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Title 47 Code of Federal Regulations Test Report

Regulation:
FCC Part 2 and 22

Client:
Nokia Mobile Networks

Product Evaluated:
AHCA 5G NR 2X60 & 4X40

Report Number:
TR-2019-0125-FCC2-22

Date Issued:
September 10, 2019

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Revisions

Date	Revision	Section	Change
9/4/19	0		Initial Release
9/4/19	1		Updated Specifications table
9/5/19	2		Updated FCC Part 22.917 reference
9/10/19	3	1.0	Corrected Applicants name and address
		2.0	New data with adjusted Power levels
		4.1	Occupied Bandwidth data with adjusted Power levels

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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):	AHCA 5G NR 2X60 & 4X40
FCC ID:	VBNAHCA-01
Serial Number:	L1171302323
Hardware Version:	473966A.101
Software Version:	5G19A
Frequency Range:	869-894MHz
GPCL Project Number:	2019-0125
Applicant	Nokia Solutions and Networks US LLC
Manufacturer:	Nokia Solutions and Networks US LLC 6000 Connection Drive Irving, Texas, USA 75039
Test Requirement(s):	Title 47 CFR Parts 2 and 22
Test Standards:	<ul style="list-style-type: none"> • Title 47 CFR Parts 2 and 22 • KDB 971168 D01 Power Measurement License Digital Systems v03r01 April 9, 2018. • KDB 662911 D01 Multiple Transmitter Output v02r01 Oct 2013 • ANSI C63.26 (2015) • ANSI C63.4 (2014)
Measurement Procedure(s):	<ul style="list-style-type: none"> • 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):	July/August 2019
Test Performed By:	Nokia Global Product Compliance Laboratory 600-700 Mountain Ave. P.O. Box 636 Murray Hill, NJ 07974-0636
Product Engineer(s):	Ron Remy
Lead Engineer:	Steve Gordon
Test Engineer (s):	Jaideep Yadav, Nilesh Patel, Eugene Mitchell, Mike Soli
Test Results: The EUT, <i>as tested</i> 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 AHCA 5G NR 2X60 & 4X40, hereinafter referred to as the Equipment Under Test (EUT).

1.2 Purpose and Scope

The purpose of this document is to provide the testing data required for qualifying the EUT in compliance with FCC Parts 2 and 22, per requirements for Class II permissive changes certification, measured in accordance with the procedures set out in Section 2.1033 (c) (14) of the Rules.

This project requires a FCC Class II change to add new emissions designators for 5G technology. This includes 5, 10, 15, and 20 MHz BW Emission designators using 5G NR modulation, along with multicarrier options that were previously certified for 4G LTE technology. The current FCC Grant of Equipment Authorization certification has maximum power listed as 38.02 W (45.80 dBm) and 59.02 W (47.71 dBm) and Grant notes indicate operation for 4 x 40 W and 2 X 60 W modes.

1.3 EUT Details

The EUT is an LTE Base transceiver station RRH 850 MHz with 4 power amplifiers.

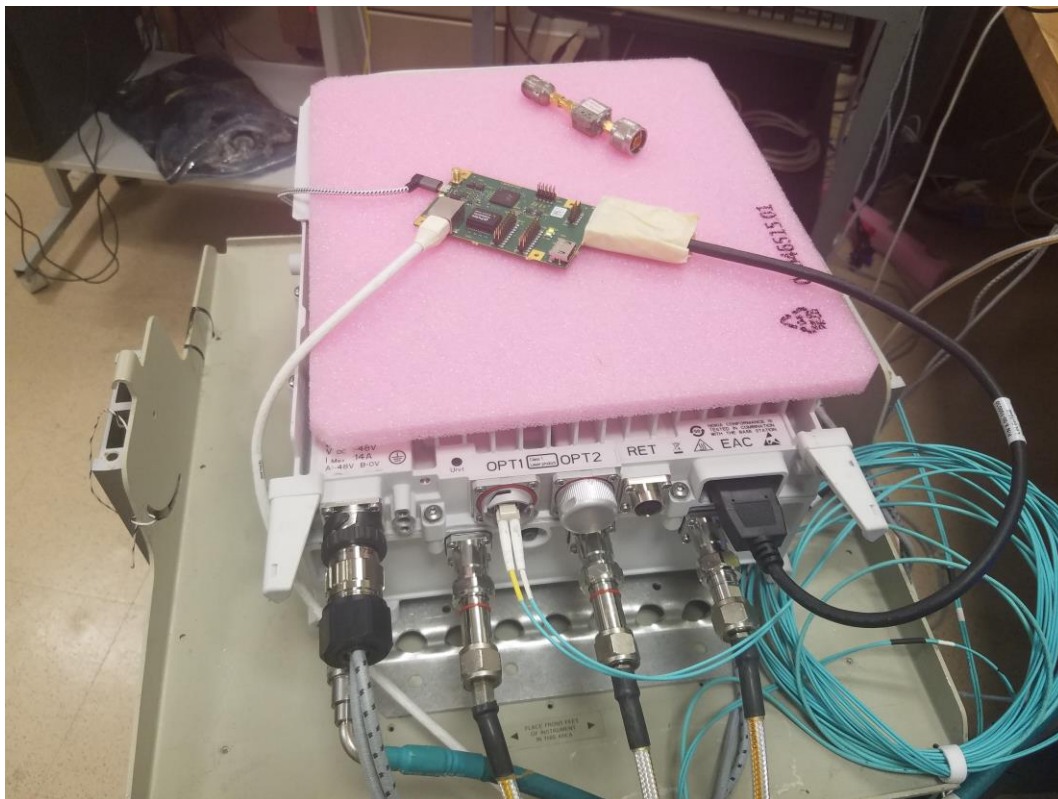
The BTS performs the full RAN function of LTE system (evolved UTRA). This is sometimes referred to as collapsed RAN, where equivalent functions of former 3G BTS and 3G RNC are all integrated into BTS. BTS is connected directly to the core network via S1 interface, and to mobile stations via Air interface (Uu). In addition, BTS's are optionally connected directly to each other via X2 interface for handover purposes.

The tested equipment is representative for serial production.

1.3.1 Specifications

Specification Items	Description	
Radio Access Technology	E-UTRA	
Duplex Mode	Frequency Division Duplex (FDD)	
Modulation Type(s)	QPSK, 16QAM, 64QAM, 256QAM	
Operation Frequency Range	869-894MHz	
Channel Bandwidth	5, 10, 15 and 20MHz	
Supply Voltage	48.0 VDC	
Single carrier		
Rated Output Power (Prat)	60W (47.8 dBm) and 40W (46.0 dBm) conducted / carrier	
	RX	TX
Number of Antenna Ports	4 (ANT1 to ANT4, 40W) 2 (ANT1 and ANT3, 60W)	4 (ANT1 to ANT4, 40W) 2 (ANT1 and ANT3, 60W)
MiMo	Yes	Yes

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	RF Power Output	Yes
2.1047	Modulation Characteristics	Yes
2.1049	(a) Occupied Bandwidth (b) Out-of-Band Emissions	Yes
2.1051	Conducted Out-of-Band Emissions Spurious Emissions at Antenna Terminals	Yes
2.1053, 22.917	Field Strength of Spurious Radiation	Yes

1.5 Standards & Procedures

1.5.1 Standards

- Title 47 Code of Federal Regulations, Federal Communications Commission Part 2.
- Title 47 Code of Federal Regulations, Federal Communications Commission Part 22.
- ANSI C63.26, American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services
- ANSI C63.4 (2014) entitled: “American National Standard for Methods of Measurement of Radio-Noise Emissions from Low Voltage Electrical and Electronic Equipment in the Range of 9kHz to 40 GHz”, American National Standards Institute, Institute of Electrical and Electronic Engineers, Inc., New York, NY 10017-2394, USA.

1.5.2 Procedures

1. FCC-IC-0B and FCC-IC-SE
2. 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	±5.1 dB
		30 MHz – 200 MHz V	±5.1 dB
		200 MHz – 1000 MHz H	±4.7 dB
		200 MHz – 1000 MHz V	±4.7 dB
	1 GHz - 18 GHz	±3.3 dB	

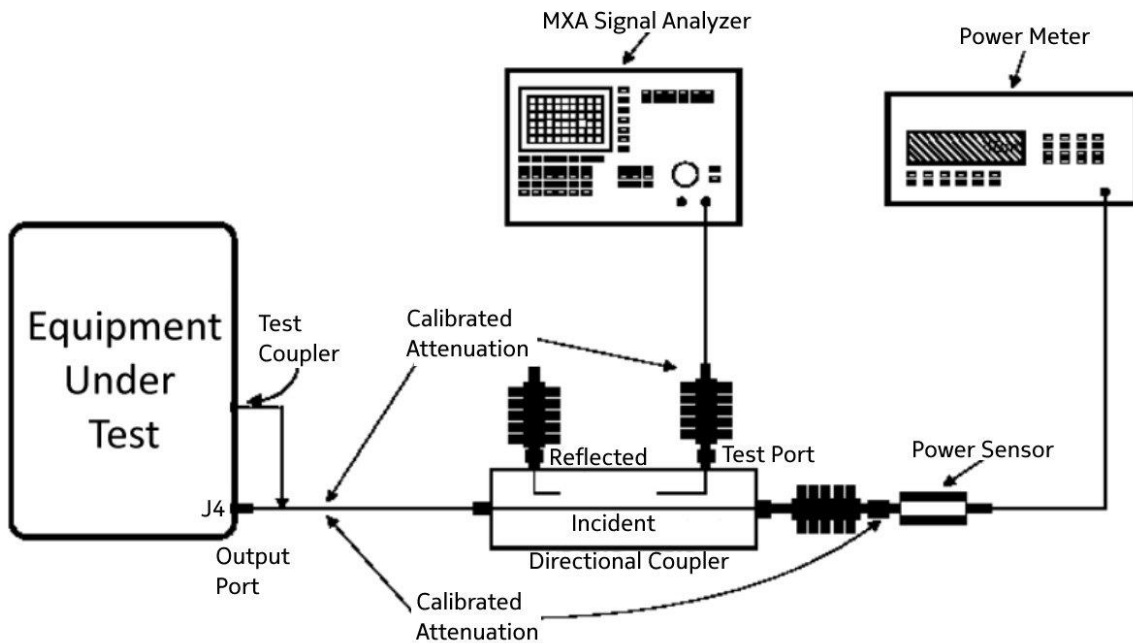
Antenna Port Test	Signal Bandwidth	Frequency Range	Expanded Uncertainty (k=2), Amplitude
Occupied Bandwidth, Edge of Band, Conducted Spurious Emissions	10 Hz	9 kHz to 20 MHz	1.78 dB
	100 Hz	20 MHz to 1 GHz	
	10 kHz to 1 MHz	1 GHz to 10 GHz	
	1MHz	10 GHz to 40 GHz:	
RF Power	10 Hz to 20 MHz	50 MHz to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

1.6 Executive Summary

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

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 (40W)

Channel Frequency MHz	Signal BW MHz	Modulation	Channel Power Watts	Channel Power dBm
871.5	5	QPSK	39.26	45.94
884	20	QPSK	37.1	45.70
874	10	64QAM	37.41	45.73
881.5	5	64QAM	37.33	45.72
889	10	64QAM	36.89	45.67
884	20	256QAM	37.24	45.71
891	5	256QAM	38.46	45.85
879	20	QPSK + 16QAM	37.33	45.72
886.5	15	QPSK + 16QAM	37.67	45.76

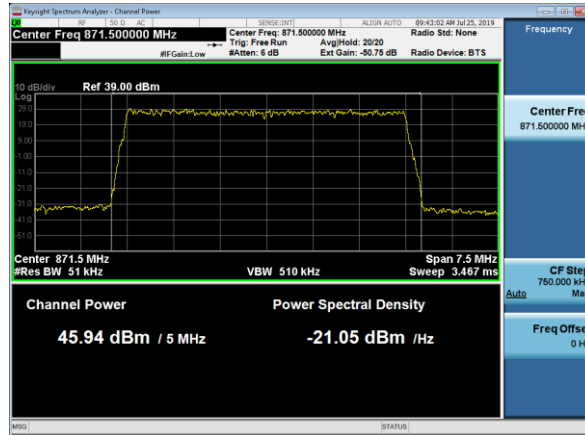
Tabular Data – Channel RF Power (60W)

Channel Frequency MHz	Signal BW MHz	Modulation	Channel Power dBm	Channel Power dBm
871.5	5	QPSK	53.70	47.30
884	20	QPSK	59.43	47.74
874	10	64QAM	55.85	47.47
879	20	256QAM	58.2	47.65
891.5	5	256QAM	51.29	47.10
886.5	15	QPSK + 16QAM	55.85	47.47

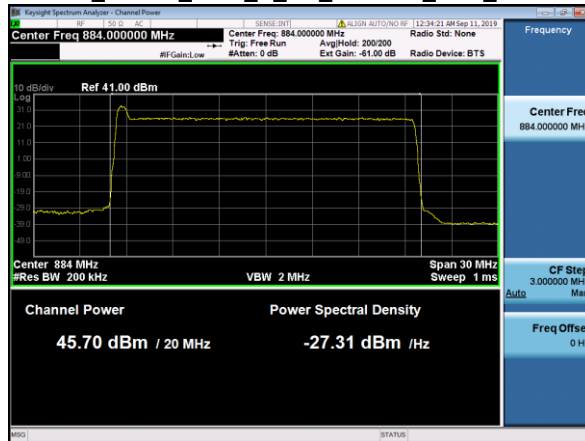
2.1.1 Channel RF Power – Plots (40W)

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.

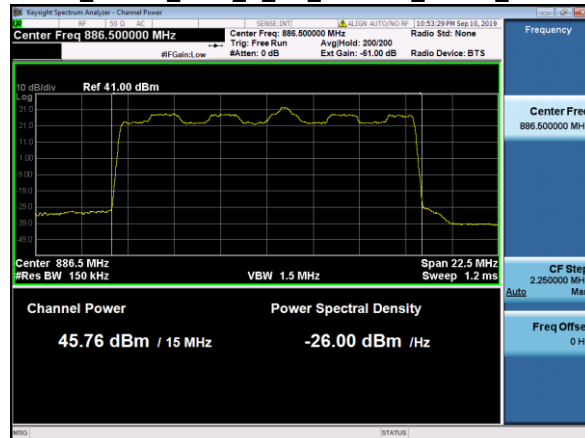
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Ch_Power_TM1_1_1C_20MBW_884_TX1



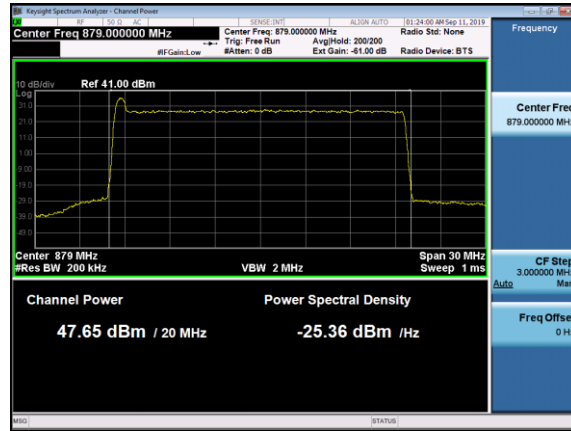
Ch_Power_TM3_2_1C_15MBW_886.5_TX1



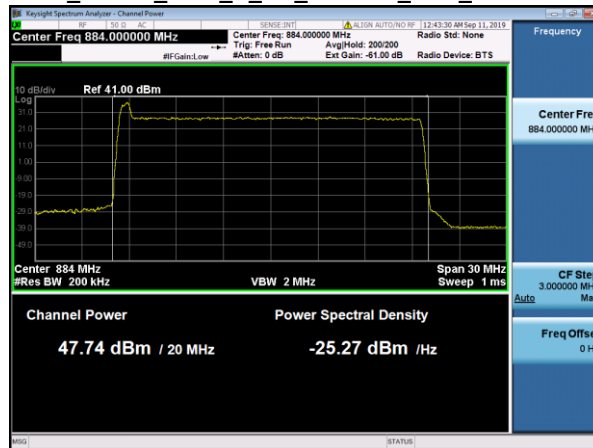
2.1.2 Channel RF Power – Plots (60W)

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.

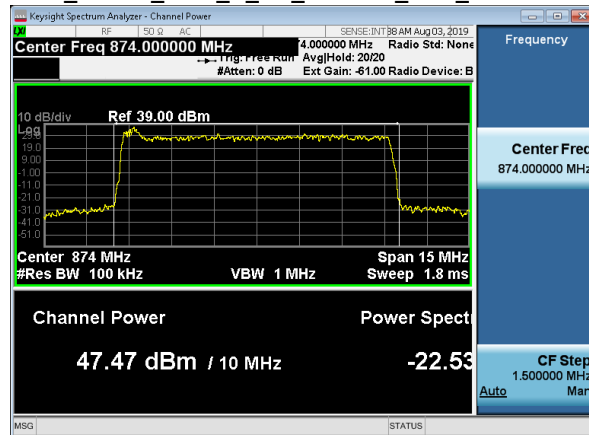
Ch_Power_TM3_1A_1C_20MBW_879_TX1 60W



Ch_Power_TM1_1_1C_20MBW_884_TX1 60W



Ch_Power_TM3_1_1C_10MBW_874_TX1 60W

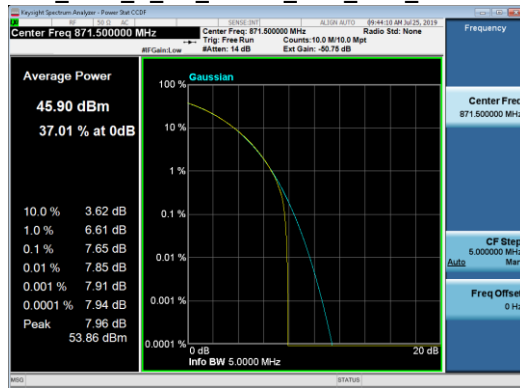


2.1.3 Peak-to-Average Power Ratio (PAPR) – Plots (40W)

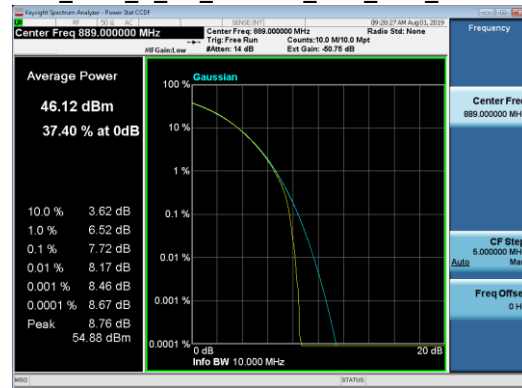
The Peak-to-Average Power Ratio (PAPR) was evaluated per KDB 971168 for 5, 10, 15 and 20MHz bandwidths. The PAPR values of all carriers measured are below 13dB.

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.

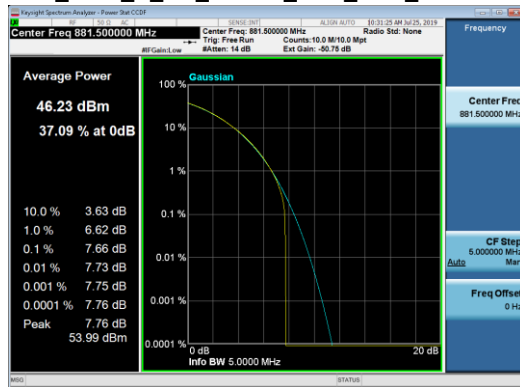
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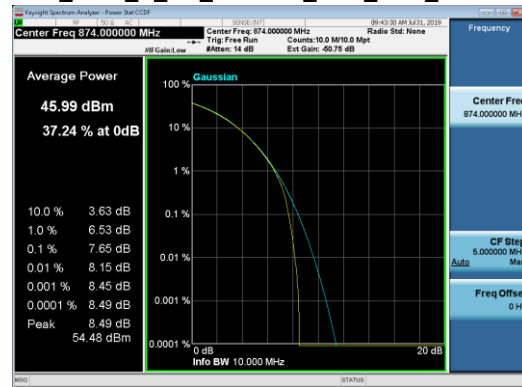
PAR_TM3_1_1C_10MBW_889_TX1_889



PAR_TM3_1_1C_5MBW_881_TX1_881



PAR_TM3_1_1C_10MBW_874_TX2_874

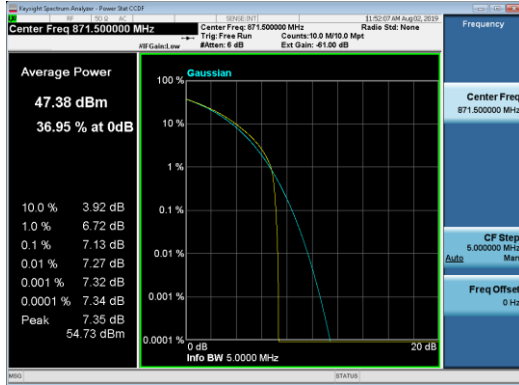


2.1.4 Peak-to-Average Power Ratio (PAPR) – Plots (60W)

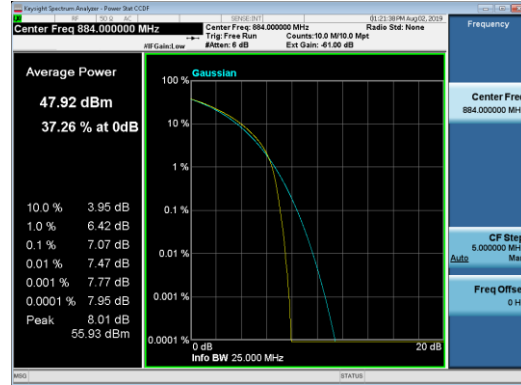
The Peak-to-Average Power Ratio (PAPR) was evaluated per KDB 971168 for 5, 10, 15 and 20MHz bandwidths. The PAPR values of all carriers measured are below 13dB.

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.

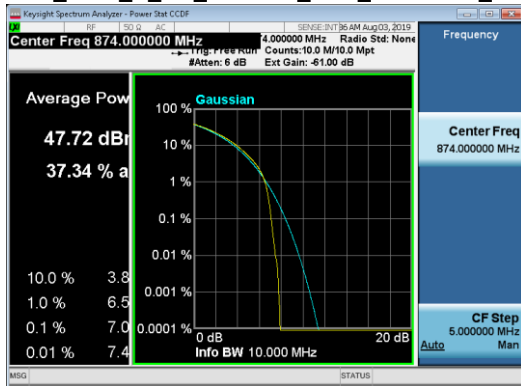
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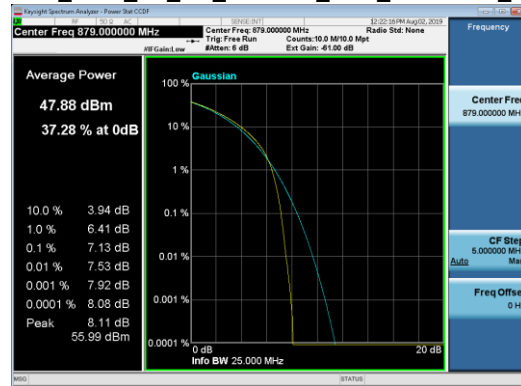
PAR_TM1_1_1C_20MBW_884_TX1 60W_884



PAR_TM3_1_1C_10MBW_874_TX1 60W_874



PAR_TM3_1a_1C_20MBW_879_TX1 60W_879



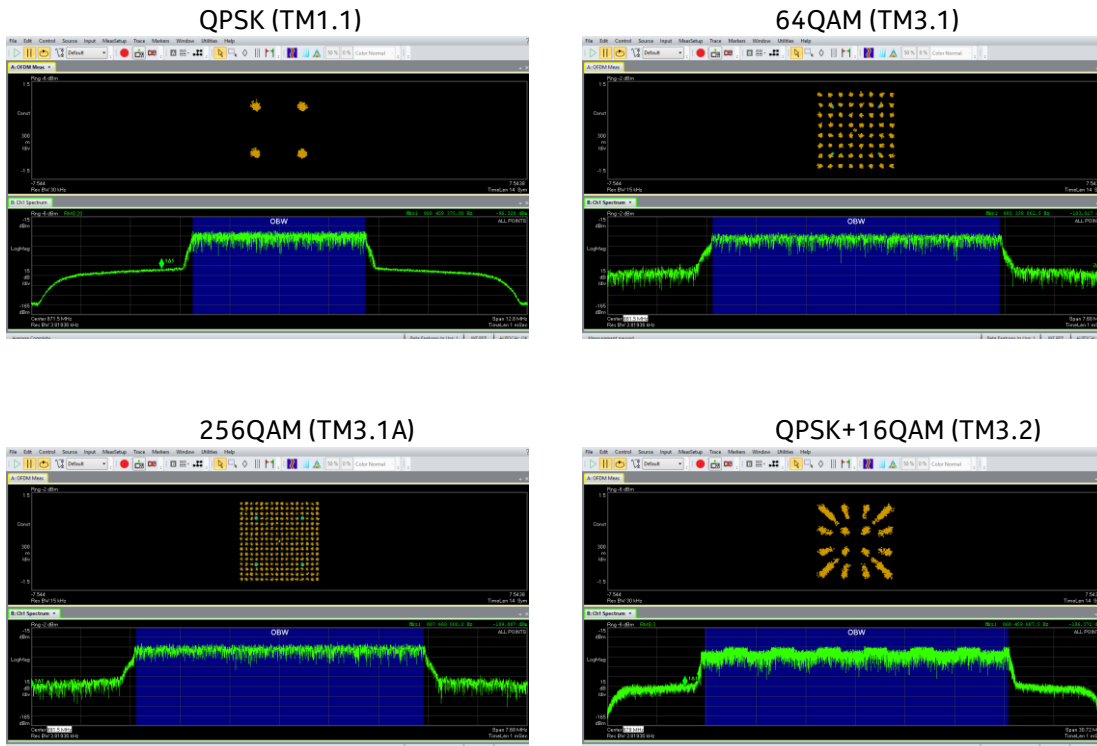
3. FCC Section 2.1047 - Modulation Characteristics

3.1 Modulation Characteristics

The RF signal at the antenna port was demodulated and verified for correctness of the modulation signal used before each test was performed. For these products the operation with QPSK, 64QAM, 256QAM, and QPSK + 16QAM modulation was evaluated.

3.1.1 Modulation Characteristics – 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.



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 (40W)

Channel Frequency MHz	Signal BW MHz	Modulation	Occupied BW MHz
871.5	5	QPSK	4.467
884	20	QPSK	19.015
874	10	64QAM	9.3675
881.5	5	64QAM	4.478
889	10	64QAM	9.292
884	20	256QAM	18.986
891.5	5	256QAM	4.473
879	20	QPSK + 16QAM	18.854
886.5	15	QPSK + 16QAM	14.079

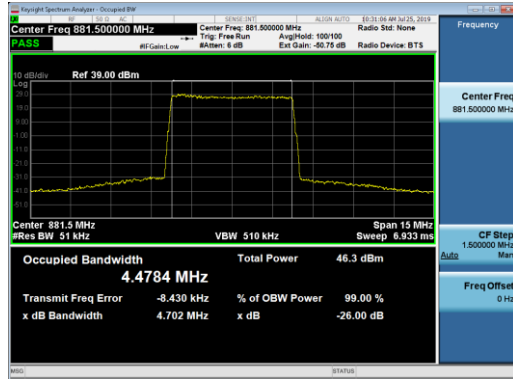
Tabular Data – Occupied Bandwidth (60W)

Channel Frequency MHz	Signal BW MHz	Modulation	Occupied BW MHz
871.5	5	QPSK	4.481
884	20	QPSK	19.006
874	10	64QAM	9.317
879	20	256QAM	19.025
891.5	5	256QAM	4.470
886.5	15	QPSK + 16QAM	14.015

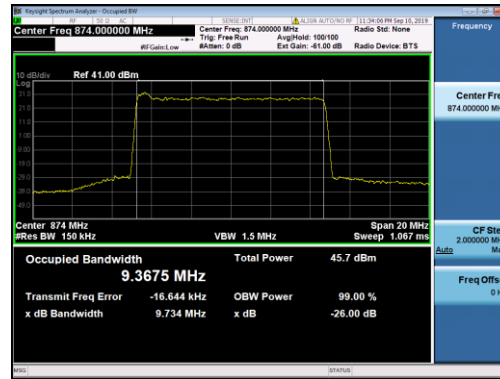
4.1.1 Occupied Bandwidth – Plots (40W)

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.

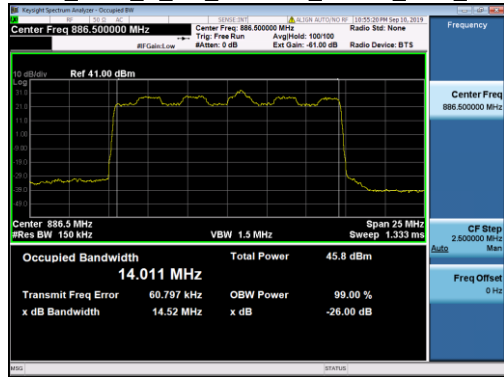
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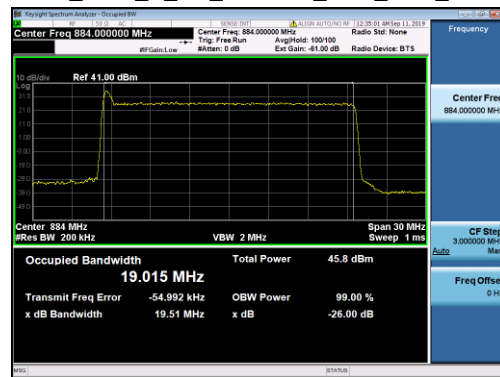
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OBW_TM3_2_1C_15MBW_886.5_TX1_886.5



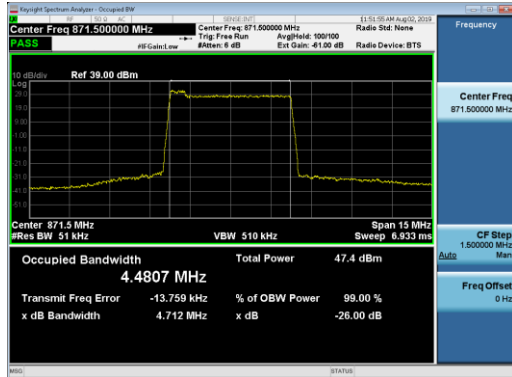
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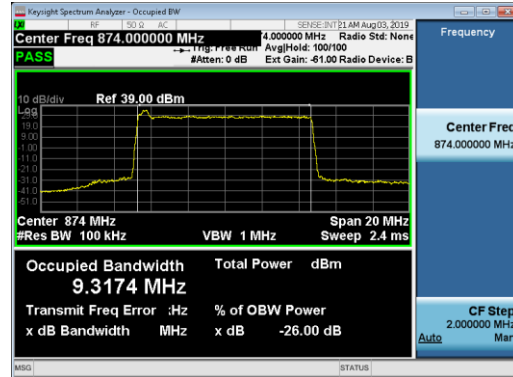
4.1.2 Occupied Bandwidth – Plots (60W)

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.

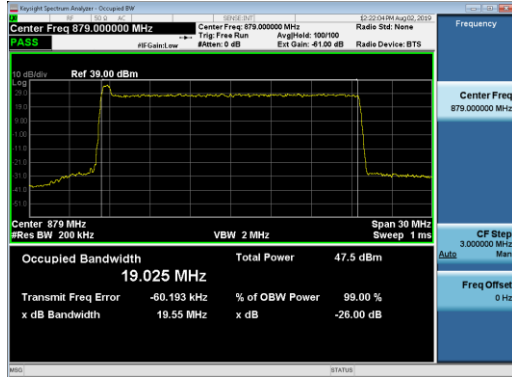
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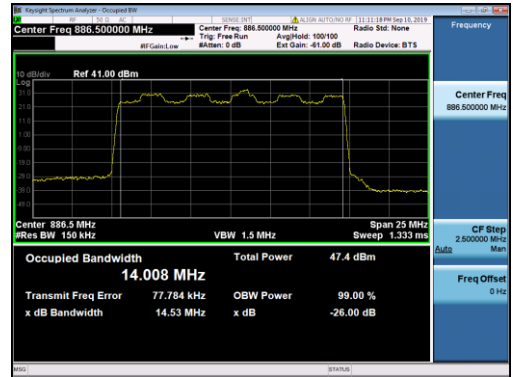
OBW_TM3_1_1C_10MBW_874_TX1 60W_874



OBW_TM3_1a_1C_20MBW_879_TX1 60W_879



OBW_TM3_2_1C_15MBW_886_TX1 60W_886



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 (40W)

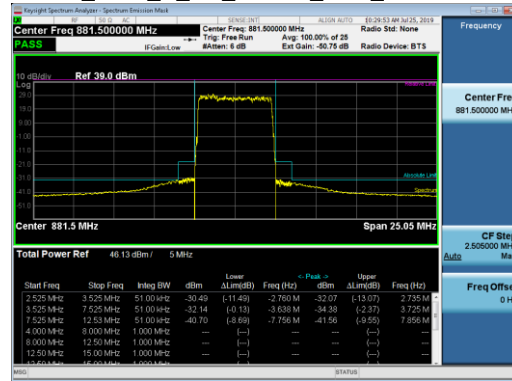
All of the measurements met the requirements of Part 2.1049.

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.

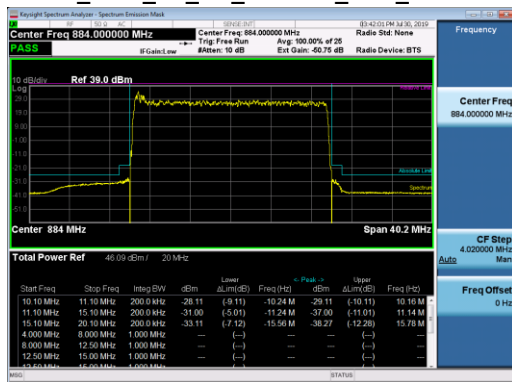
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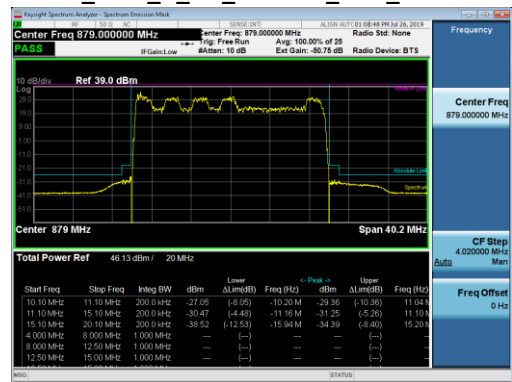
OOBE_TM3_1_1C_5MBW_881_TX1



OOBE_TM3_1a_1C_20MBW_884_TX4



OOBE_TM3_2_1C_20MBW_879_TX1

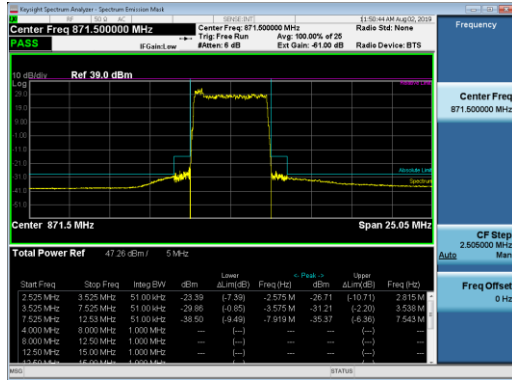


4.2.2 Edge of Band Emissions – Plots (60W)

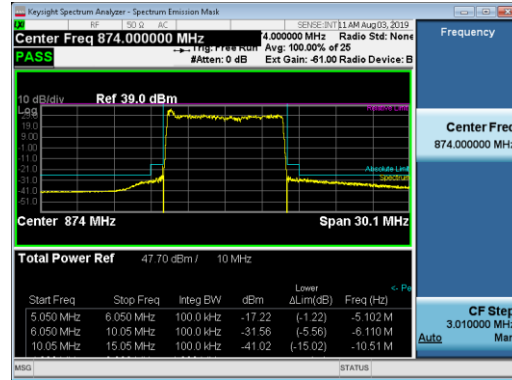
All of the measurements met the requirements of Part 2.1049.

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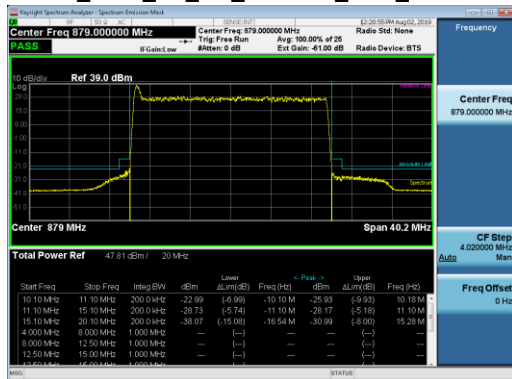
OOBE_TM1_1_1C_5MBW_871_TX1 60W



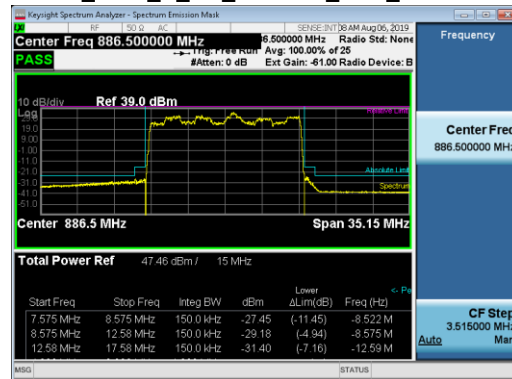
OOBE_TM3_1_1C_10MBW_874_TX1 60W



OOBE_TM3_1a_1C_20MBW_879_TX1 60W



OOBE_TM3_2_1C_15MBW_886_TX1 60W



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

5.1 Measurement of Spurious Emissions at Transmit Antenna Port

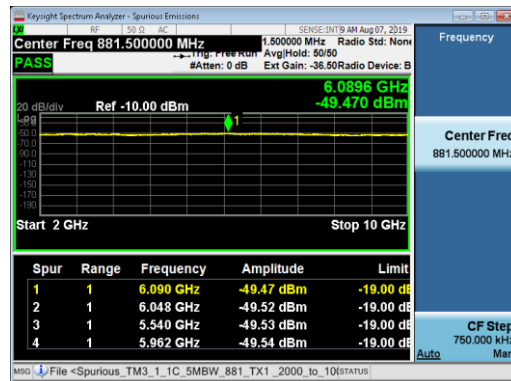
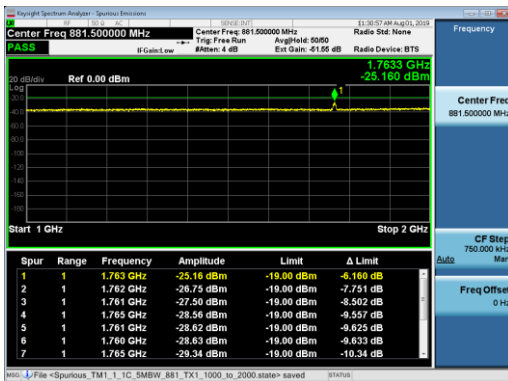
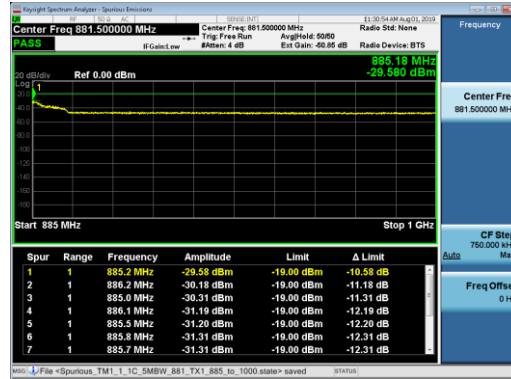
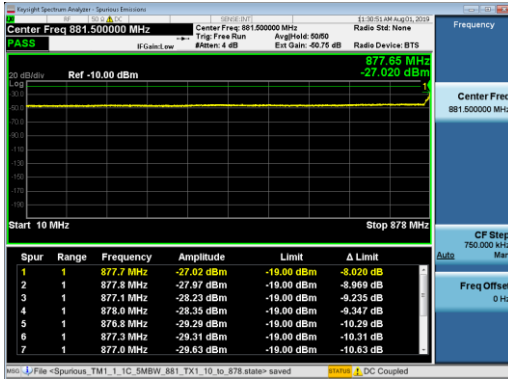
Spurious Emissions at the transmit-antenna terminals were investigated over the frequency range of 10 MHz to beyond the 10th harmonic of the specific transmit band. For this band of operation, the measurements were performed up to 10GHz. Measurements were made using a Keysight MXA Signal Analyzer. The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

The required emission limitation is specified as appropriate in 22.917. The measured spurious emission levels were plotted for the frequency range as specified in 2.1057. There were no reportable emissions. Data below documents performance up to 10 GHz.

5.1.1 Spurious Emissions at Tx Port – Plots (40W)

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.

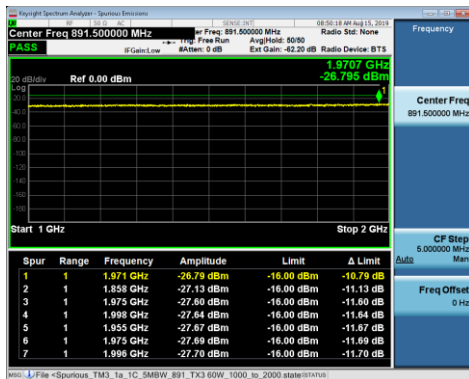
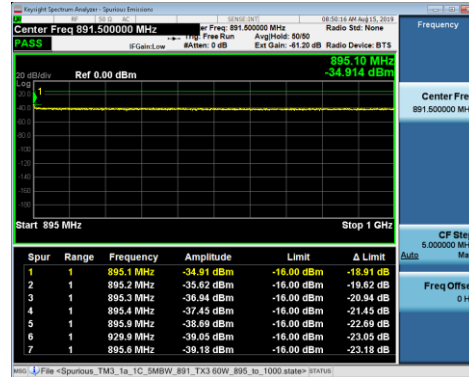
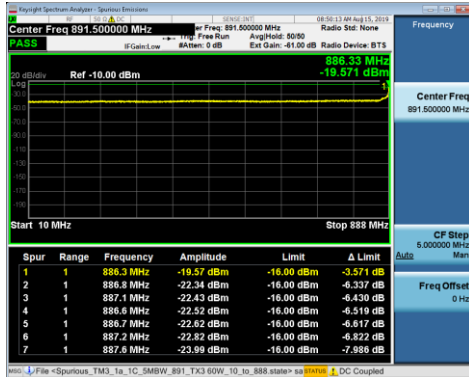
Spurious_TM3_1_1C_5MBW_881_TX1



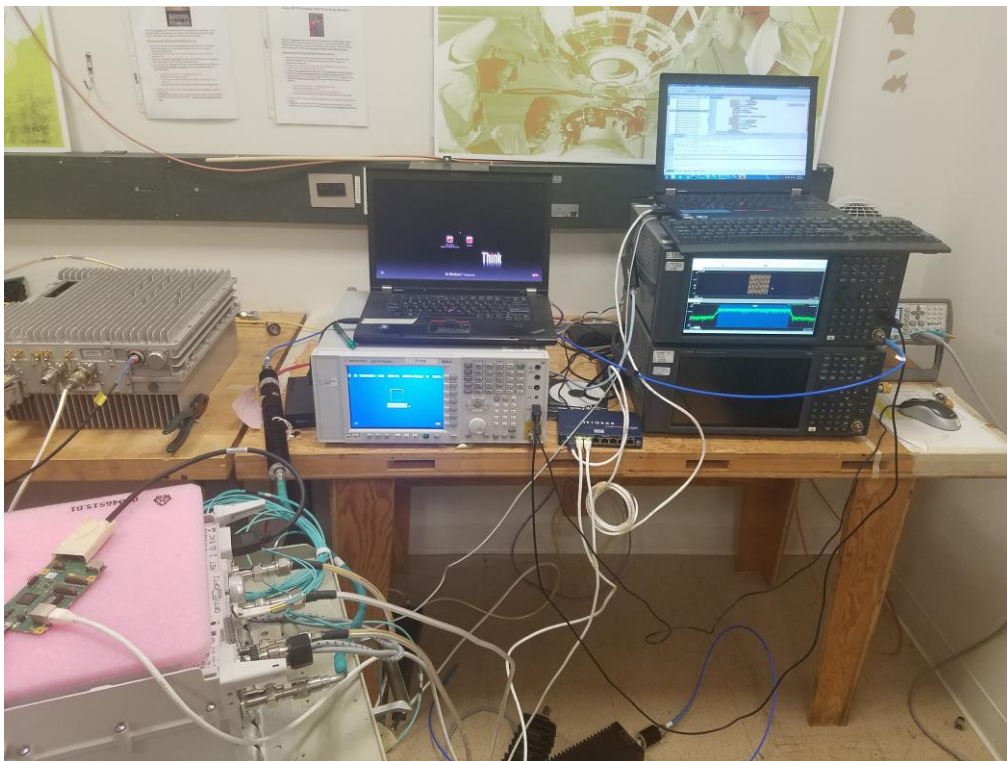
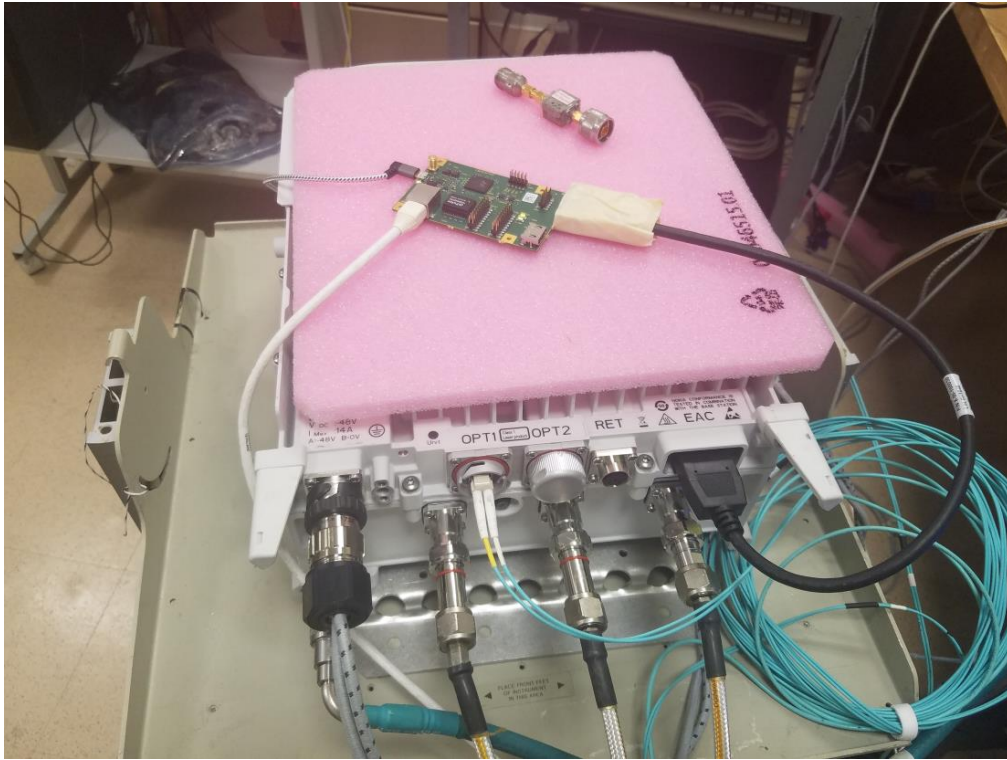
5.1.2 Spurious Emissions at Tx Port – Plots (60W)

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_5MBW_891_TX3



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
E1338	KeySight Technologies	MXA Signal Analyzer		N9020B	MY57430927	2018-09-13	2019-09-13
E903	Trilithic	High Pass Filter	Hi-Pass Filter 850 MHz 5 W	4HC1400/800-1-KK	23042	CNR	CNR
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

CNR: Calibration Not Required

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, 18 GHz, was searched for spurious radiation. Measurements were made using both horizontally and vertically polarized broadband antennas. Per FCC regulations, the comparison of out of band spurious emissions directly to the limit is appropriately made using the substitution method. However, when the emissions are more than 20 dB below the specification limit, the use of field strength measurements for compliance determination is acceptable and those emissions are considered not reportable (Section 2.1053 and the FCC Interpretive database for 2.1053). For this case the evaluation of acceptable radiated field strength is as follows.

6.2 Field Strength of Spurious Emissions - Limits

Sections 2.1053 and 22.917 contain the requirements for the levels of spurious radiation as a function of the level of the unmodulated carrier. The reference level for the unmodulated carrier is calculated as the field produced by an ideal dipole excited by the transmitter output power according to the following relation taken from Reference Data for Radio Engineers, page 676, 4th edition, IT&T Corp.

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

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

Where:

E = Field Intensity in Volts/meter

P = Transmitted Power in Watts

R = Measurement distance in meters = 3 m

The Part 22 Limit is 82.23 dB μ V/m at 3m and 91.77 dB μ V/m at 1m

The Part 22 non-report level is 62.23 dB μ V/m at 3m.

The calculated emission levels were found by:

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

RESULTS:

For compliance with 47CFR Parts 2 and 22, the field strength of any spurious radiation, measured at 3m, is required to be less than 82.23 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 18 GHz). No reportable spurious emissions were detected.

7. 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).*

2018-09-05 through 2019-09-30
Effective Dates




For the National Voluntary Laboratory Accreditation Program