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

Product Evaluated:
AHBCD AirScale Dual RRH 4T4R 240W

Report Number:
TR-2023-0100-FCC2-27

Date Issued:
August 8, 2023

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## Revisions

| Date | Revision | Section | Change |
|---|---|---|---|
| 8/8/2023 | 0 | | Initial Release |
| | | | |
| | | | |
| | | | |

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# 1. System Information and Requirements

| | |
|---|---|
| **Equipment Under Test (EUT):** | AHBCD AirScale Dual RRH 4T4R 240W |
| **Serial Number:** | RW2201000010 |
| **FCC ID:** | VBNAHBCD-01 |
| **Hardware Version:** | 476021A.X21 |
| **Software Version:** | SBTS23R4 |
| **Frequency Range:** | 746 – 756 MHz |
| **GPCL Project Number:** | 2023-0100 |
| **Applicant** | NOKIA SOLUTIONS AND NETWORKS<br>Steve Mitchell<br>3201 Olympus Blvd,<br>Dallas, Texas 75019<br>United States |
| **Test Requirement(s):** | Title 47 CFR Parts 2 and 27 |
| **Test Standards:** | • Title 47 CFR Parts 2 and 27<br>• KDB 971168 D01 Power Measurement License Digital Systems v03r01 April 9, 2018.<br>• KDB 662911 D01 Multiple Transmitter Output v02r01 Oct 2013<br>• ANSI C63.26 (2015)<br>• ANSI C63.4 (2014) |
| **Measurement Procedure(s):** | • FCC-IC-OB - GPCL Power Measurement, Occupied Bandwidth & Modulation Test Procedure 6-20-2019<br>• FCC-IC-SE - GPCL Spurious Emissions Test Procedure 6-20-2019 |
| **Test Date(s):** | 7/12/2023 – 7/20/2023 |
| **Test Performed By:** | Nokia<br>Global Product Compliance Laboratory<br>600-700 Mountain Ave.<br>P.O. Box 636<br>Murray Hill, NJ 07974-0636<br>Test Site Number: US5302 |
| **Product Engineer(s):** | Ron Remy |
| **Lead Engineer:** | Steve Gordon |
| **Test Engineer (s):** | Nilesh Patel, Norman Albrecht |
| **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 **AHBCD AirScale Dual RRH 4T4R 240W**, hereinafter referred to as the Equipment Under Test (EUT).

The Nokia AHBCD AirScale Dual RRH 4T4R 240W is a low power Remote Radio Head (RRH) , operating in the Frequency Band 746-756 MHz.

The AHBCD consists of four transceiver chains (main and diversity) that are capable of transmitting up to a maximum RF Conducted power of 80 W and EIRP power of 1640 W/MHz (62.15dBm).

The AHBCD is typically installed on poles or walls in fixed locations. Therefore, AHBCD is neither a portable nor a mobile wireless device.

## 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.

The purpose of this current test program is to demonstrate 5G-NR operation at 80W power for the following bandwidths in the frequency band 746 – 758 MHz:

- 5 MHz
- 10MHz

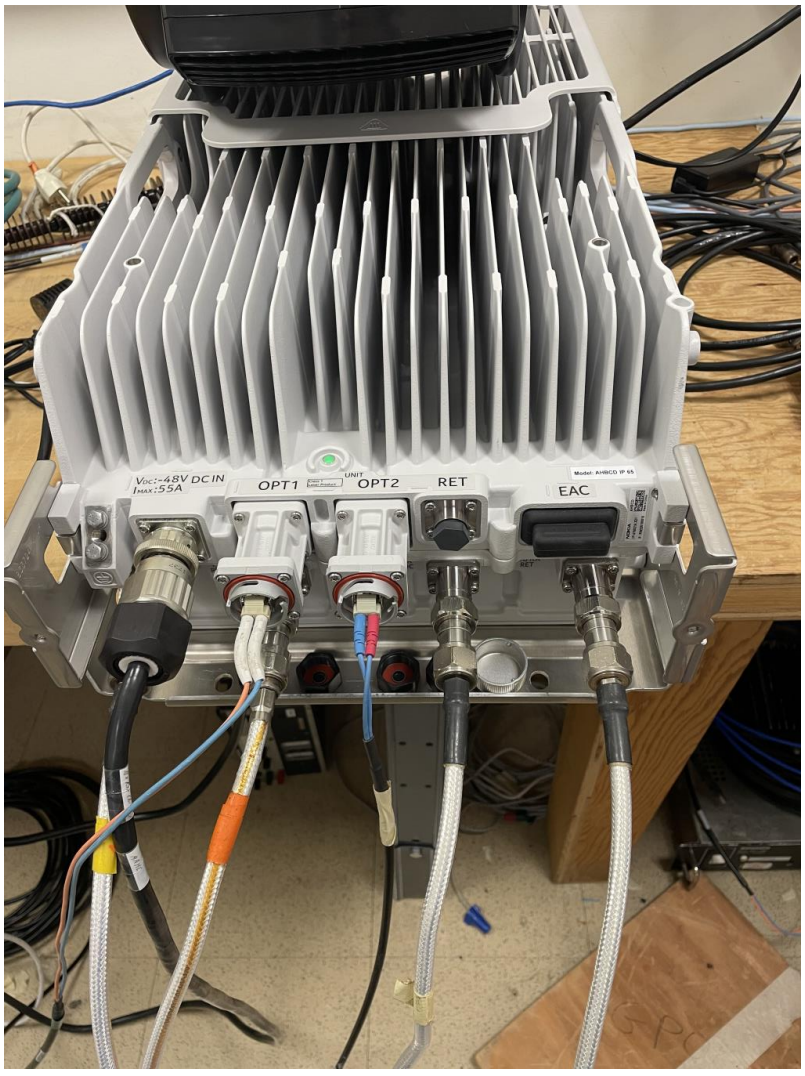
No Frequency Stability testing was considered necessary for this test program since there were no changes to the basic frequency determining and stabilizing circuitry (including clock and data rates).

## 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** | 746 – 756 MHz |
| **Channel Bandwidth** | 5 and 10 MHz |
| **Number of Tx Ports per Unit** | 4 |
| **MIMO** | Yes |
| **Deployment Environment** | Outdoor |
| **Supply Voltage** | -48.0 VDC |
| **Max RF Output Power** | 4X20 W (43.01 dBm ± 2.0dBm) |

## 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<br>(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). Refer to GPCL Project 2022-0010 for Results.

## 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<br>30 MHz – 200 MHz V<br>200 MHz – 1000 MHz H<br>200 MHz – 1000 MHz V<br>1 GHz - 18 GHz | ±5.1 dB<br>±5.1 dB<br>±4.7 dB<br>±4.7 dB<br>±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<br>100 Hz<br>10 kHz to 1 MHz<br>1MHz | 9 kHz to 20 MHz<br>20 MHz to 1 GHz<br>1 GHz to 10 GHz<br>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

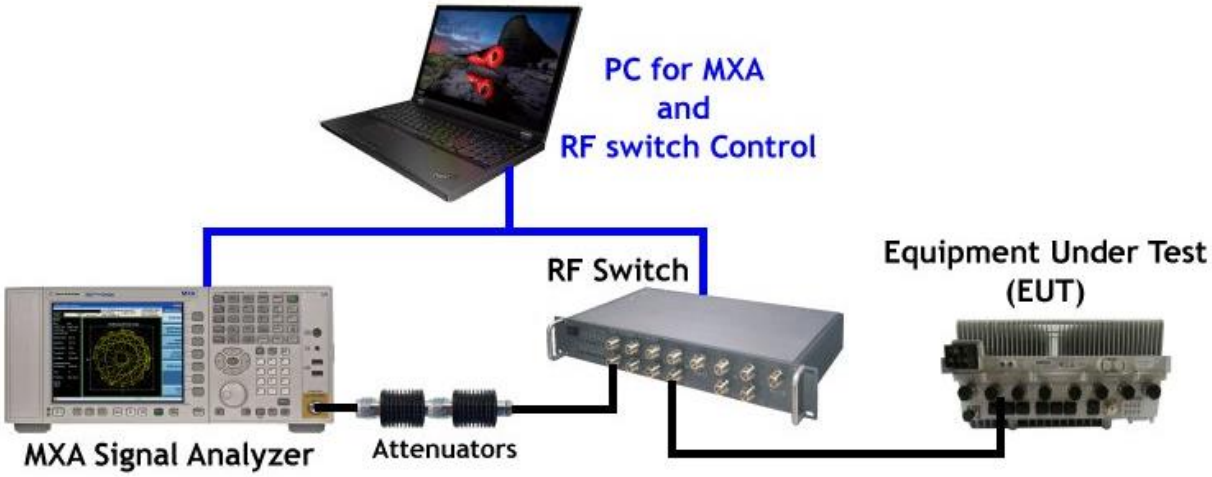
| Requirement | Description | Result |
|---|---|---|
| **47 CFR FCC Parts 2 and 27** | | |
| 2.1046, 27.50 | RF Power Output<br>Peak to Average Power Ratio | COMPLIES |
| 2.1047 | Modulation Characteristics | COMPLIES |
| 2.1049, 27.53 | (a) Occupied Bandwidth<br>(b) Edge of Band Emissions | COMPLIES |
| 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).

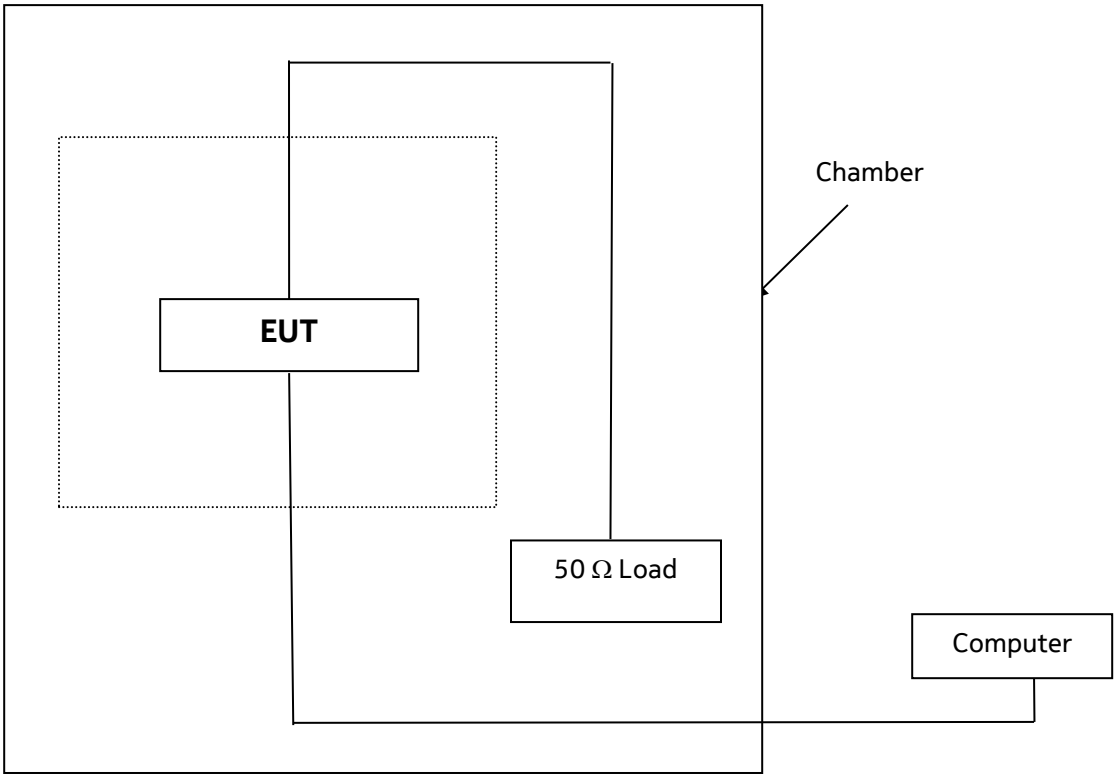
1. **COMPLIES -** Passed all applicable tests.
2. **N/A –** Not Applicable.
3. **NT –** Not Tested.

## 1.8 Test Configurations

Test Setup for all Antenna Port Measurements




Test Setup for Radiated Measurement



# 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

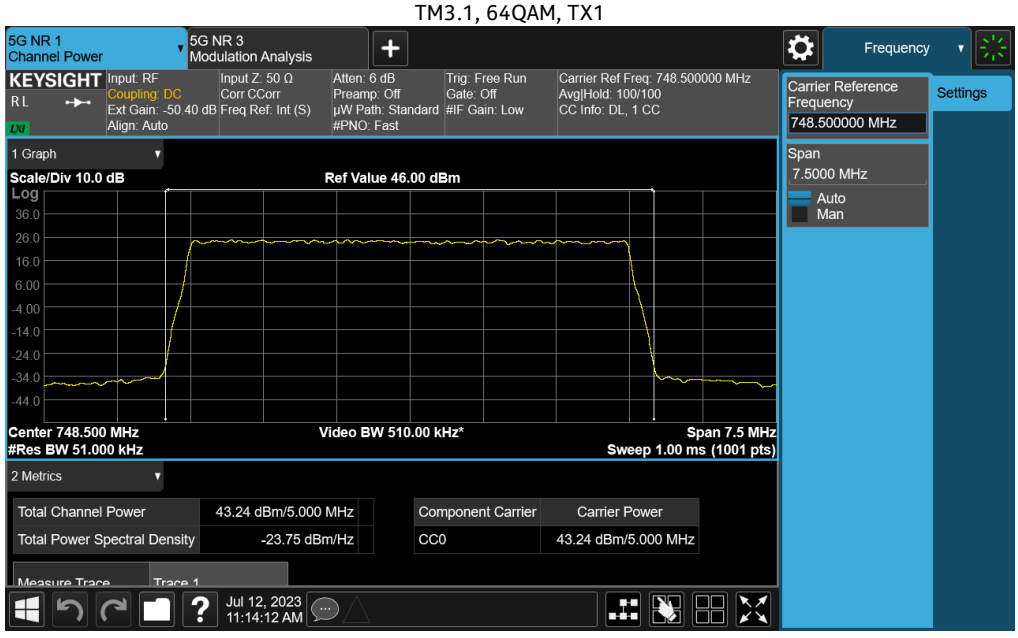
**Tabular Data – RF Power (5G-NR)**

| Test Model 3.1<br>Modulation 64QAM<br>Channel Frequency 748.5MHz<br>Signal BW 5MHz | | Test Model 3.1<br>Modulation 64QAM<br>Channel Frequency 751MHz<br>Signal BW 10MHz | | Test Model 3.1a<br>Modulation 256QAM<br>Channel Frequency 753.5MHz<br>Signal BW 5MHz | |
|---|---|---|---|---|---|
| TX Port | (dBm) | TX Port | (dBm) | TX Port | (dBm) |
| 0 | 43.10 | 0 | 42.98 | 0 | 43.11 |
| 1 | **43.24** | 1 | **43.00** | 1 | **43.22** |
| 2 | 43.14 | 2 | 43.00 | 2 | 43.08 |
| 3 | 43.10 | 3 | 42.93 | 3 | 43.11 |
| Total Power (dBm) | 49.17 | Total Power (dBm) | 49.00 | Total Power (dBm) | 49.15 |
| Total Power (W) | 82.53 | Total Power (W) | 79.40 | Total Power (W) | 82.24 |

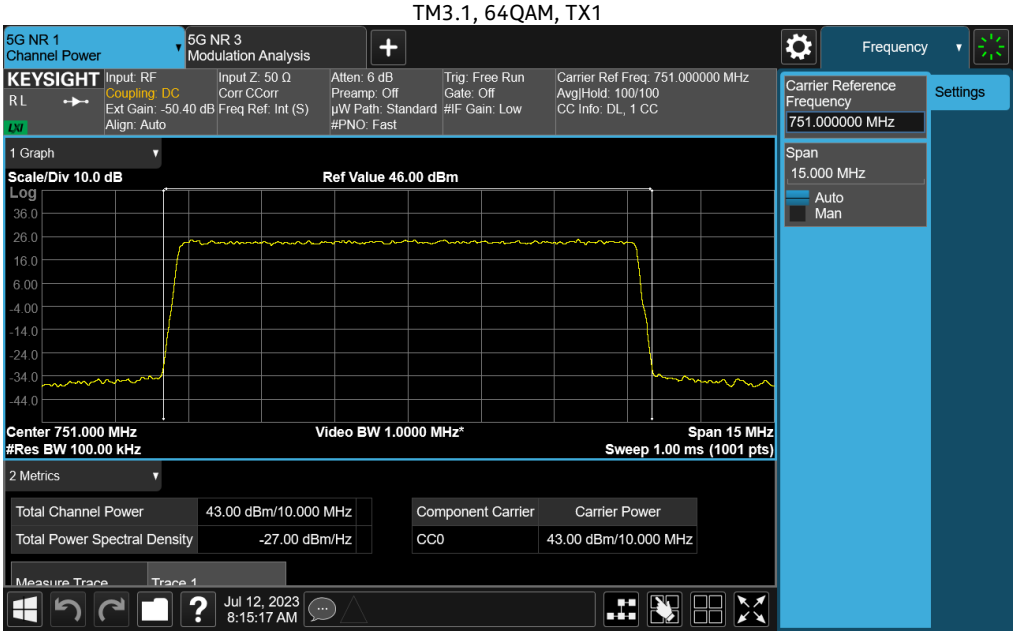
### 2.1.1 Channel RF Power – Plots

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.

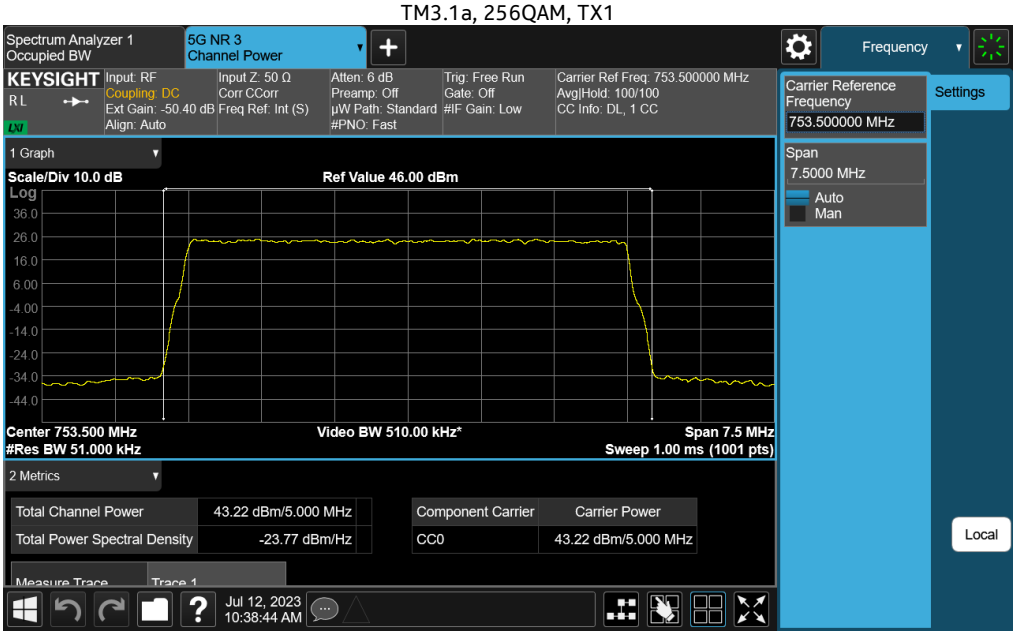
5G-NR, 5MHz BW, 748.5MHz
TM3.1, 64QAM, TX1



5G-NR, 10MHz BW, 751MHz
TM3.1, 64QAM, TX1




5G-NR, 5MHz BW, 753.5MHz
TM3.1a, 256QAM, TX1



## 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.

**Tabular Data – PAPR Data**

| Signal BW MHz | Test Model | Modulation | TX Port | Channel Frequency MHz | PAR at 0.1% Limit - 13 dB |
|---|---|---|---|---|---|
| 5 | 3.1 | 64QAM | 1 | 748.5 | 6.71 |
| 10 | 3.1 | 64QAM | 1 | 751 | **6.75** |
| 5 | 3.1a | 256QAM | 1 | 753.5 | 6.71 |

### 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.

5G-NR, 10MHz BW, 751MHz, TM3.1, 64QAM, TX1

# 3. FCC Section 2.1047 - Modulation Characteristics

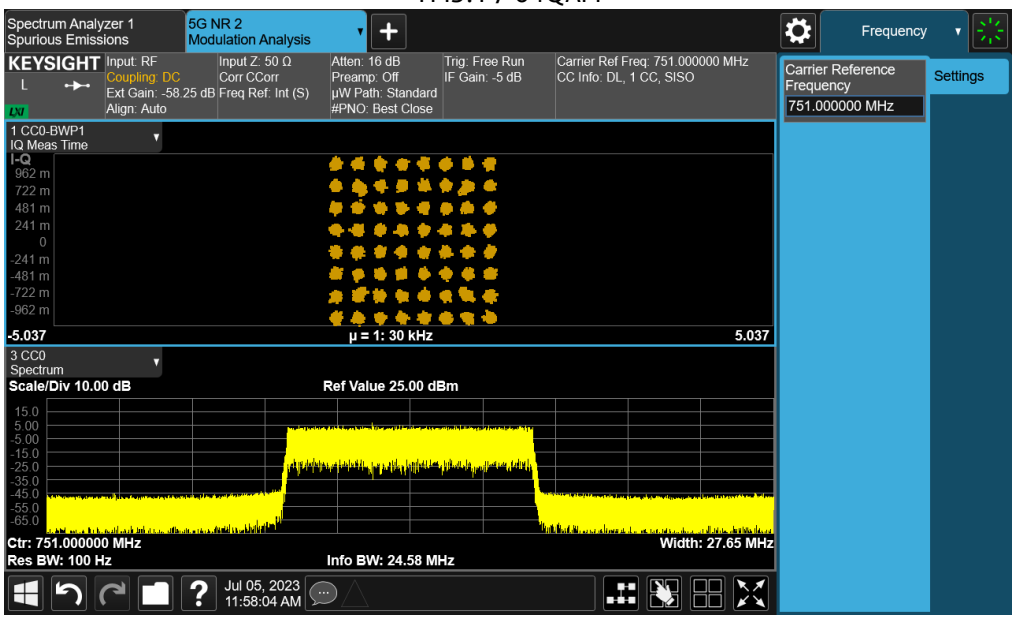
## 3.1 Modulation Characteristics

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

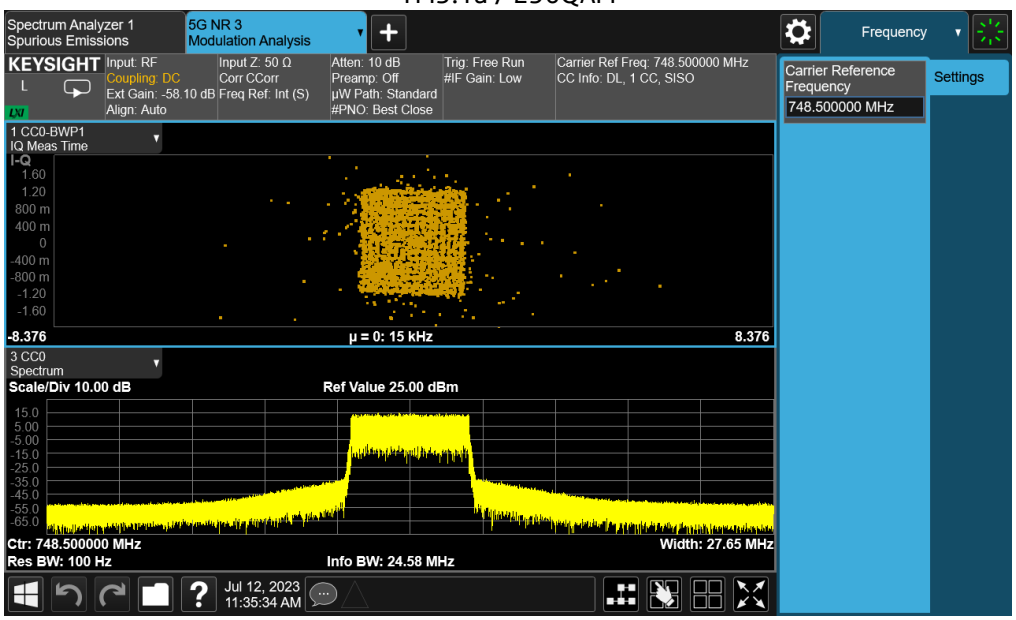
### 3.1.1 Modulation Characteristics Plot(s)

The typical measured modulation characteristics of the EUT are shown below:

TM3.1 / 64QAM




TM3.1a / 256QAM



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

## 4.1 Occupied Bandwidth

In 47CFR 2.1049 the FCC requires:

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

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

**Tabular Data – 99% Occupied Bandwidth**

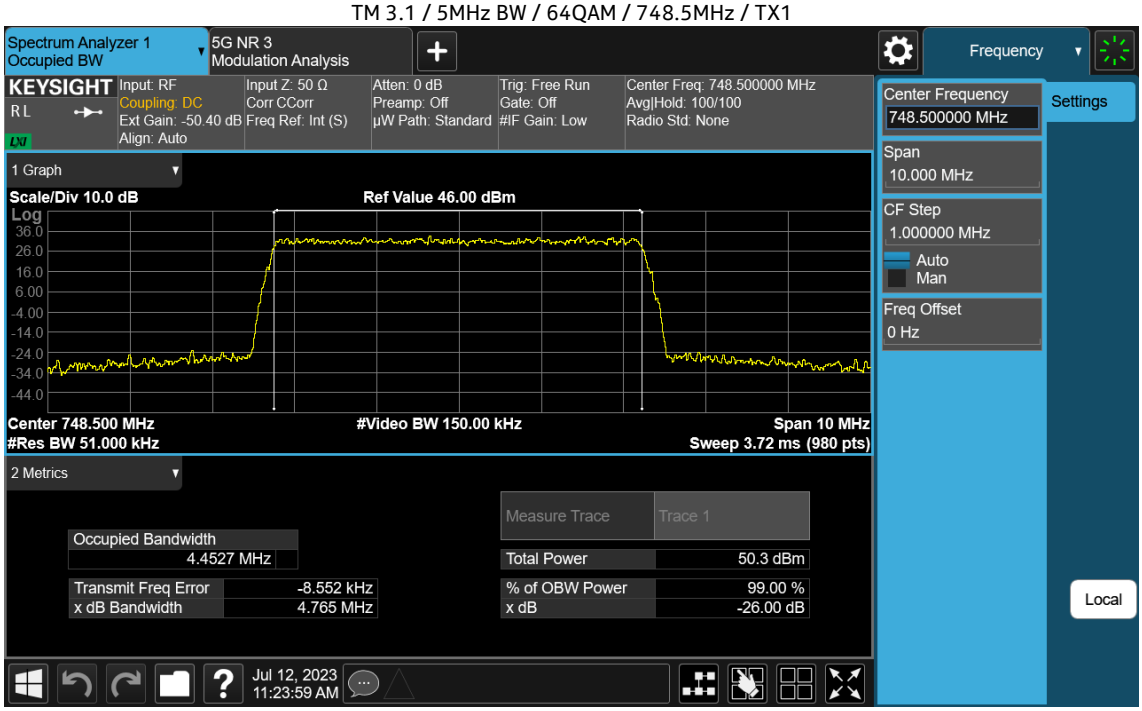
| Signal BW MHz | Test Model | Modulation | TX Port | Channel Frequency MHz | 99% Occupied BW MHz |
|---|---|---|---|---|---|
| 5 | 3.1 | 64QAM | 1 | 748.5 | 4.4527 |
| 10 | 3.1 | 64QAM | 1 | 751.0 | 9.2641 |
| 5 | 3.1a | 256QAM | 1 | 753.5 | 4.4737 |

**Tabular Data – 26 dB Occupied Bandwidth**

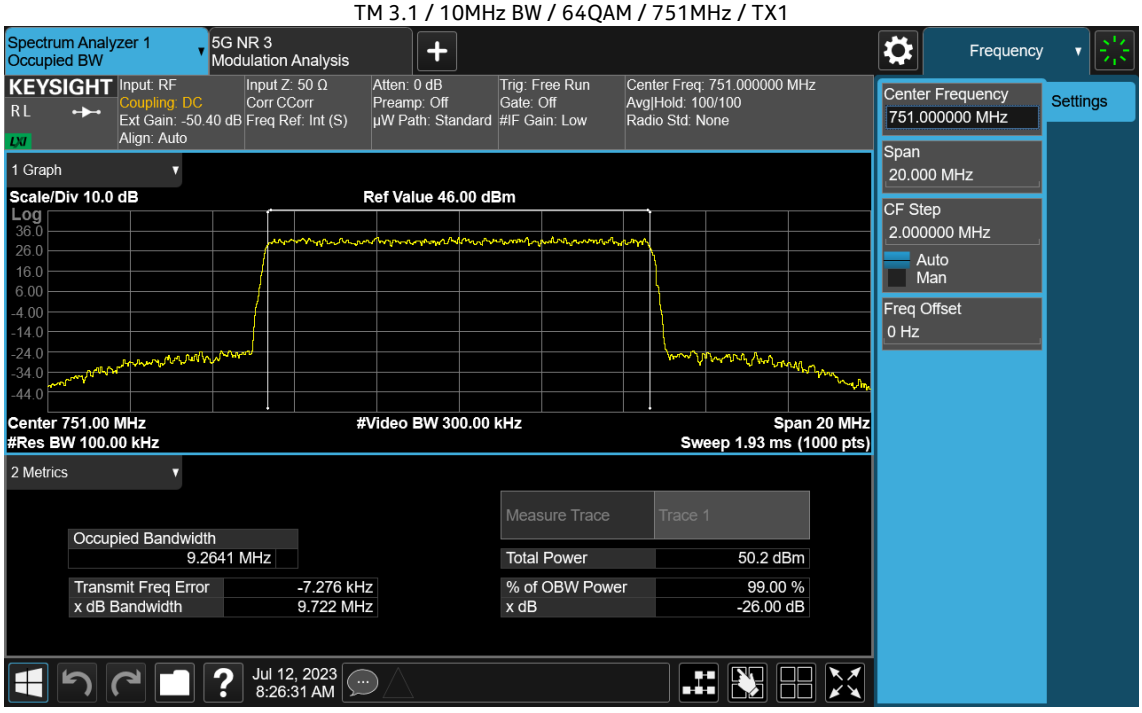
| Signal BW MHz | Test Model | Modulation | TX Port | Channel Frequency MHz | 26dB Emission Bandwidth MHz |
|---|---|---|---|---|---|
| 5 | 3.1 | 64QAM | 1 | 748.5 | 4.765 |
| 10 | 3.1 | 64QAM | 1 | 751.0 | 9.722 |
| 5 | 3.1a | 256QAM | 1 | 753.5 | 4.799 |

## 4.2 Occupied Bandwidth – Plots

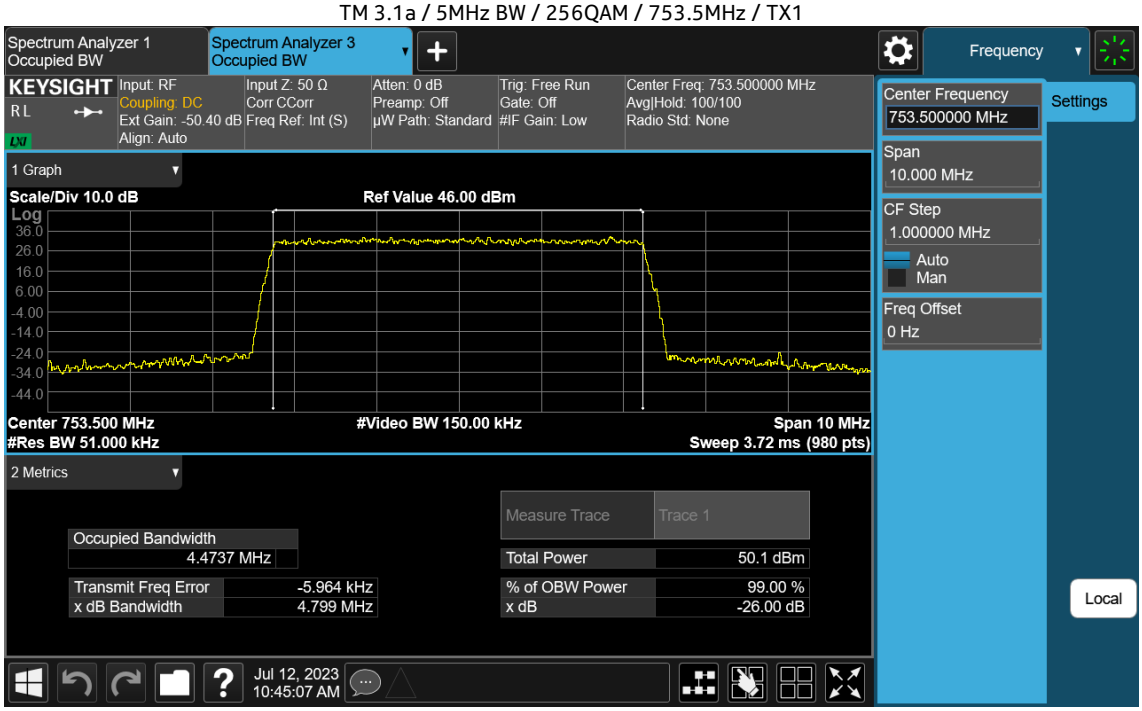
TM 3.1 / 5MHz BW / 64QAM / 748.5MHz / TX1




TM 3.1 / 10MHz BW / 64QAM / 751MHz / TX1



TM 3.1a / 5MHz BW / 256QAM / 753.5MHz / TX1



## 4.3 Edge of band Emissions

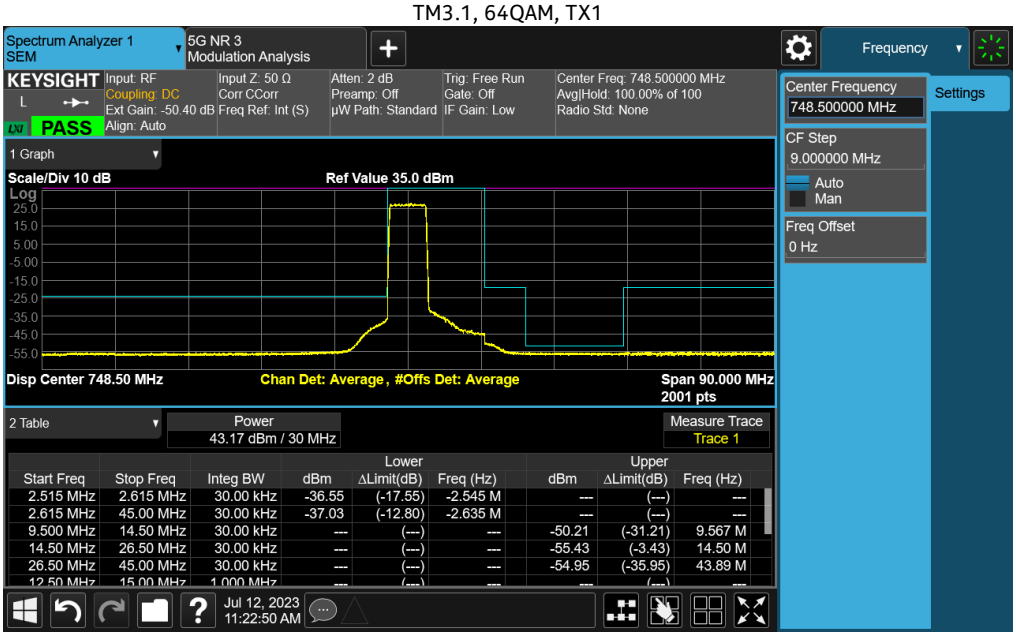
The Edge of Band emissions of the EUT at the external antenna connector (EAC) were measured using a Keysight MXA Signal Analyzer. The RF output from the EAC port to signal analyzer was reduced (to an amplitude usable by the signal analyzer) by using a calibrated attenuator. The path attenuation was offset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

The base station was configured to transmit a single carrier continuously (≥ 98% duty cycle) between 746 – 756 MHz. At each of the carrier frequencies, the carrier power level at each antenna terminal was adjusted to the maximum rated mean power +43 dBm (20W). In accordance with KDB 662911 D01 Multiple Transmitter Output, the limit has been adjusted to -19 dBm to reflect 10 log(n) where n=4 for the 4x4 MIMO operation.

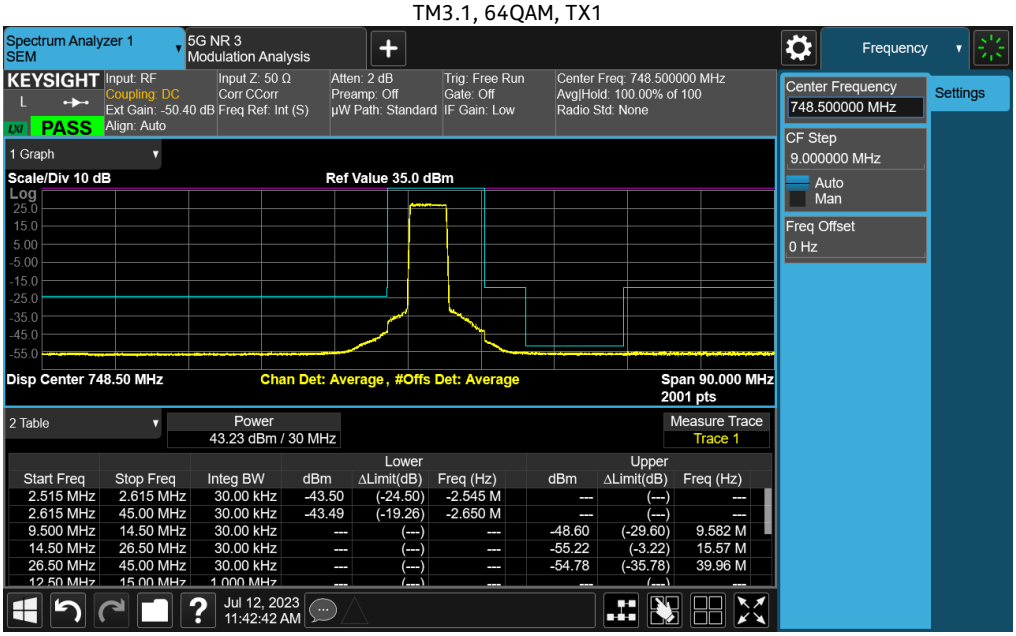
### 4.3.1 Edge of Band Emissions – Plots

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

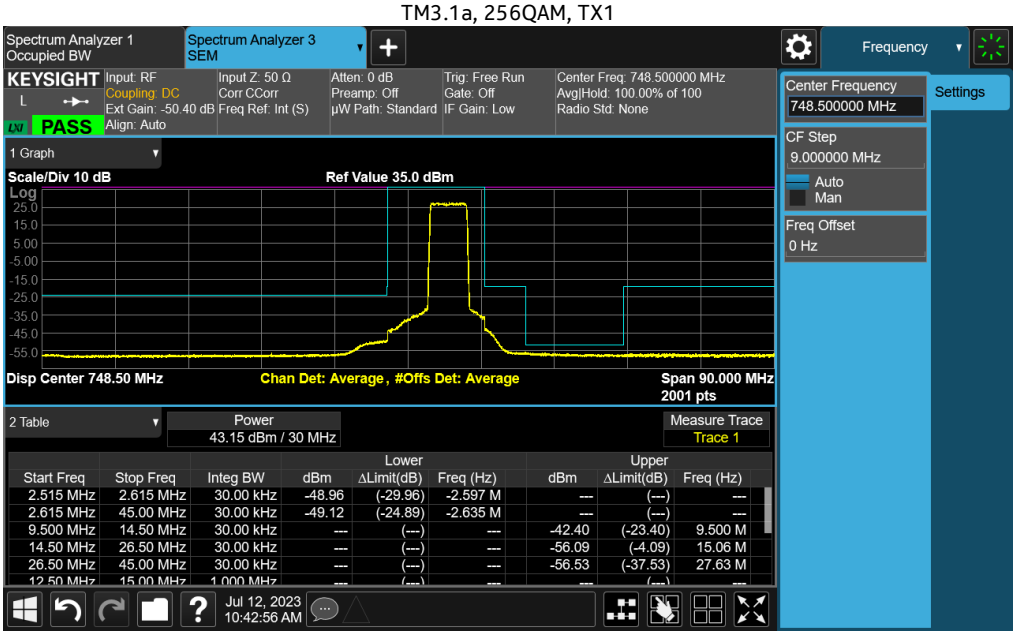
5G-NR, 5MHz BW, 748.5MHz
TM3.1, 64QAM, TX1



5G-NR, 10MHz BW, 751MHz
TM3.1, 64QAM, TX1




5G-NR, 5MHz BW, 753.5MHz
TM3.1a, 256QAM, TX1



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

## 5.1 Measurement of Spurious Emissions at Transmit Antenna Port

Spurious Emissions at the transmit-antenna terminals were investigated over the frequency range of 10 MHz to beyond the 10th harmonic of the specific transmit band. 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.

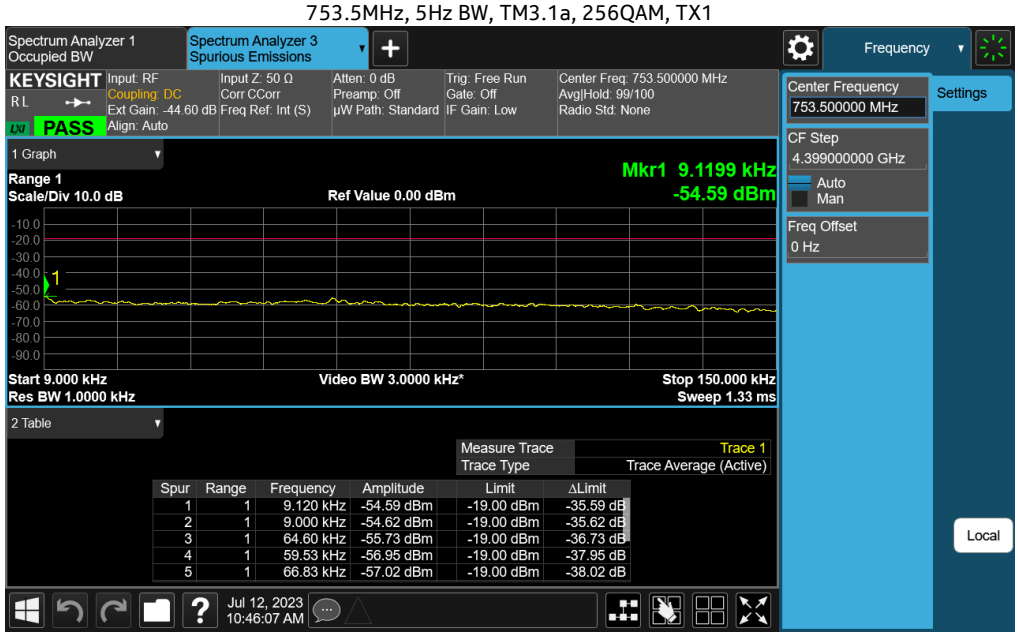
NOTE: Only plots with lowest margin in each frequency range are used in this report. The full suite of raw data resides at the MH, New Jersey location.

### 5.1.1 Transmitter Spurious Emissions – Plots

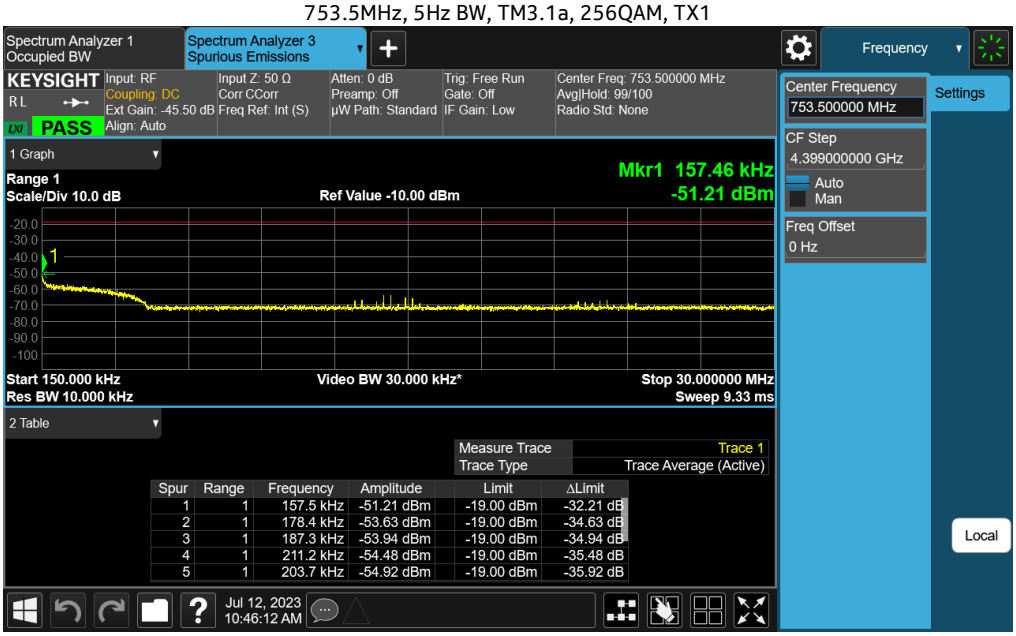
The spurious emissions measured were all below the required limits and are in full compliance with the Rules of the Department.

NOTES: Only plots with minimum margin plots are used in this report. The full suite of raw data resides at the MH, New Jersey location.

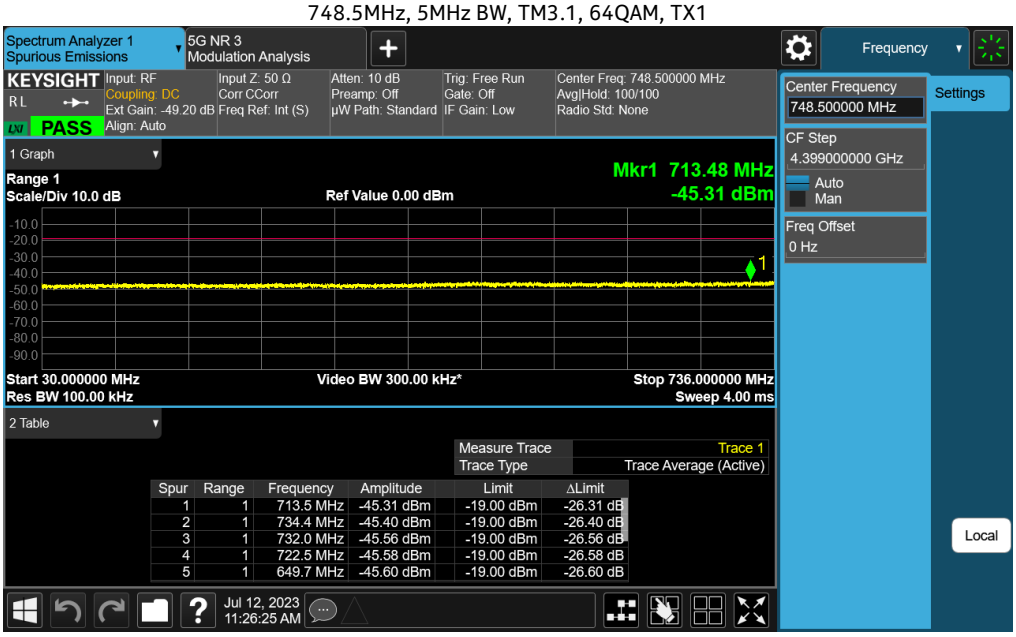
9kHz – 150kHz
753.5MHz, 5Hz BW, TM3.1a, 256QAM, TX1



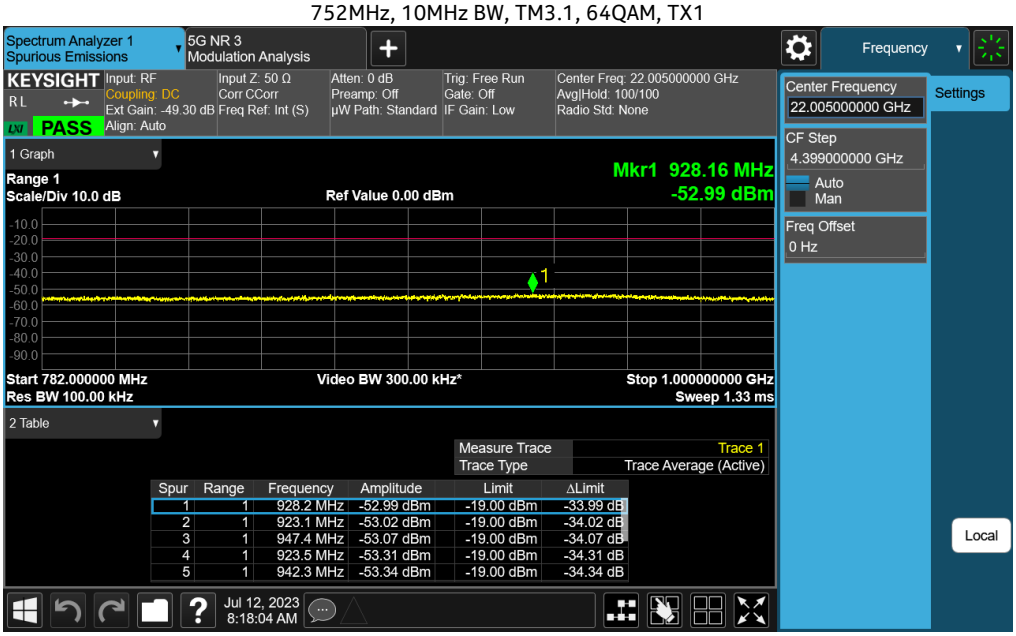
150kHz – 30MHz
753.5MHz, 5Hz BW, TM3.1a, 256QAM, TX1



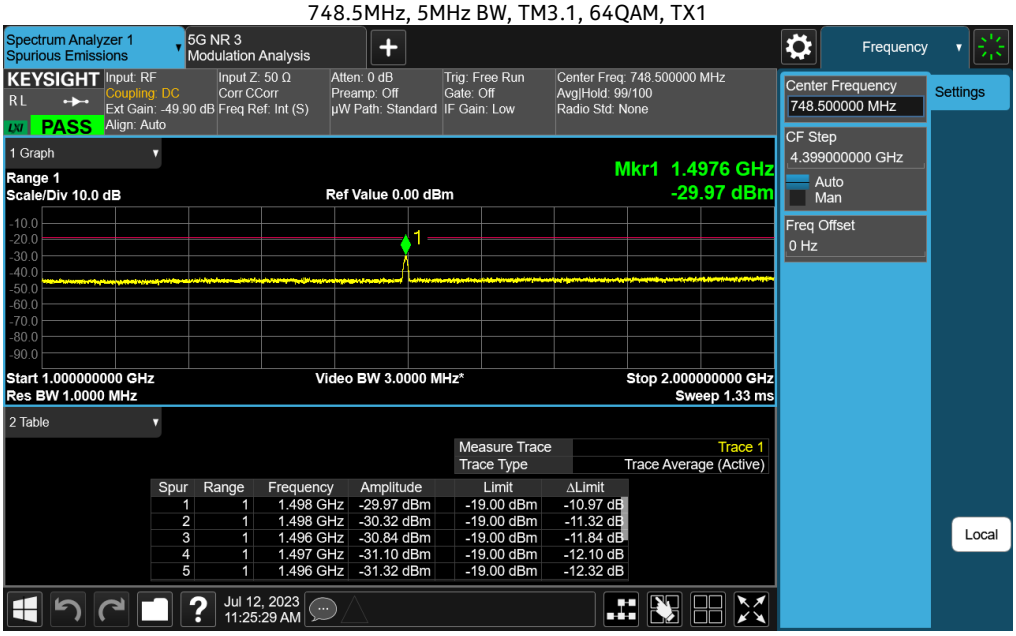

30MHz – 736MHz
748.5MHz, 5MHz BW, TM3.1, 64QAM, TX1



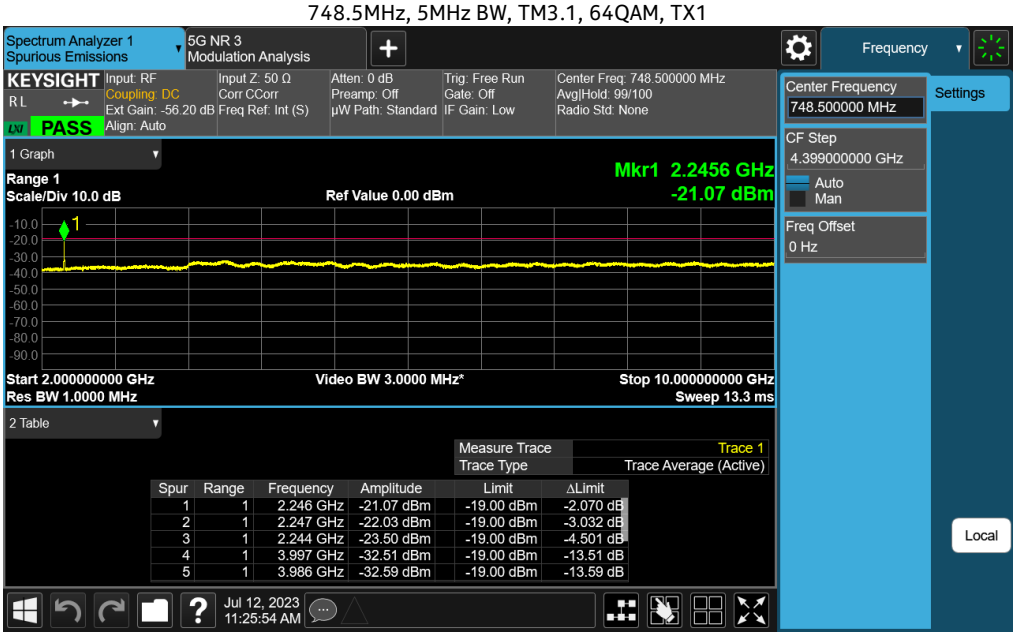
782MHz – 1GHz
752MHz, 10MHz BW, TM3.1, 64QAM, TX1




1GHz – 2GHz
748.5MHz, 5MHz BW, TM3.1, 64QAM, TX1



2GHz – 10GHz
748.5MHz, 5MHz BW, TM3.1, 64QAM, TX1



# 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, 30 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:

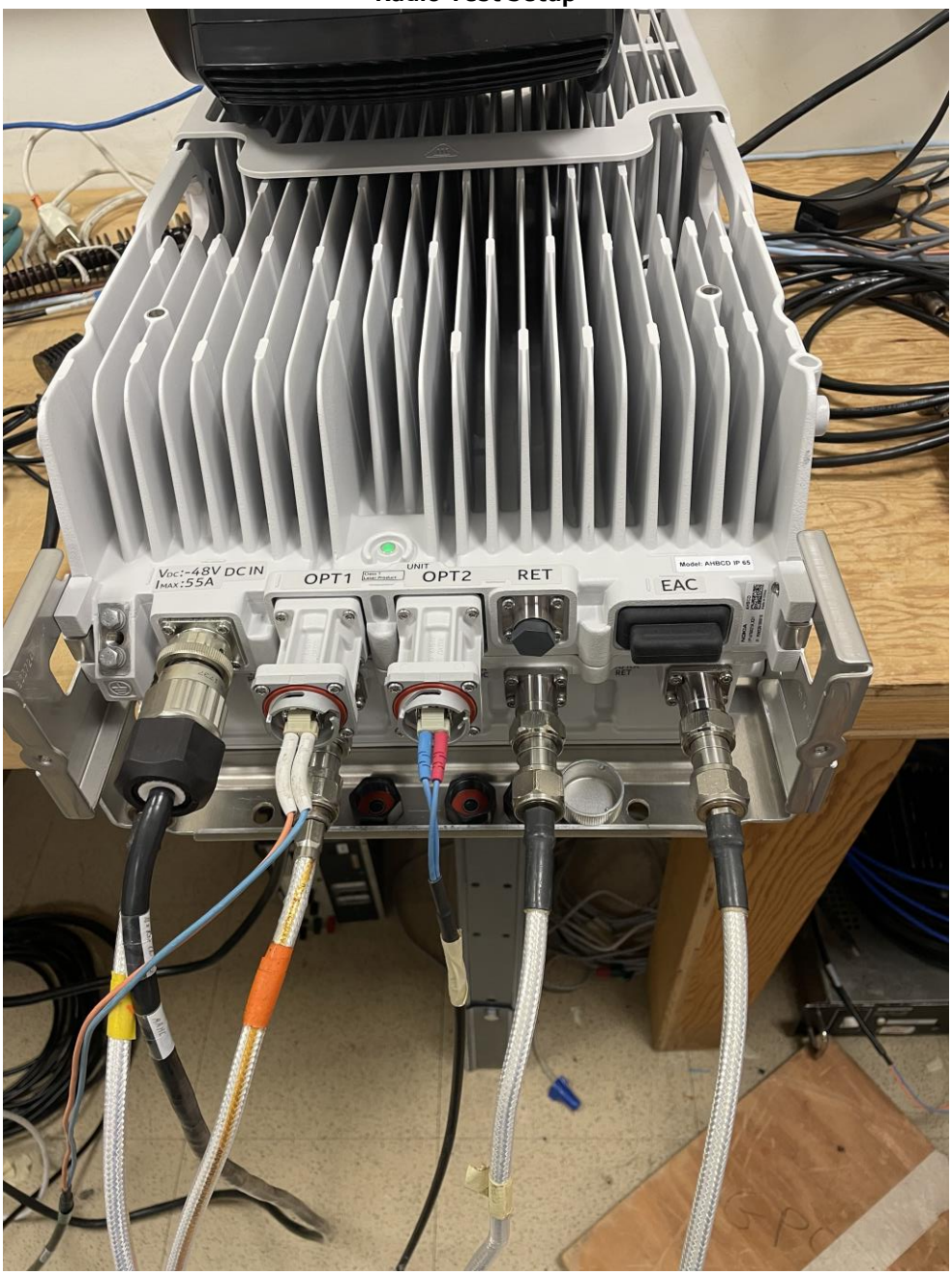
For compliance with 47CFR Parts 2 and 27, the field strength of any spurious radiation, measured at 3m, is required to be less than 82.23 dBµV/meter (82.23 @ 3m). Emissions equal to or less than 62.23 dBµV/meter at 3m are not reportable and may be verified using field strength measurements and broadband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

# 7. FCC Section 2.1053 – Frequency Stability

Frequency Stability testing not required. Refer to GPCL project 2022-0010 for results.

## Photographs

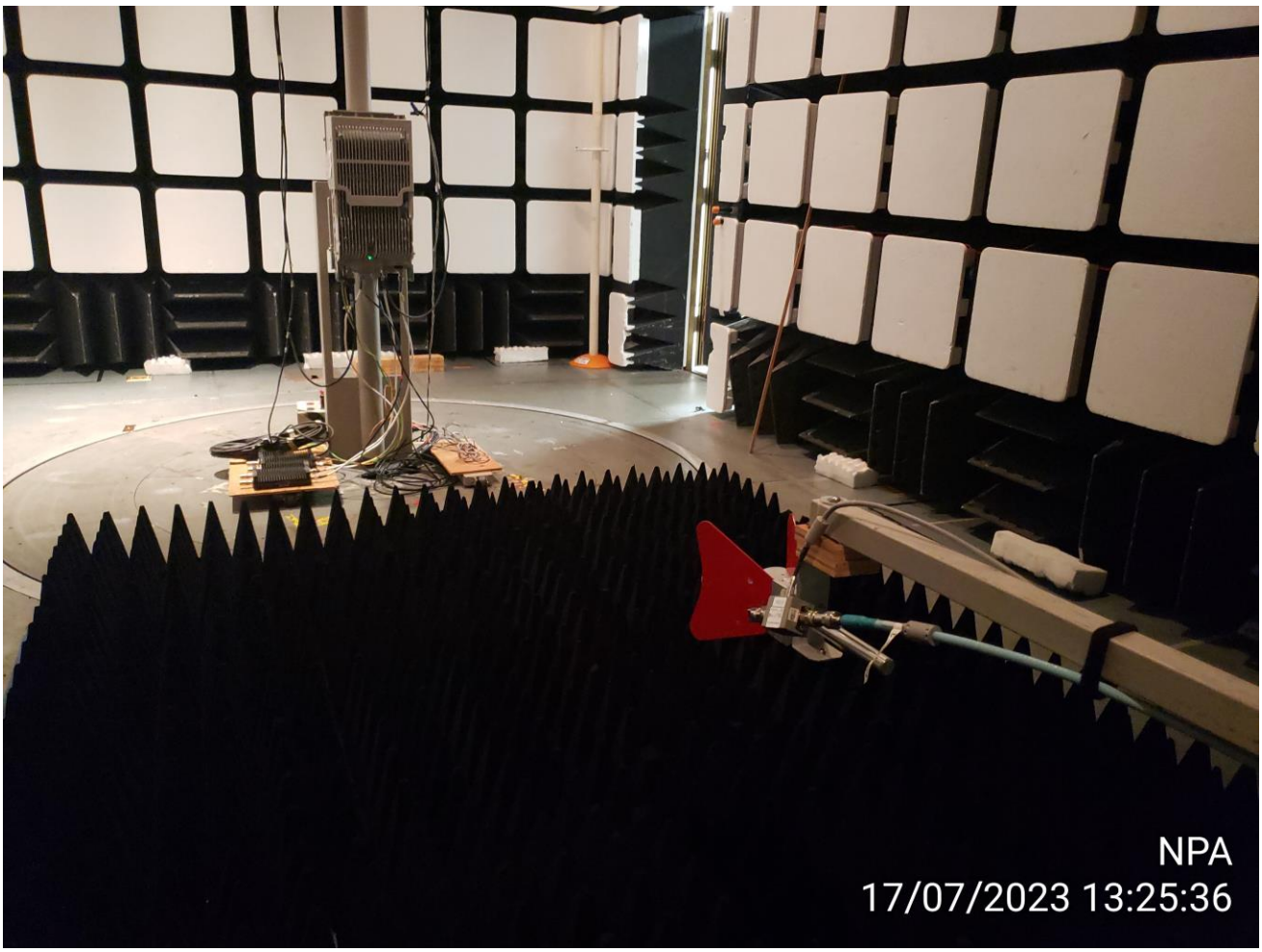
**Radio Test Setup**



## Radiated Emission Test Setup

**30MHz – 1GHz**

**1GHz-15GHz**



## Test Equipment List

**Radio 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 |
| | Weinschel | Attenuator | 20dB/50W DC-8.5GHz | 24-20-12-LIM | CE5786 | CNR-V | CNR-V |
| | Weinschel | Attenuator | 10dB 25W DC - 18GHz | 46-10-34 | BH8105 | CNR-V | CNR-V |
| | Fairview Microwave | Attenuator | 30dB/150W, DC – 18GHz | 66-30-34 | BJ5920 | CNR-V | CNR-V |
| | Weinschel | Attenuator | 30dB/150W DC-18GHz | 6528-30-34-LIM | BN4177 | CNR-V | CNR-V |
| | Weinschel | Attenuator | 30dB/150W DC-18GHz | 6528-30-34-LIM | BN4181 | CNR-V | CNR-V |
| | Fairview Microwave | Attenuator | 10 dB, DC - 40 GHz, 20 watt | SA4023-10 | N/A | CNR-V | CNR-V |
| | Weinschel | Attenuator | 30 dB / 150 W | 66-30-33 | BV2473 | CNR-V | CNR-V |

CNR-V: Calibration Not Required. Must Be Verified.
Test Date: 7/12/2023

**Radiated Emission Test Equipment**

| Asset ID | Manufacturer | Type | Description | Model | Serial | Calibration Date | Calibration Due |
|---|---|---|---|---|---|---|---|
| EIH43 | A.H. Systems Inc. | Bilogical Antenna | 25 - 2000 MHz | SAS-521-2 | 511 | 2021-09-09 | 2023-09-09 |
| E1073 | ETS Lindgren | Horn Antenna | Double-Ridged Waveguide Horn 1-18 GHz | 3117 | 00135198 | 2023-06-06 | 2025-06-06 |
| E1119 | Extech | Data Logger | Pressure Humidity Temp data logger | SD700 | Q668960 | 2022-12-13 | 2024-12-13 |
| E1608 | KeySight Technologies | EMI Receiver | MXE EMI Receiver, 3 Hz - 44 GHz | N9038B | MY61380146 | 2022-11-29 | 2024-11-29 |
| E1604 | KeySight Technologies | Pre-Amplifier | 0.1 - 18.0GHz, 15dbM | 87405C | MY61410017 | 2023-05-18 | 2025-05-18 |
| E814 | Sonoma Instrument Co. | Amplifier | 9kHz-1GHz | 310N | 186747 | 2022-11-30 | 2024-11-30 |

Test Date: 7/18/2023 – 7/20/2023

# 8. NVLAP Certificate of Accreditation

United States Department of Commerce
National Institute of Standards and Technology

NVLAP®

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## 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*