NOKIA Bell Labs

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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 Mobile Networks

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

Report Number:
TR-2019-0189-FCC2-27

Date Issued:
January 21, 2020

Table of Contents

Revisions

Date	Revision	Section	Change
1/21/20	0		Initial Release

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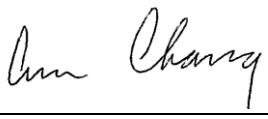
Prepared By:

Signed:  1/21/2020

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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:	EB193661018
FCC ID:	2AD8UAWHHF01
Hardware Version:	475181A.X22
Software Version:	5G19A
Frequency Range:	2496-2690 MHz
GPCL Project Number:	2019-0189
Manufacturer:	NOKIA SOLUTIONS AND NETWORKS OY KARAPORTTI 3, FI-02610 ESPOO FINLAND
Test Requirement(s):	Title 47 CFR Parts 2 and 27
Test Standards:	• Title 47 CFR Parts 2 and 27 • KDB 971168 D01 Power Measurement License Digital Systems v03r01 April 9, 2018. • KDB 662911 D01 Multiple Transmitter Output v02r01 Oct 2013 • ANSI C63.26 (2015) • ANSI C63.4 (2014)
Measurement Procedure(s):	• FCC-IC-OB - GPCL Occupied Bandwidth and Power Measurement Test Procedure 12-4-2017 • FCC-IC-SE - GPCL Spurious Emissions Test Procedure 12-4-2017
Test Date(s):	December 2019 – January 2020
Test Performed By:	Nokia Global Product Compliance Laboratory 600-700 Mountain Ave. P.O. Box 636 Murray Hill, NJ 07974-0636
Product Engineer(s):	Jeff Webb
Lead Engineer:	Steve Gordon
Test Engineer (s):	Steve Gordon, Joe Bordonaro, Nilesh Patel
Test Results: The EUT, *as tested* met the above listed 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 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.

1.3 EUT Details

1.3.1 Specifications

Specification Items	Description
Radio Access Technology	LTE-TDD, 5G NR
Duplex Mode	Time Division Duplex (TDD)
Modulation Type(s)	QPSK 16QAM 64QAM 256QAM
Operation Frequency Range	2496-2690 MHz
Channel Bandwidth	40 MHz
Number of Tx Ports per Unit	4
MIMO	Yes
Deployment Environment	Outdoor
Supply Voltage	-48.0 VDC

1.3.2 Photographs

Front View

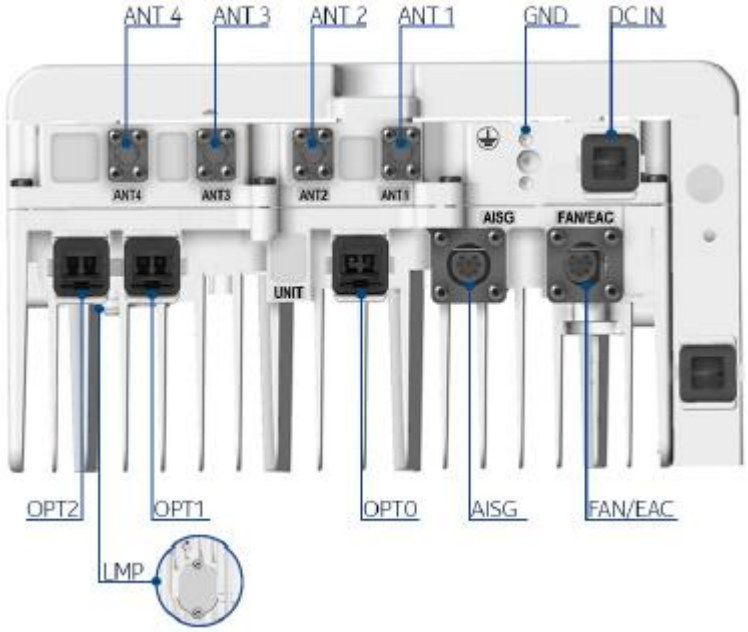
Rear View

Left View

Right View

Top View

Bottom View



Interface	Label on the HW	Number of interfaces	Connector type	Additional info
Power Connector	DC IN	1	DC OCTIS Plug Kit	Hot insert not supported
Antenna connector	ANT	4	NEX 10	-
External Alarm Connection/Fan	EAC/FAN	1	CIRC 8F IP67 Flange	Two external alarms supported
Optical interface	OPT	3	OCTIS Plug Kit SFP/SFP+	9.8 Gbps, CPRI
Ethernet	RJ	1	RJ45	-
Grounding	⏚	1	M8 or dual M5 screws	-
AISG connector	AISG	1	8-pin circular	-
Local Management Port (LMP)	-	1	2x20-pin female header	-


NOKIA
AWHHF Unit
(1P) 475181A.X22
(S) EB193661018
Made in China


NOKIA
AWHHF
Frequency : 2496-2690 MHz
Power Input : -48V ⎓ 13A
RF Output : 4x20W
ASS 1 LASER PRODUCT
Solutions and Networks Oy
ortti 3FI-02610 Espoo Finland
Made in China

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	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 27.
- ANSI C63.26, American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services

1.5.2 Procedures

1. FCC-IC-0B and FCC-IC-SE

2. 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”, American National Standards Institute, Institute of Electrical and Electronic Engineers, Inc., New York, NY 10017-2394, USA.

3. FCC KDB 971168 D01 Power Measurement License Digital Systems v03r01 April 9, 2018.
   FCC KDB 662911 D01 Multiple Transmitter Output v02r01 Oct 2013

1.5.3 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

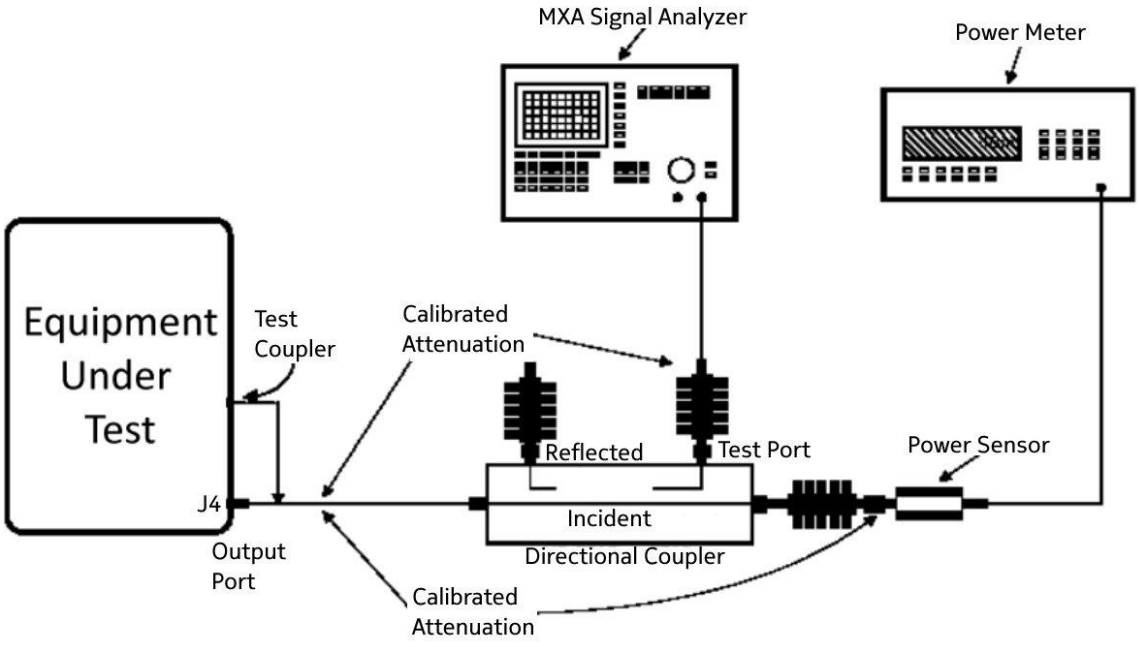
Antenna Port Test	Signal Bandwidth	Frequency Range	Expanded Uncertainty (k=2), Amplitude
Occupied Bandwidth, Edge of Band, Conducted Spurious Emissions	10 Hz 100 Hz 10 kHz to 1 MHz 1MHz	9 kHz to 20 MHz 20 MHz to 1 GHz 1 GHz to 10 GHz 10 GHz to 40 GHz:	1.78 dB
RF Power	10 Hz to 20 MHz	50 MHz to 18 GHz	0.5 dB

1.6 Executive Summary

Requirement	Description	Result
47 CFR FCC Parts 2 and 27		
2.1046, 27.53	RF Power Output Peak to Average Power Ratio	COMPLIES
2.1047, 27.53	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, 27.53	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.



2. FCC Section 2.1046 - RF Power Output

2.1 RF Power Output

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

Power measurements were made with an MXA Signal Analyzer.

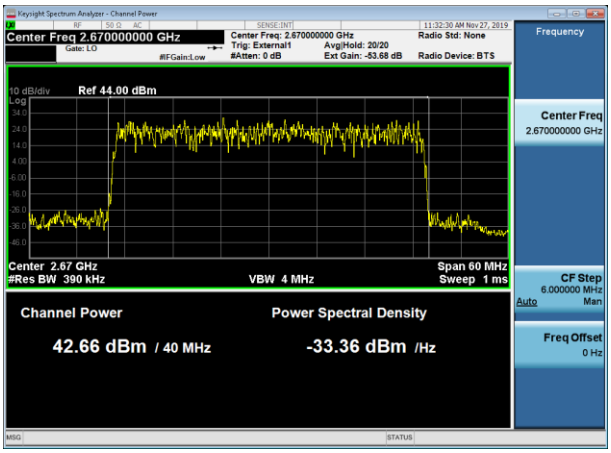
Tabular Data – Channel RF Power

TM	TX	Channel Frequency MHz	Signal BW MHz	Modulation	Channel Power dBm
1.1	1	2670	40	QPSK	42.66
1.1	2	2670	40	QPSK	42.53
1.1	3	2670	40	QPSK	42.38
1.1	4	2670	40	QPSK	42.99
3.1a	1	2670	40	256QAM	42.73
3.1a	2	2670	40	256QAM	42.79
3.1a	3	2670	40	256QAM	42.64
3.1a	4	2670	40	256QAM	42.69
3.2	1	2593	40	QPSK/16QAM	42.62
3.2	2	2593	40	QPSK/16QAM	42.46
3.2	3	2593	40	QPSK/16QAM	42.36
3.2	4	2593	40	QPSK/16QAM	42.38
3.1	1	2516	40	64QAM	42.73
3.1	2	2516	40	64QAM	42.4
3.1	3	2516	40	64QAM	42.8
3.1	4	2516	40	64QAM	42.92

2.1.1 Channel RF Power - Plots

TM1.1 / Channel Frequency 2670 MHz / Signal BW 40 MHz / Modulation QPSK

TX1



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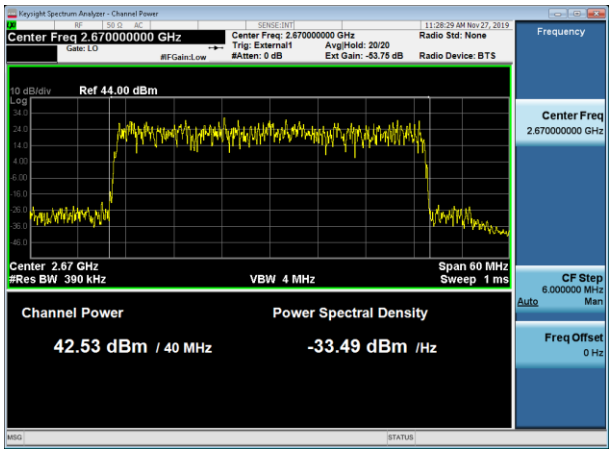

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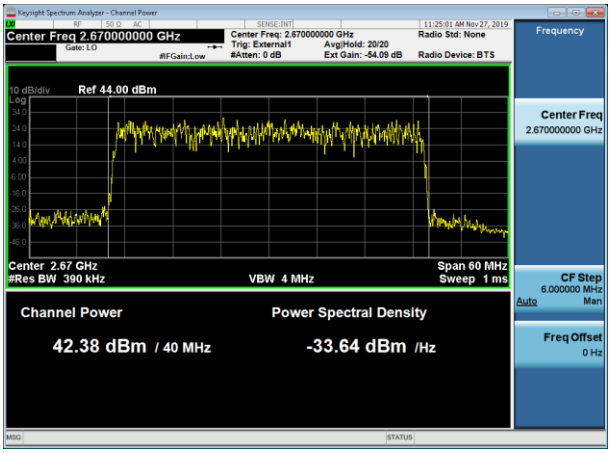

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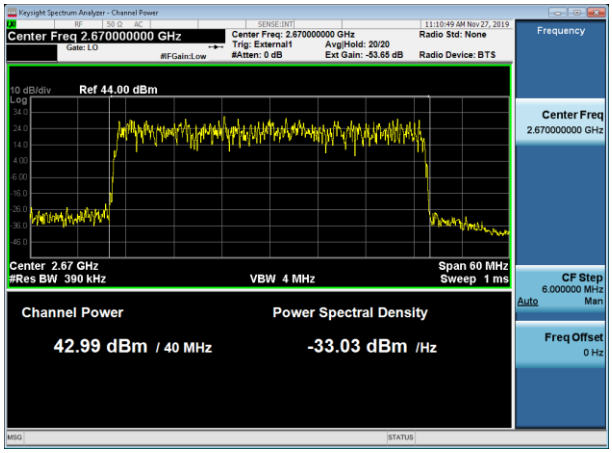

TM3 .1a / Channel Frequency 2670 MHz / Signal BW 40 MHz / Modulation 256QAM

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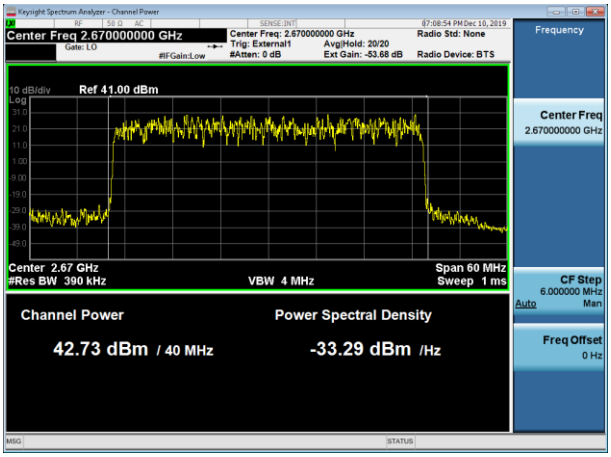

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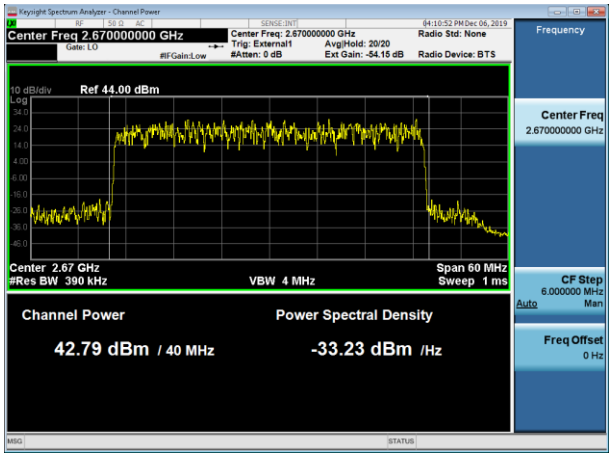

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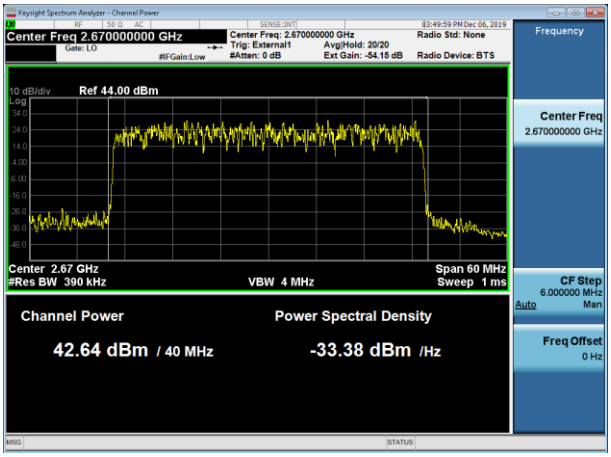

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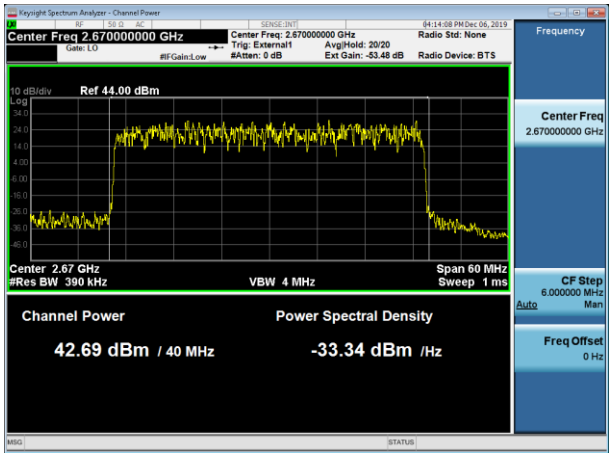

TM3.2 / Channel Frequency 2593 MHz / Signal BW 40 MHz / Modulation QPSK 16QAM

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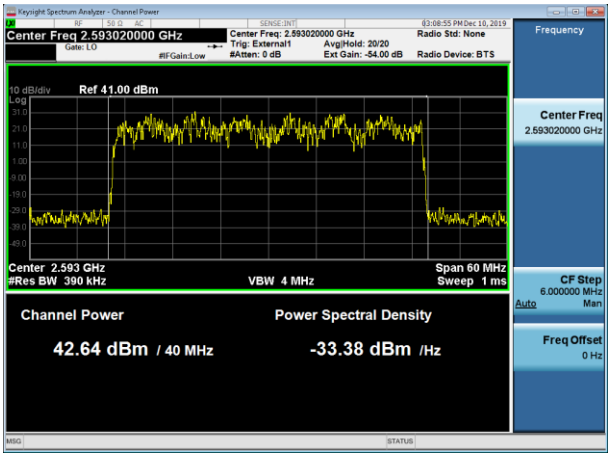

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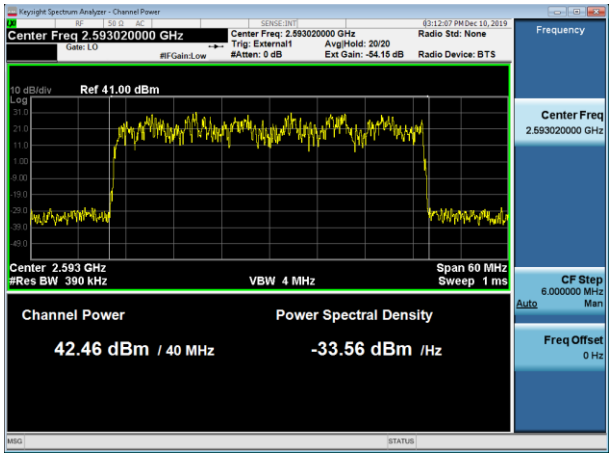

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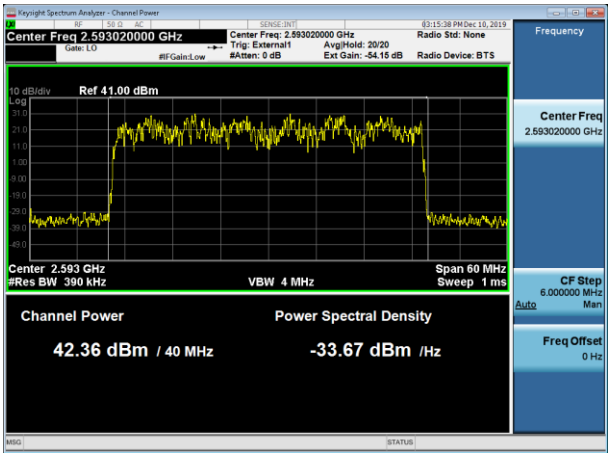

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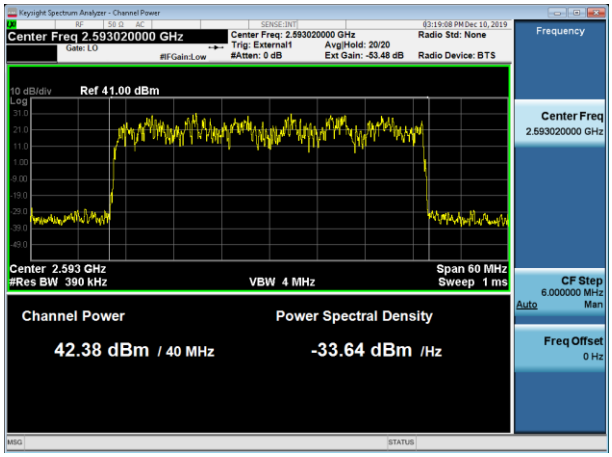

TM3.1 / Channel Frequency 2516 MHz / Signal BW 40 MHz / Modulation 64QAM

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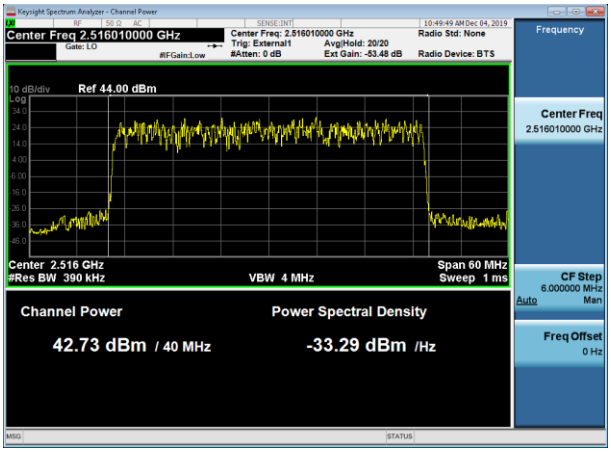

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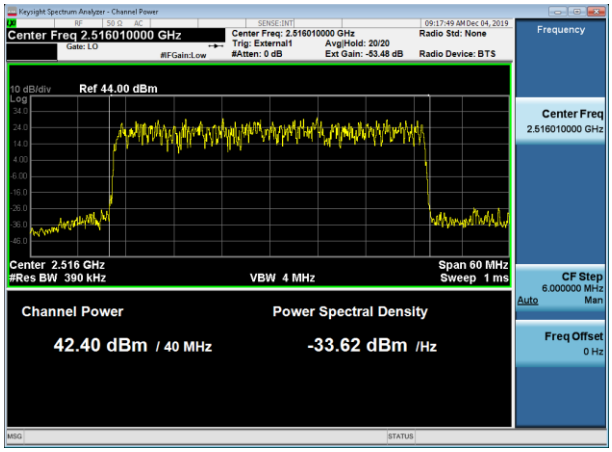

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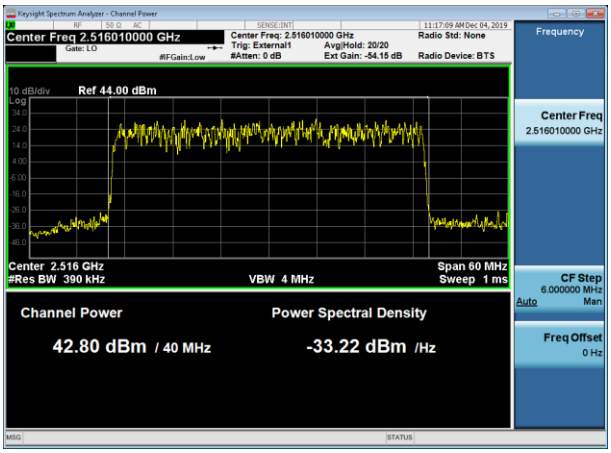

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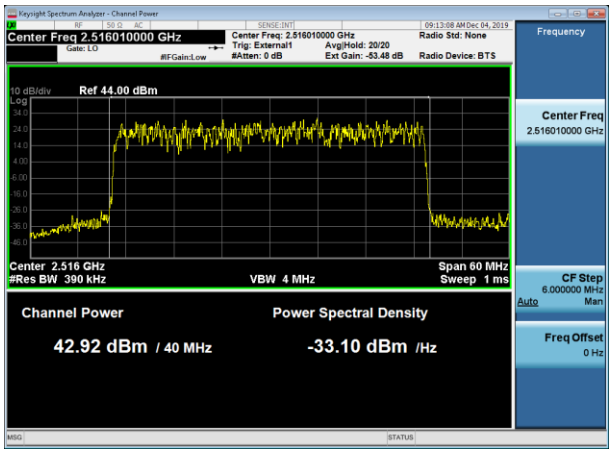
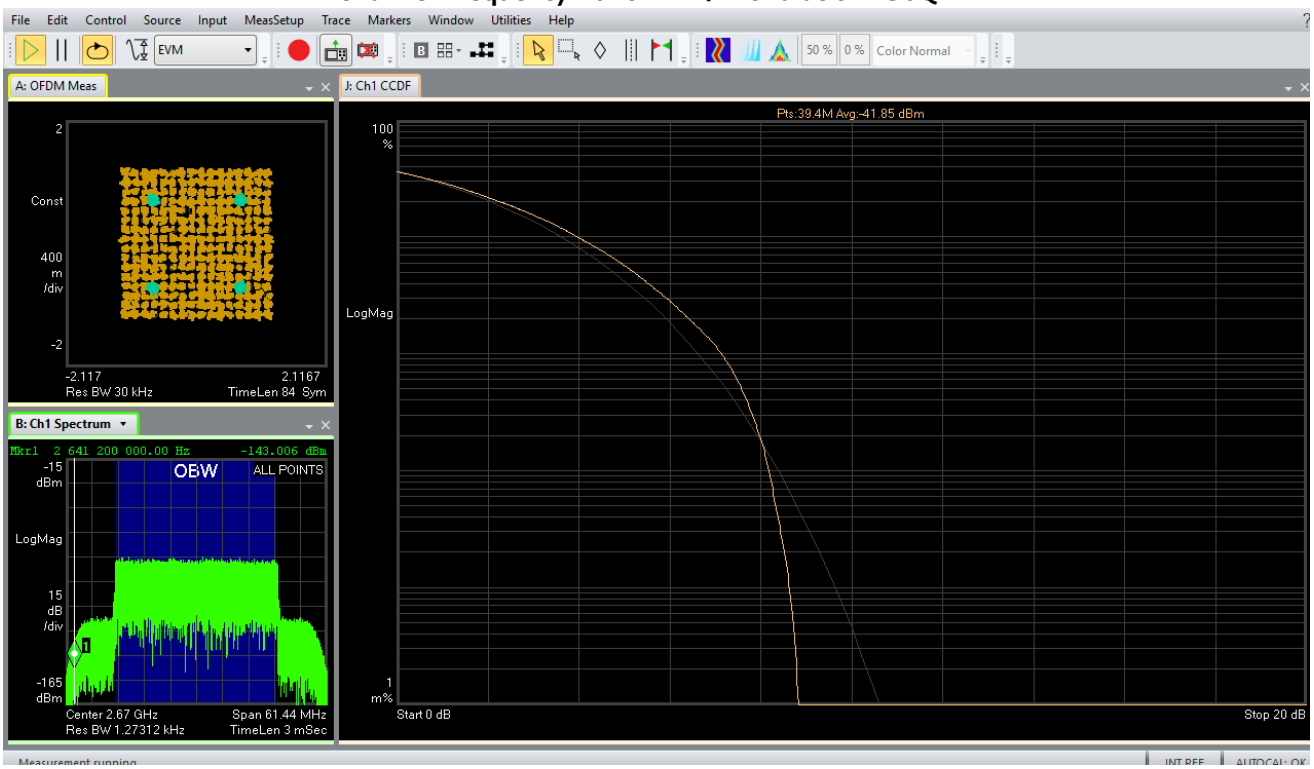


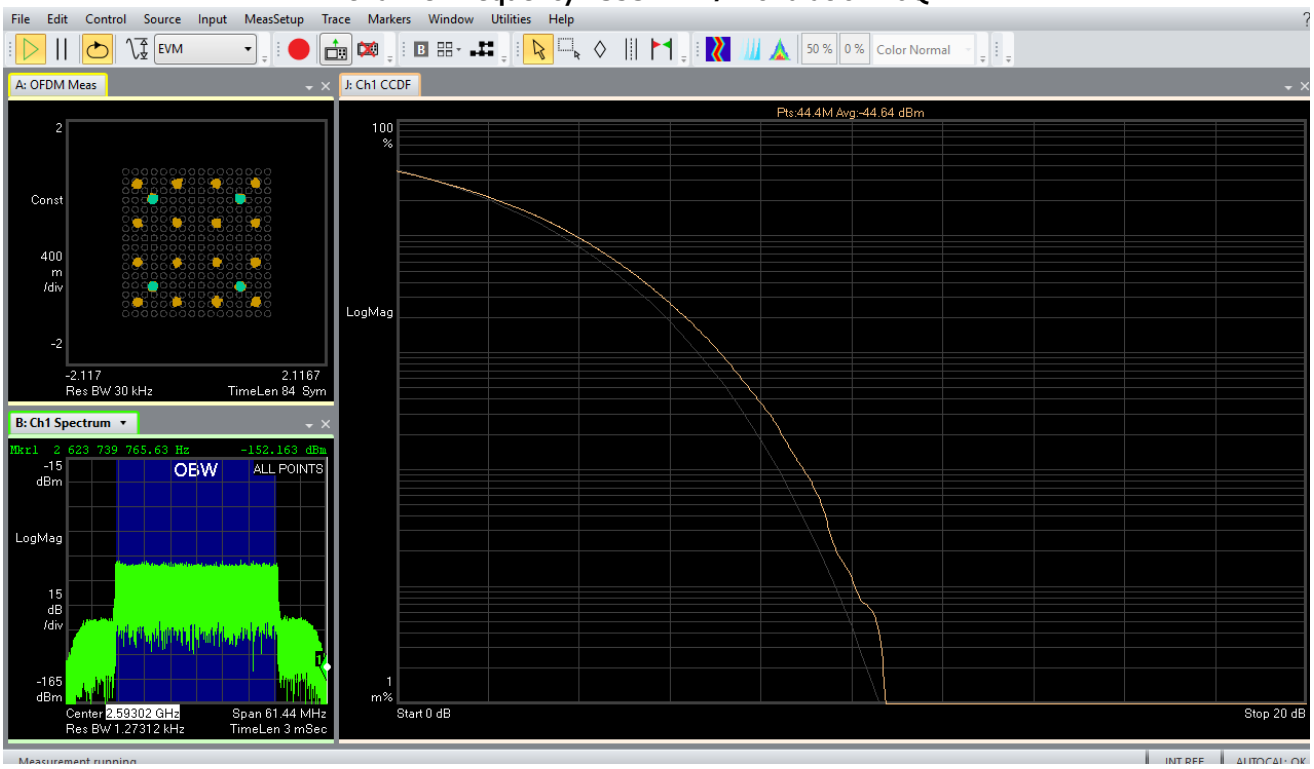
2.1.2 Peak-to-Average Power Ratio (PAPR) – Plots

The Peak-to-Average Power Ratio (PAPR) was evaluated per KDB 971168 for 40MHz bandwidths. The PAPR values of all carriers measured are below 13dB.

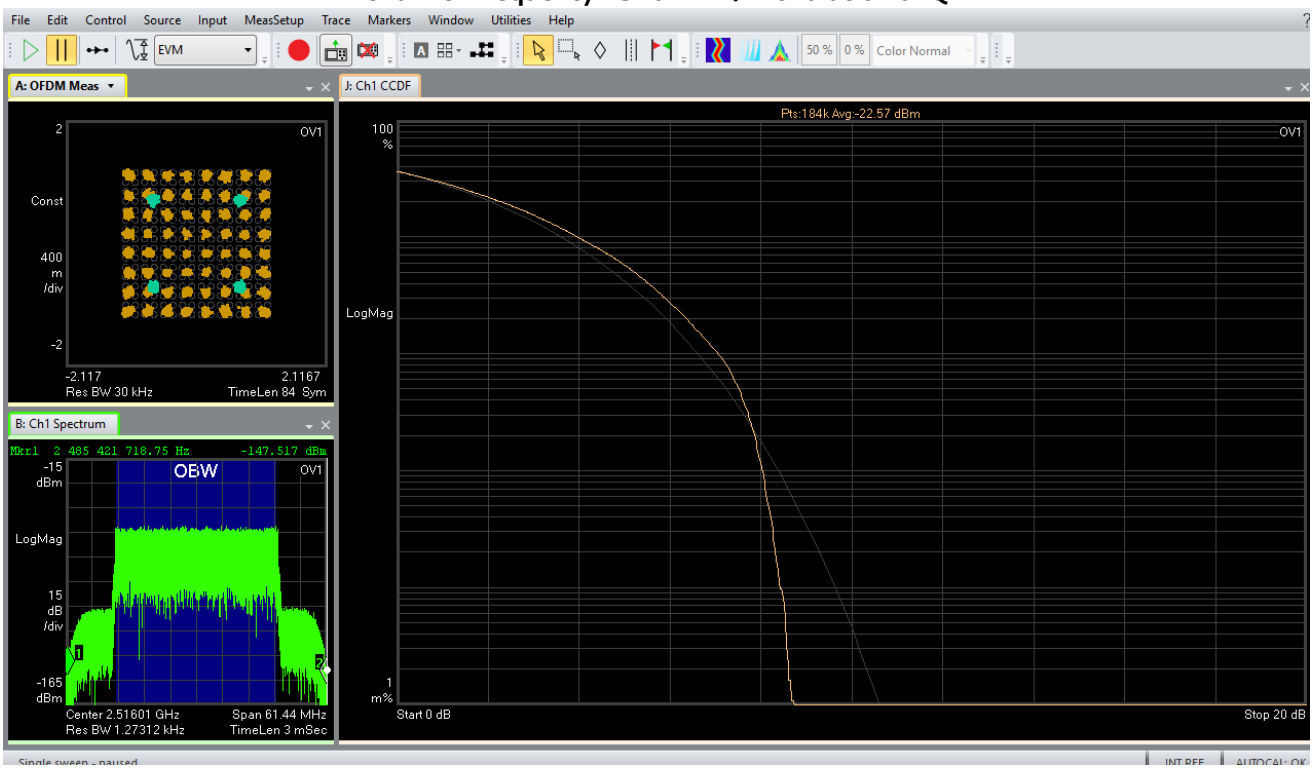
Channel Frequency 2670 MHz / Modulation 256QAM



Channel Frequency 2593 MHz / Modulation 16QAM



Channel Frequency 2516 MHz / Modulation 64QAM



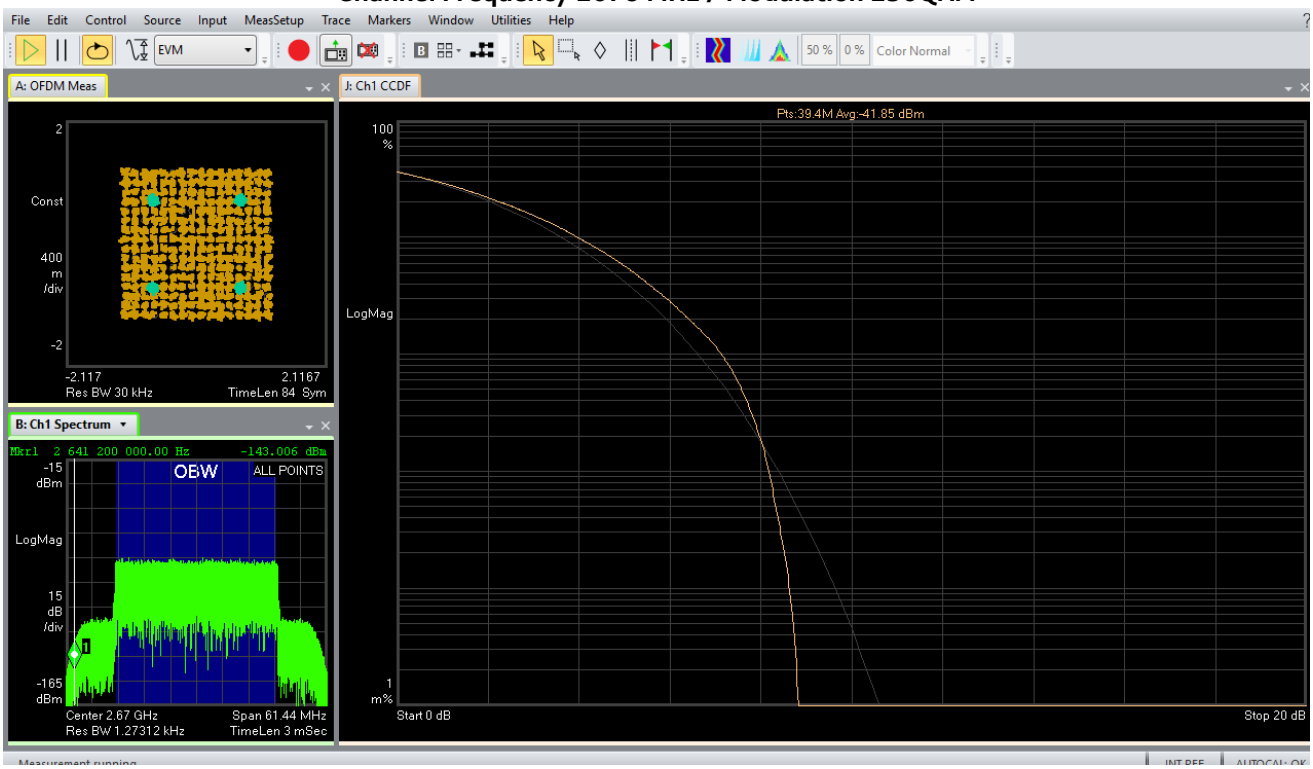
3. FCC Section 2.1047 - Modulation Characteristics

3.1 Modulation Characteristics

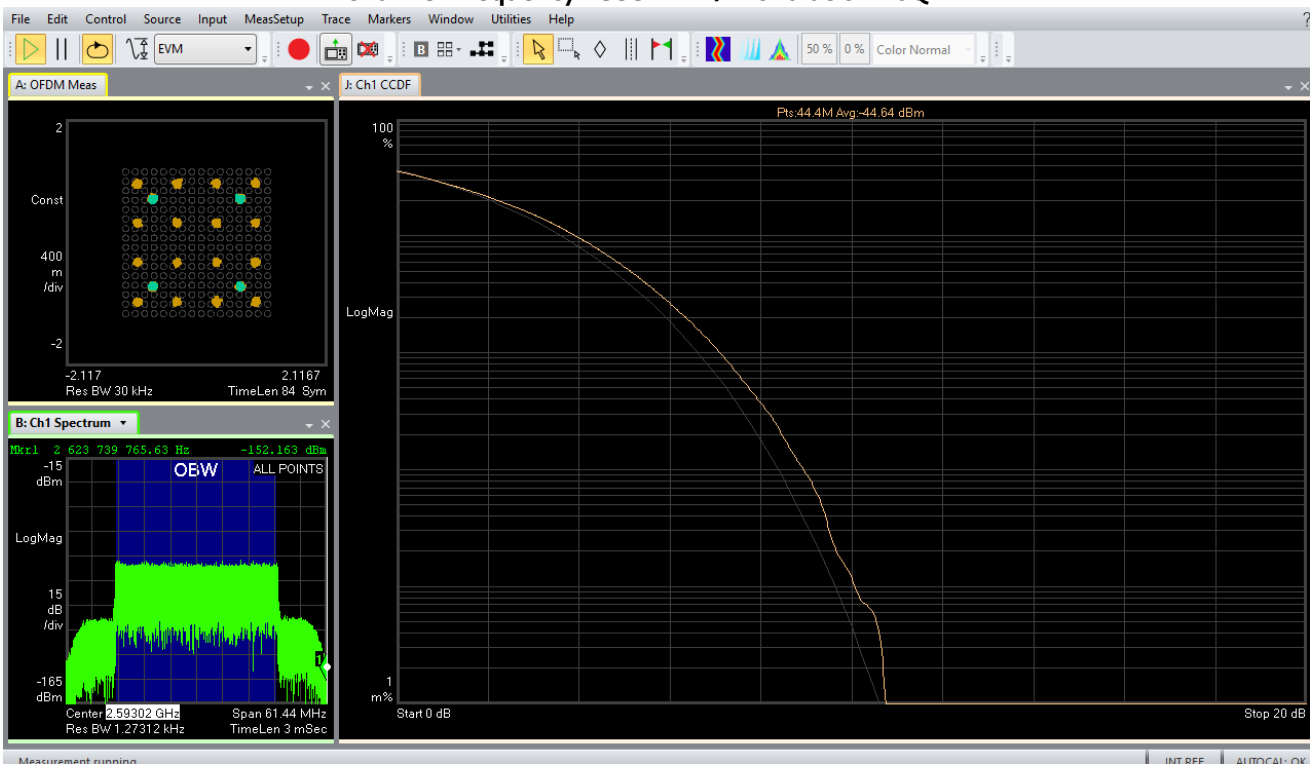
The RF signal at the antenna port was demodulated and verified for correctness of the modulation signal used before each test was performed.

3.1.1 Modulation Characteristics – Plots

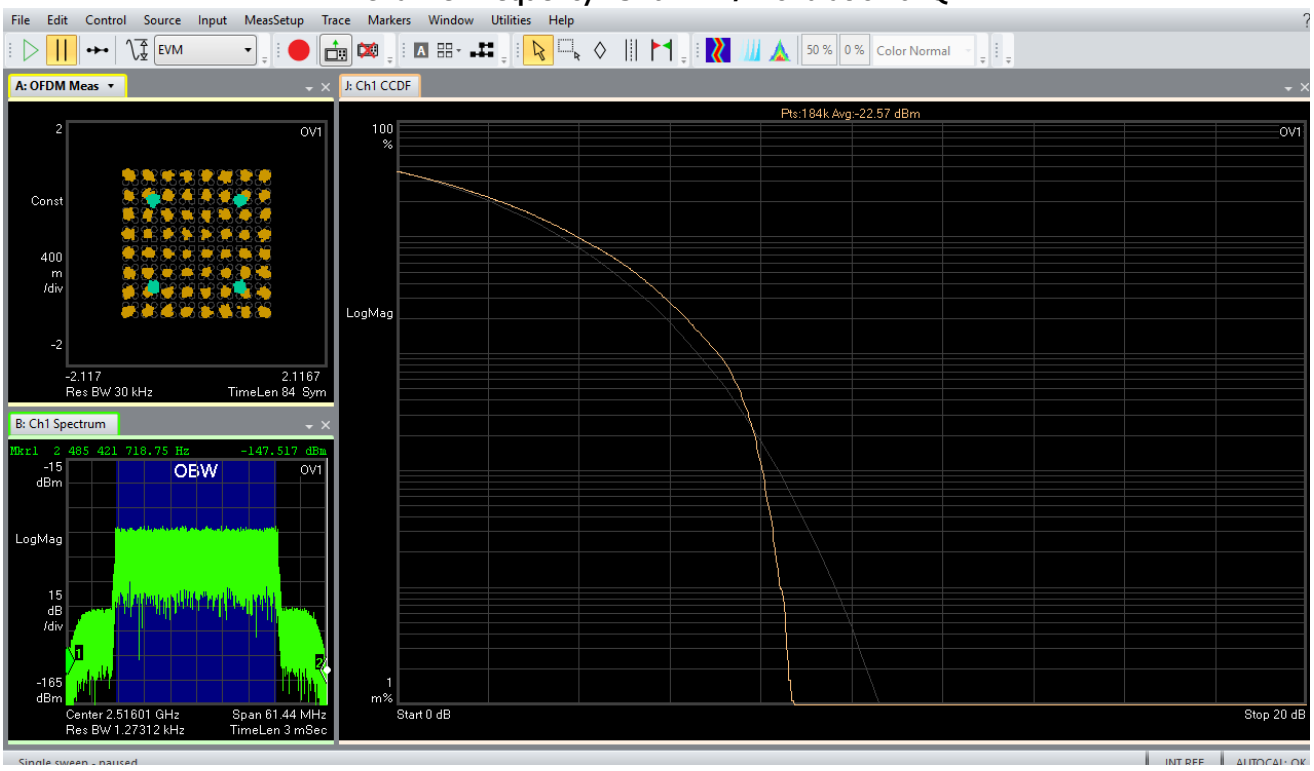
Channel Frequency 2670 MHz / Modulation 256QAM



Channel Frequency 2593 MHz / Modulation 16QAM



Channel Frequency 2516 MHz / Modulation 64QAM



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.

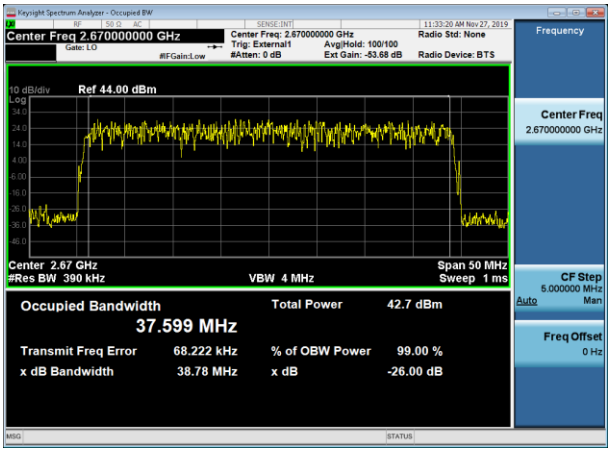
Tabular Data – Occupied Bandwidth

TM	TX	Channel Frequency MHz	Signal BW MHz	Modulation	Occupied BW MHz
1.1	1	2670	40	QPSK	37.599
1.1	2	2670	40	QPSK	37.604
1.1	3	2670	40	QPSK	37.599
1.1	4	2670	40	QPSK	37.592
3.1a	1	2670	40	256QAM	37.759
3.1a	2	2670	40	256QAM	37.761
3.1a	3	2670	40	256QAM	37.756
3.1a	4	2670	40	256QAM	37.755
3.2	1	2593	40	QPSK/16QAM	37.421
3.2	2	2593	40	QPSK/16QAM	37.397
3.2	3	2593	40	QPSK/16QAM	37.419
3.2	4	2593	40	QPSK/16QAM	37.413
3.1	1	2516	40	64QAM	37.873
3.1	2	2516	40	64QAM	37.877
3.1	3	2516	40	64QAM	37.872
3.1	4	2516	40	64QAM	37.869

4.1.1 Occupied Bandwidth – Plots

TM1.1 / Channel Frequency 2670 MHz / Signal BW 40 MHz / Modulation QPSK

TX1



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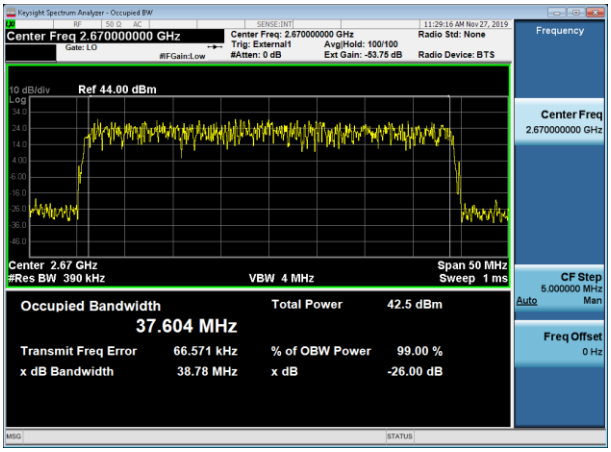

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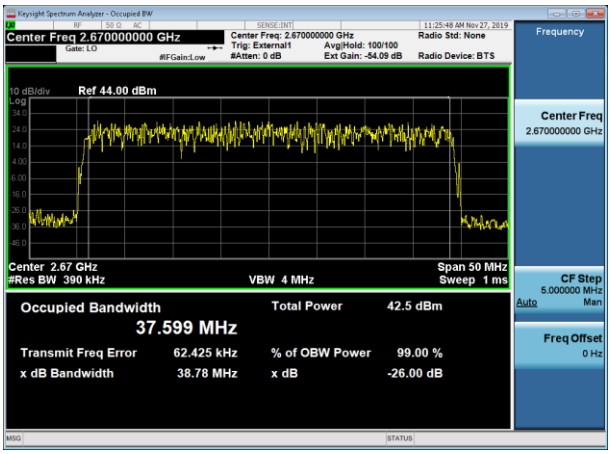

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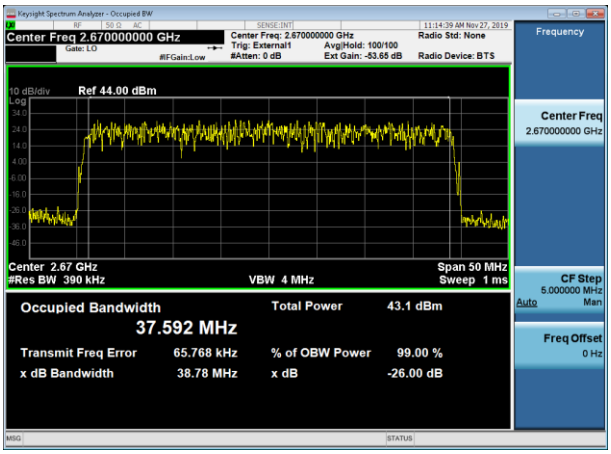

TM3.1a / Channel Frequency 2670 MHz / Signal BW 40 MHz / Modulation 256QAM

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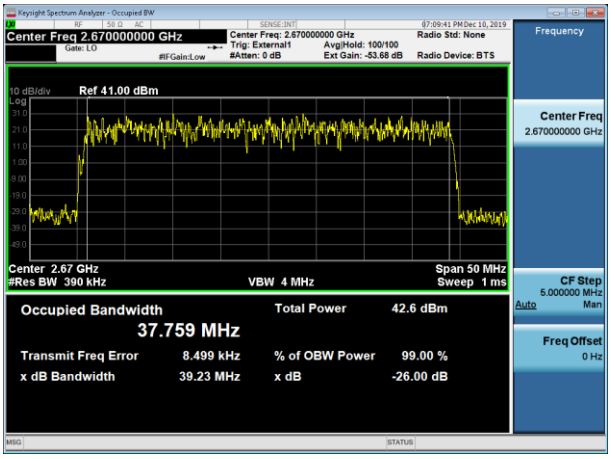

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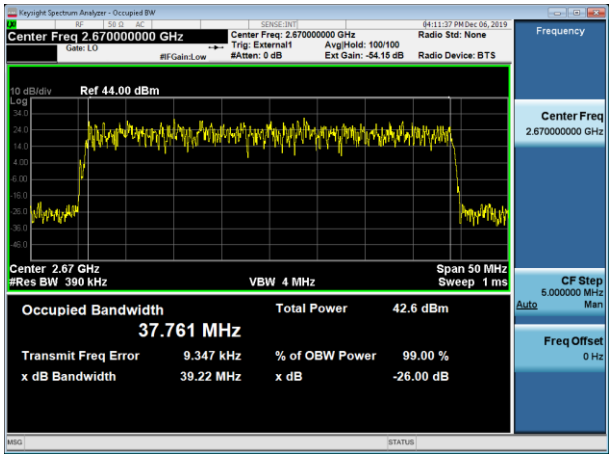

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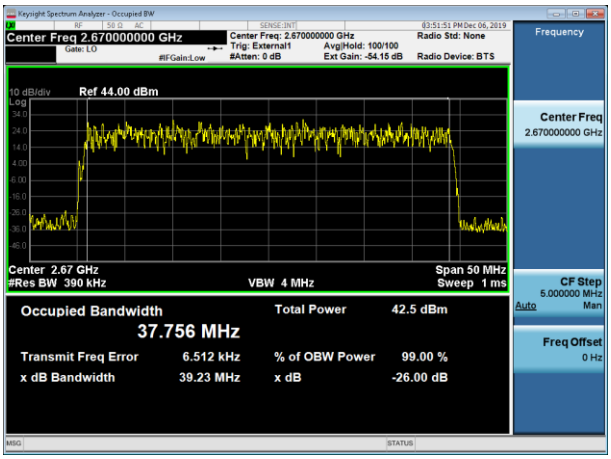
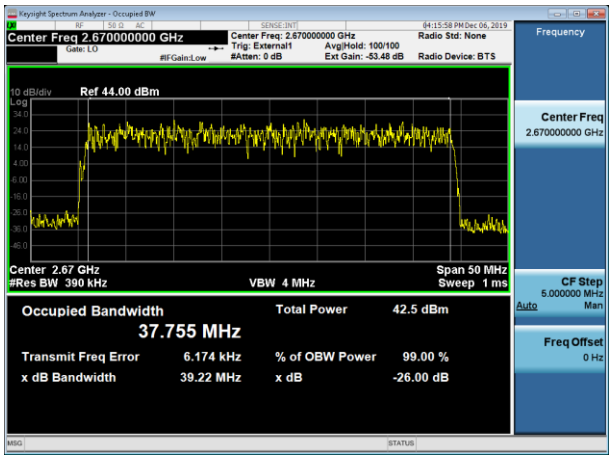
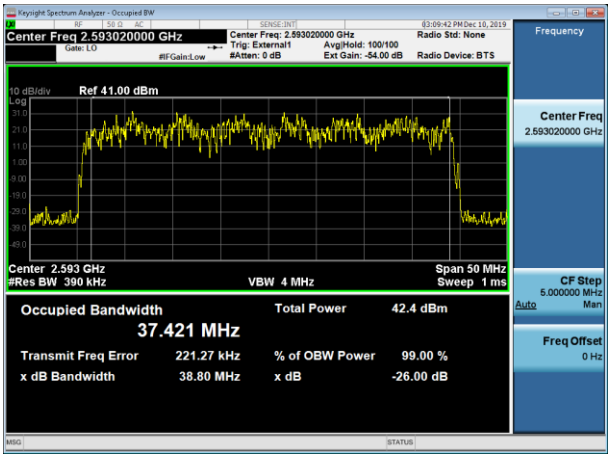


TX4

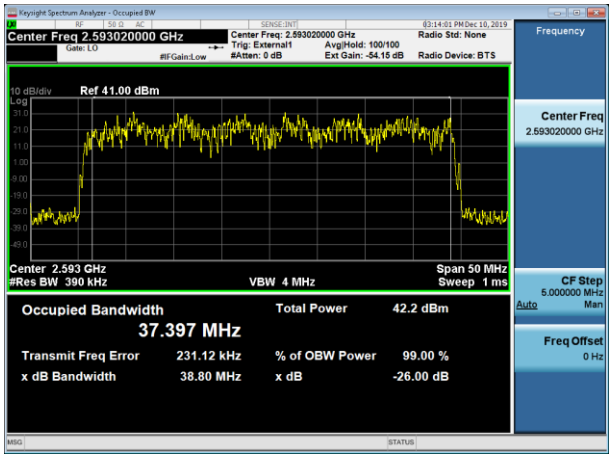


TM3.2 / Channel Frequency 2593 MHz / Signal BW 40 MHz / Modulation QPSK 16QAM

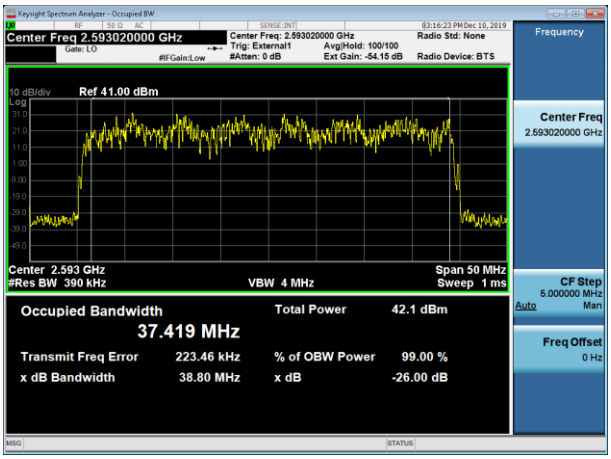
TX1



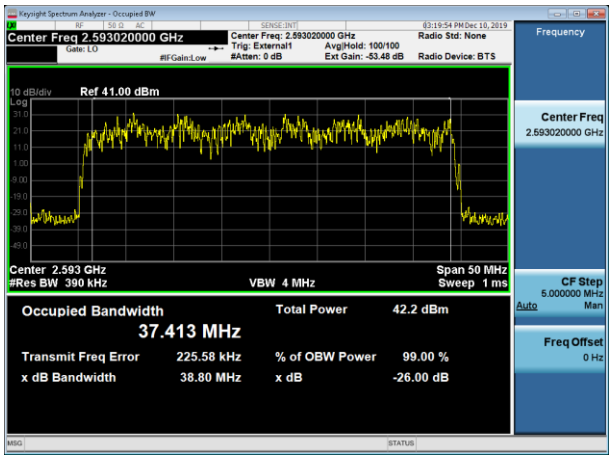
TX2



TX3

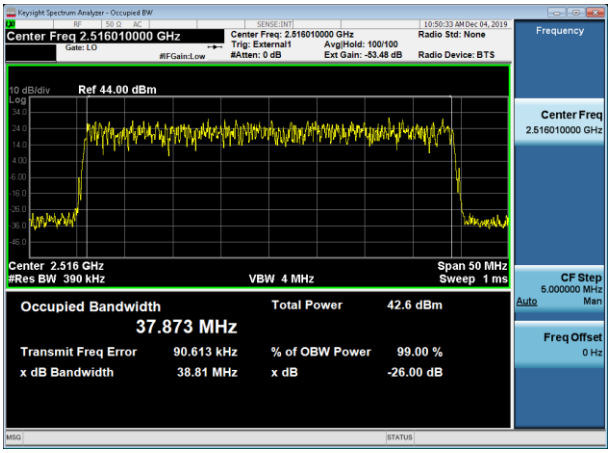


TX4

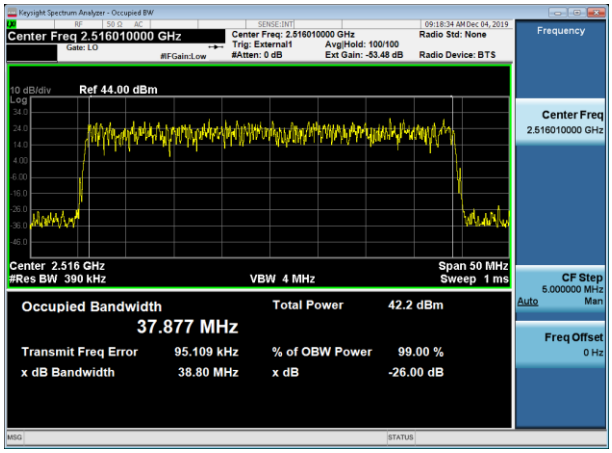


TM3.1 / Channel Frequency 2516 MHz / Signal BW 40 MHz / Modulation 64QAM

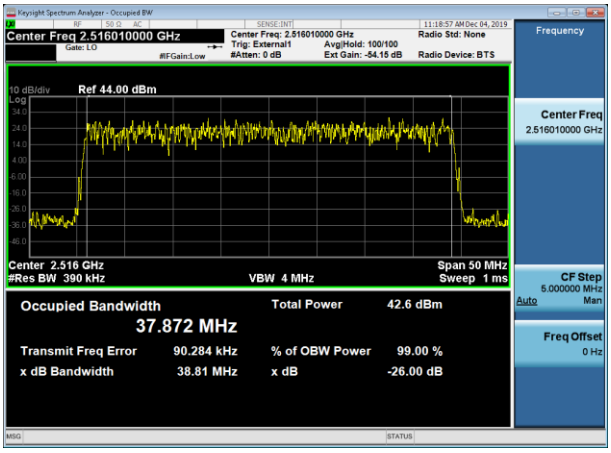
TX1



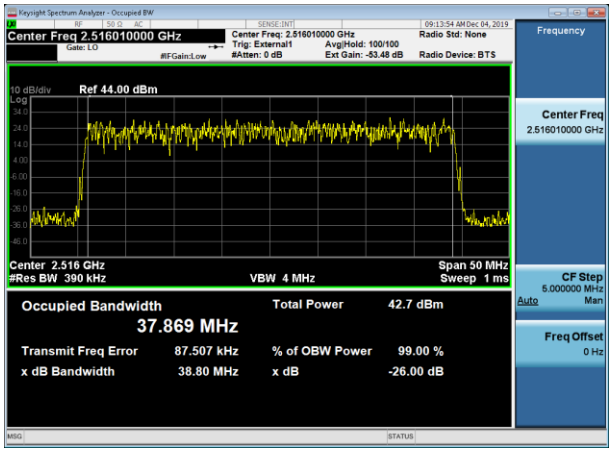
TX2



TX3



TX4



4.2 Edge of band Emissions

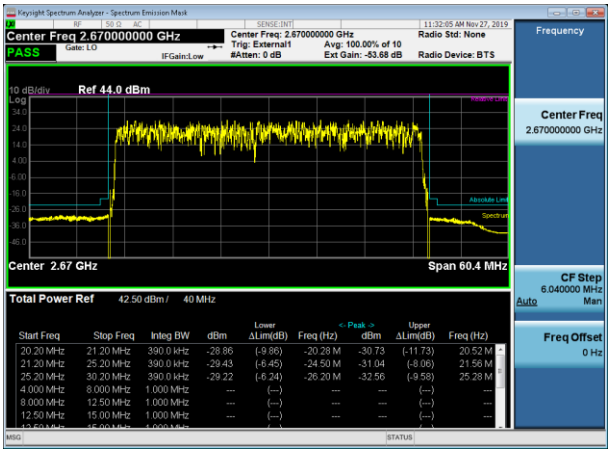
The Edge of Band emissions of the EUT at the external antenna connector (EAC) were measured using a Keysight MXA Signal Analyzer. The RF power level was continuously measured using a RF broadband power meter. The RF output from the EAC port to signal analyzer was reduced (to an amplitude usable by the 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.

4.2.1 Edge of Band Emissions - Plots.

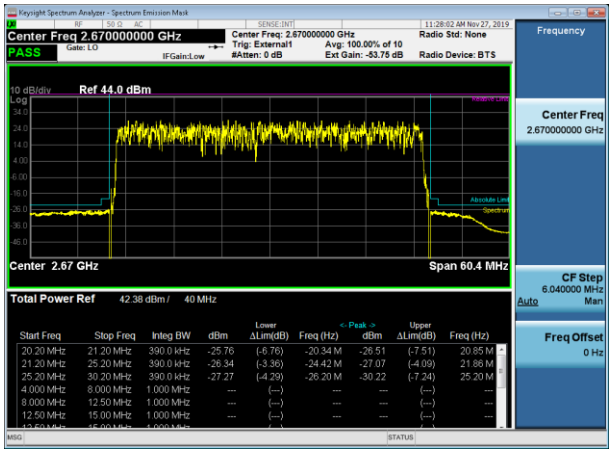
All of the measurements met the requirements of Part 27.53 when measured per Part 2.1049.

TM1.1 / Channel Frequency 2670 MHz / Signal BW 40 MHz / Modulation QPSK

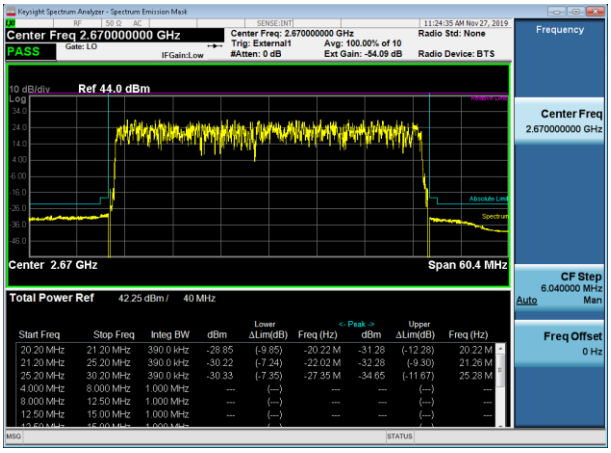
TX1



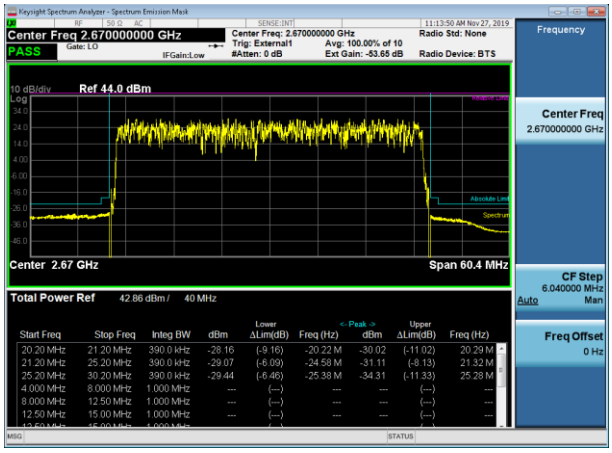
TX2



TX3

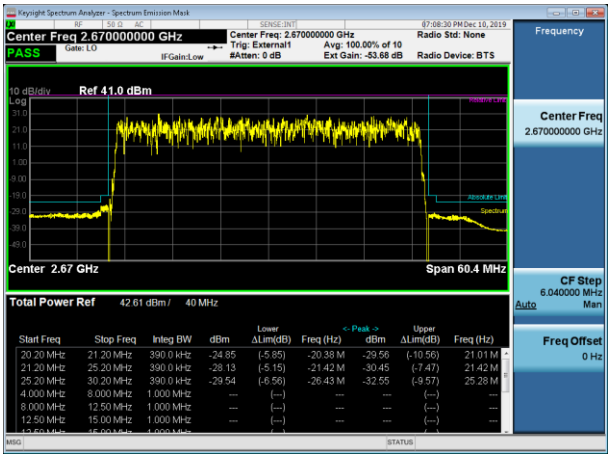


TX4

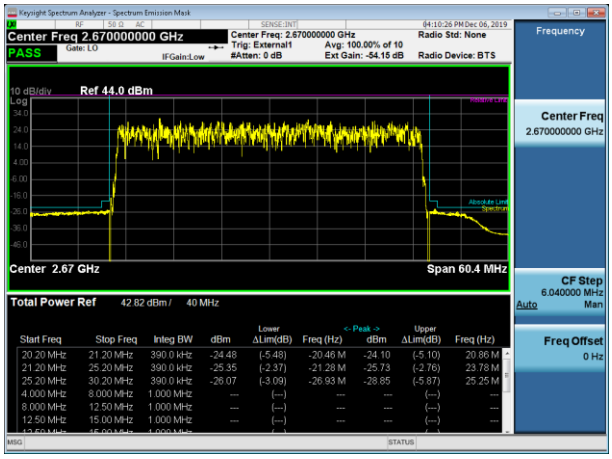


TM3.1a / Channel Frequency 2670 MHz / Signal BW 40 MHz / Modulation 256QAM

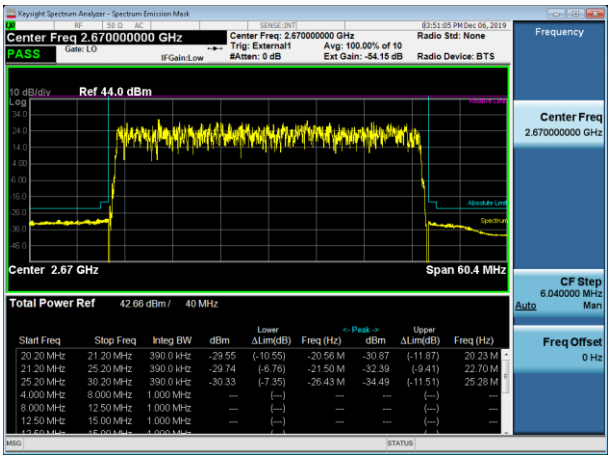
TX1



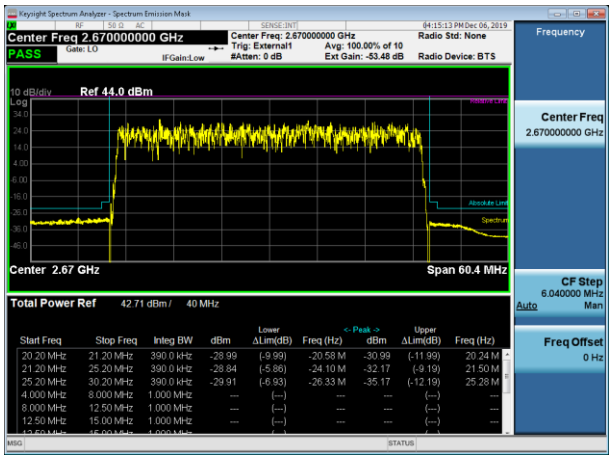
TX2



TX3

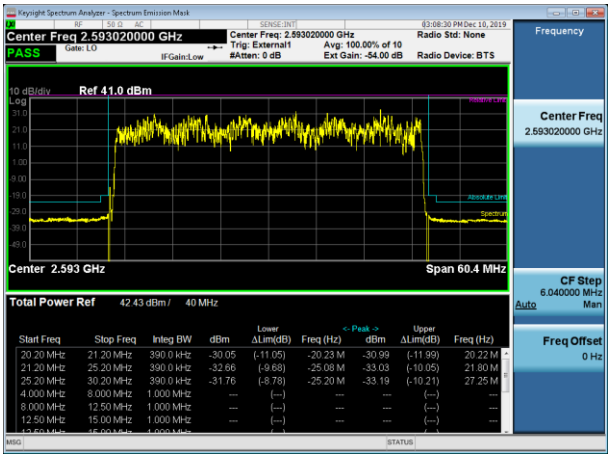


TX4

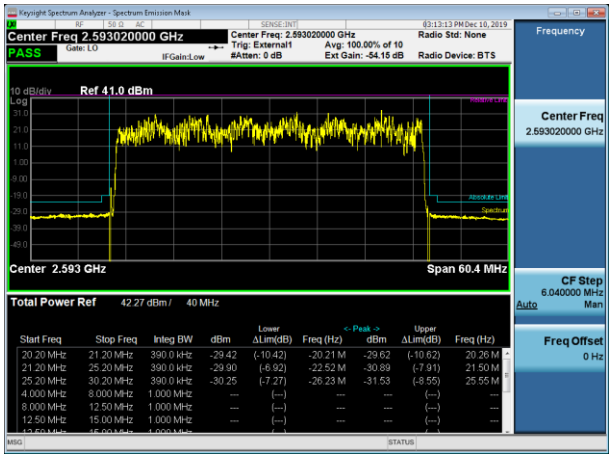


TM3.2 / Channel Frequency 2593 MHz / Signal BW 40 MHz / Modulation QPSK 16QAM

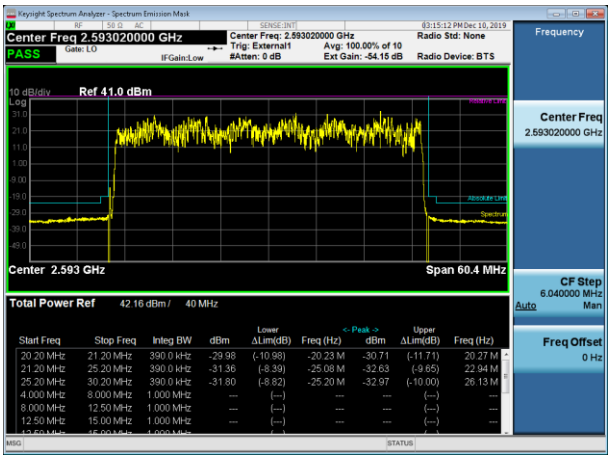
TX1



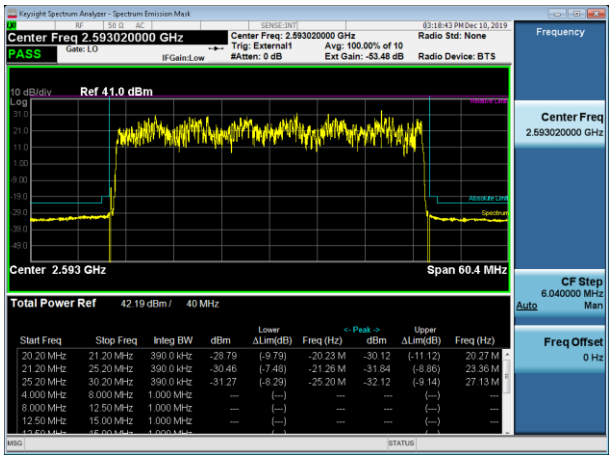
TX2



TX3

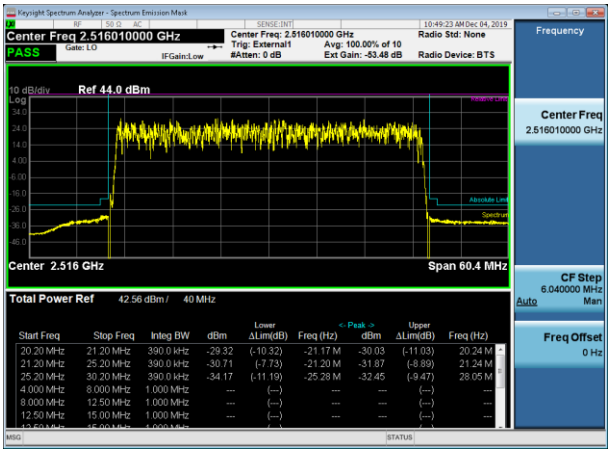


TX4

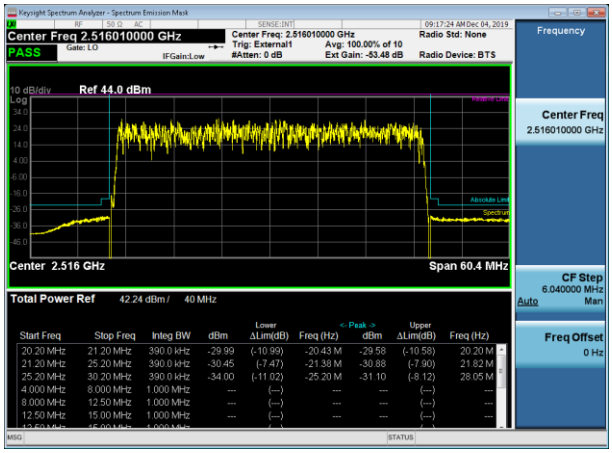


TM3.1 / Channel Frequency 2516 MHz / Signal BW 40 MHz / Modulation 64QAM

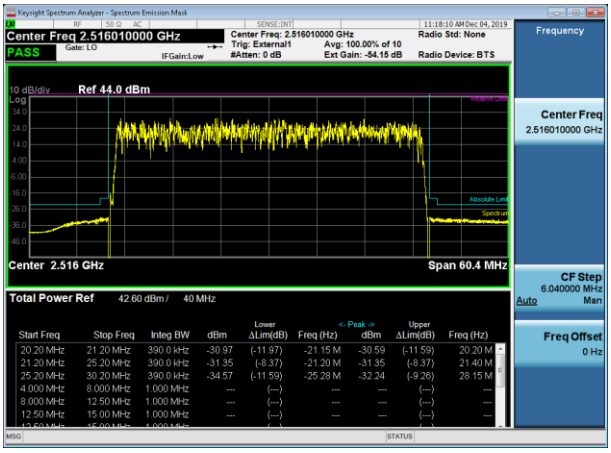
TX1



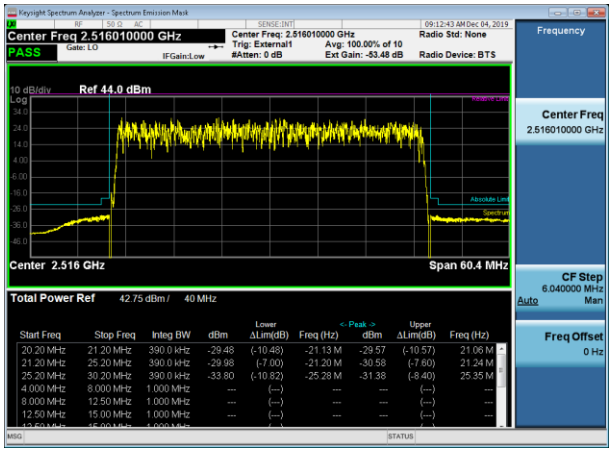
TX2



TX3



TX4



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

5.1 Measurement of Spurious Emissions at Transmit Antenna Port

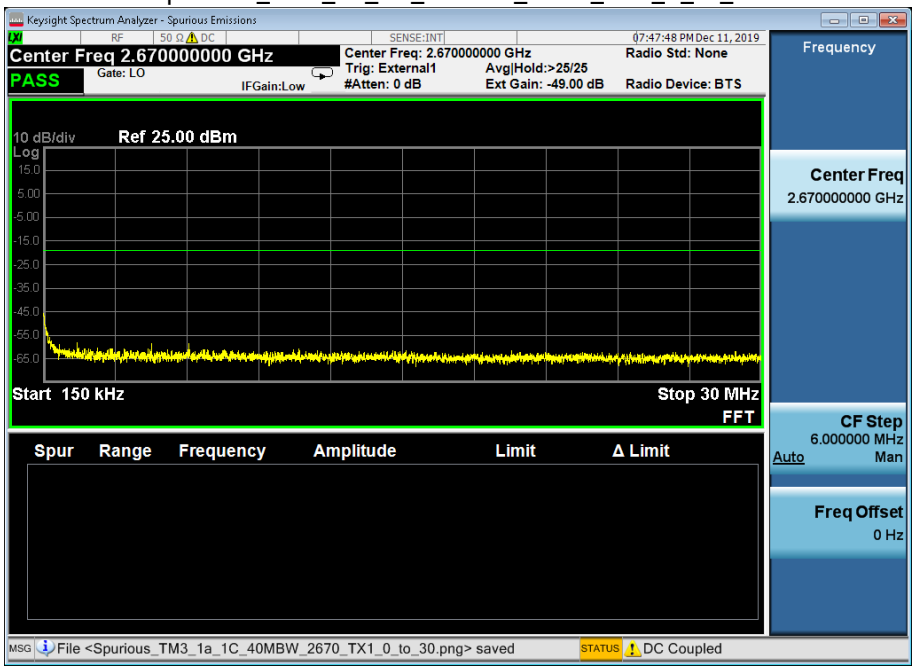
Spurious Emissions at the transmit-antenna terminals were investigated over the frequency range of 10 MHz to beyond the 10th harmonic of the specific transmit band. Carrier Bandwidth is exempt. For this band of operation, the measurements were performed up to 10 GHz. Measurements were made using a Keysight MXA Signal Analyzer. The RF output from the transmitter was reduced (to an amplitude usable by the receivers) using calibrated attenuators. The 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. There were no reportable emissions. Data below documents performance up to 27 GHz.

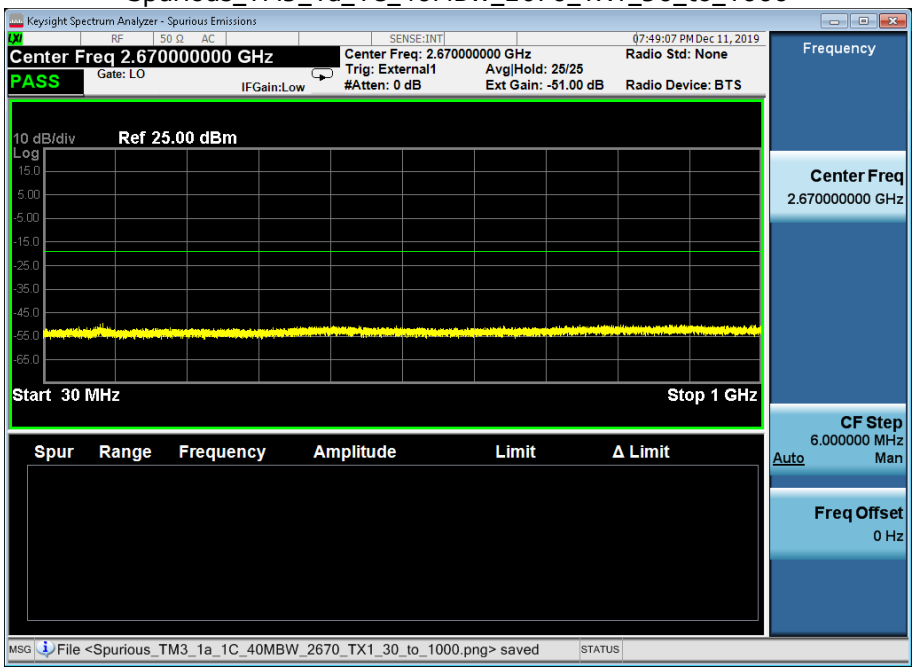
5.1.1 Spurious Emissions at Tx Port - Plots

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.

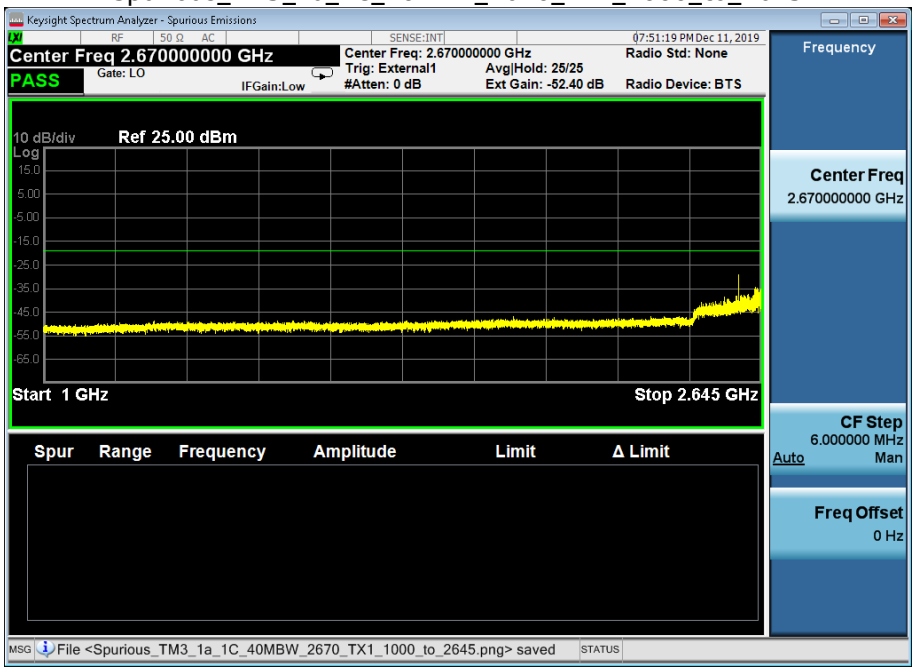
Spurious_TM3_1a_1C_40MBW_2670_TX1_0_to_30



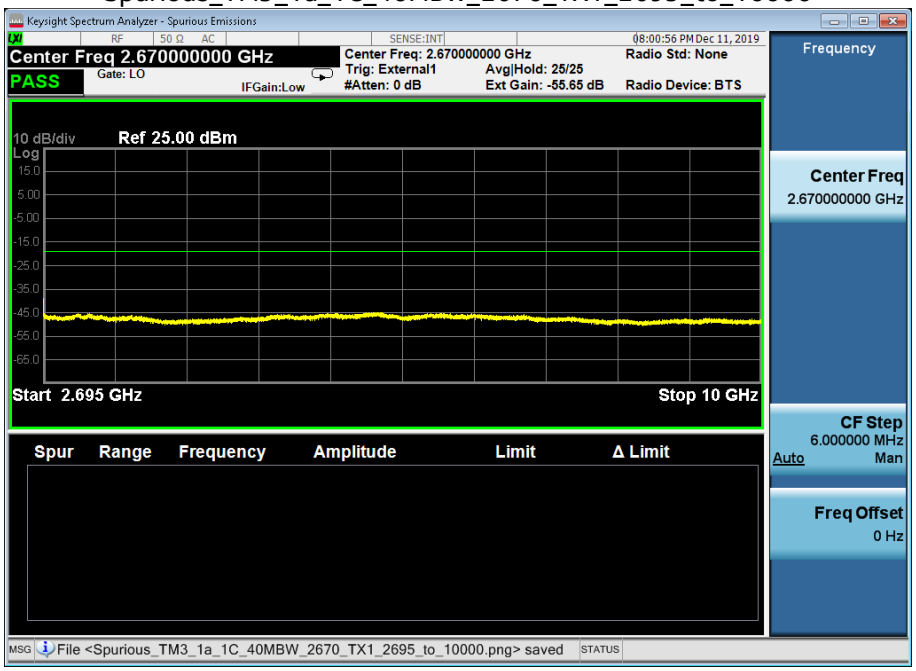
Spurious_TM3_1a_1C_40MBW_2670_TX1_30_to_1000



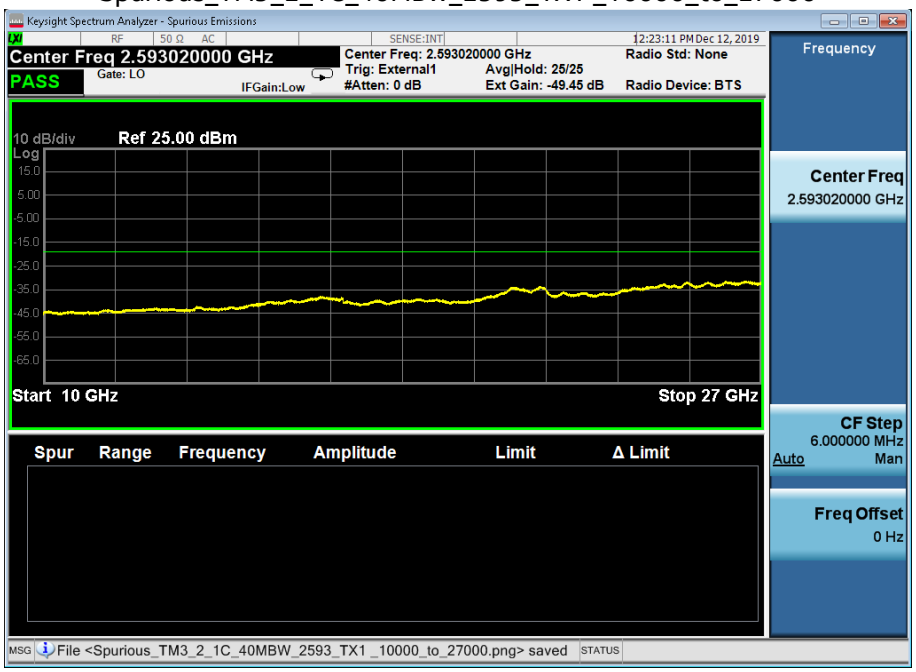
Spurious_TM3_1a_1C_40MBW_2670_TX1_1000_to_2645



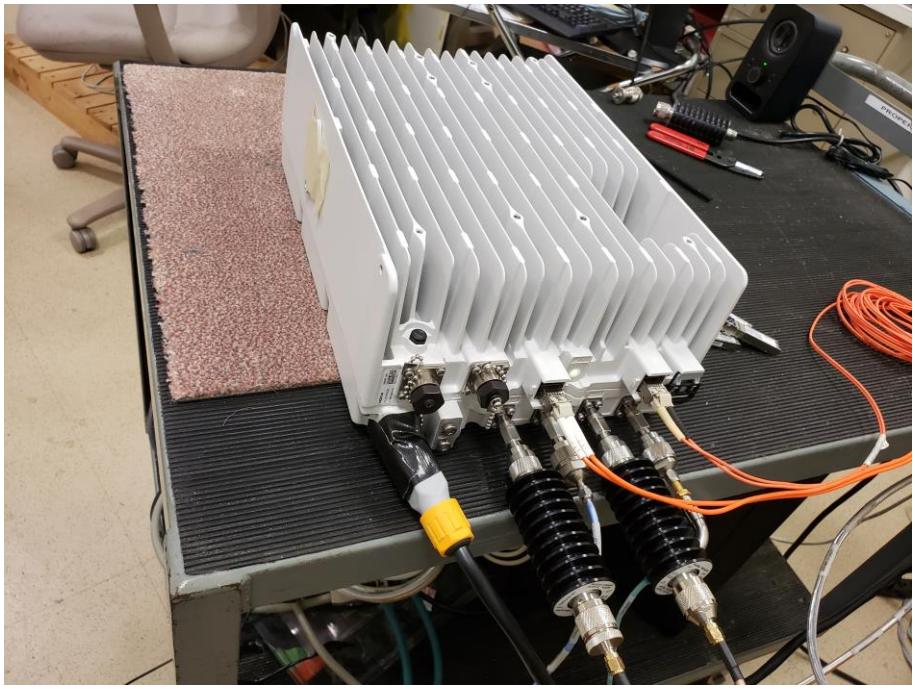
Spurious_TM3_1a_1C_40MBW_2670_TX1_2695_to_10000

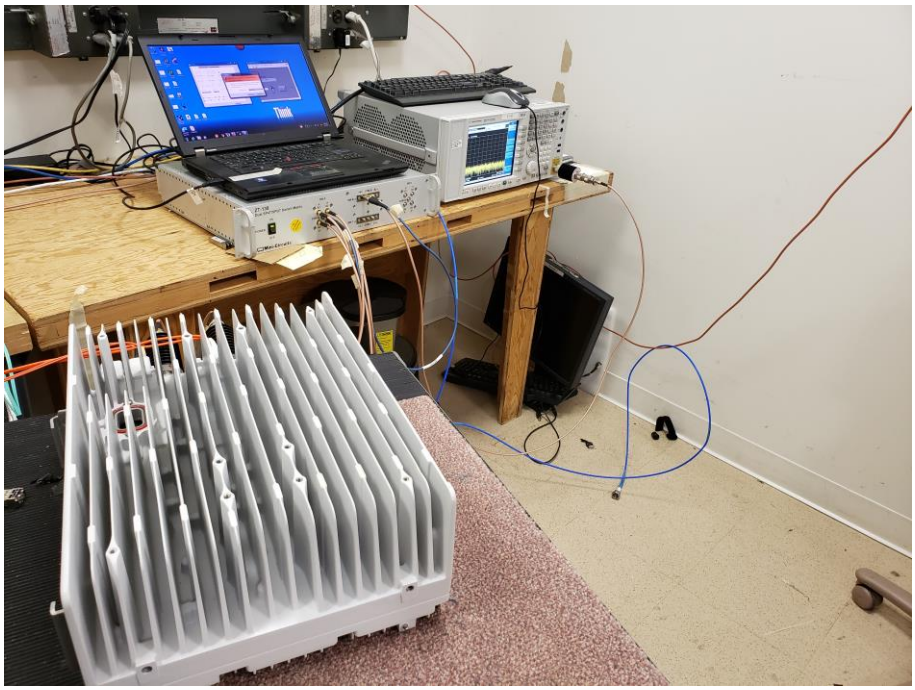


Spurious_TM3_2_1C_40MBW_2593_TX1 _10000_to_27000



Photographs





Test Equipment

Asset ID	Manufacturer	Type	Description	Model	Serial	Calibration Date	Calibration Due
E1152	Agilent Technologies	MXA Signal Analyzer	20Hz-26.5GHz Analyzer	N9020A	MY53420147	2019-04-24	2021-04-24
E1006	Weinschel	Attenuator	30 dB DC-18GHz 150W	6528-30-34-LIM	BN4172	CNR	CNR
E896	Agilent Technologies	Network Analyzer	10 MHz - 40 GHz	N5230C	MY49000897	2019-01-31	2021-01-31
E1120	Extech	Data Logger	Pressure Humidity Temp Data Logger	SD700	Q673552	2019-01-16	2021-01-16

CNR: Calibration Not Required
Environmental Conditions: RH= 16.2.0%, Temp=23.4oC, Pressure=1010.6hPa

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 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 dBuV/m at 3m and 91.77 dBuV/m at 1m
The Part 27 non-report level is 62.23 dBuV/m at 3m.

The calculated emission levels were found by:

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

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 10 GHz), no reportable spurious emissions were detected.

7. FCC Section 2.1055 - Measurement of Frequency Stability

Frequency Block Tested: CF = 2593.02MHz

Transmit Frequency Deviation at +25°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	0.39811
0.5	-1.7246
1.0	-2.6574
1.5	1.5104
2.0	0.19546
2.5	-1.4250
3.0	-1.1909
FCC SPECIFICATION	2593.02 MHz (±0.05ppm) ±0.05ppm = ± 129.65 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +50°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	0.9979
0.5	1.3618
1.0	0.80534
1.5	3.1875
2.0	1.5903
2.5	3.5339
3.0	-1.4292
FCC SPECIFICATION	2593.02 MHz (±0.05ppm) ±0.05ppm = ± 129.65 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +40°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	0.93014
0.5	-1.0828
1.0	1.2968
1.5	0.28392
2.0	1.3072
2.5	-0.2146
3.0	1.2500
FCC SPECIFICATION	2593.02 MHz (±0.05ppm) ±0.05ppm = ± 129.65 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +30°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	1.0769
0.5	2.2056
1.0	1.7379
1.5	0.5800
2.0	1.6963
2.5	1.0385
3.0	1.1579
FCC SPECIFICATION	2593.02 MHz (±0.05ppm) ±0.05ppm = ± 129.65 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +20°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	1.8270
0.5	-0.64430
1.0	1.0341
1.5	0.11581
2.0	2.4718
2.5	0.28472
3.0	1.2596
FCC SPECIFICATION	2593.02 MHz (±0.05ppm) ±0.05ppm = ± 129.65 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +10°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	1.5555
0.5	0.45559
1.0	0.76444
1.5	-2.4604
2.0	2.0686
2.5	-2.1009
3.0	-0.8551
FCC SPECIFICATION	2593.02 MHz (±0.05ppm) ±0.05ppm = ± 129.65 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at 0°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-1.2283
0.5	1.2998
1.0	2.0418
1.5	0.849
2.0	0.174
2.5	1.0213
3.0	-0.296
FCC SPECIFICATION	2593.02 MHz (±0.05ppm) ±0.05ppm = ± 129.65 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at -10°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	0.607
0.5	-1.2890
1.0	-1.3821
1.5	0.6215
2.0	0.1685
2.5	0.2269
3.0	4.0008
FCC SPECIFICATION	2593.02 MHz (±0.05ppm) ±0.05ppm = ± 129.65 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at -20°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	1.3189
0.5	-1.8871
1.0	-4.0669
1.5	1.8748
2.0	0.1112
2.5	-0.5211
3.0	1.4123
FCC SPECIFICATION	2593.02 MHz (±0.05ppm) ±0.05ppm = ± 129.65 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at -30°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-1.3363
0.5	0.4015
1.0	0.281
1.5	0.2588
2.0	0.6081
2.5	-0.4272
3.0	1.6795
FCC SPECIFICATION	2593.02 MHz (±0.05ppm) ±0.05ppm = ± 129.65 Hz
FCC RESULT	PASS

Upon return to +20°C, vary voltage to +15% and -15% of nominal and record frequency difference. Result will be 12 readings for each voltage (nominal, +15%, and nominal, -15%).

Transmit Frequency Deviation at +20°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-1.6096
0.5	0.91679
1.0	-0.4410
1.5	2.9278
2.0	1.5315
2.5	0.34731
3.0	-2.8089
FCC SPECIFICATION	2593.02 MHz (±0.05ppm) ±0.05ppm = ± 129.65 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +20°C at 115% of Nominal Voltage, -55.20VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	1.4490
0.5	0.87357
1.0	2.1270
1.5	0.9390
2.0	-1.0557
2.5	2.0732
3.0	0.24001
FCC SPECIFICATION	2593.02 MHz (±0.05ppm) ±0.05ppm = ± 129.65 Hz
FCC RESULT	PASS

Return to +20°C at -48.0 VDC

Transmit Frequency Deviation at +20°C at 100% of Nominal Voltage, -48.0VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-1.6742
0.5	-0.4032
1.0	-1.6011
1.5	-0.2587
2.0	-1.9243
2.5	1.1673
3.0	1.7334
FCC SPECIFICATION	2593.02 MHz (±0.05ppm) ±0.05ppm = ± 129.65 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +20°C at -15% of Nominal Voltage, -40.80VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	0.30241
0.5	-0.7324
1.0	2.4608
1.5	2.8715
2.0	-2.4876
2.5	1.4782
3.0	2.8620
FCC SPECIFICATION	2593.02 MHz (±0.05ppm) ±0.05ppm = ± 129.65 Hz
FCC RESULT	PASS

Frequency Block Tested: low F = 2516.01MHz

Transmit Frequency Deviation at +50°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	2.6656
0.5	0.50794
1.0	1.8018
1.5	0.63887
2.0	1.3157
2.5	-0.1759
3.0	0.37050
FCC SPECIFICATION	2516.01 MHz (±0.05ppm) ±0.05ppm = ± 125.80 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +40°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	1.8405
0.5	30.772
1.0	-1.1359
1.5	0.90560
2.0	1.1323
2.5	1.3433
3.0	-1.9677
FCC SPECIFICATION	2516.01 MHz (±0.05ppm) ±0.05ppm = ± 125.80 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +30°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	1.6957
0.5	0.8321
1.0	3.3029
1.5	-0.4822
2.0	1.4971
2.5	1.8425
3.0	- 0.8068
FCC SPECIFICATION	2516.01 MHz (±0.05ppm) ±0.05ppm = ± 125.80 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +20°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	1.3231
0.5	-1.3355
1.0	1.0142
1.5	0.16143
2.0	1.4914
2.5	-1.5646
3.0	-0.1627
FCC SPECIFICATION	2516.01 MHz (±0.05ppm) ±0.05ppm = ± 125.80 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +10°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	0.12877
0.5	-1.316
1.0	1.2124
1.5	0.66811
2.0	1.5633
2.5	-1.0591
3.0	-0.6764
FCC SPECIFICATION	2516.01 MHz (±0.05ppm) ±0.05ppm = ± 125.80 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at 0°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-2.1620
0.5	3.1239
1.0	-0.3912
1.5	-2.5813
2.0	0.4706
2.5	0.5606
3.0	0.3189
FCC SPECIFICATION	2516.01 MHz (±0.05ppm) ±0.05ppm = ± 125.80 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at -10°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	1.4927
0.5	2.2975
1.0	4.2367
1.5	0.0657
2.0	0.7727
2.5	2.3976
3.0	2.0212
FCC SPECIFICATION	2516.01 MHz (±0.05ppm) ±0.05ppm = ± 125.80 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at -20°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	0.40498
0.5	-1.5519
1.0	2.7204
1.5	1.8186
2.0	1.4626
2.5	0.43675
3.0	-3.1571
FCC SPECIFICATION	2516.01 MHz (±0.05ppm) ±0.05ppm = ± 125.80 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at -30°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-1.9024
0.5	2.4360
1.0	3.6934
1.5	3.8080
2.0	-1.4877
2.5	-1.4019
3.0	-0.9678
FCC SPECIFICATION	2516.01 MHz (±0.05ppm) ±0.05ppm = ± 125.80 Hz
FCC RESULT	PASS

Upon return to +20°C, vary voltage to +15% and -15% of nominal and record frequency difference. Result will be 12 readings for each voltage (nominal, +15%, and nominal, -15%).

Transmit Frequency Deviation at +20°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	1.6859
0.5	0.46823
1.0	1.0995
1.5	0.03672
2.0	0.86061
2.5	0.74933
3.0	1.1776
FCC SPECIFICATION	2516.01 MHz (±0.05ppm) ±0.05ppm = ± 125.80 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +20°C at 115% of Nominal Voltage, -55.20VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	0.33691
0.5	1.9266
1.0	-1.5814
1.5	1.8463
2.0	-0.1123
2.5	-0.5455
3.0	- 1.5244
FCC SPECIFICATION	2516.01 MHz (±0.05ppm) ±0.05ppm = ± 125.80 Hz
FCC RESULT	PASS

Return to +20°C @ 48.0VDC

Transmit Frequency Deviation at +20°C at 100% of Nominal Voltage, -48.0VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	0.47762
0.5	-1.4368
1.0	2.6702
1.5	2.5575
2.0	-0.1546
2.5	2.1727
3.0	0.68323
FCC SPECIFICATION	2516.01 MHz (±0.05ppm) ±0.05ppm = ± 125.80 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +20°C at -15% of Nominal Voltage, -40.80VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	0.62864
0.5	2.1134
1.0	-0.2969
1.5	-2.6502
2.0	1.9950
2.5	2.4228
3.0	1.0790
FCC SPECIFICATION	2516.01 MHz (±0.05ppm) ±0.05ppm = ± 125.80 Hz
FCC RESULT	PASS

Frequency Block Tested: High F = 2670.00MHz

Transmit Frequency Deviation at +50°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	0.40174
0.5	3.0125
1.0	-2.0262
1.5	1.0017
2.0	0.32382
2.5	0.30169
3.0	1.7814
FCC SPECIFICATION	2670.00 MHz (±0.05ppm) ±0.05ppm = ± 133.50 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +40°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	1.7755
0.5	-0.3926
1.0	1.1787
1.5	0.71426
2.0	-1.2734
2.5	-0.7797
3.0	1.7799
FCC SPECIFICATION	2670.00 MHz (±0.05ppm) ±0.05ppm = ± 133.50 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +30°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	0.8128
0.5	-1.8563
1.0	1.3993
1.5	4.7146
2.0	1.7591
2.5	1.0726
3.0	0.01421
FCC SPECIFICATION	2670.00 MHz (±0.05ppm) ±0.05ppm = ± 133.50 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +20°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	0.79086
0.5	0.58800
1.0	1.3872
1.5	1.1079
2.0	-1.6097
2.5	3.82508
3.0	- 0.6958
FCC SPECIFICATION	2670.00 MHz (±0.05ppm) ±0.05ppm = ± 133.50 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +10°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	3.4315
0.5	-0.4122.
1.0	-0.2073.
1.5	-1.1516
2.0	-0.3371
2.5	1.2196
3.0	1.1654
FCC SPECIFICATION	2670.00 MHz (±0.05ppm) ±0.05ppm = ± 133.50 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at 0°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	1.6599
0.5	0.1362
1.0	2.3757
1.5	-1.5477
2.0	-0.06488
2.5	- 0.5547
3.0	- 0.1941
FCC SPECIFICATION	2670.00 MHz (±0.05ppm) ±0.05ppm = ± 133.50 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at -10°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	1.1868
0.5	1.1075
1.0	0.54036
1.5	0.58766
2.0	0.16289
2.5	-1.5906
3.0	-0.1431
FCC SPECIFICATION	2670.00 MHz (±0.05ppm) ±0.05ppm = ± 133.50 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at -20°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	2.1410
0.5	-1.6355
1.0	0.4356
1.5	2.6764
2.0	2.4992
2.5	0.77876
3.0	1.5563
FCC SPECIFICATION	2670.00 MHz (±0.05ppm) ±0.05ppm = ± 133.50 Hz
FCC RESULT	PASS

Transmit Frequency Deviation at -30°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	1.2706
0.5	-0.7344
1.0	1.9295
1.5	-1.4735
2.0	2.7419
2.5	0.3897
3.0	1.0828
FCC SPECIFICATION	2670.00 MHz (±0.05ppm) ±0.05ppm = ± 133.50 Hz
FCC RESULT	PASS

Upon return to +20°C, vary voltage to +15% and -15% of nominal and record frequency difference. Result will be 12 readings for each voltage (nominal, +15%, and nominal, -15%).

Transmit Frequency Deviation at +20°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-1.2130
0.5	0.65086
1.0	1.7293
1.5	-0.8766
2.0	0.10983
2.5	3.2373
3.0	-0.3850
FCC SPECIFICATION	2670.00 MHz (±0.05ppm) ±0.05ppm = ± 133.50 Hz
FCC RESULT	PASS

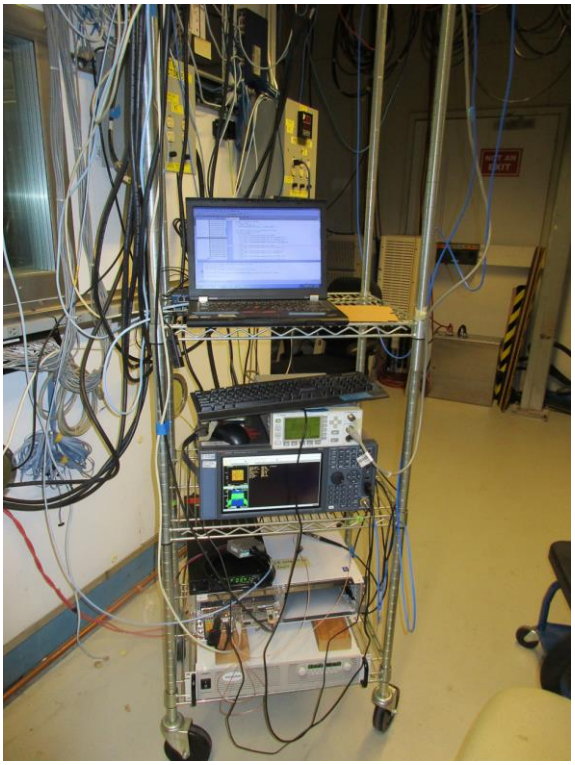
Transmit Frequency Deviation at +20°C at 115% of Nominal Voltage, -55.20VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	0.14521
0.5	1.0674
1.0	0.82206
1.5	1.4580
2.0	0.89183
2.5	0.73733
3.0	3.1978
FCC SPECIFICATION	2670.00 MHz (±0.05ppm) ±0.05ppm = ± 133.50 Hz
FCC RESULT	PASS

Return to +20°C @ 48.0VDC

Transmit Frequency Deviation at +20°C at 100% of Nominal Voltage, -48.0VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-1.4540
0.5	2.3033
1.0	1.8232
1.5	-1.3119
2.0	-1.6720
2.5	- 2.6816
3.0	- 0.4982
FCC SPECIFICATION	2670.00 MHz (±0.05ppm) ±0.05ppm = ± 133.50 Hz
FCC RESULT	PASS

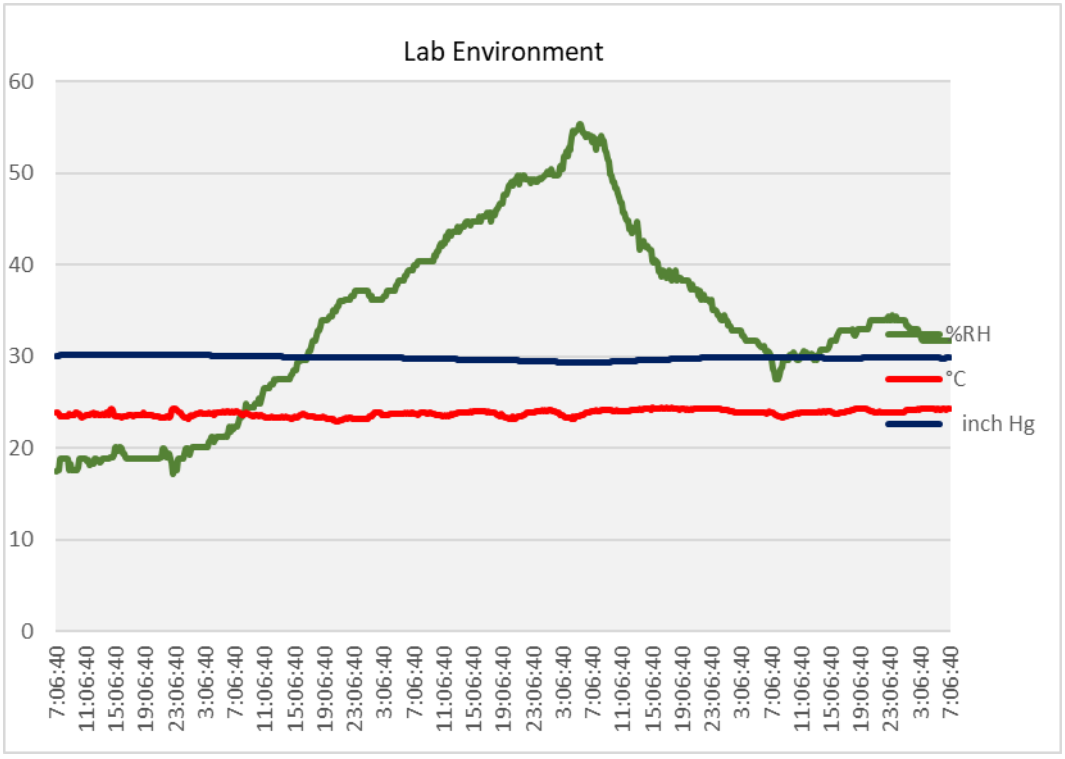
Transmit Frequency Deviation at +20°C at -15% of Nominal Voltage, -40.80VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	0.39351
0.5	-0.5183
1.0	1.3488
1.5	0.69154
2.0	0.48122
2.5	-1.1247
3.0	1.9495
FCC SPECIFICATION	2670.00 MHz (±0.05ppm) ±0.05ppm = ± 133.50 Hz
FCC RESULT	PASS

Photographs



Test Equipment

Asset ID	Manufacturer	Type	Description	Model	Serial	Calibration Date	Calibration Due
TH534-T13	Envirotronics	Controller		Envirotronics SPPCM	SP000638	2019-05-22	2021-05-22
TH-T13	Envirotronics	Thermal Chamber		N/A	0999-4722	2018-09-20	2020-09-20
TH069	Extech	Data Logger	Barometric Pressure/Humidity/Temperature	SD700	Q690305	2019-06-26	2021-06-26
TH054	Yokogawa	Recorder	MobileCorder Paperless Videographic Recorder	MV2048	S5JC04076	2019-02-26	2021-02-26



8. NVLAP Certificate of Accreditation

United States Department of Commerce
National Institute of Standards and Technology

NVLAP®

Certificate of Accreditation to ISO/IEC 17025:2005

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 17025:2005. 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).

2019-09-20 through 2020-09-30
Effective Dates

DEPARTMENT OF COMMERCE * UNITED STATES OF AMERICA *

For the National Voluntary Laboratory Accreditation Program