz BW

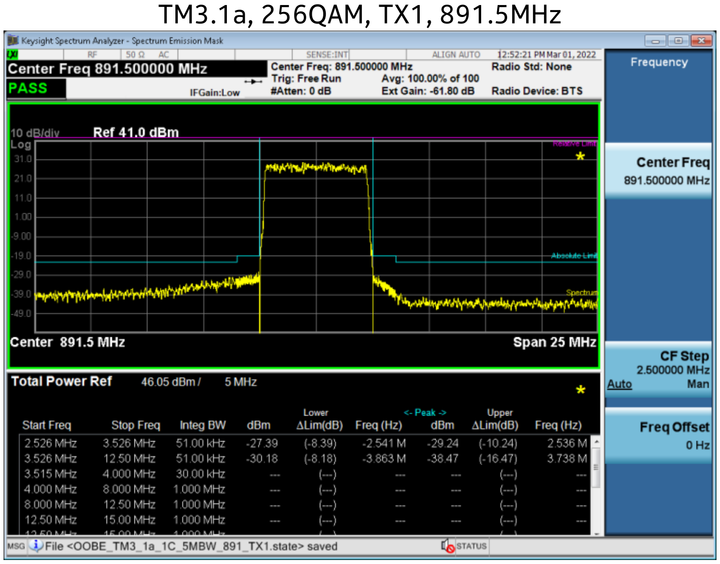
TM3.1, 64QAM, TX1, 871.5MHz



TM3.2, QPSK/16QAM, TX4, 881.5MHz

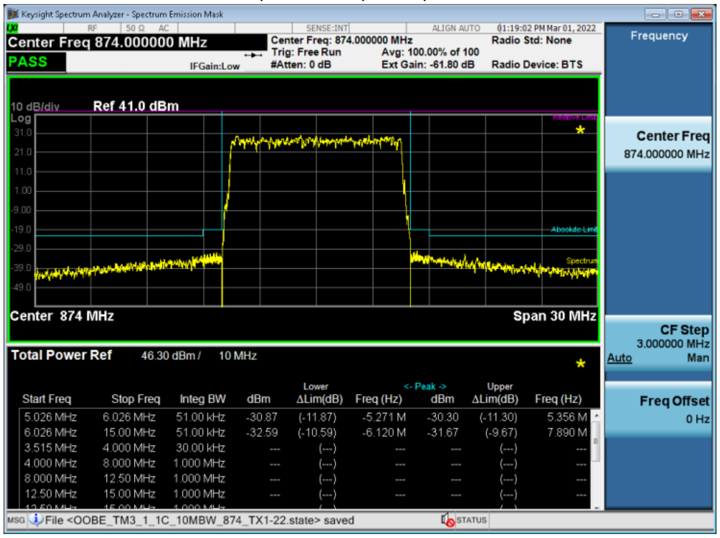


TM3.1a, 256QAM, TX1, 891.5MHz

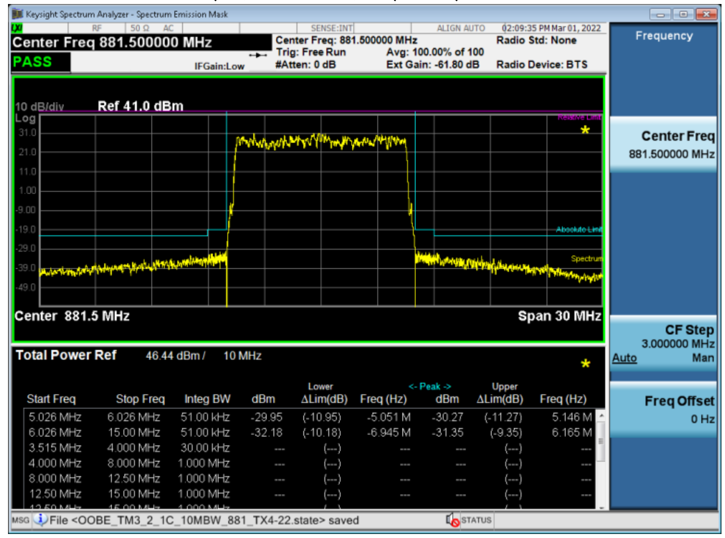


10MHz BW

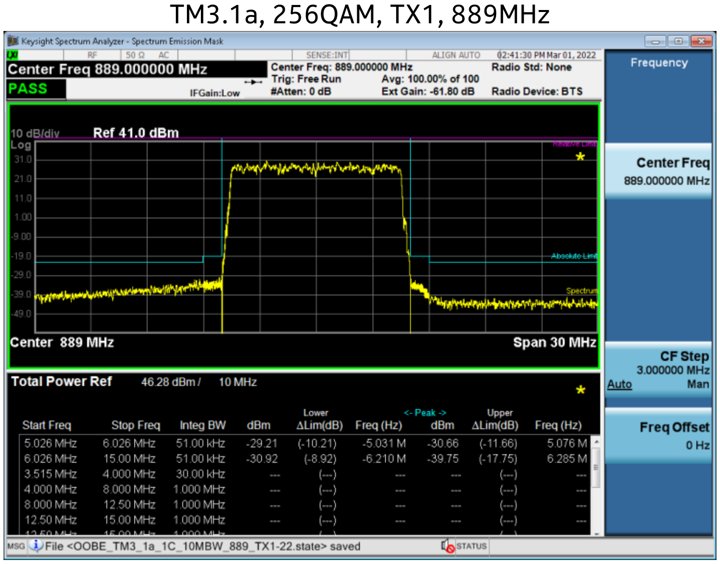
TM3.1, 64QAM, TX1, 874MHz



TM3.2, QPSK/16QAM, TX1, 881.5MHz

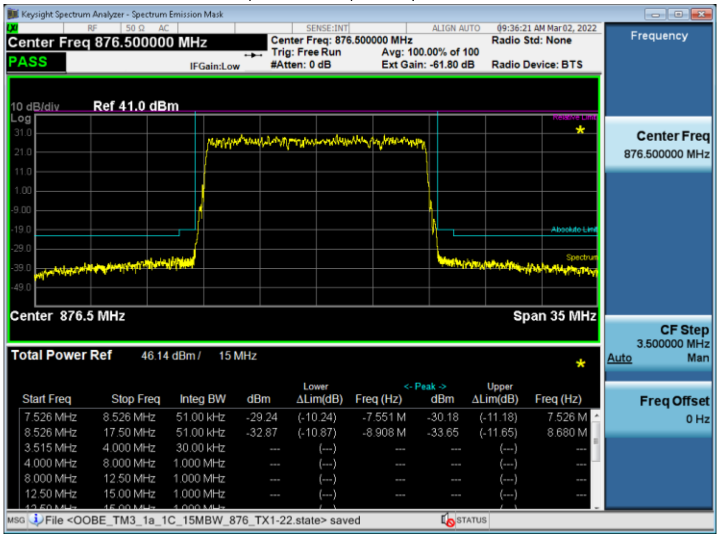


TM3.1a, 256QAM, TX1, 889MHz

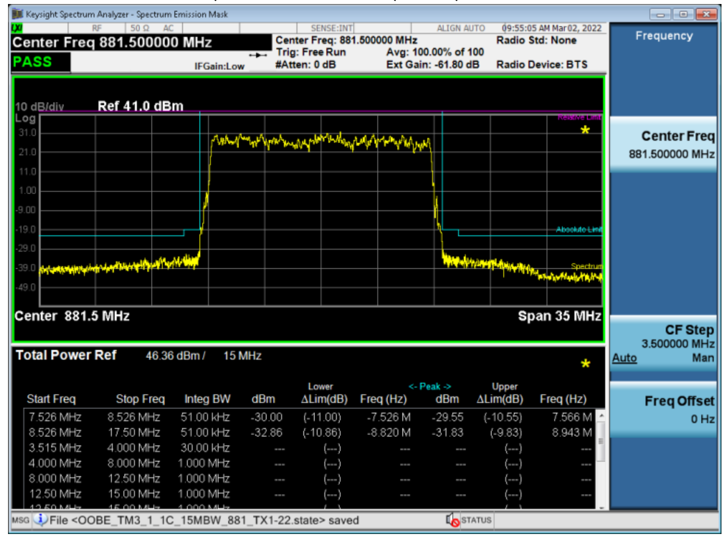


15MHz BW

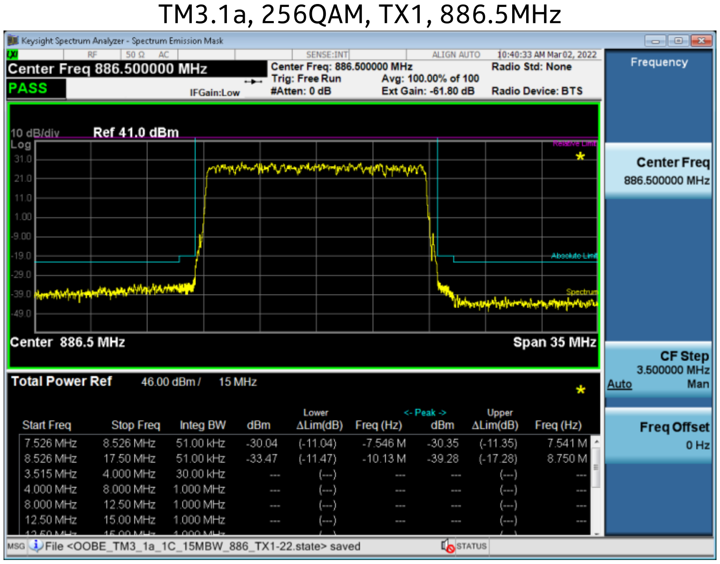
TM3.1, 64QAM, TX1, 876.5MHz



TM3.2, QPSK/16QAM, TX1, 881.5MHz



TM3.1a, 256QAM, TX1, 886.5MHz



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 9kHz to beyond the 10th harmonic of the specific transmit band. 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.

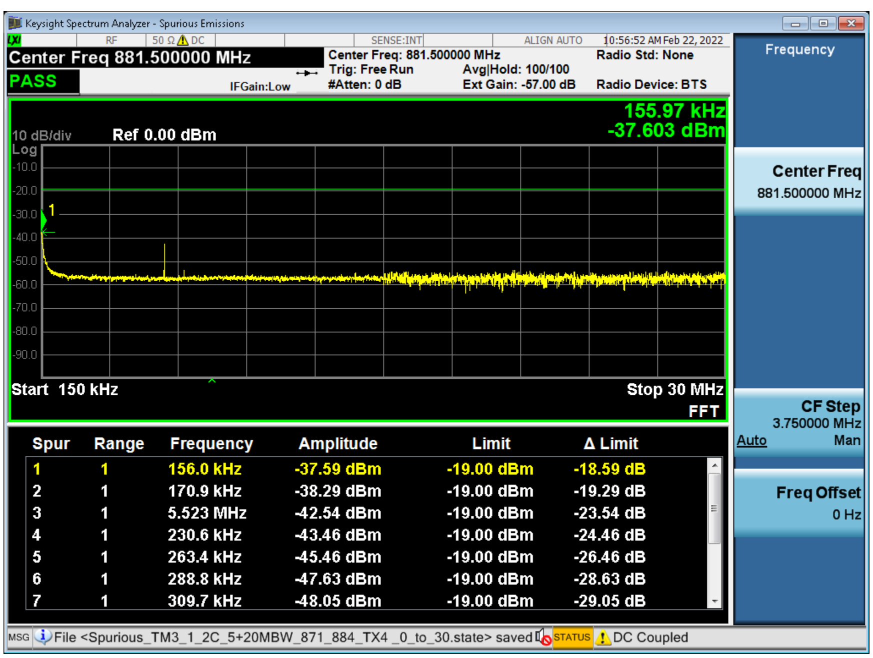
The required emission limitation is specified as appropriate in 22.917. The measured spurious emission levels were plotted for the frequency range as specified in 2.1057. In accordance with KDB 662911 D01 Multiple Transmitter Output, the limit of -13 dBm has been adjusted to -19 dBm to reflect 10 log(n) where n=4 for the 4x4 MIMO operation of the stacked unit configuration.

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 – 5G-NR

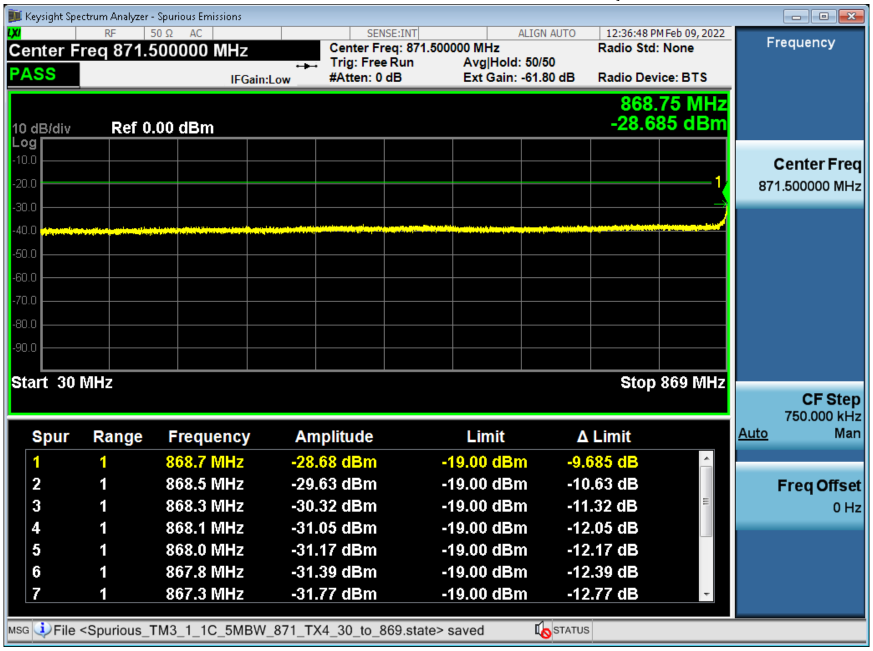
150kHz – 30MHz

Radio Technology	# of Carrier	Signal BW MHz	Test Model	Modulation	TX Port	Channel Frequency MHz
5G-NR	2	5+20	3.1	64QAM	4	871+884



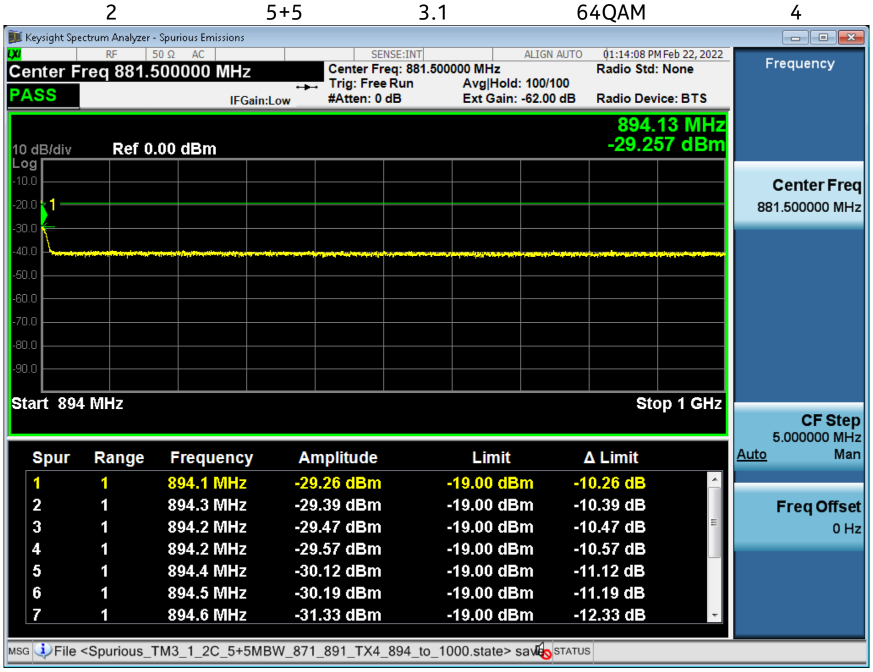
30MHz – 869MHz

Radio Technology	# of Carrier	Signal BW MHz	Test Model	Modulation	TX Port	Channel Frequency MHz
5G-NR	1	5	3.1	64QAM	4	871.5



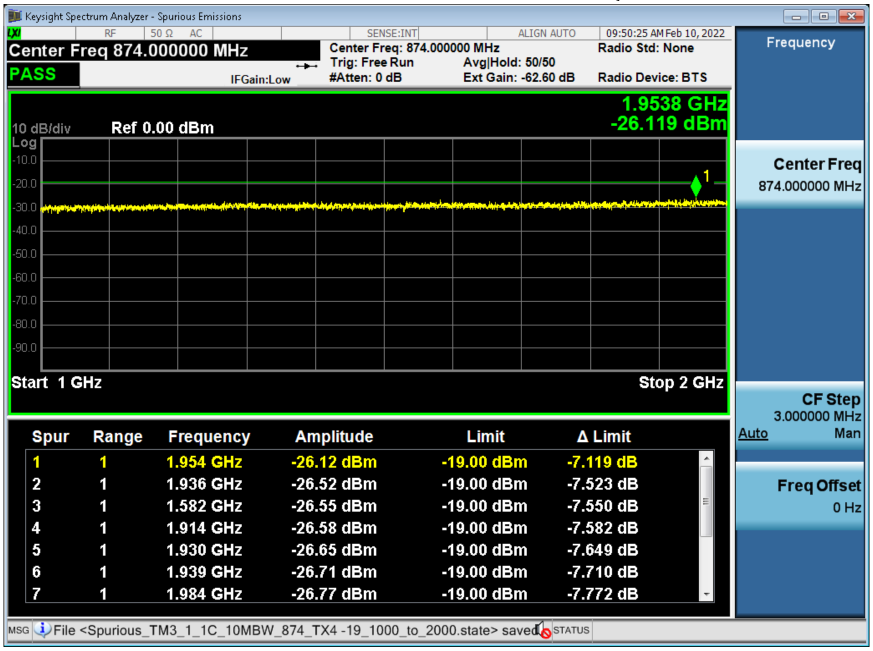
894MHz – 1GHz

Radio Technology	# of Carrier	Signal BW MHz	Test Model	Modulation	TX Port	Channel Frequency MHz
5G-NR	2	5+5	3.1	64QAM	4	871+891.5



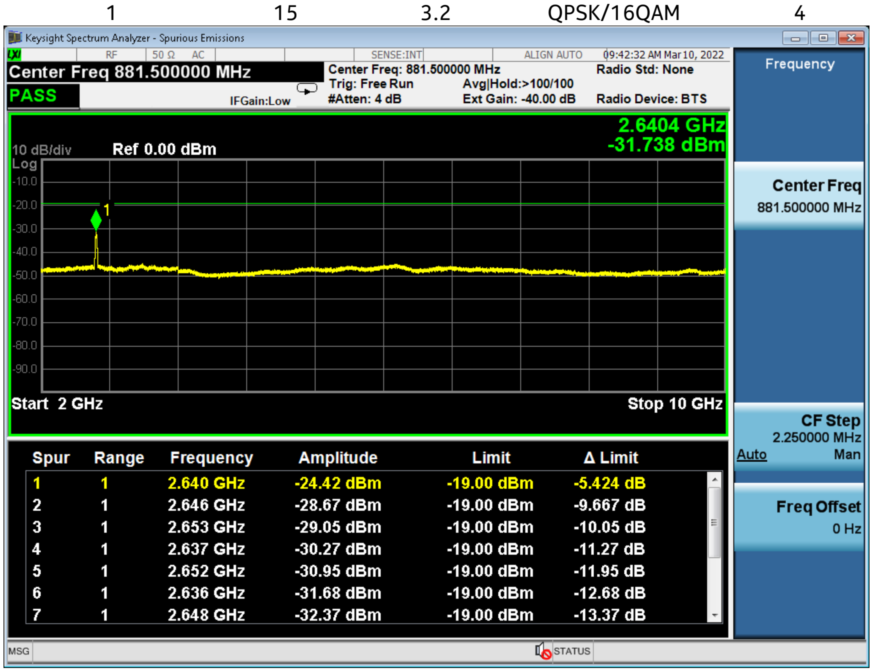
1GHz – 2GHz

Radio Technology	# of Carrier	Signal BW MHz	Test Model	Modulation	TX Port	Channel Frequency MHz
5G-NR	1	10	3.1	64QAM	4	874



2GHz – 10GHz

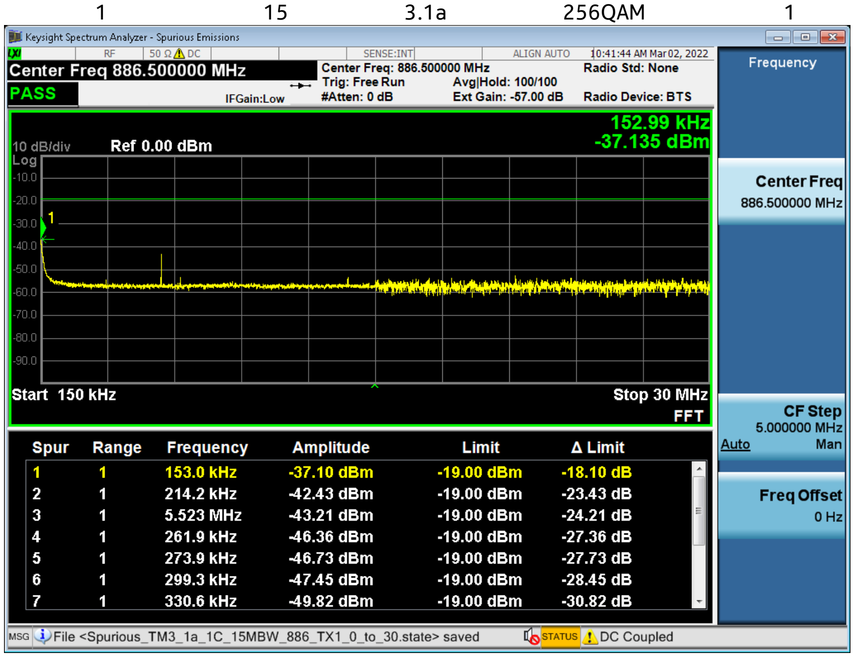
Radio Technology	# of Carrier	Signal BW MHz	Test Model	Modulation	TX Port	Channel Frequency MHz
5G-NR	1	15	3.2	QPSK/16QAM	4	881.5



5.1.2 Spurious Emissions at Tx Port Plots – LTE

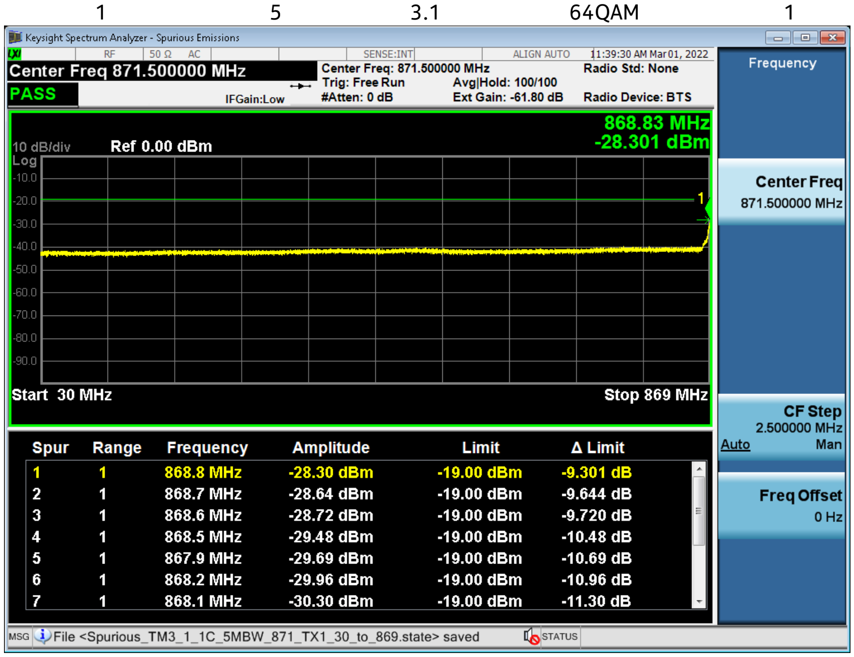
150kHz – 30MHz

Radio Technology	# of Carrier	Signal BW MHz	Test Model	Modulation	TX Port	Channel Frequency MHz
LTE	1	15	3.1a	256QAM	1	886.5



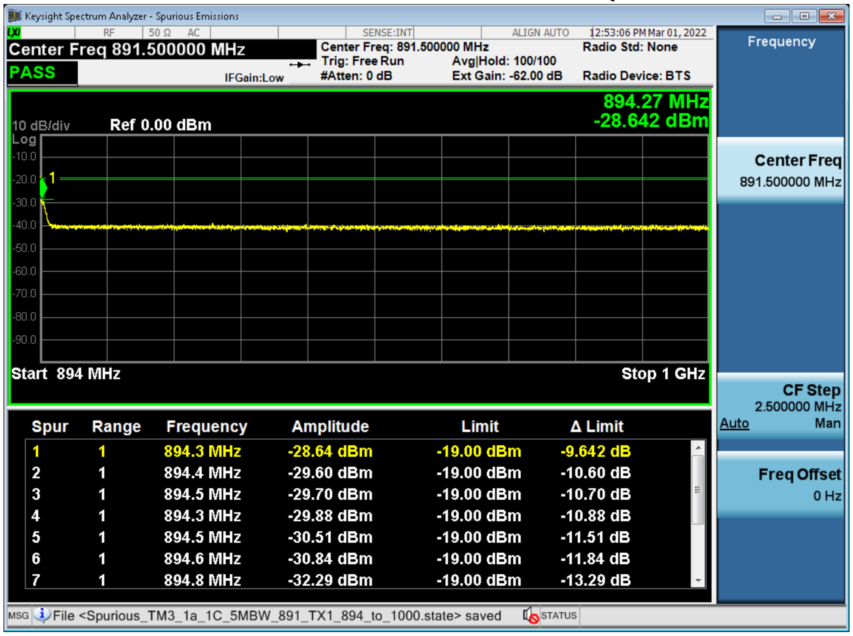
30MHz – 869MHz

Radio Technology	# of Carrier	Signal BW MHz	Test Model	Modulation	TX Port	Channel Frequency MHz
LTE	1	5	3.1	64QAM	1	871.5



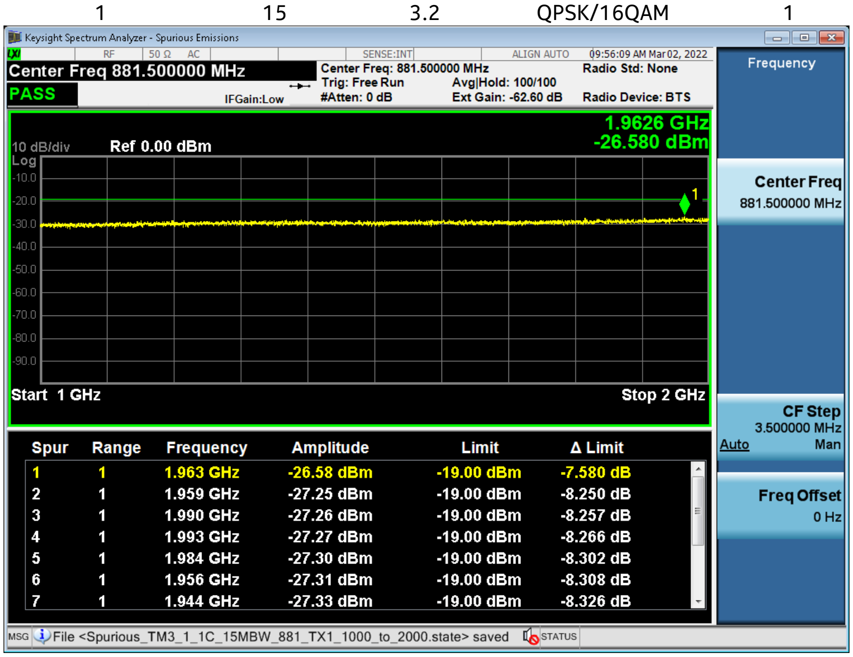
894MHz – 1GHz

Radio Technology	# of Carrier	Signal BW MHz	Test Model	Modulation	TX Port	Channel Frequency MHz
LTE	1	5	3.1a	256QAM	1	891.5



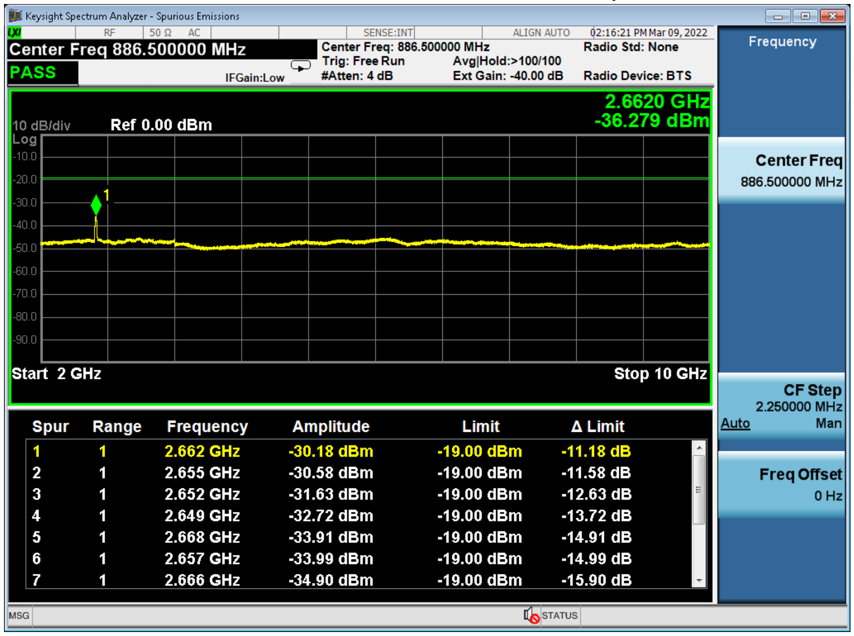
1GHz – 2GHz

Radio Technology	# of Carrier	Signal BW MHz	Test Model	Modulation	TX Port	Channel Frequency MHz
LTE	1	15	3.2	QPSK/16QAM	1	881.5

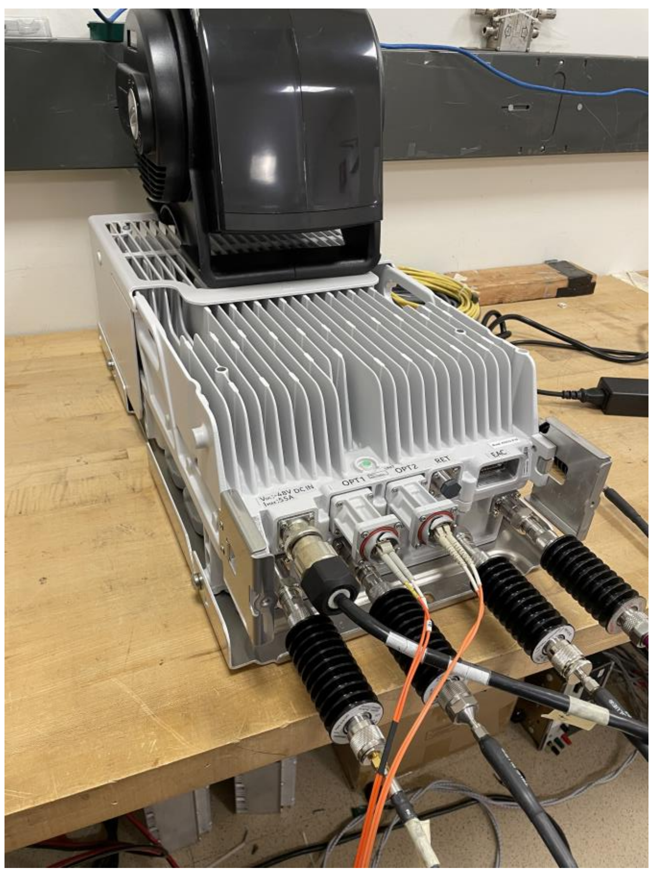


2GHz – 10GHz

Radio Technology	# of Carrier	Signal BW MHz	Test Model	Modulation	TX Port	Channel Frequency MHz
LTE	1	15	3.1a	256QAM	1	886.5



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
EIH74	KeySight Technologies	EMI Receiver	20 Hz-44 GHz (Analysis Bandwidth 125 MHz)	N9020B	MY57120303	2020-12-21	2022-12-21
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	2020-10-21	2022-10-21
E1212	RLC Electronics	Filter, High Pass	10 - 30 GHz, 2W, 5dB	F-19414	1444002	CNR-V	CNR-V
E1022	Weinschel	Attenuator	10dB DC-18GHz 25W	46-10-34-LIM	BN3118	CNR-V	CNR-V
E1023	Weinschel	Attenuator	20 dB DC-18 GHz 25W	46-20-34	BJ4772	CNR-V	CNR-V
E1344	Macom	Attenuator	3 dB, DC - 4 GHz, 2W	2082-6171-03	N/A	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	Aeroflex	Attenuator	30dB 150W DC-18GHz Attenuator	66-30-33	BV1667	CNR-V	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.

6.2 Field Strength of Spurious Emissions - Limits

Sections 2.1053 and 22.917 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 22 Limit is 82.23 dBµV/m at 3m and 91.77 dBµV/m at 1m
The Part 22 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 22, 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. FCC Section 2.1055 - Measurement of Frequency Stability

Frequency Stability testing was completed on AHBCD with Center Frequency 881.5 MHz. Testing was performed from 2/24/2022 – 3/1/2022, which was located in the T-15 Thermal chamber of the Global Product Compliance Laboratory (GPCL) test facility located in Building 4, Room 4-280, Murray Hill, NJ, by Joe
Bordonaro from GPCL.

The temperatures to which the UUT were subjected ranged from a high temperature of +50°C system ambient to a low temperature of -30ºC system ambient with measurements recorded at +20°C, +50°C, and -30°C.

Frequency Stability performance was verified by measuring Frequency Tolerance using an MXA Signal Analyzer. Frequency Tolerance is a measurement of the difference between the actual transmit frequency and the assigned frequency.

Frequency Block Tested: ***ABHCD (CF = 881.5 MHz)***

Baseline Measurement at +25°C

Transmit Frequency Deviation at +25°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	**Transmit Carrier Deviation (milli Hz)**
0	**523.55**
0.5	**-212.8**
1.0	**327.10**
1.5	**150.31**
2.0	**-274.6**
2.5	**-72.96**
3.0	**644.57**
FCC SPECIFICATION	**881.5 MHz (±0.05ppm)** **±0.05ppm = ± 44.075Hz**
FCC RESULT	**PASS**

Transmit Frequency Deviation at +50°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	**Transmit Carrier Deviation (milli Hz)**
0	**480.67**
0.5	**155.50**
1.0	**13.931**
1.5	**83.193**
2.0	**262.28**
2.5	**145.50**
3.0	**-116.6**
FCC SPECIFICATION	**881.5 MHz (±0.05ppm)** **±0.05ppm = ± 44.075Hz**
FCC RESULT	**PASS**

Transmit Frequency Deviation at +40°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	**Transmit Carrier Deviation (milli Hz)**
0	**-180.1**
0.5	**288.32**
1.0	**534.29**
1.5	**-265.0**
2.0	**344.30**
2.5	**292.62**
3.0	**-312.0**
FCC SPECIFICATION	**881.5 MHz (±0.05ppm) ±0.05ppm = ± 44.075Hz**
FCC RESULT	**PASS**

Transmit Frequency Deviation at +30°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	**Transmit Carrier Deviation (mHz)**
0	**-85.46**
0.5	**462.33**
1.0	**144.07**
1.5	**479.09**
2.0	**-102.8**
2.5	**-7.054**
3.0	**309.25**
FCC SPECIFICATION	**881.5 MHz (±0.05ppm) ±0.05ppm = ± 44.075Hz**
FCC RESULT	**PASS**

Transmit Frequency Deviation at +20°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	**Transmit Carrier Deviation (mHz)**
0	**238.60**
0.5	**51.648**
1.0	**512.80**
1.5	**-204.9**
2.0	**226.46**
2.5	**-229.6**
3.0	**60.022**
FCC SPECIFICATION	**881.5 MHz (±0.05ppm) ±0.05ppm = ± 44.075Hz**
FCC RESULT	**PASS**

Transmit Frequency Deviation at +10°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	**Transmit Carrier Deviation (mHz)**
0	**271.2**
0.5	**460.69**
1.0	**-110.2**
1.5	**518.22**
2.0	**505.56**
2.5	**-65.90**
3.0	**286.60**
FCC SPECIFICATION	**881.5 MHz (±0.05ppm) ±0.05ppm = ± 44.075Hz**
FCC RESULT	**PASS**

Transmit Frequency Deviation at 0°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	**Transmit Carrier Deviation (mHz)**
0	**440.19**
0.5	**533.63**
1.0	**201.69**
1.5	**303.03**
2.0	**62.525**
2.5	**141.21**
3.0	**378.52**
FCC SPECIFICATION	**881.5 MHz (±0.05ppm) ±0.05ppm = ± 44.075Hz**
FCC RESULT	**PASS**

Transmit Frequency Deviation at -10°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	**Transmit Carrier Deviation (mHz)**
0	**475.42**
0.5	**674.57**
1.0	**376.40**
1.5	**505.62**
2.0	**87.414**
2.5	**413.24**
3.0	**257.85**
FCC SPECIFICATION	**881.5 MHz (±0.05ppm) ±0.05ppm = ± 44.075Hz**
FCC RESULT	**PASS**

Transmit Frequency Deviation at -20°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	**Transmit Carrier Deviation (mHz)**
0	370.49
0.5	-61.44
1.0	1.7882
1.5	-29.55
2.0	435.51
2.5	-358.8
3.0	261.28
FCC SPECIFICATION	881.5 MHz (±0.05ppm) ±0.05ppm = ± 44.075Hz
FCC RESULT	PASS

Transmit Frequency Deviation at -30°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	**Transmit Carrier Deviation (mHz)**
0	-262.0
0.5	20.747
1.0	163.09
1.5	614.49
2.0	282.61
2.5	649.86
3.0	371.24
FCC SPECIFICATION	881.5 MHz (±0.05ppm) ±0.05ppm = ± 44.075Hz
FCC RESULT	PASS

Upon return to +25°C.

Transmit Frequency Deviation at +25°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	**Transmit Carrier Deviation (mHz)**
0	-59.36
0.5	458.10
1.0	-2.581
1.5	138.91
2.0	102.76
2.5	-133.1
3.0	584.49
FCC SPECIFICATION	881.5 MHz (±0.05ppm) ±0.05ppm = ± 44.075Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +25°C at 103% of Nominal Voltage, -49.44VDC	
Time (minutes)	**Transmit Carrier Deviation (mHz)**
0	505.17
0.5	-126.1
1.0	275.15
1.5	430.60
2.0	593.30
2.5	152.79
3.0	442.97
FCC SPECIFICATION	881.5 MHz (±0.05ppm) ±0.05ppm = ± 44.075Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +25°C at 106% of Nominal Voltage, -50.88VDC	
Time (minutes)	**Transmit Carrier Deviation (mHz)**
0	18.649
0.5	232.05
1.0	137.04
1.5	395.19
2.0	260.72
2.5	177.04
3.0	56.545
FCC SPECIFICATION	881.5 MHz (±0.05ppm) ±0.05ppm = ± 44.075Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +25°C at 109% of Nominal Voltage, -52.32VDC	
Time (minutes)	**Transmit Carrier Deviation (mHz)**
0	184.19
0.5	-62.71
1.0	-228.51
1.5	28.035
2.0	294.54
2.5	-124.8
3.0	249.76
FCC SPECIFICATION	881.5 MHz (±0.05ppm) ±0.05ppm = ± 44.075Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +25°C at 112% of Nominal Voltage, -53.76VDC	
Time (minutes)	Transmit Carrier Deviation (mHz)
0	-244.4
0.5	-194.1
1.0	445.55
1.5	605.62
2.0	450.36
2.5	293.64
3.0	385.58
FCC SPECIFICATION	881.5 MHz (±0.05ppm) ±0.05ppm = ± 44.075Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +25°C at 115% of Nominal Voltage, -55.20VDC	
Time (minutes)	Transmit Carrier Deviation (mHz)
0	-546.9
0.5	201.42
1.0	319.46
1.5	-9.827
2.0	297.54
2.5	185.19
3.0	457.56
FCC SPECIFICATION	881.5 MHz (±0.05ppm) ±0.05ppm = ± 44.075Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +25°C at 100% of Nominal Voltage, -48.0VDC	
Time (minutes)	Transmit Carrier Deviation (mHz)
0	36.173
0.5	623.76
1.0	481.71
1.5	181.27
2.0	-18.19
2.5	703.26
3.0	-97.67
FCC SPECIFICATION	881.5 MHz (±0.05ppm) ±0.05ppm = ± 44.075Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +25°C at -3% of Nominal Voltage, -46.56VDC	
Time (minutes)	Transmit Carrier Deviation (mHz)
0	73.065
0.5	-247.6
1.0	189.76
1.5	558.69
2.0	203.23
2.5	171.31
3.0	204.84
FCC SPECIFICATION	881.5 MHz (±0.05ppm) ±0.05ppm = ± 44.075Hz
FCC RESULT	PASS

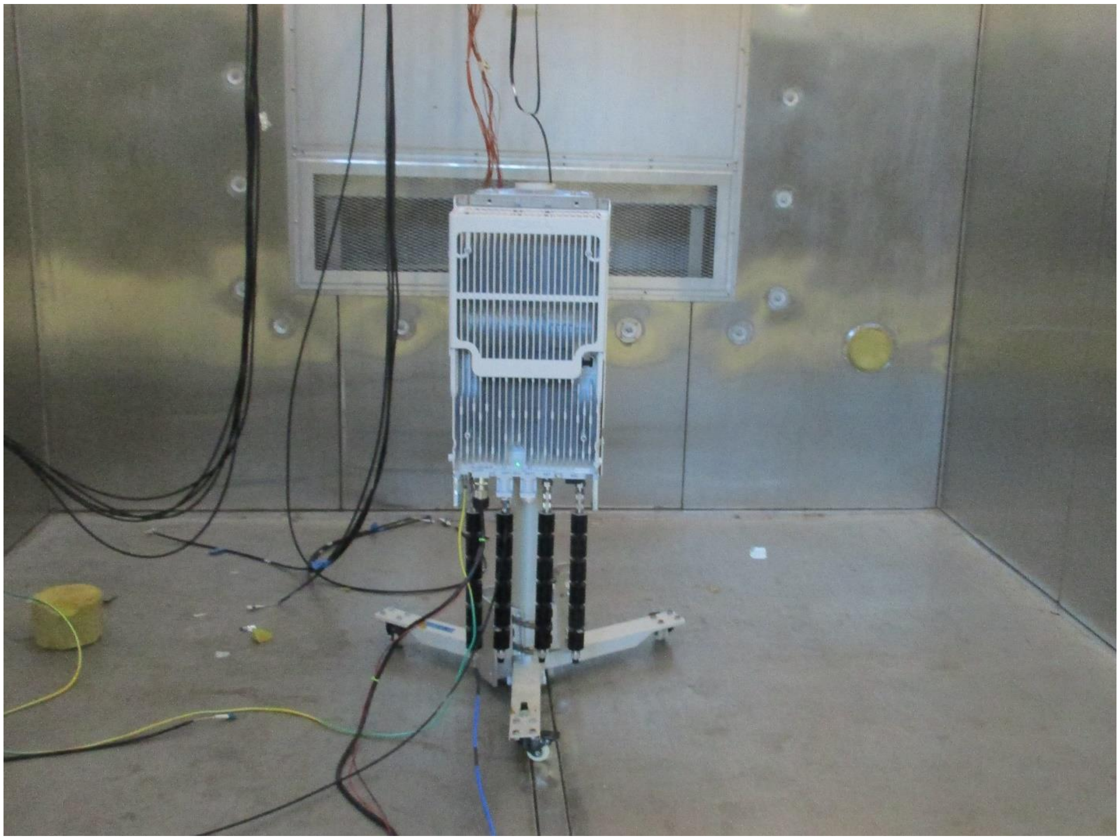
Transmit Frequency Deviation at +25°C at -6% of Nominal Voltage, -45.12VDC	
Time (minutes)	Transmit Carrier Deviation (mHz)
0	277.21
0.5	371.16
1.0	267.86
1.5	-131.7
2.0	260.78
2.5	94.389
3.0	268.40
FCC SPECIFICATION	881.5 MHz (±0.05ppm) ±0.05ppm = ± 44.075Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +25°C at -9% of Nominal Voltage, -43.68VDC	
Time (minutes)	Transmit Carrier Deviation (mHz)
0	138.02
0.5	264.51
1.0	563.28
1.5	102.05
2.0	-421.8
2.5	615.14
3.0	444.93
FCC SPECIFICATION	881.5 MHz (±0.05ppm) ±0.05ppm = ± 44.075Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +25°C at -12% of Nominal Voltage, -42.24VDC	
Time (minutes)	Transmit Carrier Deviation (mHz)
0	333.81
0.5	610.57
1.0	-417.9
1.5	151.33
2.0	-32.64
2.5	-263.5
3.0	365.03
FCC SPECIFICATION	881.5 MHz (±0.05ppm) ±0.05ppm = ± 44.075Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +25°C at -15% of Nominal Voltage, -40.80VDC	
Time (minutes)	Transmit Carrier Deviation (mHz)
0	288.72
0.5	126.01
1.0	30.529
1.5	-169.9
2.0	345.70
2.5	82.153
3.0	427.34
FCC SPECIFICATION	881.5 MHz (±0.05ppm) ±0.05ppm = ± 44.075Hz
FCC RESULT	PASS

Photographs

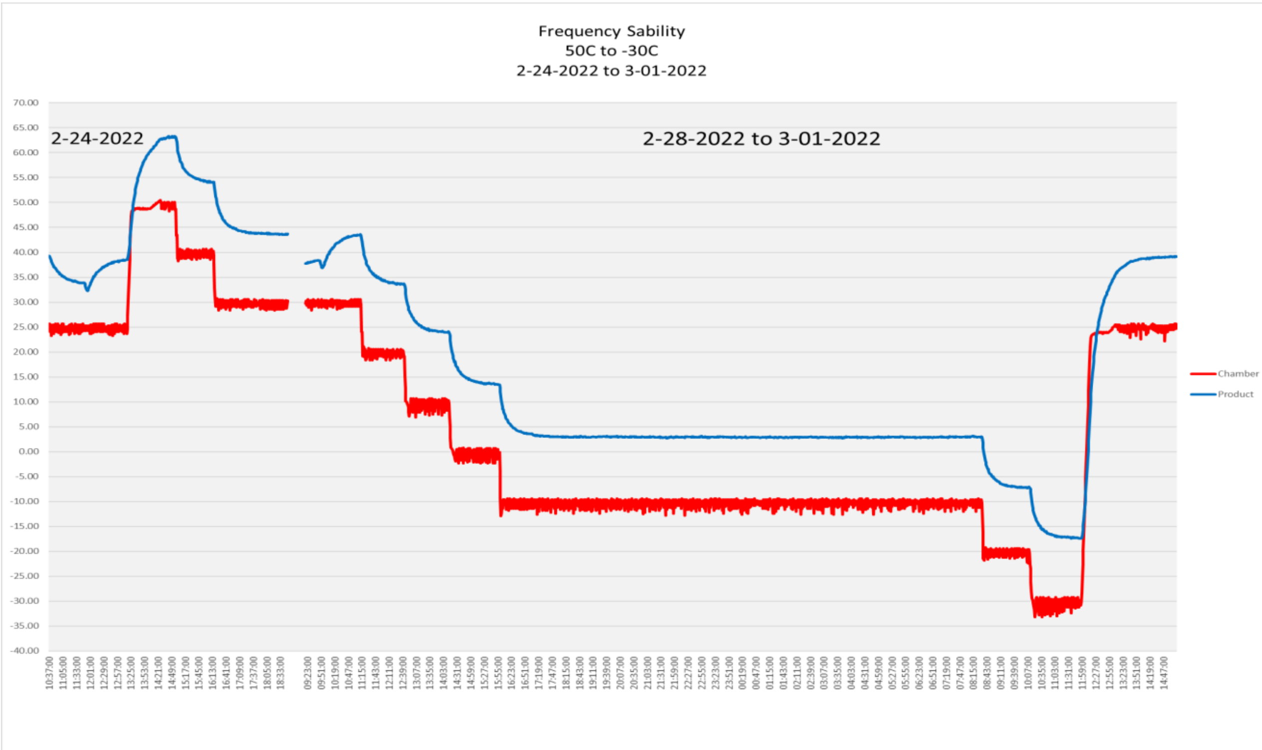


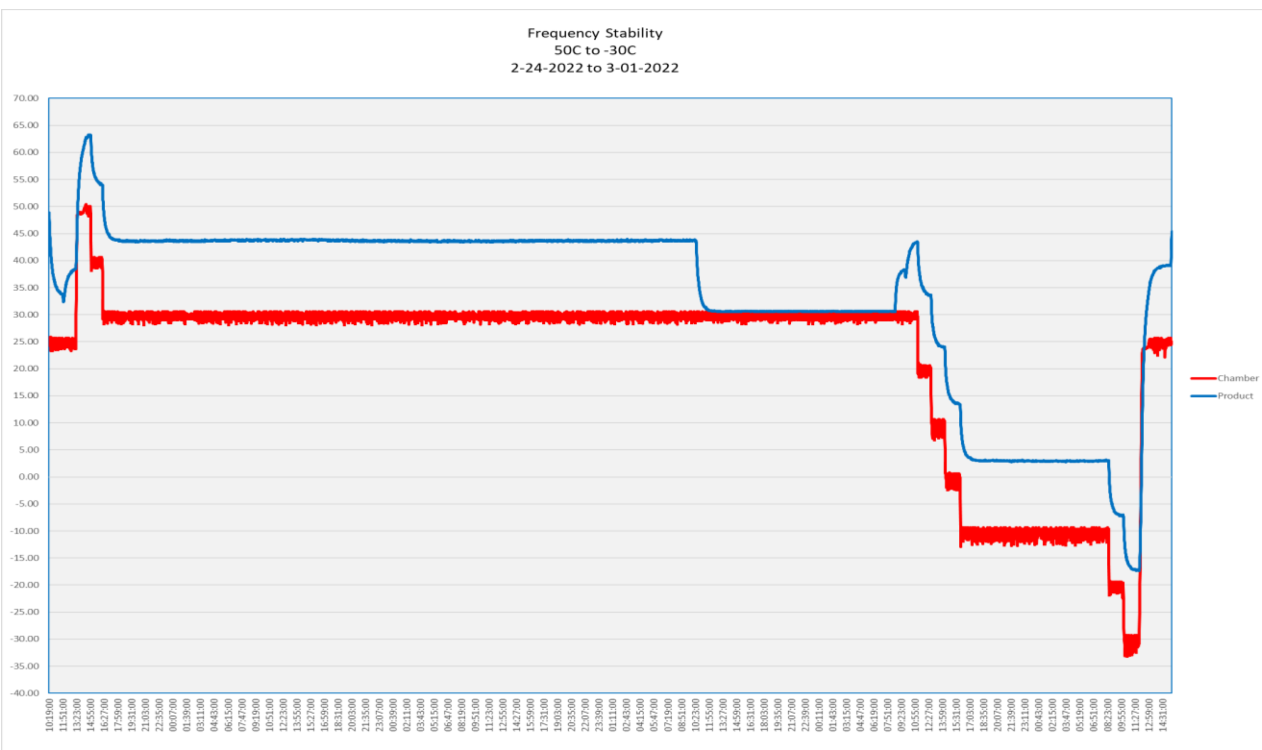
Test Equipment

Asset ID	Manufacturer	Type	Description	Model	Serial	Calibration Date	Calibration Due
TH535-T15	Envirotronics	Controller	Chamber Controller	Envirotronics SPPCM	SP001316	2022-02-16	2024-02-16
TH-T15	Envirotronics	Thermal Chamber	Thermal Chamber	N/A	3015242	CNR	CNR
TH069	Extech	Data Logger	Barometric Pressure/Humidity/Temperature	SD700	Q690305	2021-07-20	2023-07-20
TH017	Yokogawa	Recorder	MVAdvanced portable paperless recorder	MV2048	S5JC04823	2021-07-21	2023-08-21
MY57431033	KeySight Technologies	MXA Signal Analyzer	20 Hz-44 GHz (Analysis Bandwidth 125 MHz)	N9020B	MY5712033	2020-07-08	2022-07-08
TH073	Fluke	DMM	Digital Multimeter	87V	25910080	2022-02-24	2024-02-24
N/A	Power Ten	DC power supply	66V 330A DC Powersupply	R66C-60330	021AA9018	CNR	CNR

CNR: Calibration Not Required

Chamber Plots





8. 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).

2021-09-24 through 2022-09-30
Effective Dates

DEPARTMENT OF COMMERCE • UNITED STATES OF AMERICA

For the National Voluntary Laboratory Accreditation Program