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Title 47 Code of Federal Regulations

Test Report

Regulation:
FCC Part 2 and 27

Client:
NOKIA SOLUTIONS AND NETWORKS, Oy

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

Report Number:
TR-2022-0055-FCC2-27

Date Issued:
June 29, 2022

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Table of Contents

1. SYSTEM INFORMATION AND REQUIREMENTS	4
1.1 INTRODUCTION	5
1.2 PURPOSE AND SCOPE	5
1.3 EUT DETAILS	5
1.3.1 <i>Specifications</i>	5
1.3.2 <i>Photographs</i>	6
1.4 TEST REQUIREMENTS.....	7
1.5 TEST STANDARDS & MEASUREMENT PROCEDURES	7
1.5.1 <i>Test Standards</i>	7
1.5.2 <i>Measurement Procedures</i>	7
1.6 MEASUREMENT UNCERTAINTY	8
1.7 EXECUTIVE SUMMARY.....	8
1.8 TEST CONFIGURATIONS.....	9
2. FCC SECTION 2.1046 - RF POWER OUTPUT	10
2.1 CHANNEL RF POWER	10
2.2 CHANNEL RF POWER – PLOTS.....	11
2.3 PEAK-TO-AVERAGE POWER RATIO (PAPR)	13
2.3.1 <i>Peak-to-Average Power Ratio Plot(s)</i>	13
3. FCC SECTION 2.1047 - MODULATION CHARACTERISTICS	14
3.1 MODULATION CHARACTERISTICS	14
3.1.1 <i>Modulation Characteristics – Plot(s)</i>	14
4. FCC SECTION 2.1049 – OCCUPIED BANDWIDTH/EDGE OF BAND EMISSIONS	15
4.1 OCCUPIED BANDWIDTH.....	15
4.1.1 <i>Occupied Bandwidth - 1 Carrier Plots</i>	16
4.2 EDGE OF BAND EMISSIONS.....	17
4.2.1 <i>Edge of Band Emissions – Plots</i>	18
5. FCC SECTION 2.1051 - SPURIOUS EMISSIONS AT TRANSMIT ANTENNA PORT.....	20
5.1 MEASUREMENT OF SPURIOUS EMISSIONS AT TRANSMIT ANTENNA PORT	20
6. FCC SECTION 2.1053 - FIELD STRENGTH OF SPURIOUS RADIATION	26
6.1 SECTION 2.1053 FIELD STRENGTH OF SPURIOUS EMISSIONS	26
6.2 FIELD STRENGTH OF SPURIOUS EMISSIONS - LIMITS	26
7. NVLAP CERTIFICATE OF ACCREDITATION	27

Revisions

Date	Revision	Section	Change
6/29/2022	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):	AWHHF Airscale Micro RRH 4T4R 5G n41 4x20W
Serial Number:	EB2038R0181
FCC ID:	2AD8UAWHFF01
Hardware Version:	475181A.102
Software Version:	SBTS22R4
Frequency Range:	2496-2690 MHz
GPCL Project Number:	2022-0055
Applicant	Nokia Solutions and Networks, Oy Lee Klinkenborg 2000 Lucent Lane Naperville, IL 60563
Test Requirement(s):	Title 47 CFR Parts 2 and 27
Test Standards:	<ul style="list-style-type: none"> • Title 47 CFR Parts 2 and 27 • KDB 971168 D01 Power Measurement License Digital Systems v03r01 April 9, 2018. • KDB 662911 D01 Multiple Transmitter Output v02r01 Oct 2013 • ANSI C63.26 (2015) • ANSI C63.4 (2014)
Measurement Procedure(s):	<ul style="list-style-type: none"> • FCC-IC-OB - GPCL Power Measurement, Occupied Bandwidth & Modulation Test Procedure 6-20-2019 • FCC-IC-SE - GPCL Spurious Emissions Test Procedure 6-20-2019
Test Date(s):	6/15/2022 – 6/16/2022
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):	Jaideep Yadav
Test Results:	The EUT, <i>as tested</i> met the above listed Test Requirements. The decision rule employed is binary (Pass/Fail) based on the measured values without accounting for Measurement Uncertainty or any Guard Band. The measured values obtained during testing were compared to a value given in the referenced regulation or normative standard. Report copies and other information not contained in this report are held by either the product engineer or in an identified file at the Global Product Compliance Laboratory in New Providence, NJ.

1.1 Introduction

This Conformity test report applies to the AWHHF Airscale Micro RRH 4T4R 5G n41 4x20W, hereinafter referred to as the Equipment Under Test (EUT).

1.2 Purpose and Scope

The purpose of this document is to provide the testing data required for qualifying the EUT in compliance with FCC Parts 2 and 27 measured in accordance with the procedures set out in Section 2.1033 (c) (14) of the Rules.

This report covers Class II Permissive Change to add modes of operation for Split Mode (two frequencies transmitted simultaneously from 2 ports) and Concurrent LTE and 5 G multi carrier configurations. Testing addresses the Maximum and Minimum of the Multi Carrier configurations with the Maximum and Minimum IBW demonstrated and includes mixed 5G-NR and LTE Technology to demonstrate all carrier combinations of equal number of carriers and with IBW not less than or exceeding the demonstrated BW. The AWHHF product is certified under FCC ID: 2AD8UAWHHF01.

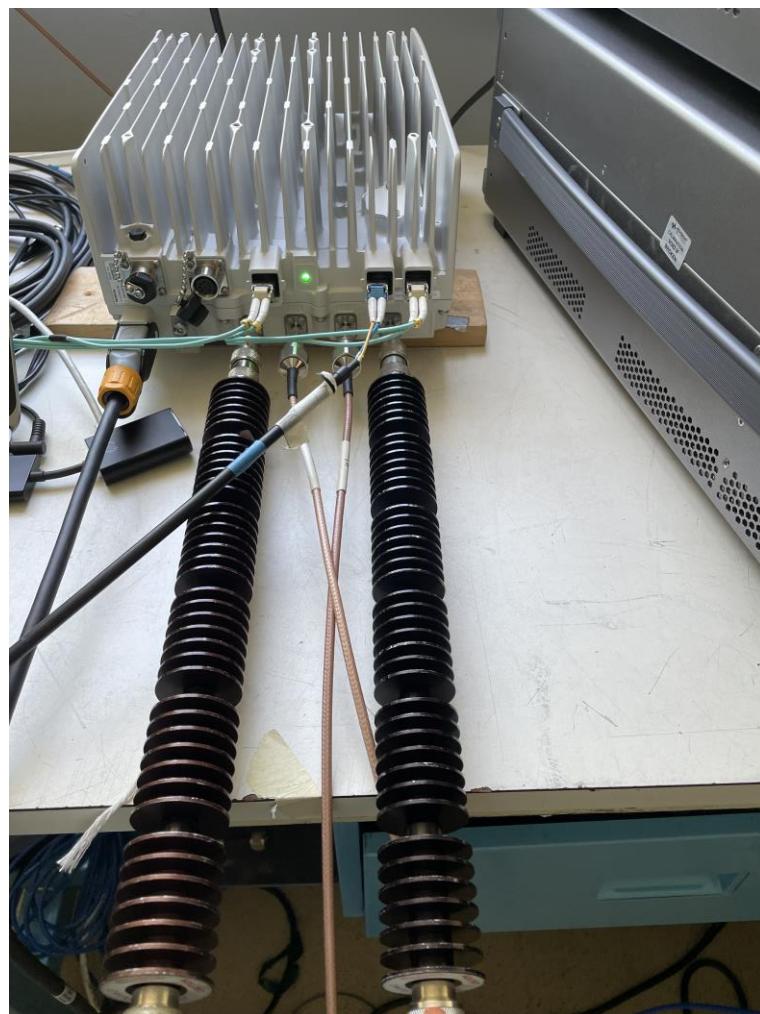
No Frequency Stability testing was considered necessary for this test program since there were no changes to the basic frequency determining and stabilizing circuitry (including clock and data rates).

1.3 EUT Details

1.3.1 Specifications

Specification Items	Description
Radio Access Technology	5G-NR & LTE
Duplex Mode	Time Division Duplex (TDD)
Modulation Type(s)	QPSK, 16QAM, 64QAM, 256QAM
Operation Frequency Range	2496-2690 MHz
Channel Bandwidth	Multicarrier - 2 to 4 carriers of approved single carrier bandwidth and technology with contiguous bandwidth of 120 - 160 MHz.
Number of Tx Ports per Unit	4
Power	20 W/port (43.0 dBm) +/- 2.0 dBm
MIMO	MIMO 4T4R
Deployment Environment	Outdoor
Supply Voltage	-48.0 VDC

1.3.2 Photographs



1.4 Test Requirements

Each required measurement is listed below:

47 CFR FCC Sections	Description of Tests	Test Required
2.1046, 27.53	RF Power Output	Yes
2.1047, 27.53	Modulation Characteristics	Yes
2.1049, 27.53	(a) Occupied Bandwidth (b) Out-of-Band Emissions	Yes
2.1051, 27.53	Spurious Emissions at Antenna Terminals	Yes
2.1053, 27.53	Field Strength of Spurious Radiation	Yes
2.1055, 27.53	Frequency Stability	No*

*Previously evaluated; no changes to the basic frequency determining and stabilizing circuitry (including clock and data rates).

1.5 Test Standards & Measurement Procedures

1.5.1 Test Standards

- Title 47 Code of Federal Regulations, Federal Communications Commission Part 2.
- Title 47 Code of Federal Regulations, Federal Communications Commission Part 27.
- KDB 971168 D01 Power Measurement License Digital Systems v03r01 April 9, 2018.
- KDB 662911 D01 Multiple Transmitter Output v02r01 Oct 2013
- ANSI C63.26-2015, American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services
- ANSI C63.4-2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

1.5.2 Measurement Procedures

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

1.6 MEASUREMENT UNCERTAINTY

The results of the calculations to estimate uncertainties for the several test methods and standards are shown in the Table below. These are the worst-case values.

Worst-Case Estimated Measurement Uncertainties

Standard, Method or Procedure	Condition	Frequency MHz	Expanded Uncertainty (k=2)
a. Classical Emissions, (e.g., ANSI C63.4, CISPR 11, 14, 32, etc., using ESHS 30,	Conducted Emissions	0.009 - 30	±3.5 dB
	Radiated Emissions (AR-6 Semi-Anechoic Chamber)	30 MHz – 200MHz H 30 MHz – 200 MHz V 200 MHz – 1000 MHz H 200 MHz – 1000 MHz V 1 GHz - 18 GHz	±5.1 dB ±5.1 dB ±4.7 dB ±4.7 dB ±3.3 dB
Antenna Port Test	Signal Bandwidth	Frequency Range	Expanded Uncertainty (k=2), Amplitude
Occupied Bandwidth, Edge of Band, Conducted Spurious Emissions	10 Hz 100 Hz 10 kHz to 1 MHz 1MHz	9 kHz to 20 MHz 20 MHz to 1 GHz 1 GHz to 10 GHz 10 GHz to 40 GHz:	1.78 dB
RF Power	10 Hz to 20 MHz	50 MHz to 18 GHz	0.5 dB

1.7 Executive Summary

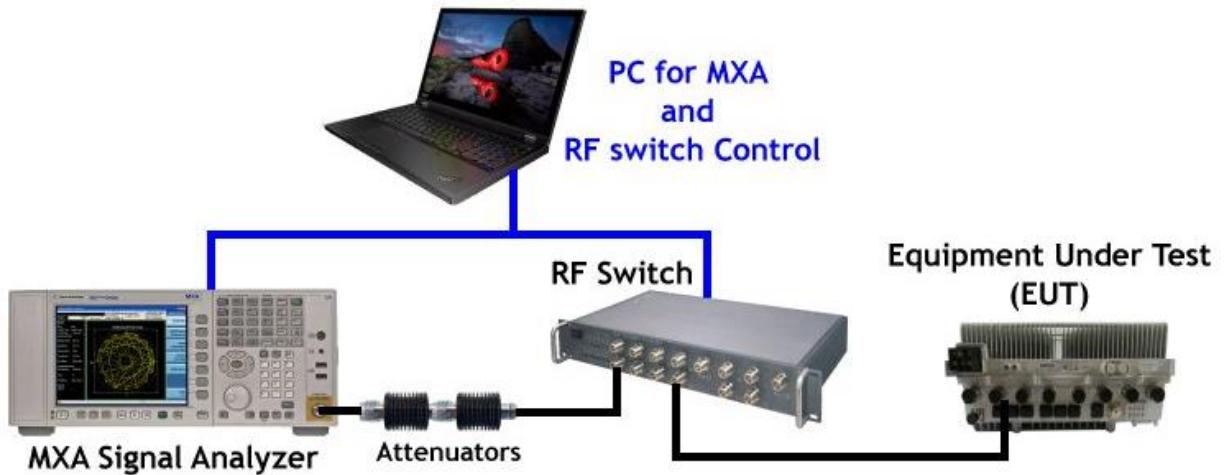
Requirement	Description	Result
47 CFR FCC Parts 2 and 27		
2.1046, 27.50	RF Power Output Peak to Average Power Ratio	COMPLIES
2.1047	Modulation Characteristics	COMPLIES
2.1049, 27.53	(a) Occupied Bandwidth (b) Edge of Band Emissions	COMPLIES
2.1051, 27.53	Spurious Emissions at Antenna Terminals	COMPLIES
2.1053, 27.53	Field Strength of Spurious Radiation	COMPLIES
2.1055, 27.54	Frequency Stability	NT*

*Previously evaluated; no changes to the basic frequency determining and stabilizing circuitry (including clock and data rates).

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

1.8 Test Configurations

Test Setup for all Antenna Port Measurements



2. FCC Section 2.1046 - RF Power Output

This test is a measurement of the total RF power level transmitted at the antenna-transmitting terminal. The product was configured for test as shown in section above and allowed to warm up and stabilize per KDB 971168 D01 and ANSI C63.26. Power measurements were made with an MXA Signal Analyzer.

2.1 Channel RF Power

2C Channel RF Power

Channel Power - 5G-NR 100MHz + 20MHz					
Test Model 1.1 Modulation QPSK Channel Frequency 2546+2606 MHz		Test Model 1.1 Modulation QPSK Channel Frequency 2546 + 2680 MHz		Test Model 1.1 Modulation QPSK Channel Frequency 2620 + 2680 MHz	
TX Port	(dBm)	TX Port	(dBm)	TX Port	(dBm)
1	42.40	1	42.04	1	42.49
2	42.84	2	42.52	2	42.49
3	42.76	3	42.41	3	42.32
4	42.80	4	42.46	4	42.44
Total Power (dBm)	48.72	Total Power (dBm)	48.38	Total Power (dBm)	48.46
Total Power (W)	74.54	Total Power (W)	68.90	Total Power (W)	70.08

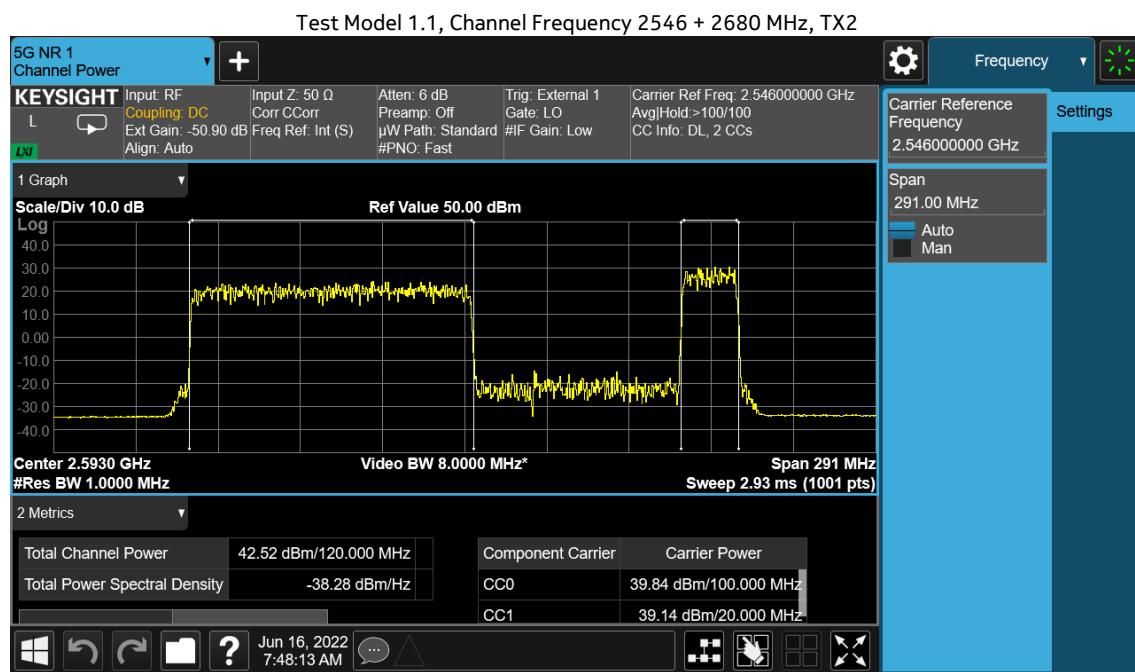
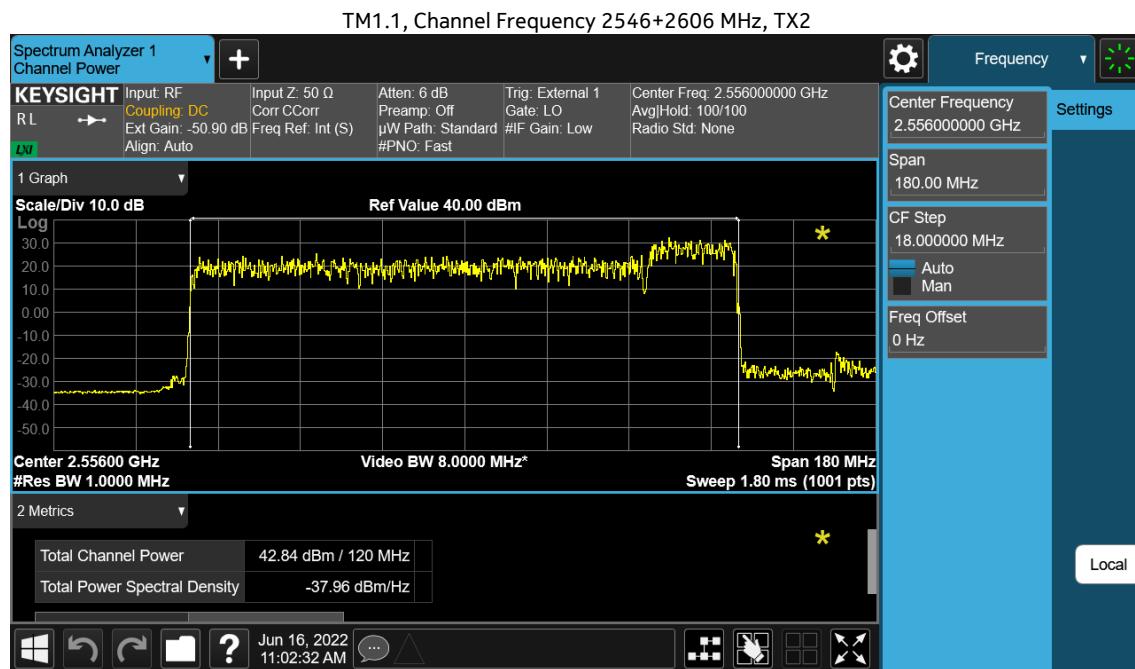
4C Channel RF Power

Channel Power - NR+NR+LTE+LTE / 20+100+20+20 MHz	
Test Model 1.1 Modulation QPSK Channel Frequency 2506+2566+2660+2680 MHz	
TX Port	(dBm)
1	42.09
2	42.53
3	42.39
4	42.47
Total Power (dBm)	48.39
Total Power (W)	69.09

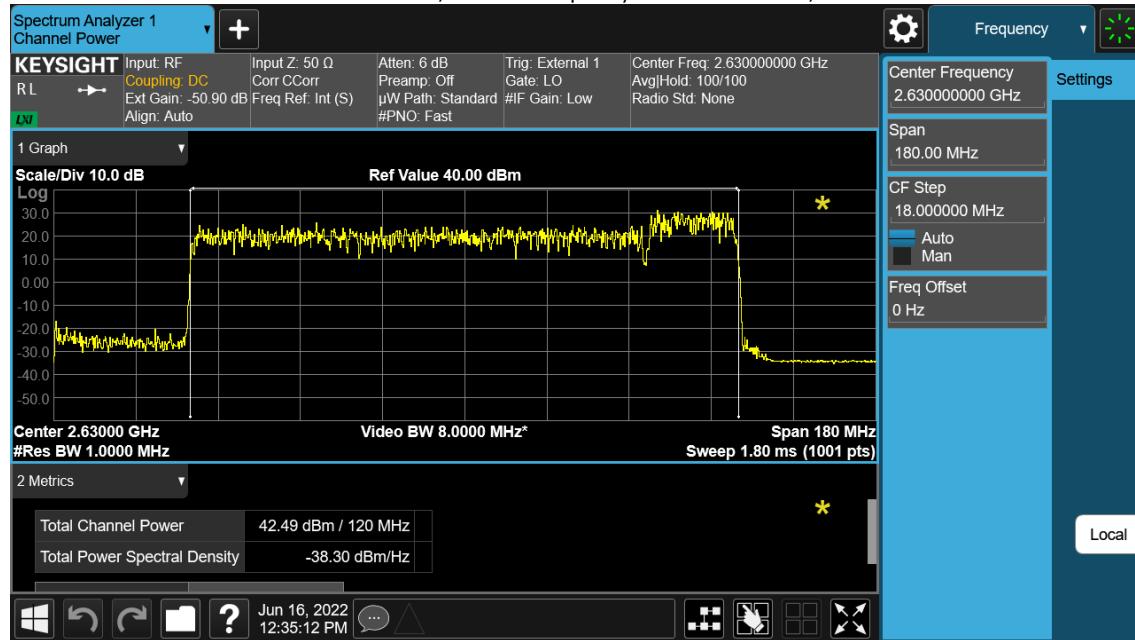
2.2 Channel RF Power – Plots

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.

2C Channel RF Power plots

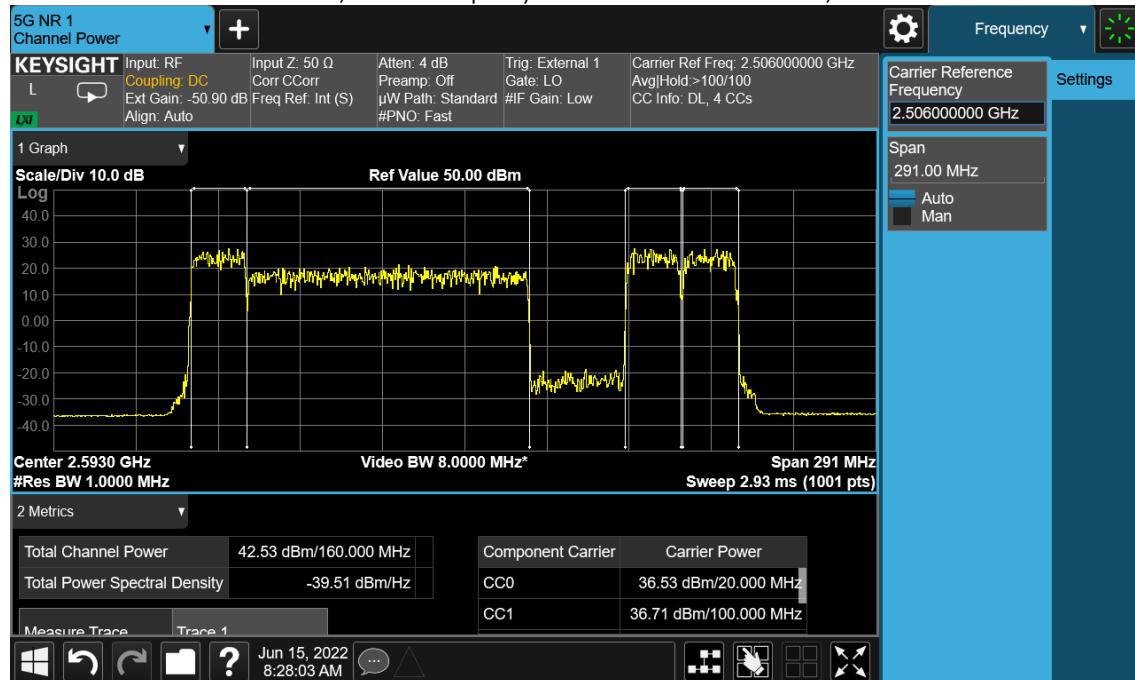


Test Model 1.1, Channel Frequency 2620 + 2680 MHz, TX2



4C Channel RF Power plots

TM1.1, Channel Frequency 2506+2566+2660+2680 MHz, TX2



2.3 Peak-to-Average Power Ratio (PAPR)

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

# of Carriers	Test Model	Modulation	TX Port	Channel Frequency MHz	Signal BW MHz	Radio Access Technology	PAR at 0.1% Limit - 13 dB
2	1.1	QPSK	2	2546 + 2606	100+20	NR+NR	8.24
2	1.1	QPSK	2	2546 + 2680	100+20	NR+NR	8.54 / 8.11
2	1.1	QPSK	2	2620 + 2680	100+20	NR+NR+LT+LTE	8.38
4	1.1	QPSK	2	2506+2566+2660+2680	20+100+20+20	NR+NR+LT+LTE	8.23 / 7.89

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

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

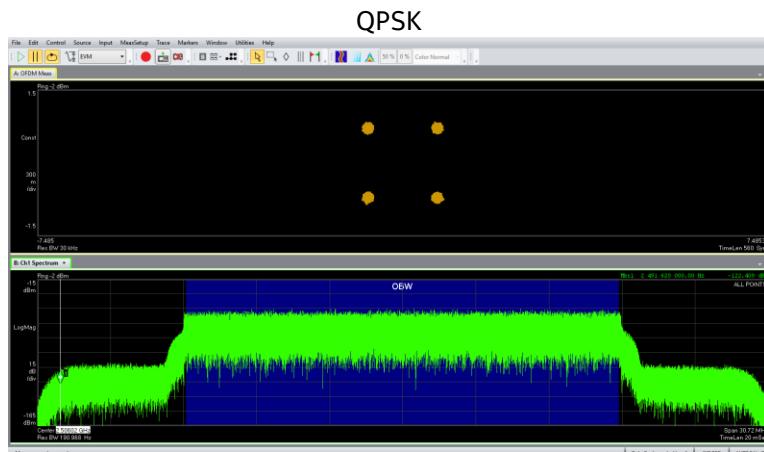


3. FCC Section 2.1047 - Modulation Characteristics

3.1 Modulation Characteristics

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

3.1.1 Modulation Characteristics – Sample Plot(s)



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

4.1 Occupied Bandwidth

In 47CFR 2.1049 the FCC requires:

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

This required measurement is the 99% Occupied Bandwidth, also called the designated signal bandwidth and needs to be within the parameters of the products specified emissions designator. During these measurements it is customary to evaluate the Edge of Band emissions at block/band edges.

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

Tabular Data – 99% Occupied Bandwidth

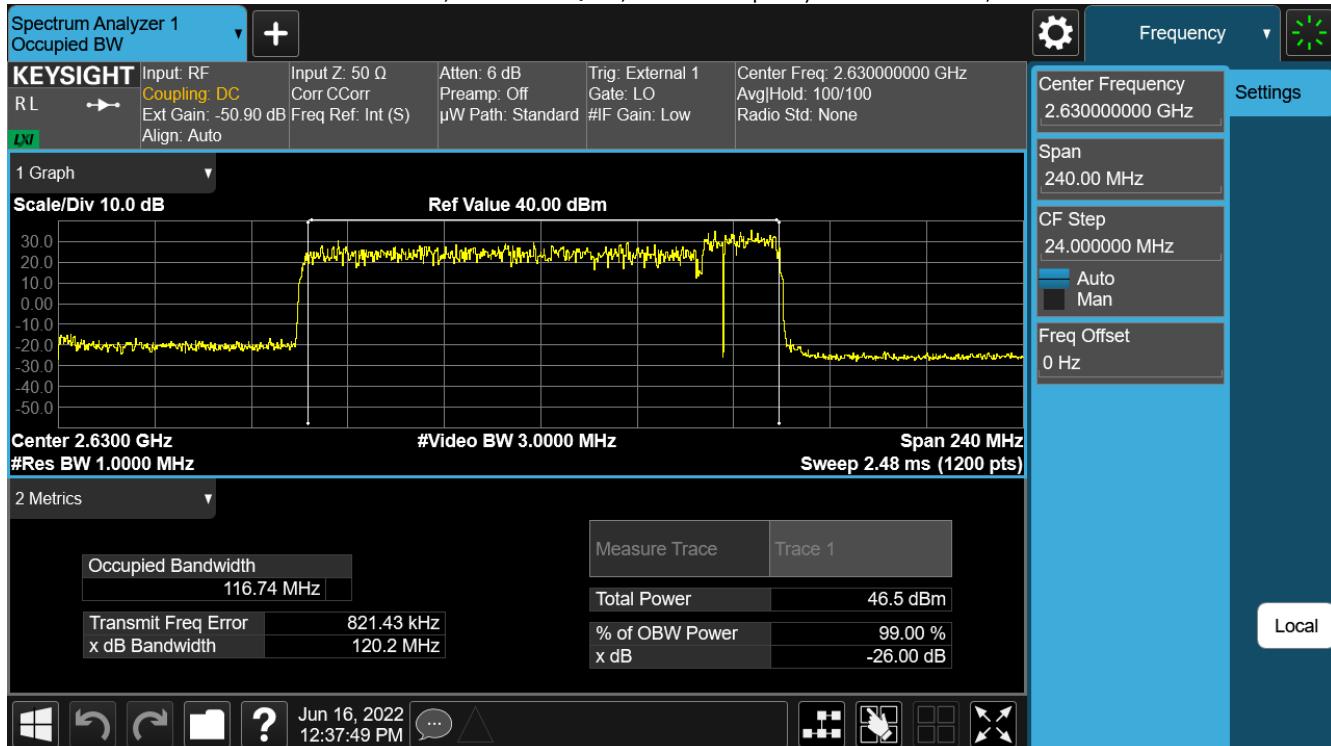
# of Carriers	Test Model	Modulation	TX Port	Channel Frequency MHz	Signal BW MHz	Radio Access Technology	99% Occupied BW MHz
2	1.1	QPSK	4	2546 + 2606	100+20	NR+NR	116.27
2	1.1	QPSK	2	2546 + 2680	100+20	NR+NR	97.387+18.19
2	1.1	QPSK	2	2620 + 2680	100+20	NR+NR+LTE+LTE	116.74
4	1.1	QPSK	2	2506+2566+2660+2680	20+100+20+20	NR+NR+LTE+LTE	117.34+37.643

4.1.1 Occupied Bandwidth - Plots

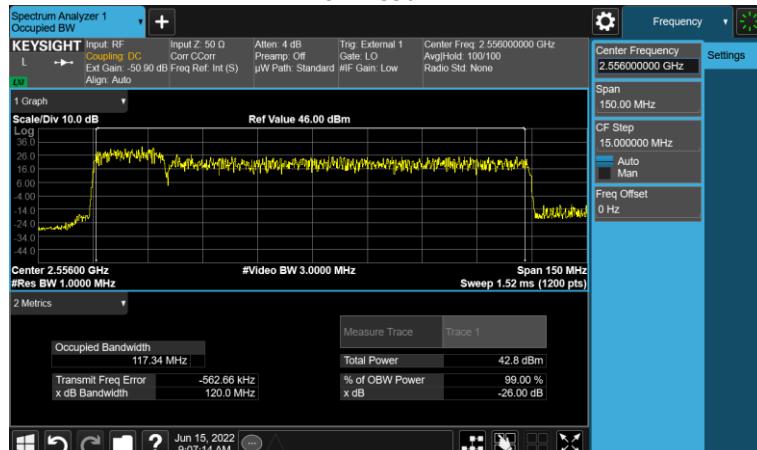
NOTE: Only a sample of the plots are used in this report. The full suite of raw data resides at the MH, New Jersey location.

2C

Test Model 1.1, Modulation QPSK, Channel Frequency 2620 + 2680MHz, TX2



4C

Test Model 1.1, Modulation QPSK, Channel Frequency 2506+2566+2660+2680MHz, TX2
CF - 2556MHz

4.2 Edge of band Emissions

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

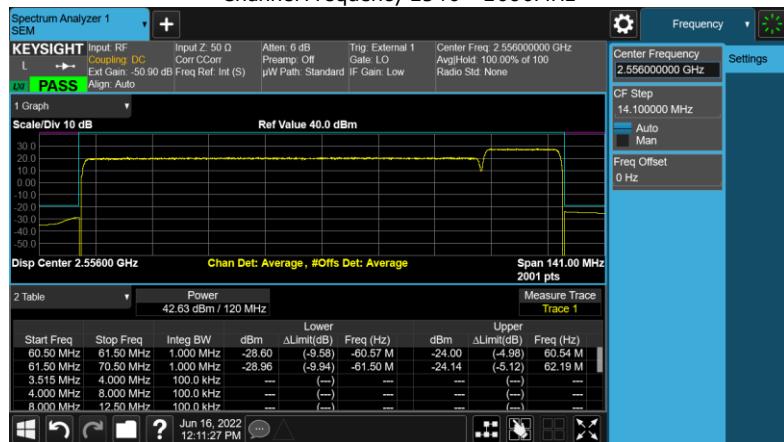
Per FCC Part 27.53 (L)(1), for base station operations in the 3700-3980 MHz band, the conducted power of any emission outside the licensee's authorized bandwidth shall not exceed -13 dBm/MHz. Compliance with this paragraph (L)(1) is based on the use of measurement instrumentation employing a resolution bandwidth of 1 megahertz or greater. However, in the 1 MHz bands immediately outside and adjacent to the licensee's frequency block, a resolution bandwidth of at least one percent of the 26dB emission bandwidth of the fundamental emission of the transmitter may be employed. Therefore, with 64 TX ports, the conducted limit per port is -31dBm/1% BW in the 1MHz immediately outside and adjacent to the licensee's frequency block and -31dBm/MHz outside the 1MHz.

4.2.1 Edge of Band Emissions – Plots

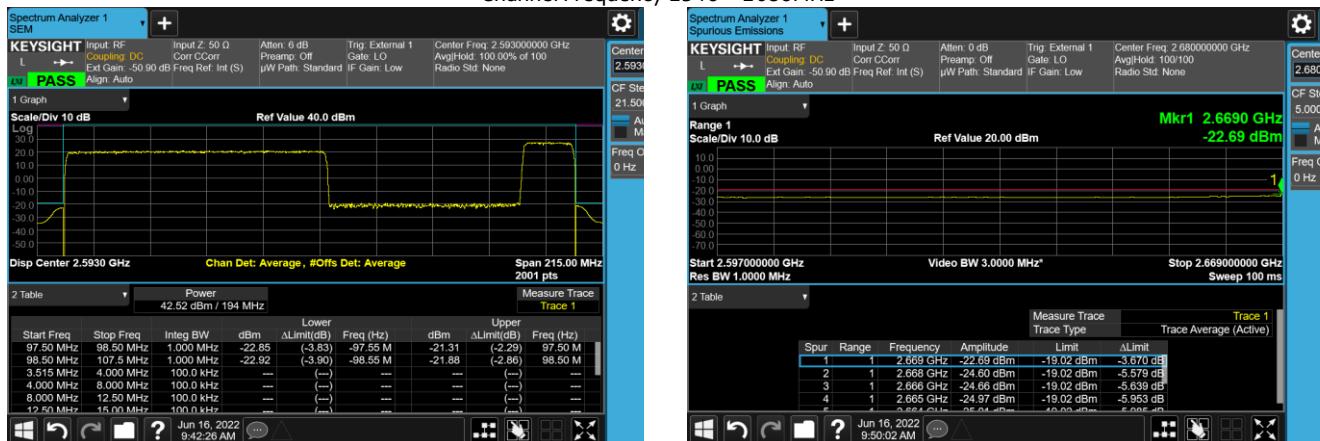
All of the measurements met the requirements of Part 27.53 when measured per Part 2.1049.

Edge of Band Emissions - 2C Test Model 1.1, Modulation QPSK, TX2

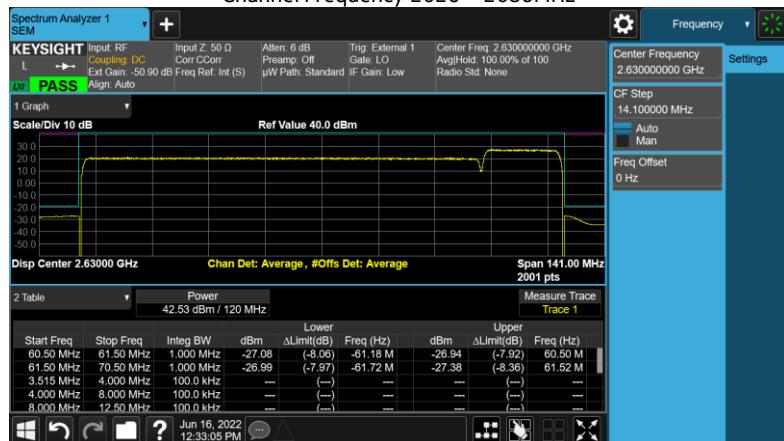
Channel Frequency 2546 + 2606MHz



Channel Frequency 2540 + 2680MHz

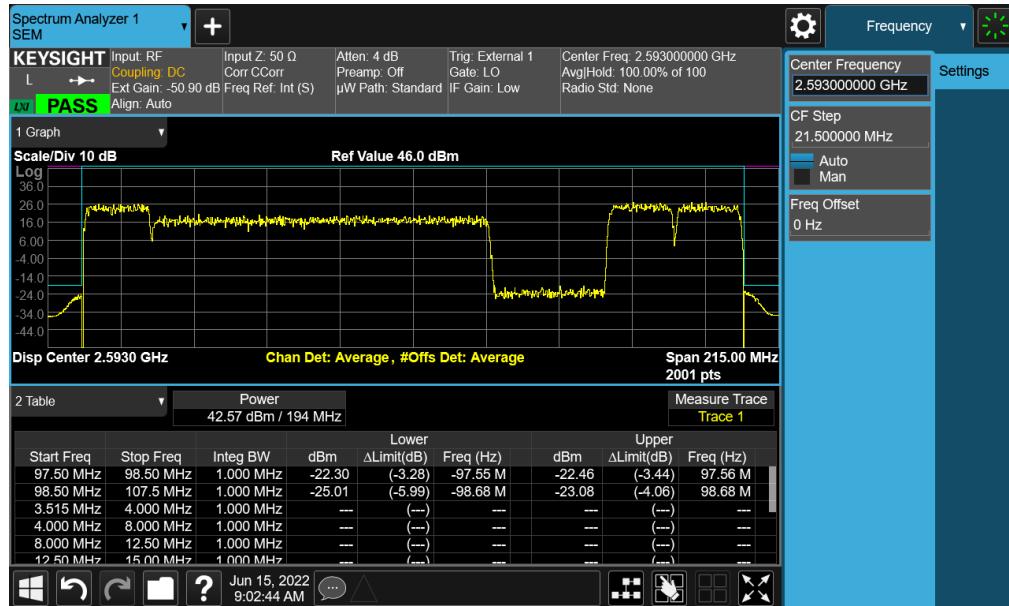


Channel Frequency 2620 + 2680MHz

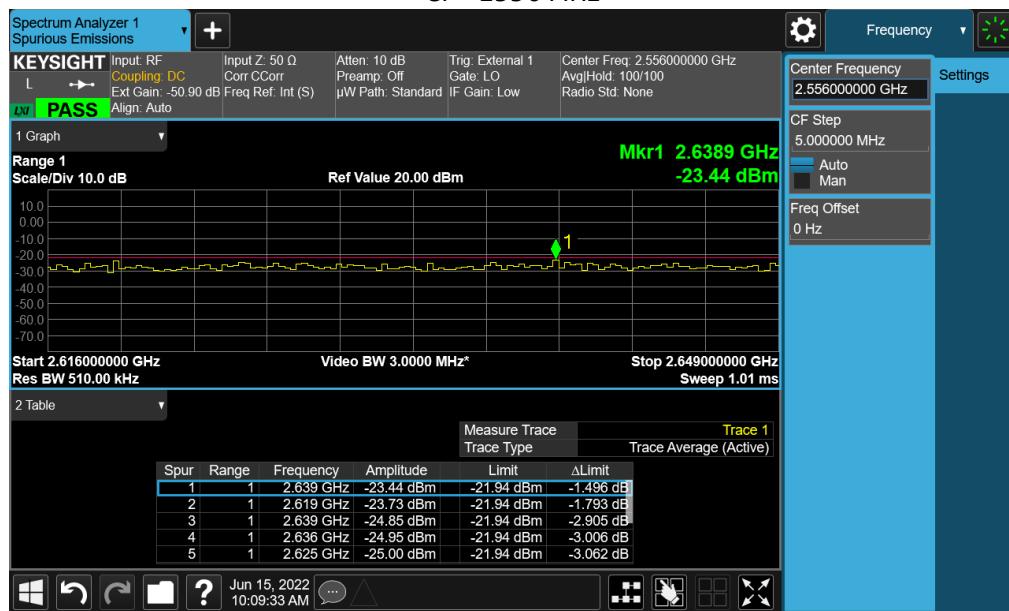


Edge of Band Emissions - 4C Test Model 1.1, Modulation QPSK, TX2

CF - 2593 MHz



CF - 2556 MHz



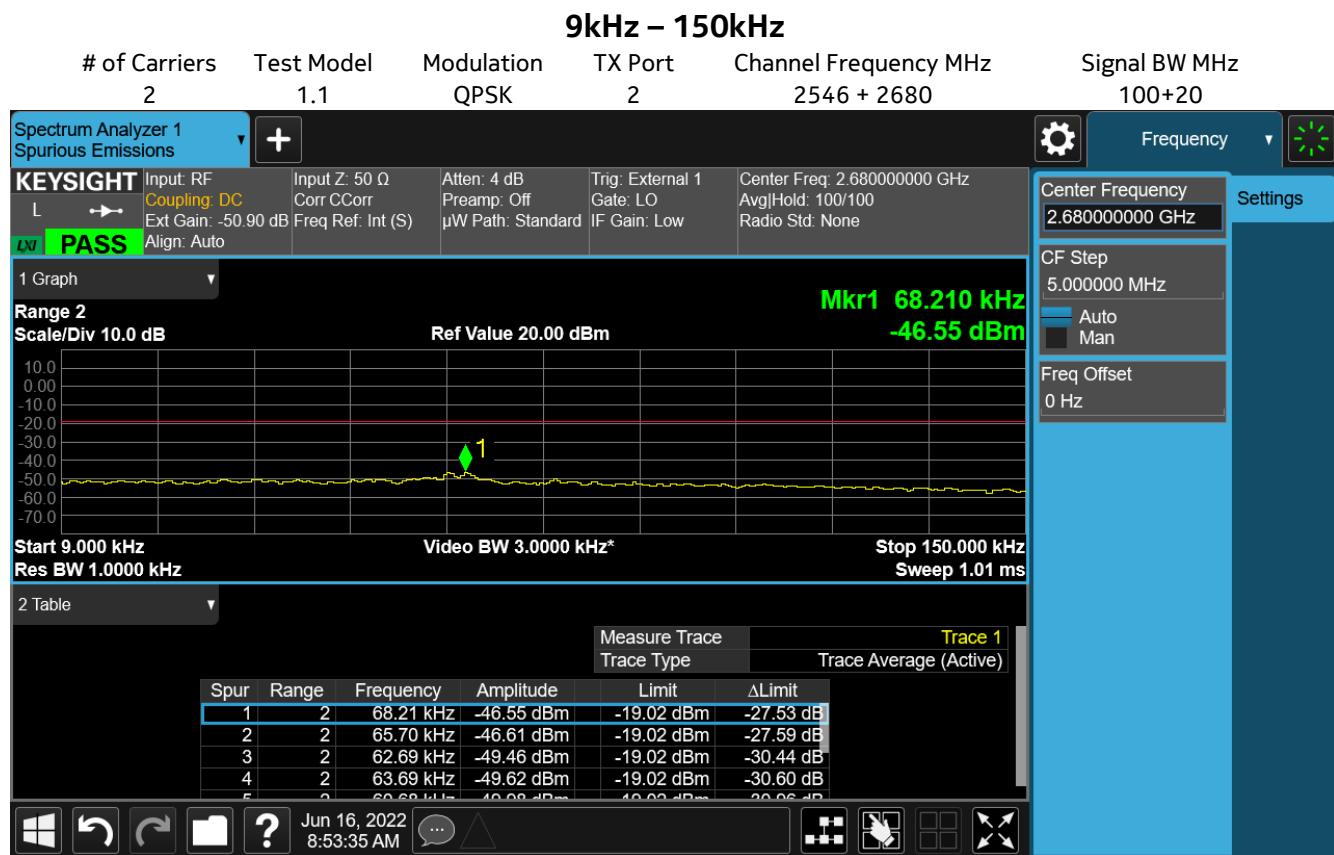
5. FCC Section 2.1051 - Spurious Emissions at Transmit Antenna Port

5.1 Measurement of Spurious Emissions at Transmit Antenna Port

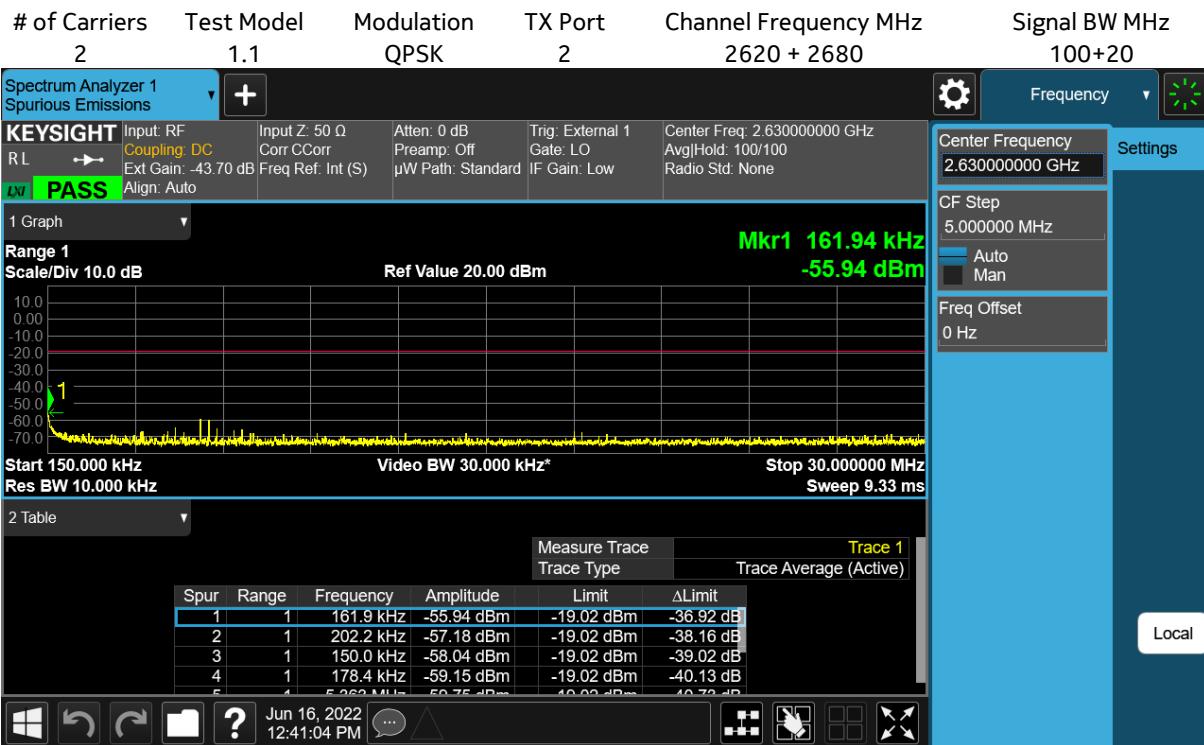
Spurious Emissions at the transmit-antenna terminals were investigated over the frequency range of 10 MHz to beyond the 10th harmonic of the specific transmit band. Carrier Bandwidth is exempt. For this band of operation, the measurements were performed up to 27 GHz. Measurements were made using a Keysight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

The required emission limitation is specified as appropriate in 27.53. The measured spurious emission levels were plotted for the frequency range as specified in 2.1057. The limit of -13 dBm was adjusted to -19 dBm based on $10 \log (4)$ for 4X MIMO as required in KDB 662911 D01.

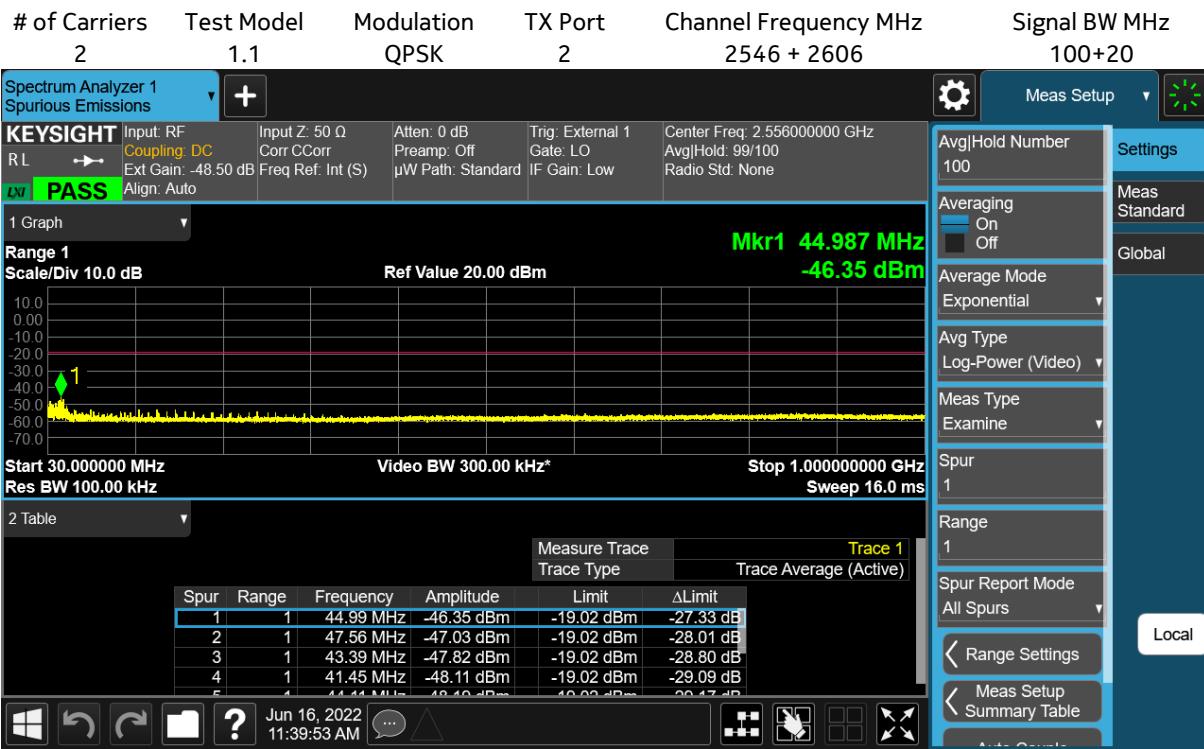
NOTE: Only plots with lowest margin in each frequency range are used in this report. The full suite of raw data resides at the MH, New Jersey location.



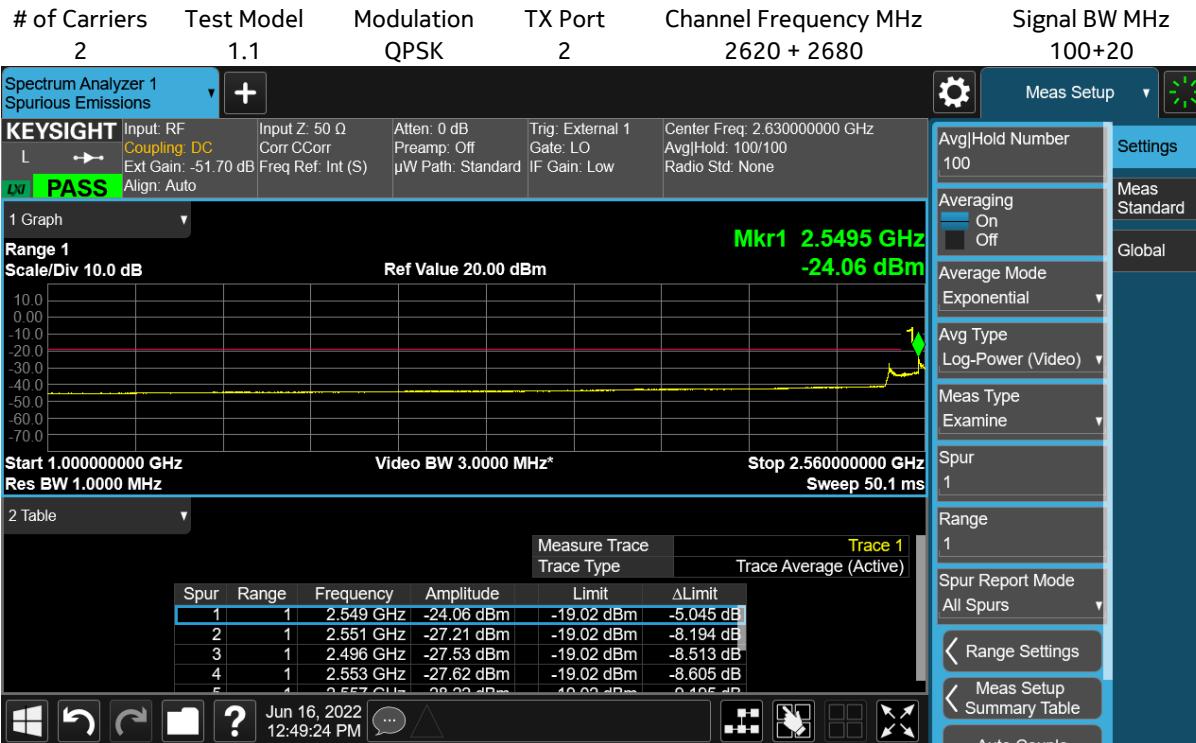
150kHz – 30MHz



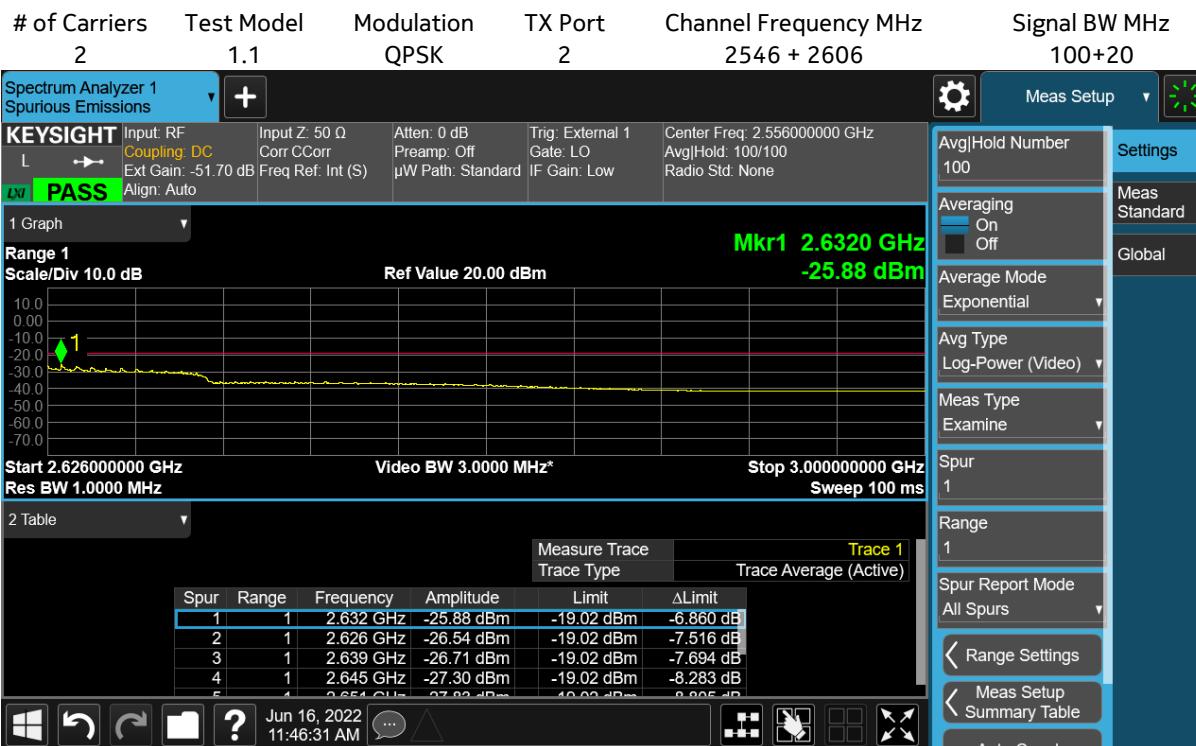
30MHz – 1GHz



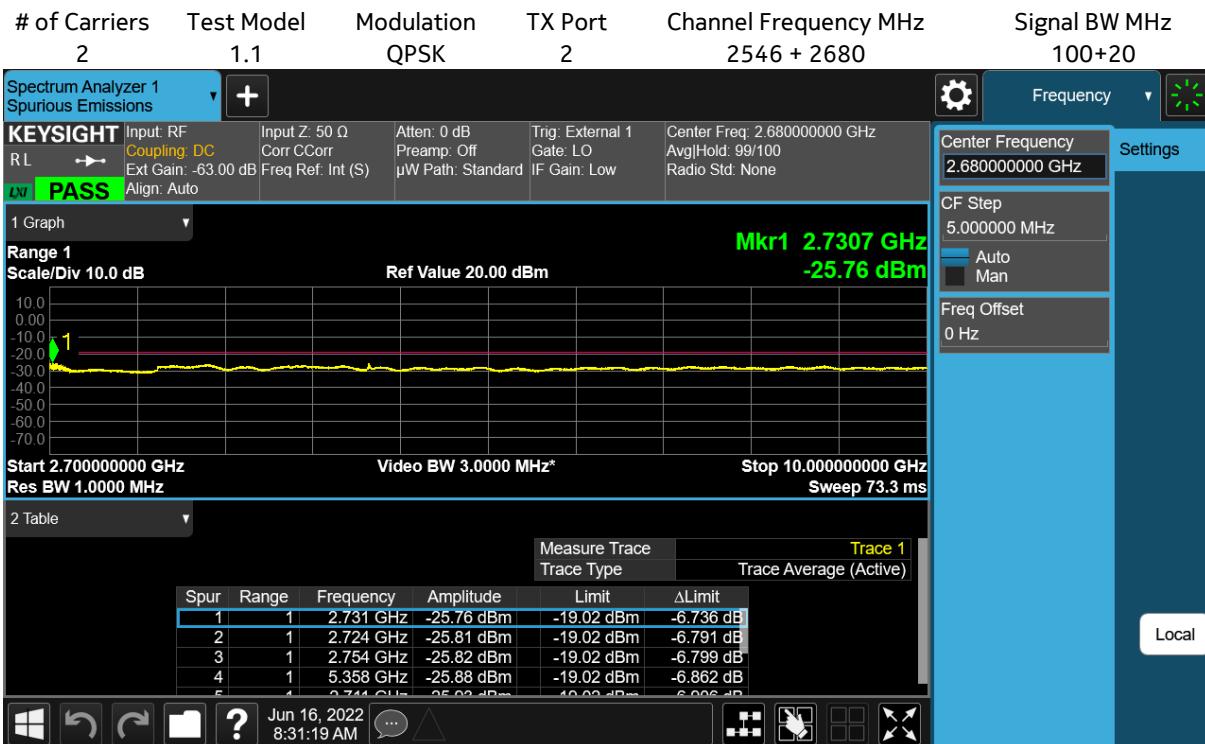
1GHz – 2.56GHz



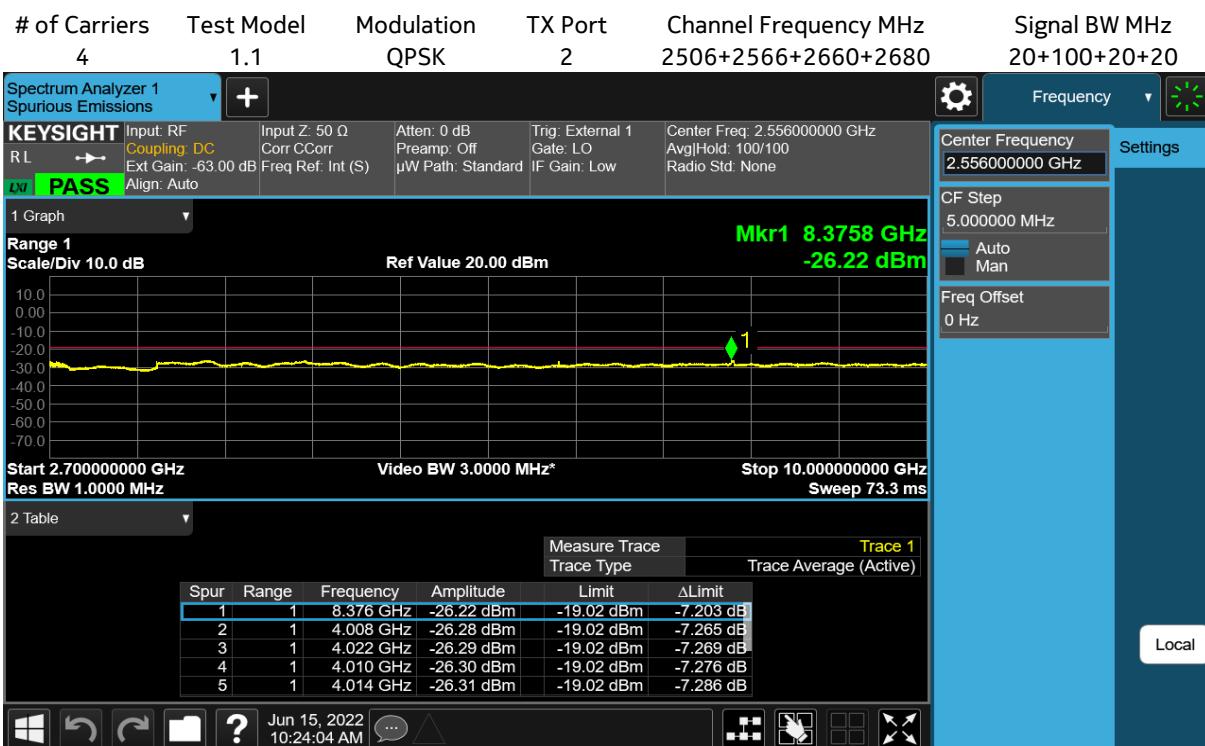
2.626GHz – 3GHz



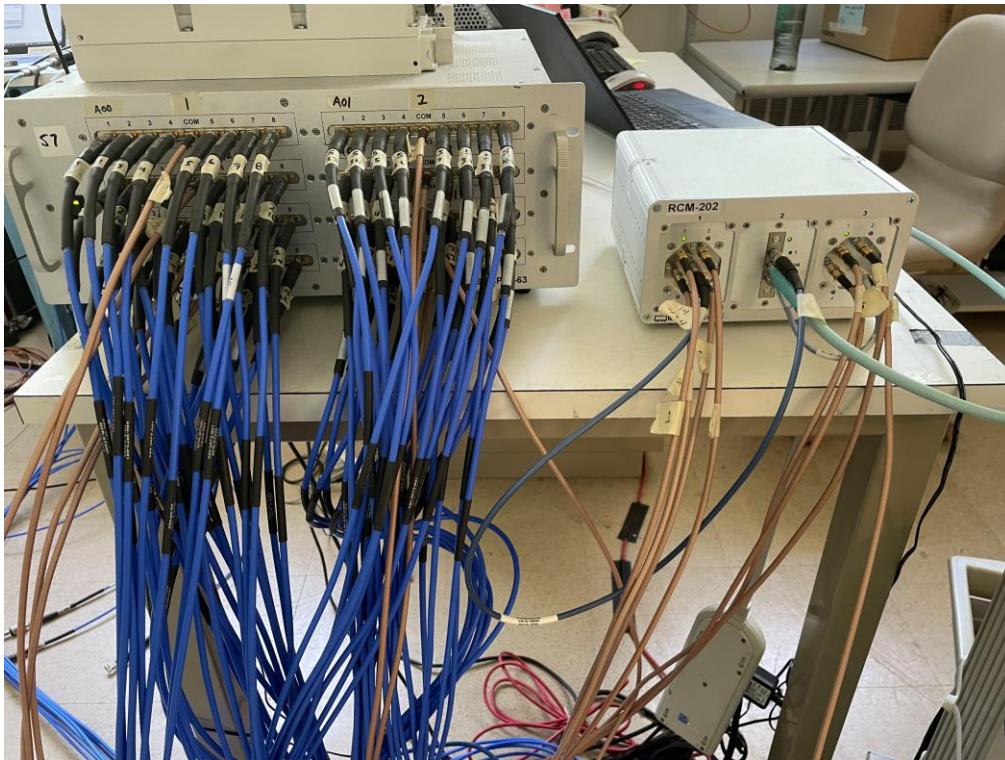
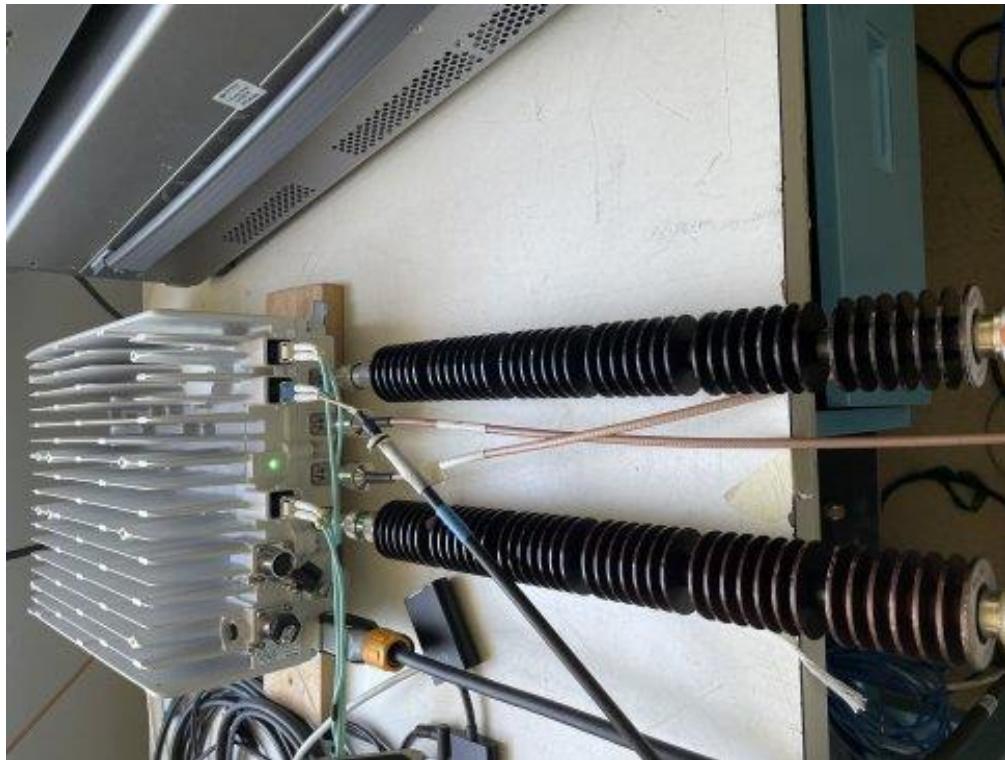
2.7GHz – 10GHz



10GHz – 27GHz



Photographs



Test Equipment

Asset ID	Manufacturer	Type	Description	Model	Serial	Calibration Date	Calibration Due
E896	Agilent Technologies	Network Analyzer	10 MHz - 40 GHz	N5230C	MY49000897	2021-03-03	2023-03-03
E1338	KeySight Technologies	MXA Signal Analyzer		N9020B	MY57430927	2021-01-07	2023-01-07
E1235	RLC Electronics Inc	Filter, High Pass	5 - 26 GHz	F-19413	1446-006	CNR-V	CNR-V
E1006	Weinschel	Attenuator	30 dB DC-18GHz 150W	6528-30-34-LIM	BN4172	CNR-V	CNR-V

Customer Provided Equipment

Asset ID	Manufacturer	Type	Description	Model	Serial	Calibration Date	Calibration Due
	Weinschel	Attenuator	40 dB DC-18GHz 150W	66-40-43	BF3790	CNR-V	CNR-V
	Utiflex Micro-coax	RF Cable		MFR6 64639 858616-001	UFB142A-Q-0760-2002G0	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, 40 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.

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

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

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 dB μ V/m at 3m and 91.77 dB μ V/m at 1m

The Part 27 non-report level is 62.23 dB μ V/m at 3m.

The calculated emission levels were found by:

$$\text{Measured level (dB}\mu\text{V)} + \text{Cable Loss(dB)} + \text{Antenna Factor(dB)} = \text{Field Strength (dB}\mu\text{V/m)}$$

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 dB μ V/meter (82.23 @ 3m). Emissions equal to or less than 62.23 dB μ V/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 40 GHz), no reportable spurious emissions were detected.

7. NVLAP Certificate of Accreditation

United States Department of Commerce
National Institute of Standards and Technology



Certificate of Accreditation to ISO/IEC 17025:2017

NVLAP LAB CODE: 100275-0

Nokia, Global Product Compliance Lab
Murray Hill, NJ

*is accredited by the National Voluntary Laboratory Accreditation Program for specific services,
listed on the Scope of Accreditation, for:*

Electromagnetic Compatibility & Telecommunications

*This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017.
This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality
management system (refer to joint ISO-ILAC-IAF Communiqué dated January 2009).*

2021-09-24 through 2022-09-30

Effective Dates



For the National Voluntary Laboratory Accreditation Program

A handwritten signature in blue ink, appearing to read "Dale S. Laman".