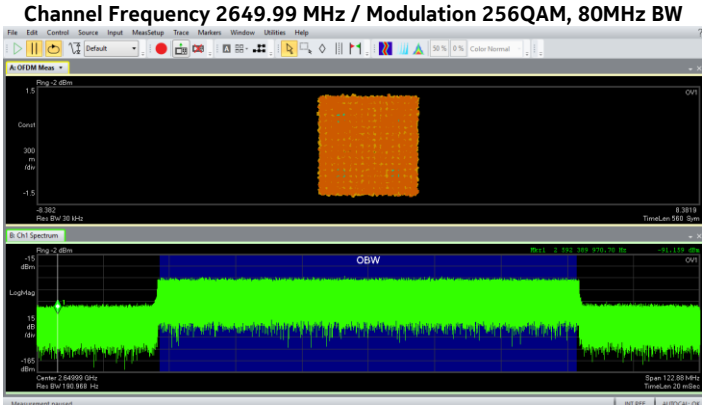
3. FCC Section 2.1047 - Modulation Characteristics

3.1 Modulation Characteristics

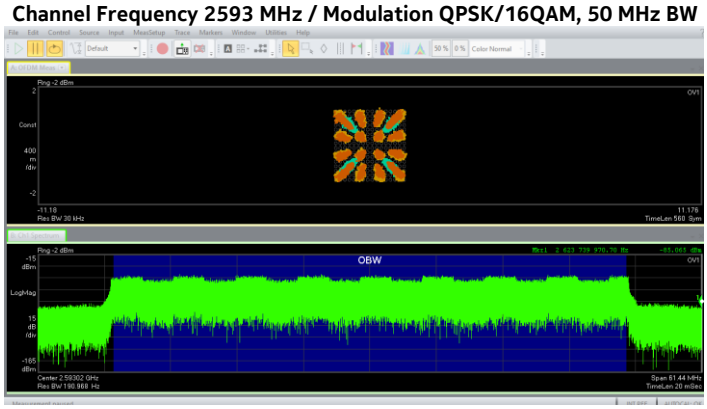
The RF signal at the antenna port was demodulated and verified for correctness of the modulation signal used before each test was performed.

3.1.1 Modulation Characteristics – Plots

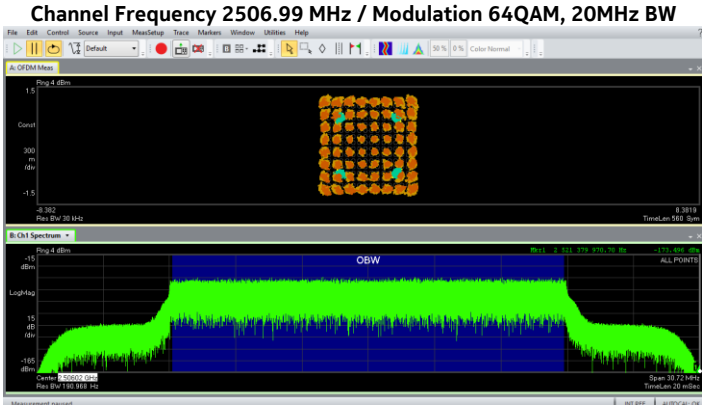
Channel Frequency 2649.99 MHz / Modulation 256QAM, 80MHz BW



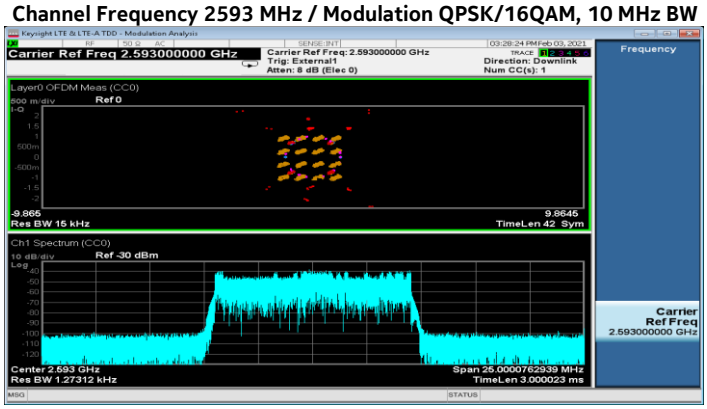
Channel Frequency 2593 MHz / Modulation QPSK/16QAM, 50 MHz BW



Channel Frequency 2506.99 MHz / Modulation 64QAM, 20MHz BW



Channel Frequency 2593 MHz / Modulation QPSK/16QAM, 10 MHz BW



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

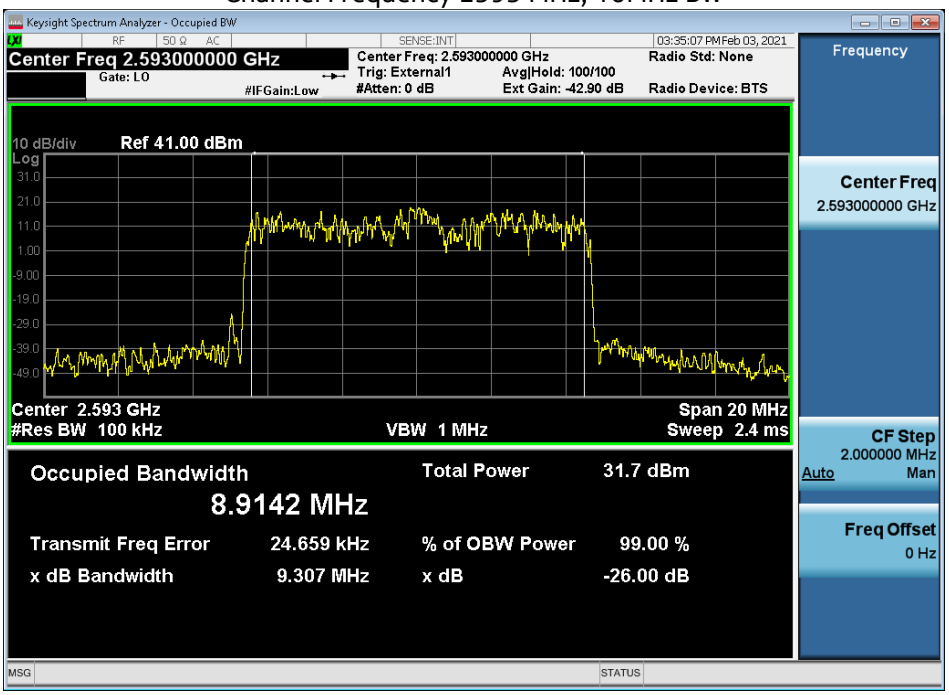
# of Carriers	Test Model	Modulation	TX Port	Channel Frequency MHz	Signal BW MHz	Radio Access Technology	Occupied BW MHz
1	3.1	64QAM	57	2501	10	LTE	8.845
1	3.2	QPSK/16QAM	57	2593	10	LTE	**8.914**
1	3.1a	256QAM	57	2685	10	LTE	8.861
1	3.1	64QAM	57	2506.02	20	5G-NR	18.187
1	3.2	QPSK/16QAM	57	2593.02	20	5G-NR	**18.302**
1	3.1a	256QAM	57	2679.99	20	5G-NR	18.167
1	3.1	64QAM	57	2521.02	50	5G-NR	**47.561**
1	3.2	QPSK/16QAM	57	2593.02	50	5G-NR	47.365
1	3.1a	256QAM	57	2664.99	50	5G-NR	47.436
1	3.1	64QAM	57	2536.02	80	5G-NR	77.256
1	3.2	QPSK/16QAM	57	2593.02	80	5G-NR	**77.689**
1	3.1a	256QAM	41	2649.99	80	5G-NR	77.096
1	3.1	64QAM	57	2541	90	5G-NR	87.207
1	3.2	QPSK/16QAM	41	2593.02	90	5G-NR	**87.458**
1	3.1a	256QAM	57	2644.98	90	5G-NR	87.072
2	3.2	QPSK/16QAM	41	2506+2680	20+20	5G-NR+LTE	18.256+17.824
2	3.1a	256QAM	17	2506+2670	20+40	LTE+5G-NR	17.895+37.789
3	3.1	64QAM	17	2506.02+2660+2680	20+20+20	5G-NR+LTE+LTE	18.331+17.989+17.911
3	3.1	64QAM	57	2506+2526+2670	20+20+40	LTE+LTE+5G-NR	18.056+17.897+37.909
4	3.1	64QAM	33	2506.02+2640+2660+2680	20+20+20+20	5G-NR+LTE+LTE+LTE	18.334+17.795+18.059+17.829
4	3.2	QPSK/16QAM	49	2506+2526+2546+2670	20+20+20+40	LTE+LTE+LTE+5G-NR	17.989+17.742+19.833+37.786

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.

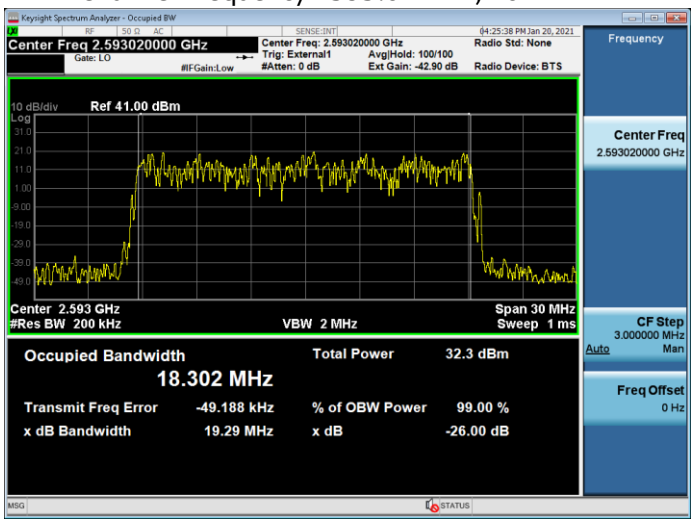
1C Data (LTE)

Channel Frequency 2593 MHz, 10MHz BW

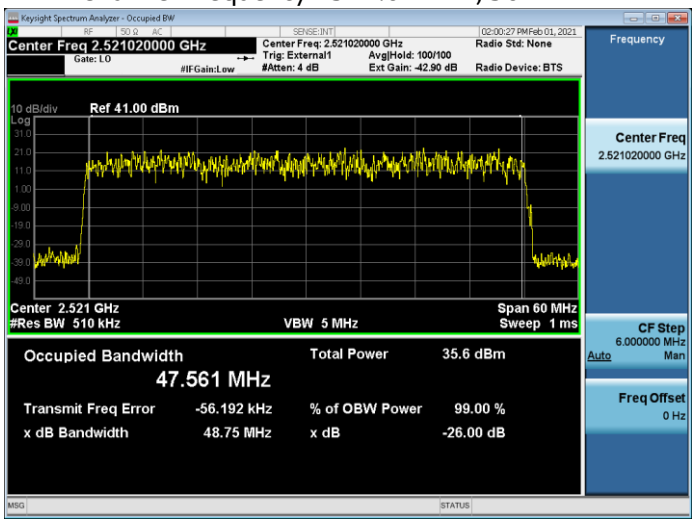


1C Data (5G-NR)

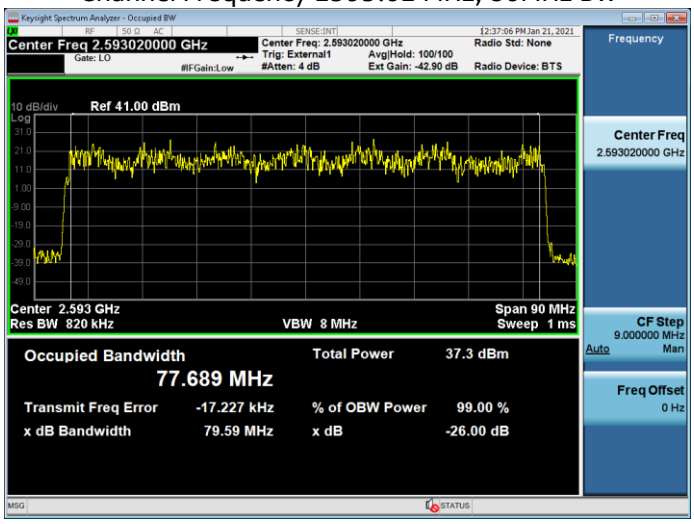
Channel Frequency 2593.02 MHz, 20MHz BW



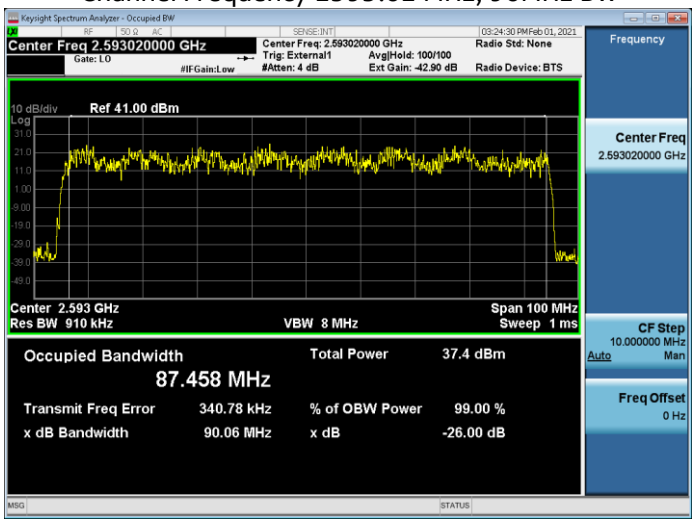
Channel Frequency 2521.02 MHz, 50MHz BW



Channel Frequency 2593.02 MHz, 80MHz BW

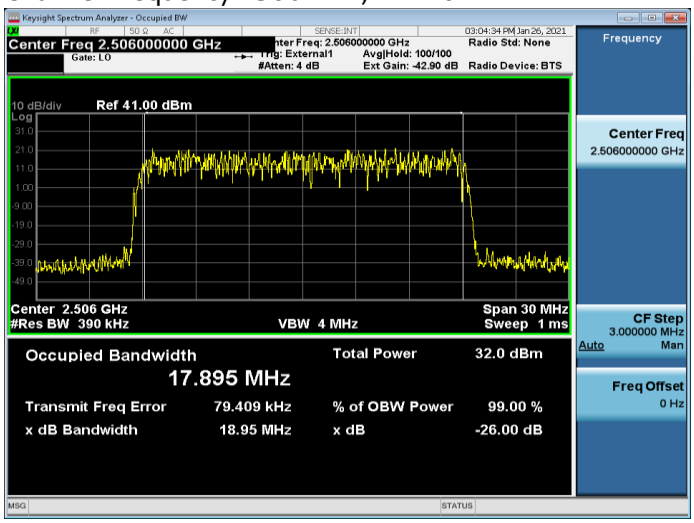


Channel Frequency 2593.02 MHz, 90MHz BW

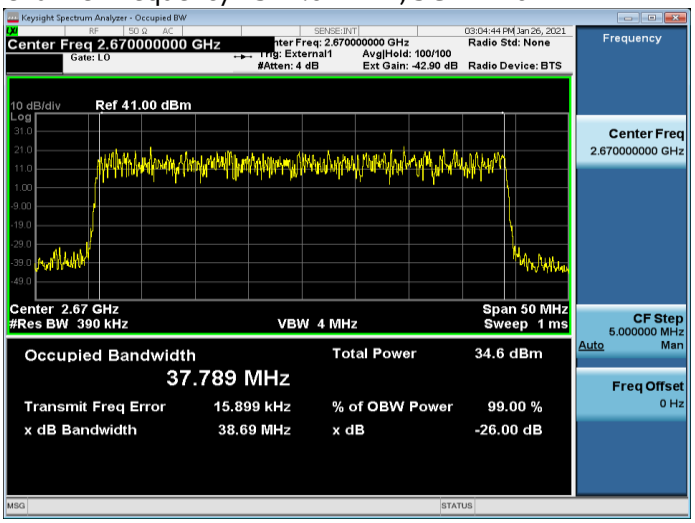


2C Data (LTE + 5G-NR)

Channel Frequency 2506 MHz, LTE 20MHz BW

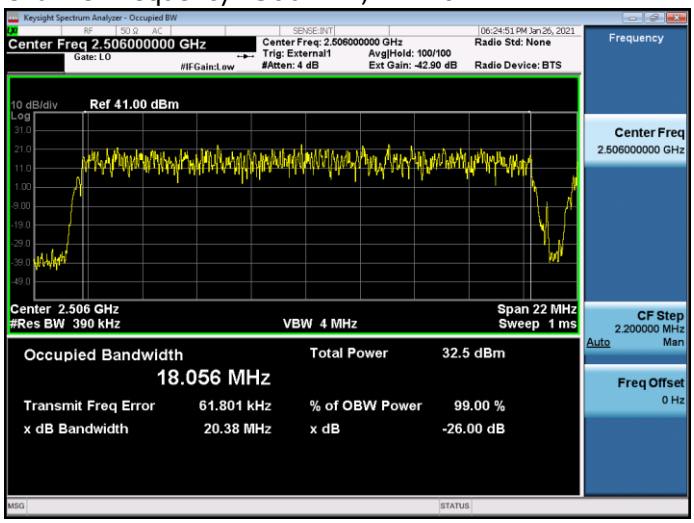


Channel Frequency 2521.02 MHz, 5G-NR 40MHz BW

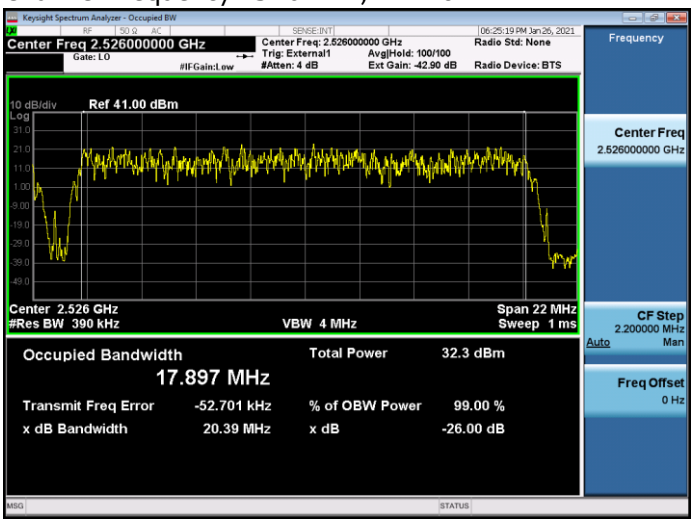


3C Data (LTE+LTE+5G-NR)

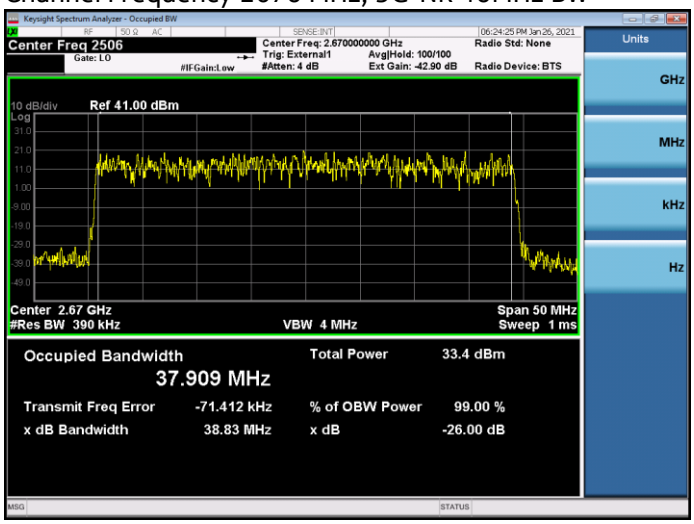
Channel Frequency 2506 MHz, LTE 20MHz BW



Channel Frequency 2526 MHz, LET 20MHz BW

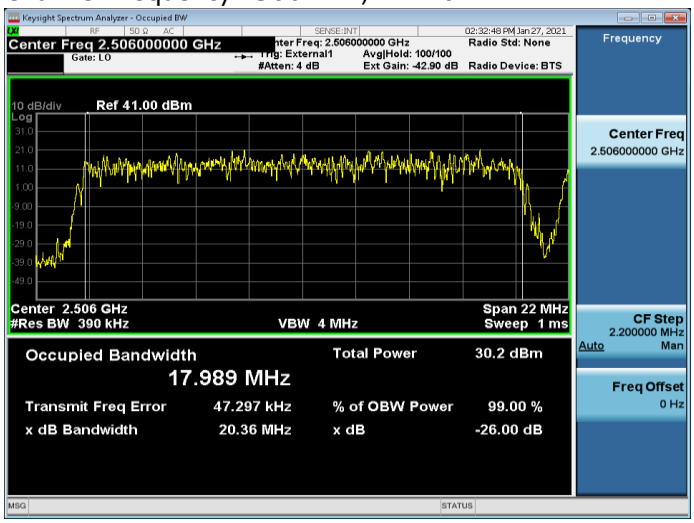


Channel Frequency 2670 MHz, 5G-NR 40MHz BW

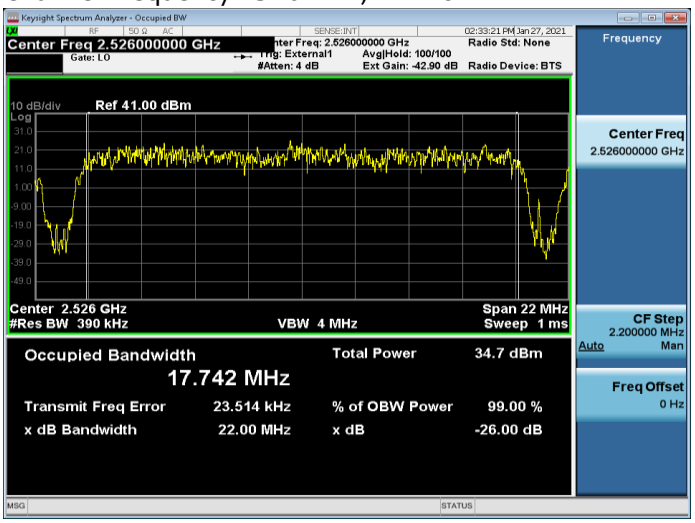


4C Data (LTE+LTE+LTE+5G-NR)

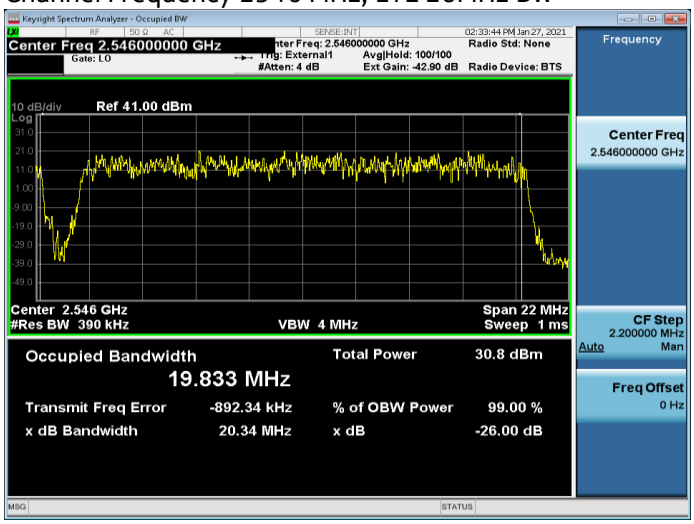
Channel Frequency 2506 MHz, LTE 20MHz BW



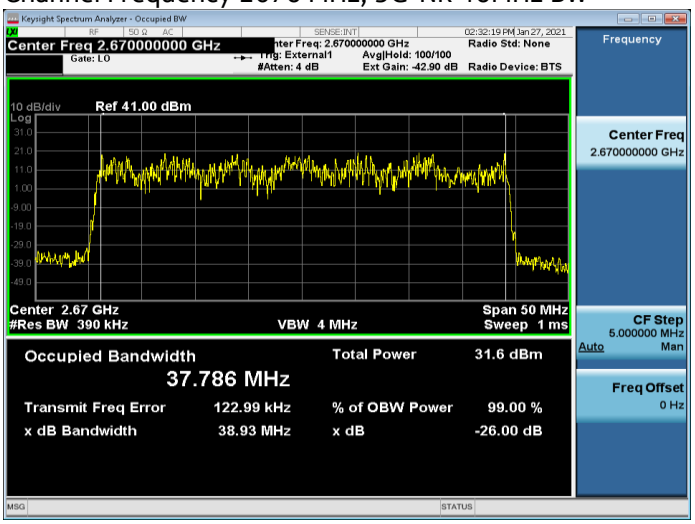
Channel Frequency 2526 MHz, LTE 20MHz BW



Channel Frequency 2546 MHz, LTE 20MHz BW



Channel Frequency 2670 MHz, 5G-NR 40MHz BW



4.2 Edge of band Emissions

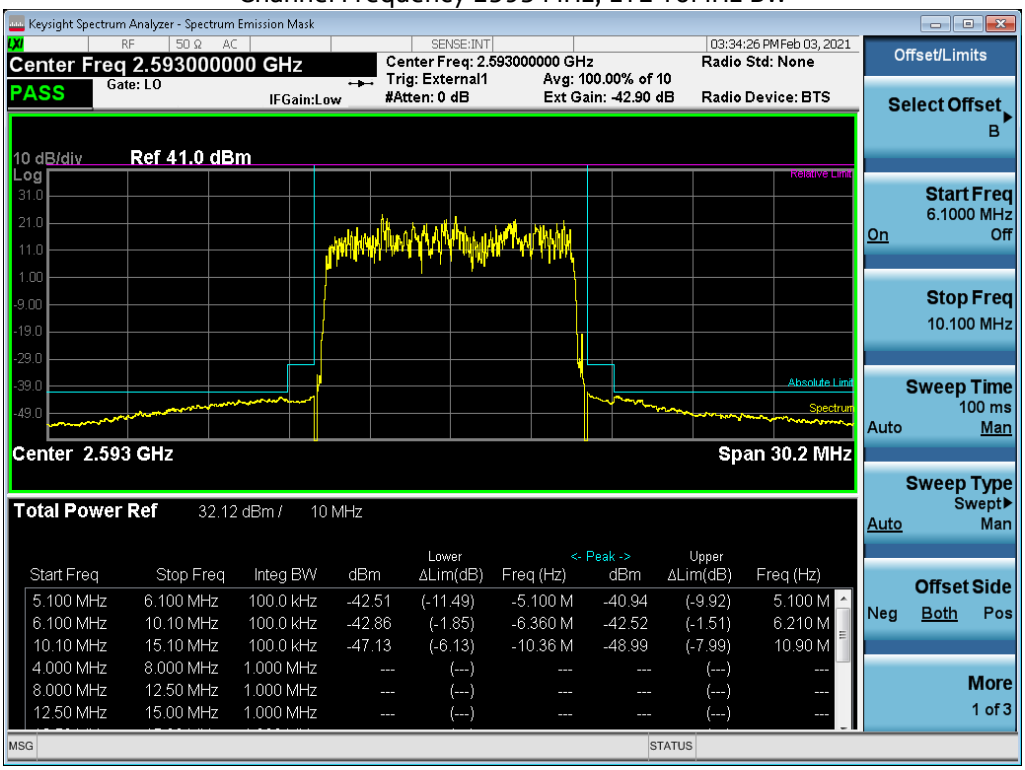
The Edge of Band emissions of the EUT at the external antenna connector (EAC) were measured using a Keysight MXA Signal Analyzer. The RF power level was continuously measured using a RF broadband power meter. The RF output from the EAC port to signal analyzer was reduced (to an amplitude usable by the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

NOTES: Only the emissions plots which give the minimum emission margin evaluated were used in this report. The full suite of raw data resides at the MH, New Jersey location. All the measurements met the requirements of Part 27.53 when measured per Part 2.1049. The limit is derived using the 10 Log (n) rule for limits with n=64

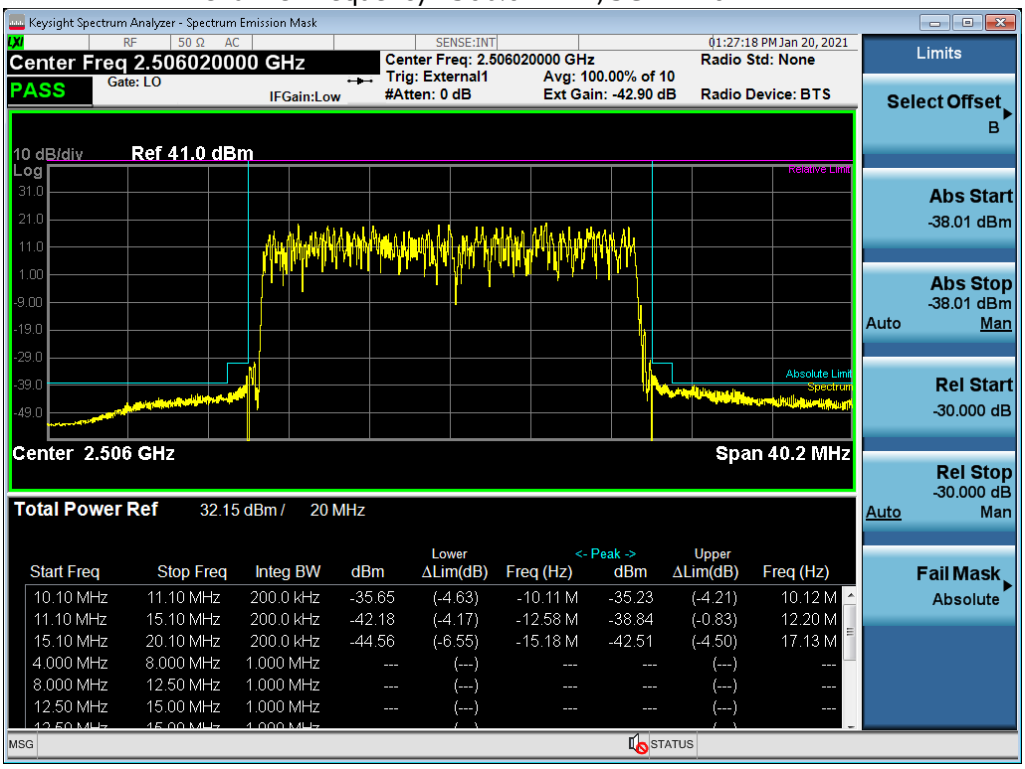
1C Data (LTE)

Channel Frequency 2593 MHz, LTE 10MHz BW



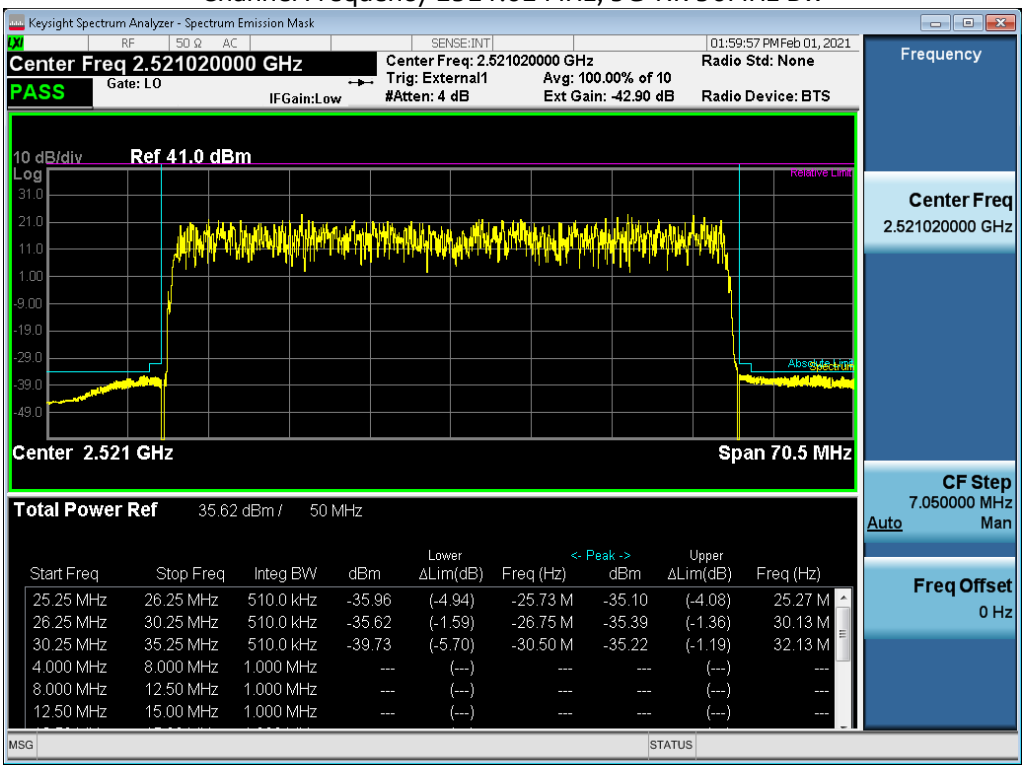
1C Data (5G-NR)

Channel Frequency 2506.02 MHz, 5G-NR 20MHz BW



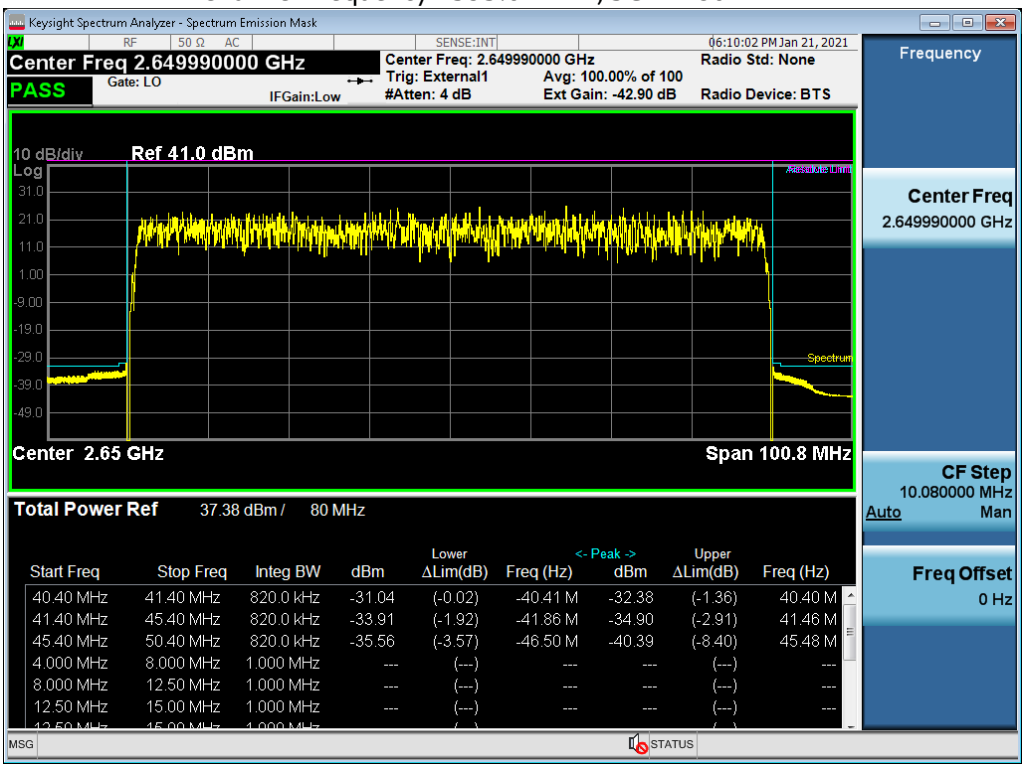
1C Data (5G-NR)

Channel Frequency 2521.02 MHz, 5G-NR 50MHz BW



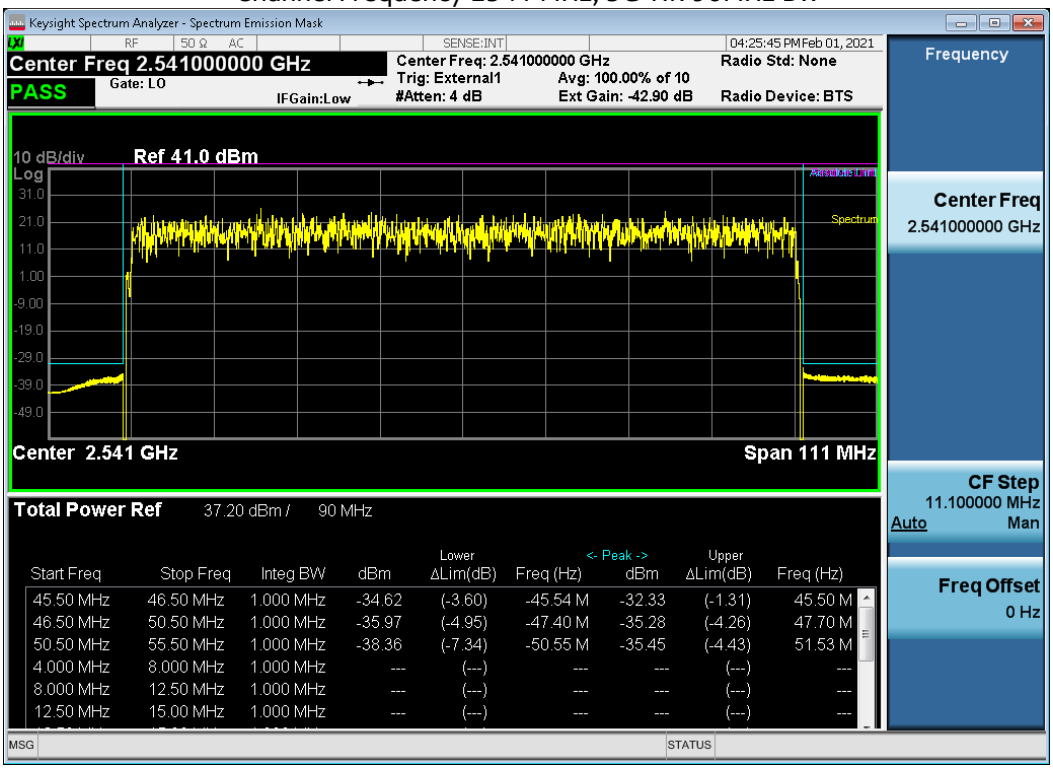
1C Data (5G-NR)

Channel Frequency 2593.02 MHz, 5G-NR 80MHz BW



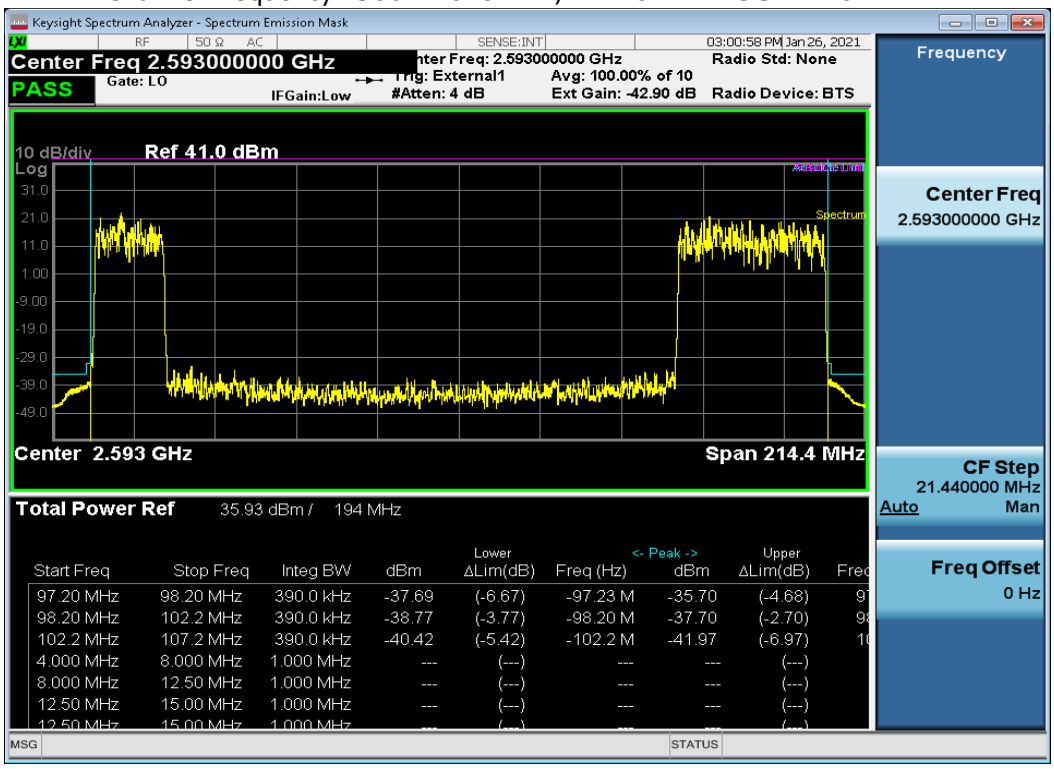
1C Data (5G-NR)

Channel Frequency 2541 MHz, 5G-NR 90MHz BW



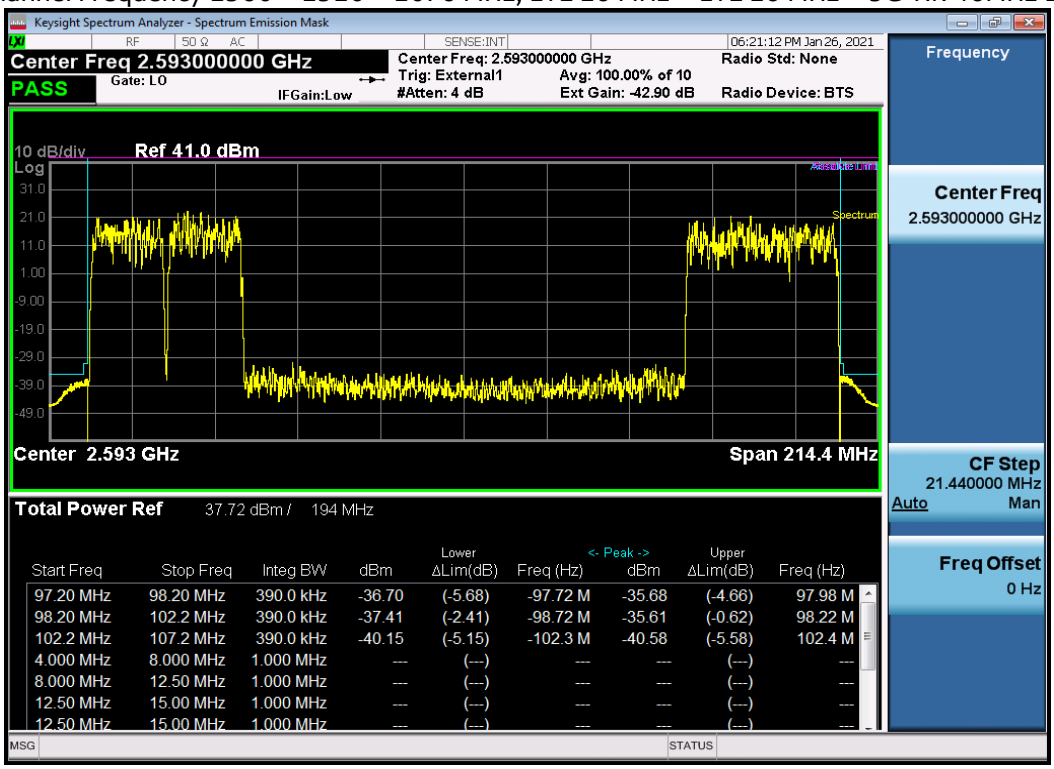
2C Data

Channel Frequency 2506 + 2670 MHz, LTE 20 MHz + 5G-NR 40MHz BW



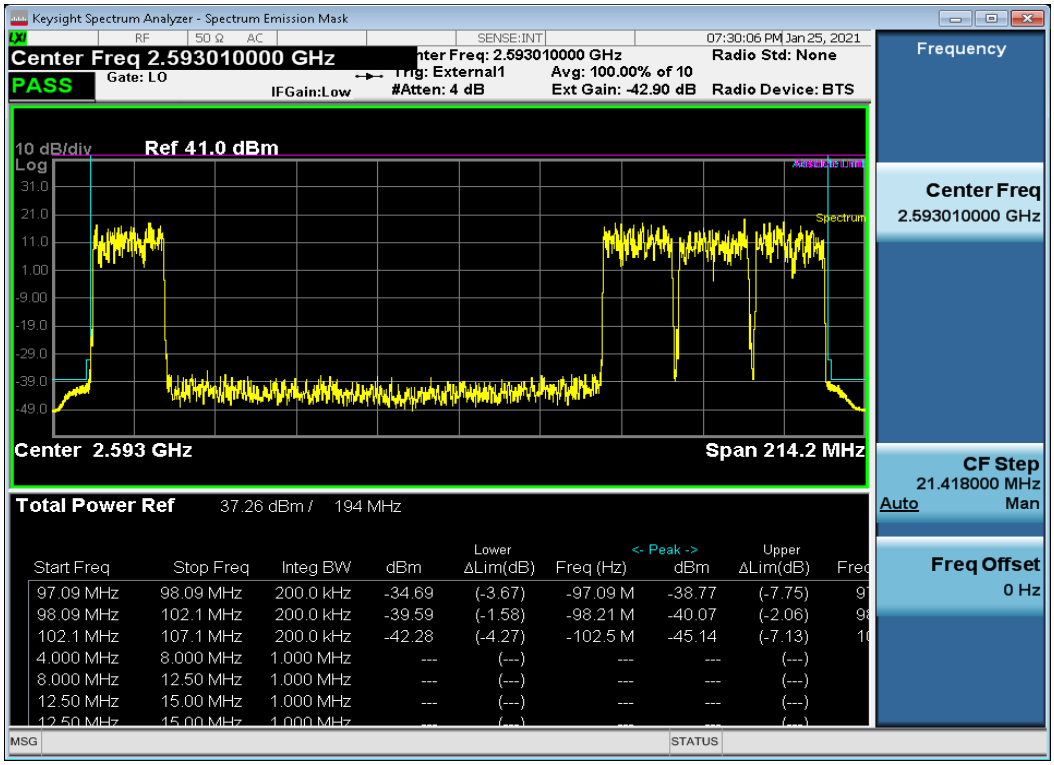
3C Data

Channel Frequency 2506 + 2526 + 2670 MHz, LTE 20 MHz + LTE 20 MHz + 5G-NR 40MHz BW



4C Data

Channel Frequency 2506.02 + 2546 + 2660 +2680 MHz, 5G-NR 20MHz + LTE 20 MHz + LTE 20 MHz + LTE 40MHz BW



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.

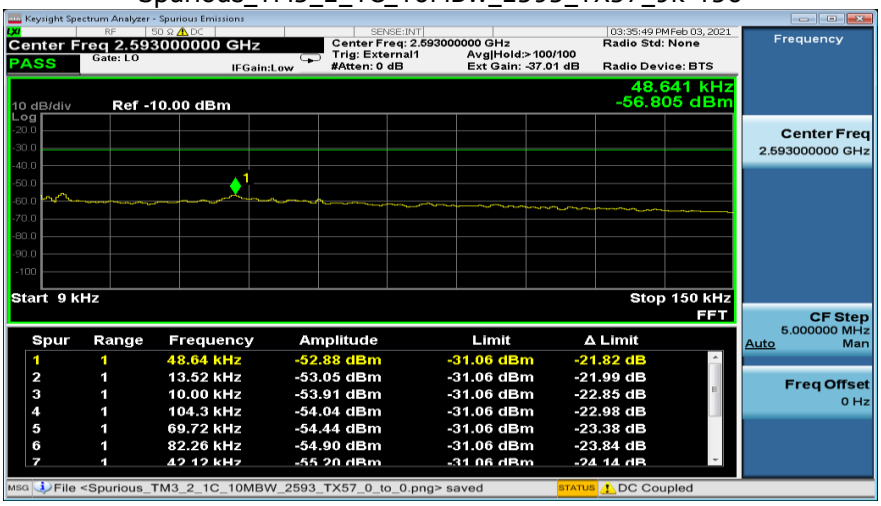
The required emission limitation is specified as appropriate in 27.53. The measured spurious emission levels were plotted for the frequency range as specified in 2.1057. There were no reportable emissions. Data below documents performance up to 27 GHz. The limit is derived using the 10 Log (n) rule for limits with n=64

5.1.1 Spurious Emissions at Tx Port - Plots

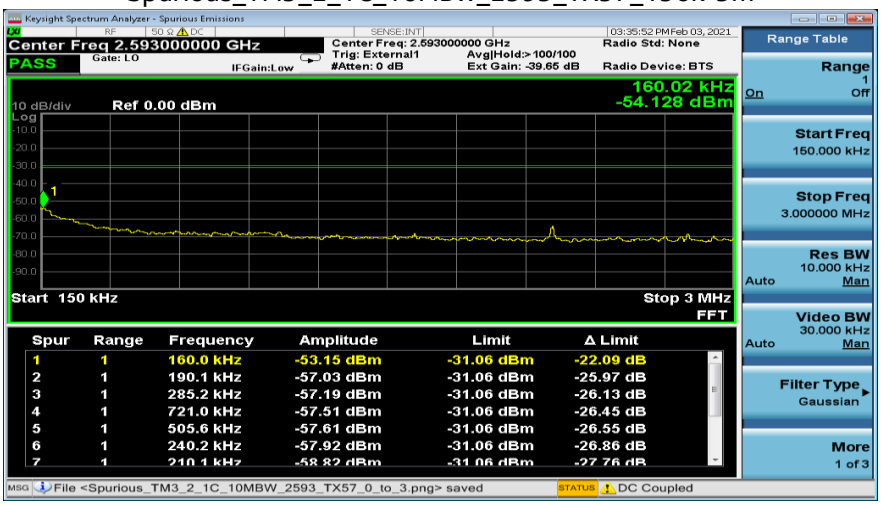
NOTE: Only a sample of the plots are used in this report. The full suite of raw data resides at the MH, New Jersey location.

1C Data (LTE)

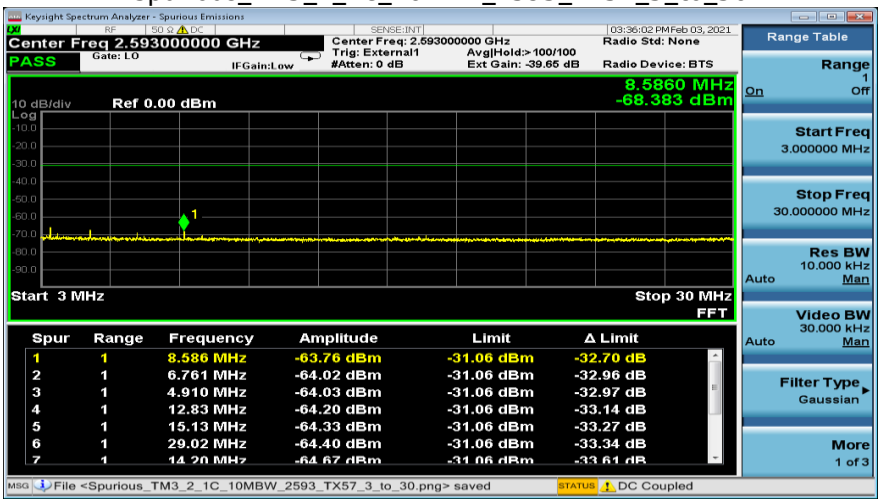
Spurious_TM3_2_1C_10MBW_2593_TX57_9k-150



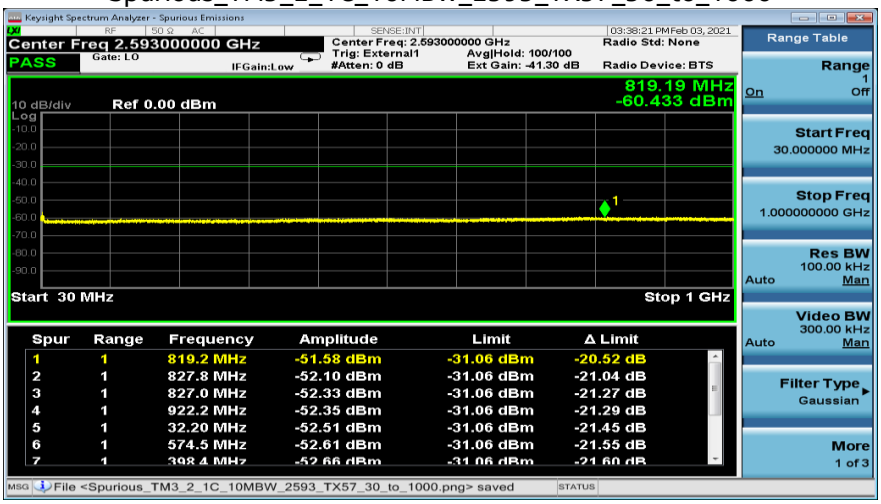
Spurious_TM3_2_1C_10MBW_2593_TX57_150k-3m



Spurious_TM3_2_1C_10MBW_2593_TX57_3_to_30

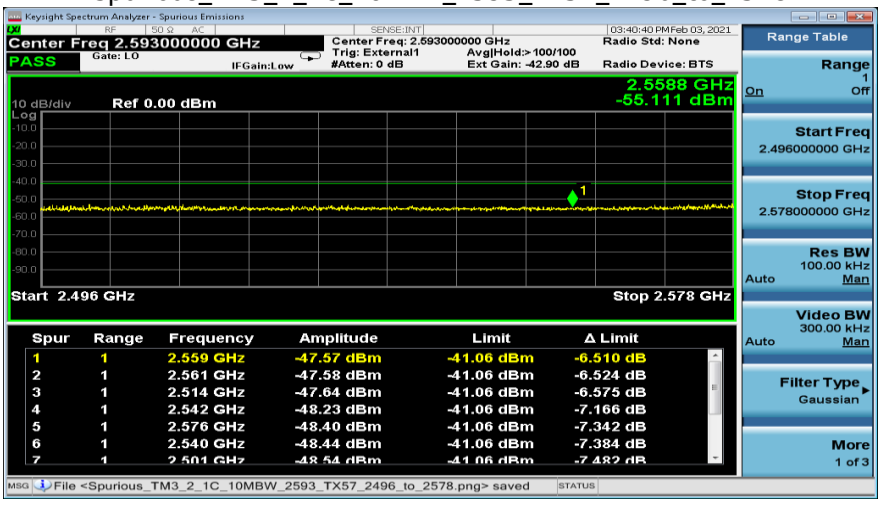


Spurious_TM3_2_1C_10MBW_2593_TX57_30_to_1000

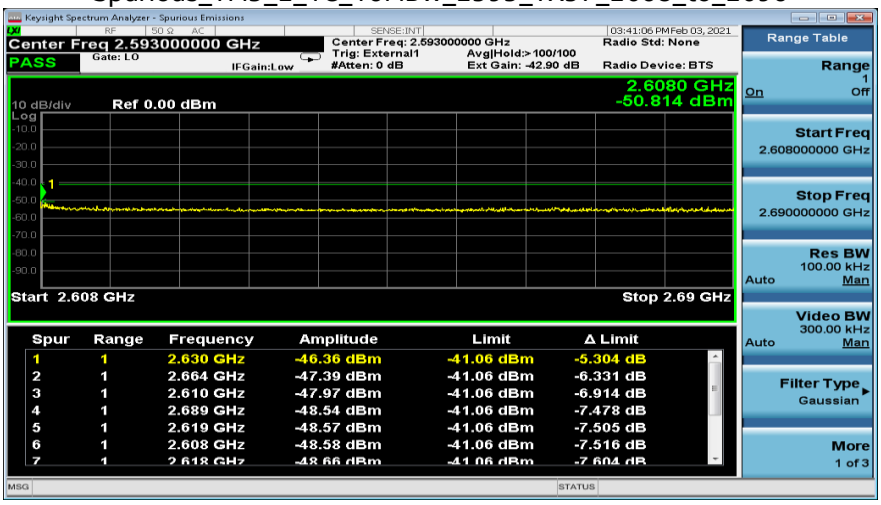


Spurious_TM3_2_1C_10MBW_2593_TX57_1000_to_2496

Spurious_TM3_2_1C_10MBW_2593_TX57_2496_to_2578



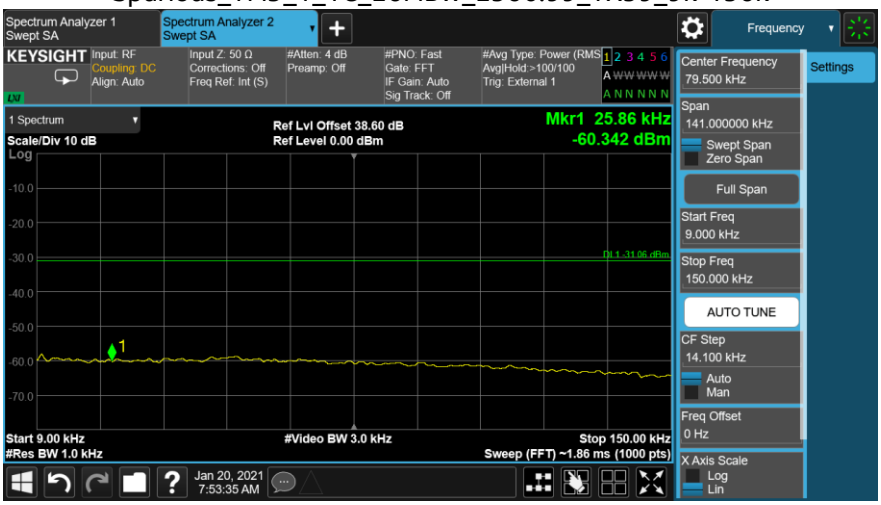
Spurious_TM3_2_1C_10MBW_2593_TX57_2608_to_2690



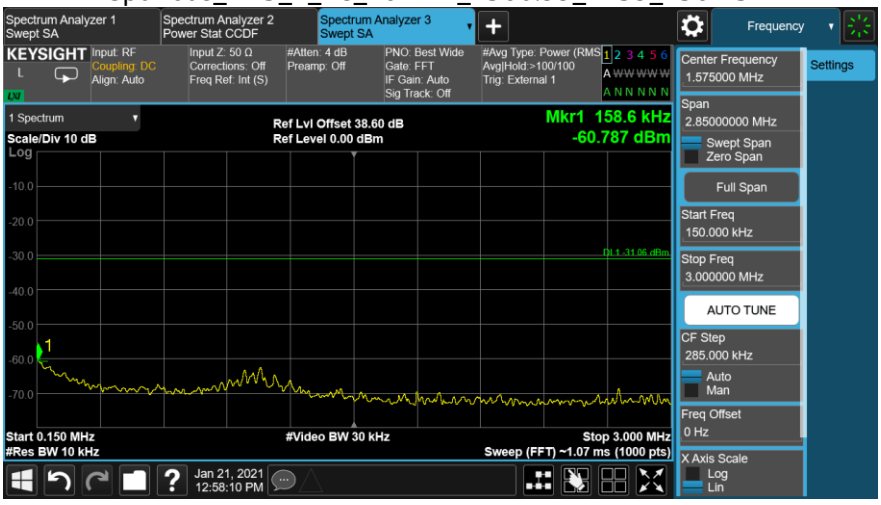
Spurious_TM3_2_1C_10MBW_2593_TX57_2690_to_10000

1C Data (5G-NR)

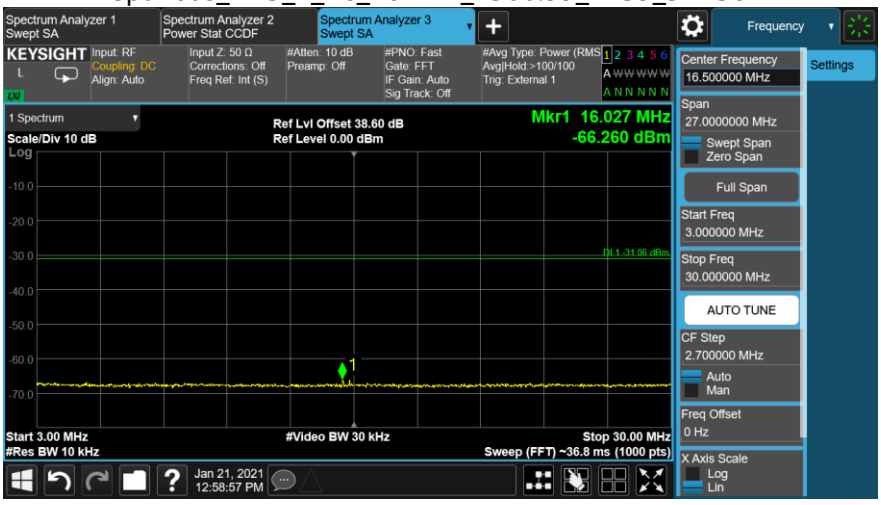
Spurious_TM3_1_1C_20MBW_2506.99_TX59_9k-150k



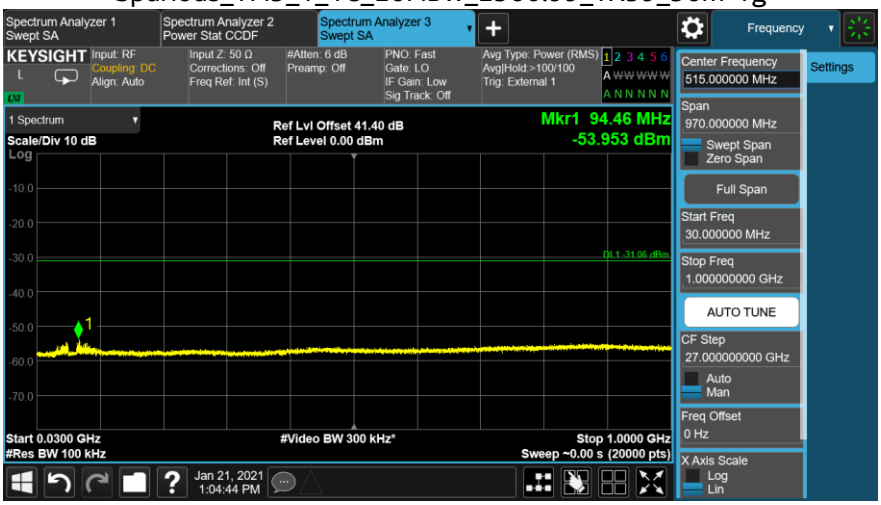
Spurious_TM3_1_1C_20MBW_2506.99_TX59_150k-3m



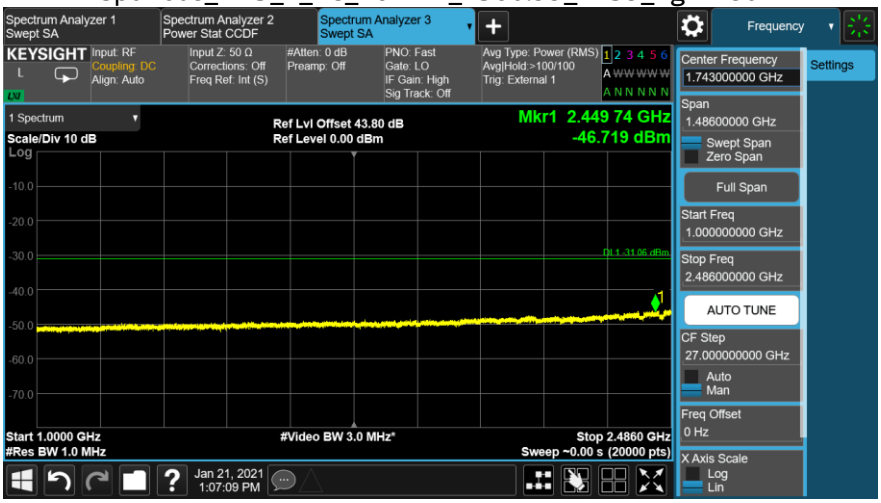
Spurious_TM3_1_1C_20MBW_2506.99_TX59_3m-30m



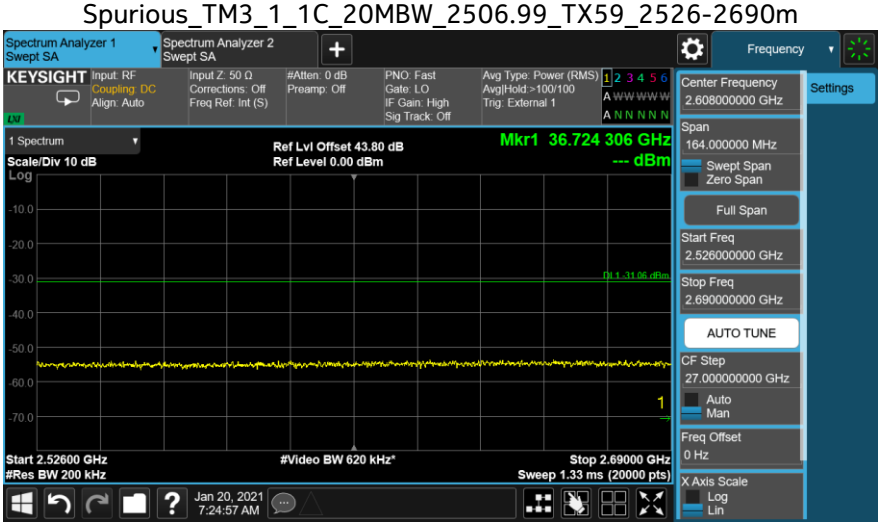
Spurious_TM3_1_1C_20MBW_2506.99_TX59_30m-1g



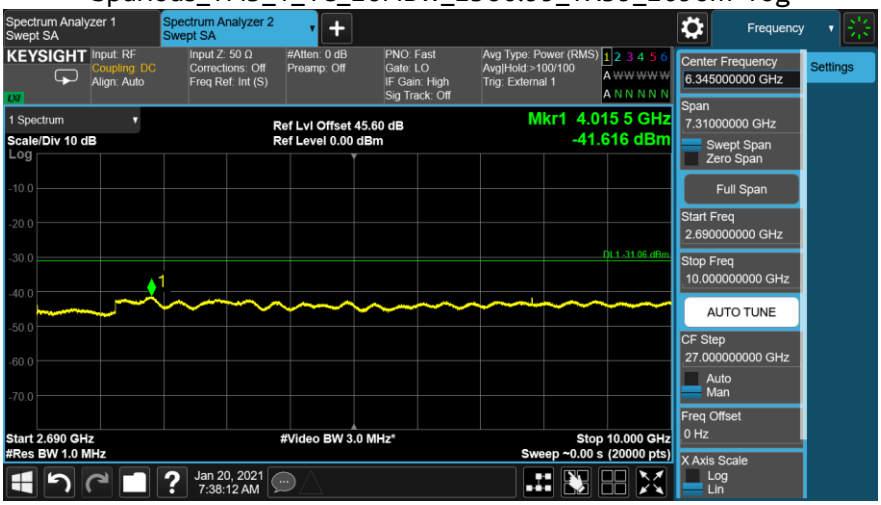
Spurious_TM3_1_1C_20MBW_2506.99_TX59_1g-2486m



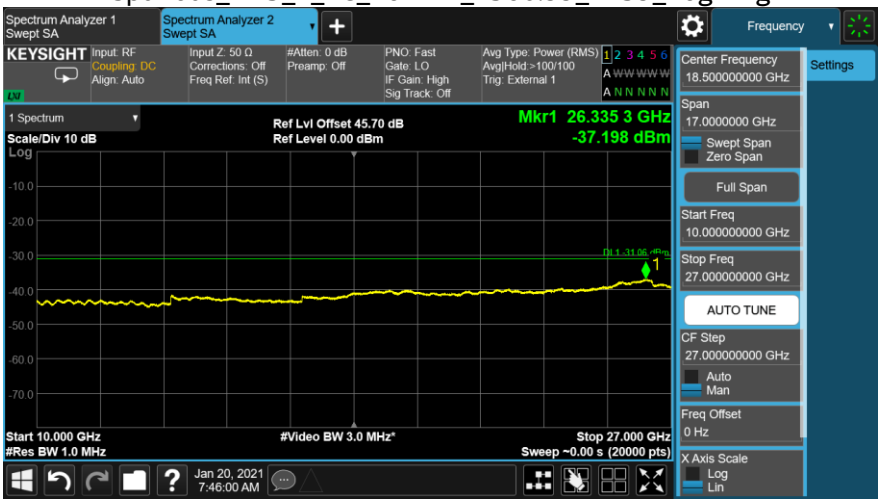
Spurious_TM3_1_1C_20MBW_2506.99_TX59_2526-2690m



Spurious_TM3_1_1C_20MBW_2506.99_TX59_2690m-10g

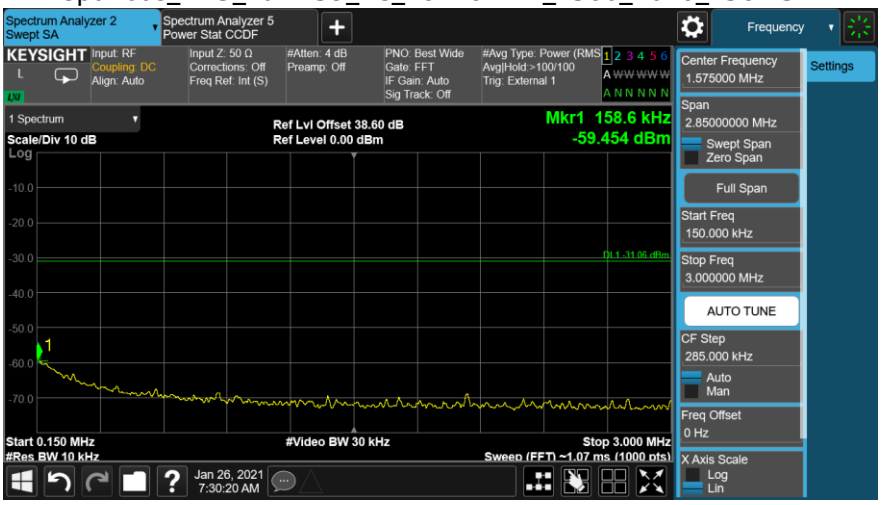


Spurious_TM3_1_1C_20MBW_2506.99_TX59_10g-27g

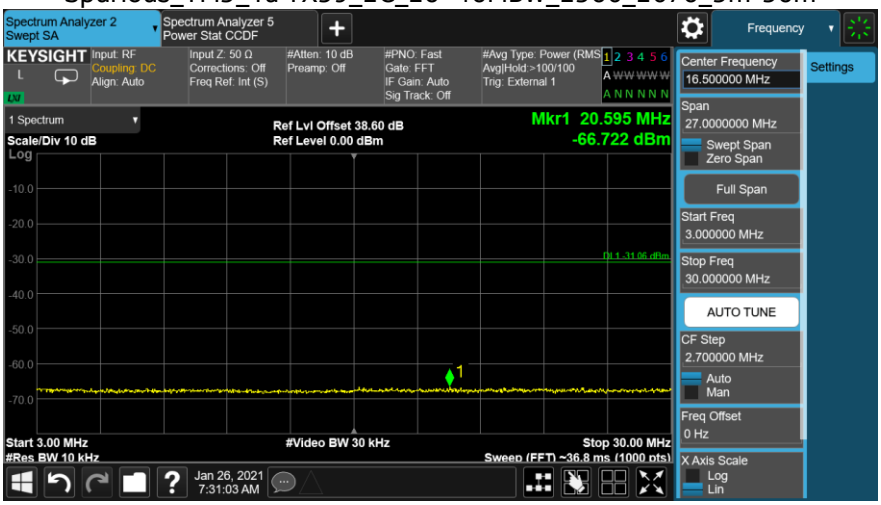


2C Data

Spurious_TM3_1a TX59_2C_20+40MBW_2506_2670_150k-3m

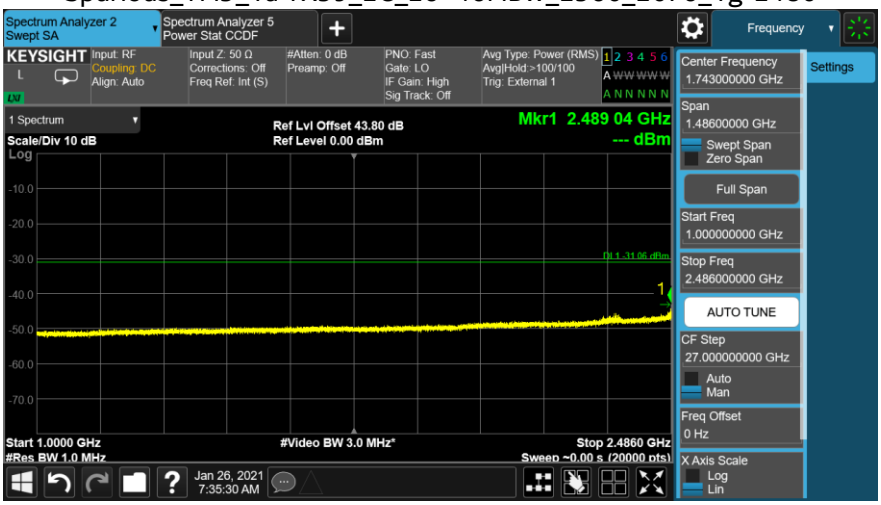


Spurious_TM3_1a TX59_2C_20+40MBW_2506_2670_3m-30m



Spurious_TM3_1a TX59_2C_20+40MBW_2506_2670_30m-1g

Spurious_TM3_1a TX59_2C_20+40MBW_2506_2670_1g-2486



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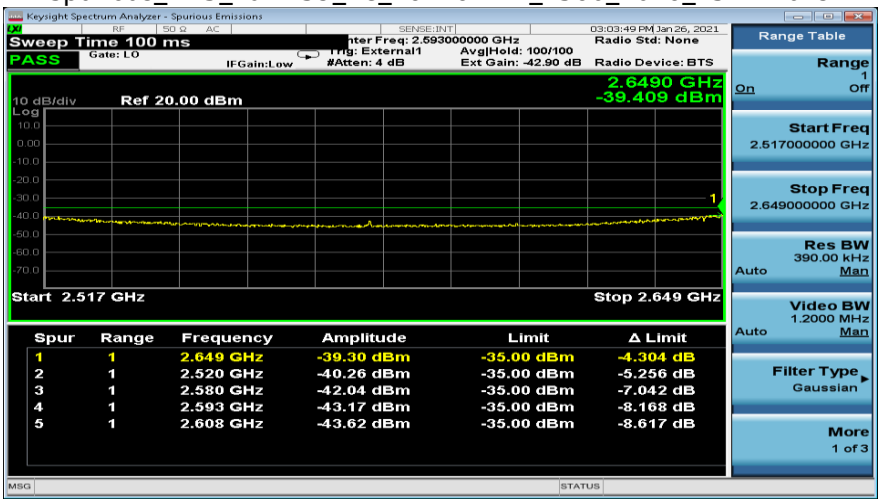

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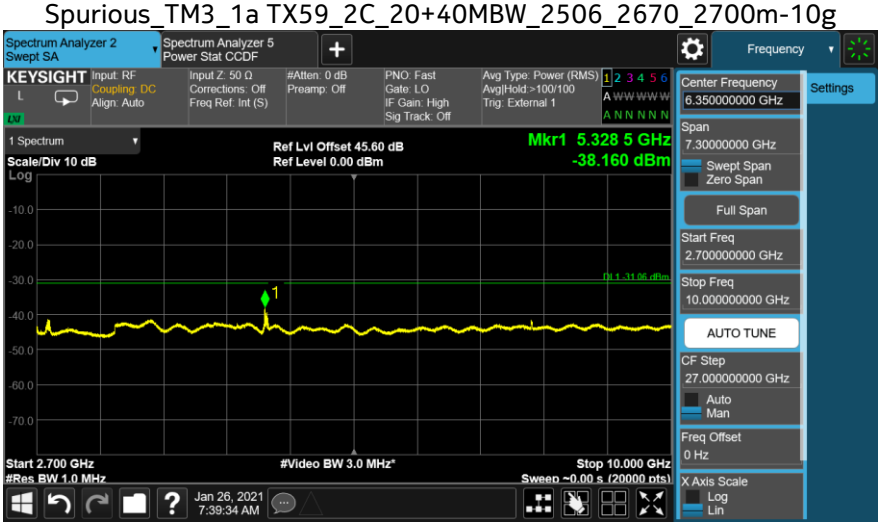

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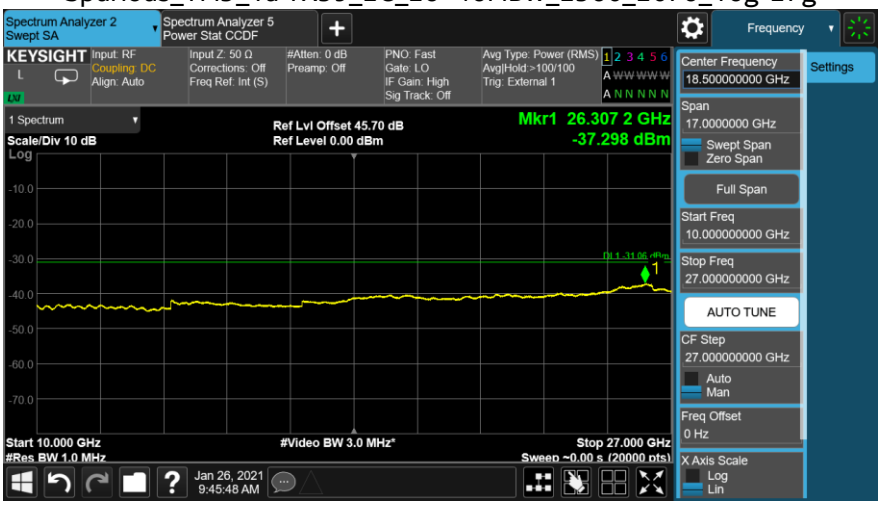
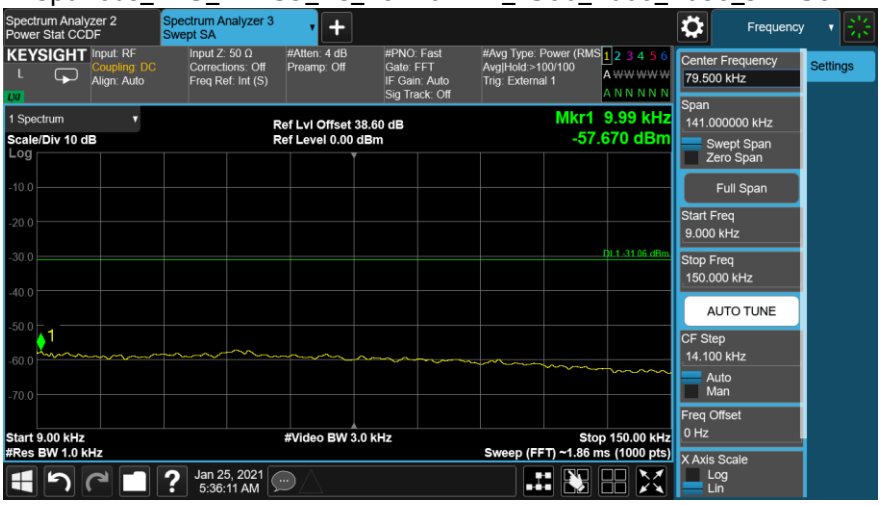


3C Data

Spurious_TM3_2 TX59_2C_20+20MBW_2506_2660_2680_9k-150k



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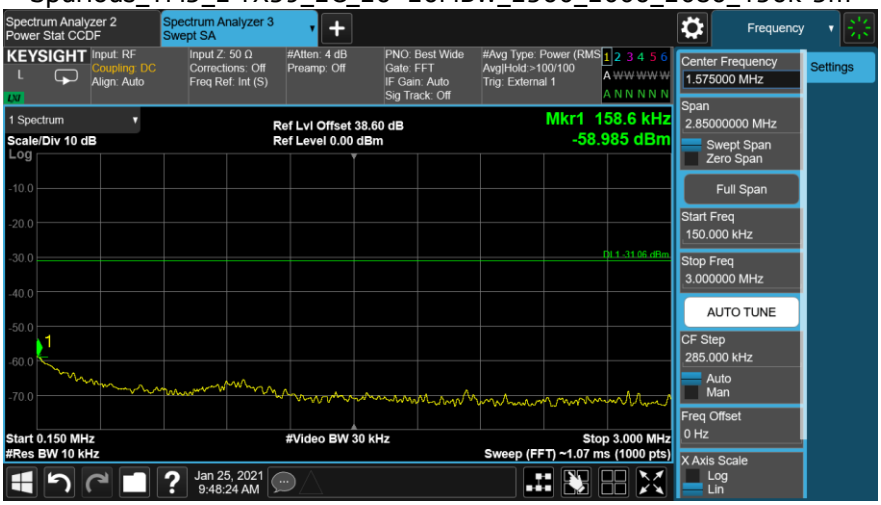

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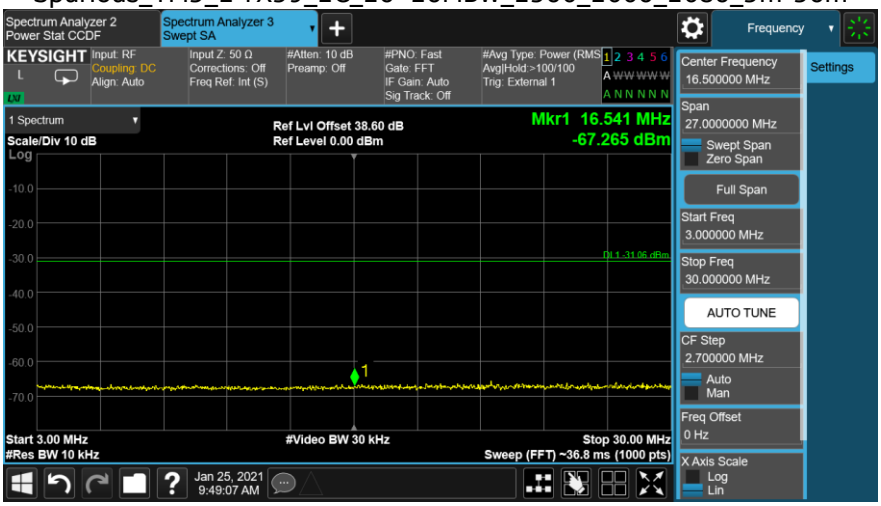

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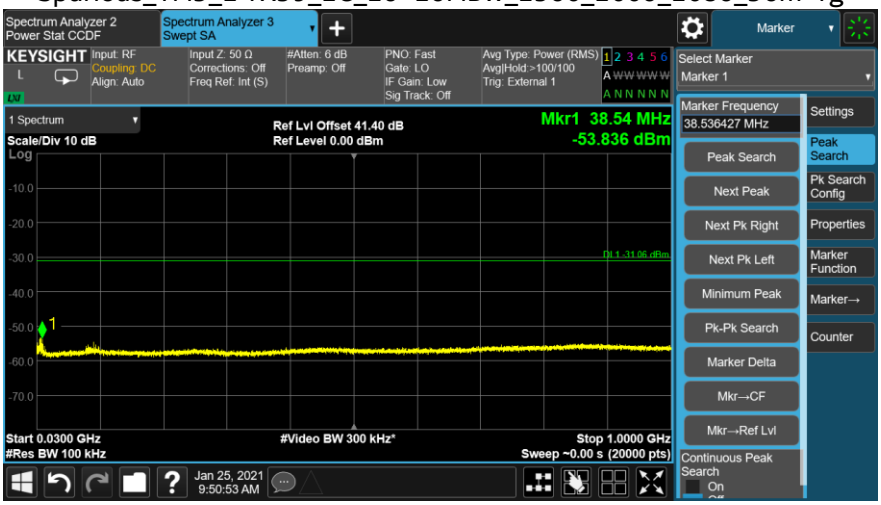

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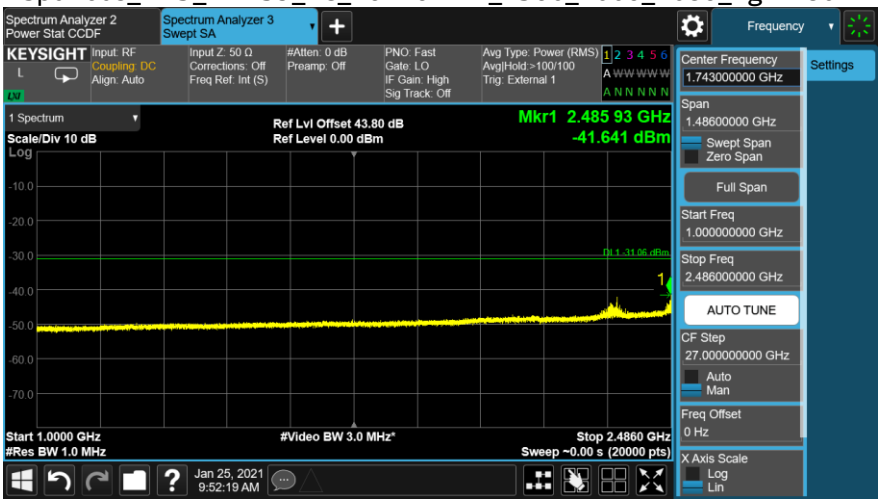

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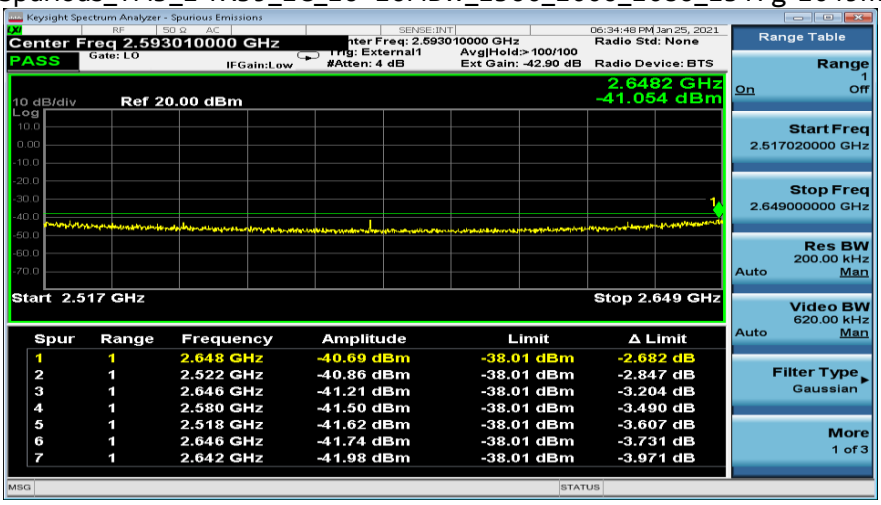

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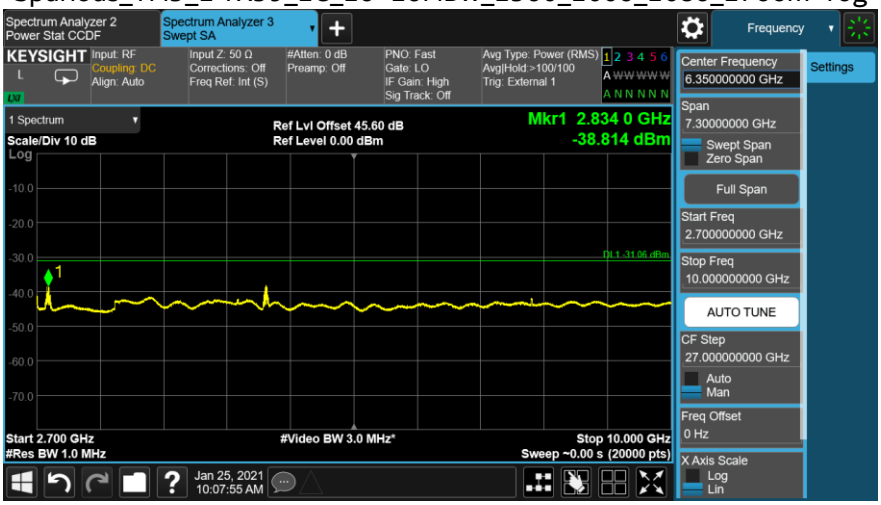

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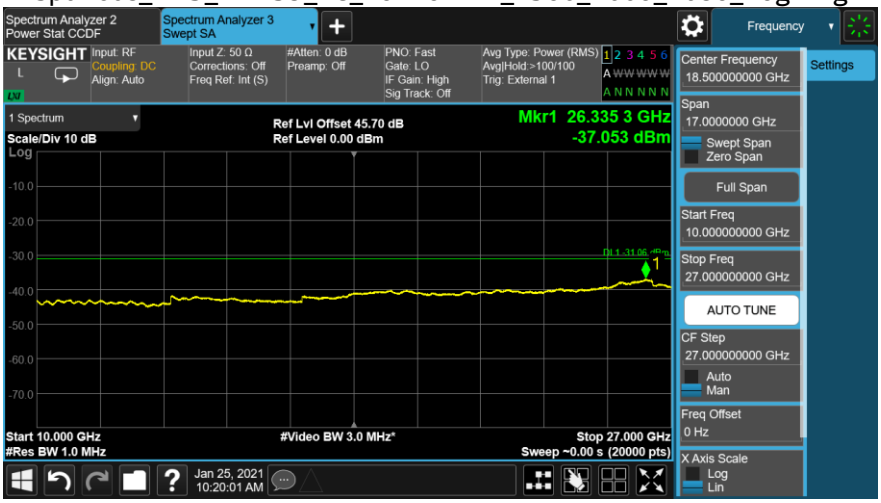
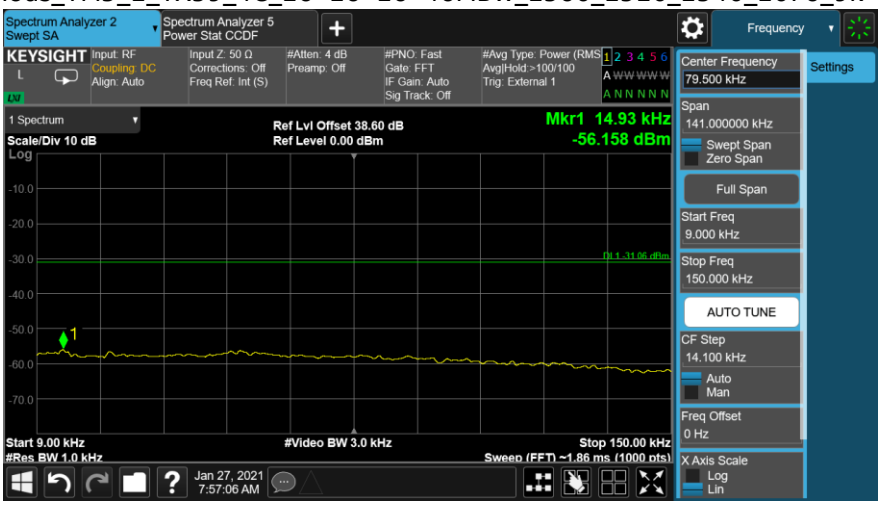


4C Data

Spurious_TM3_2_TX59_4C_20+20+20+40MBW_2506_2526_2546_2670_9k-150k



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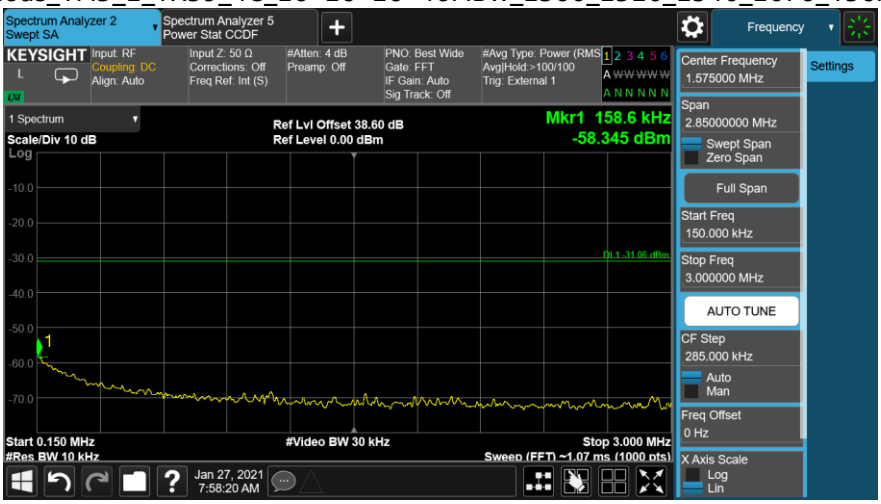
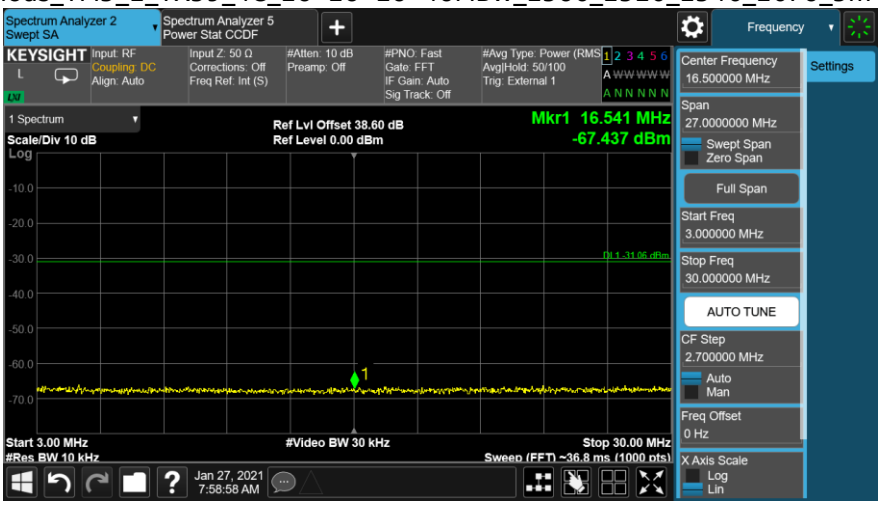
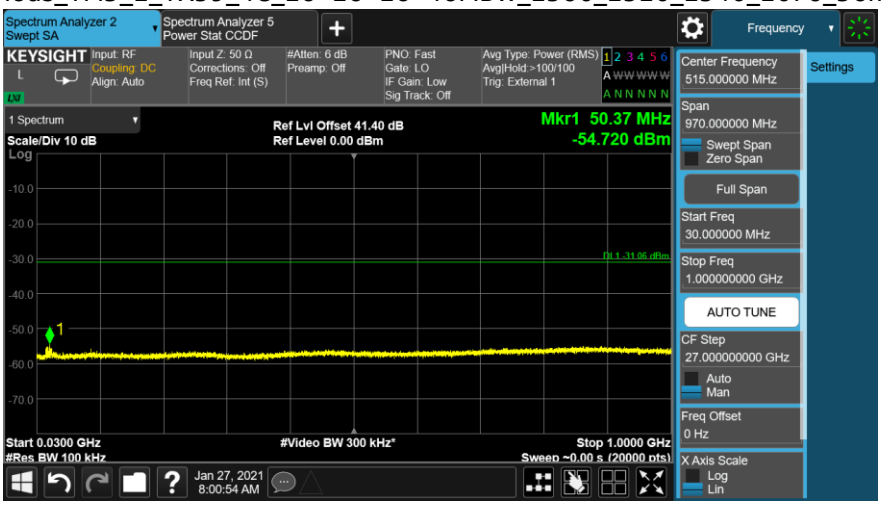


Spurious_TM3_2_TX59_4C_20+20+20+40MBW_2506_2526_2546_2670_3m-30m



Spurious_TM3_2_TX59_4C_20+20+20+40MBW_2506_2526_2546_2670_30m-1g



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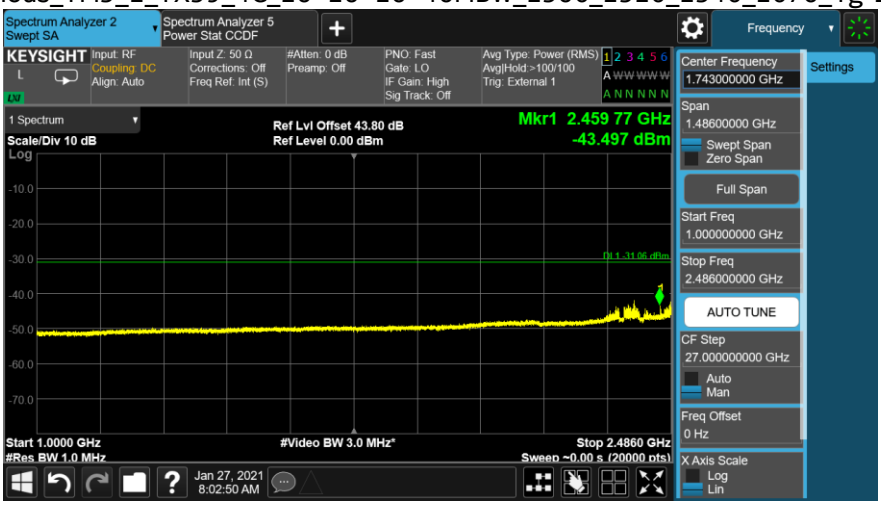
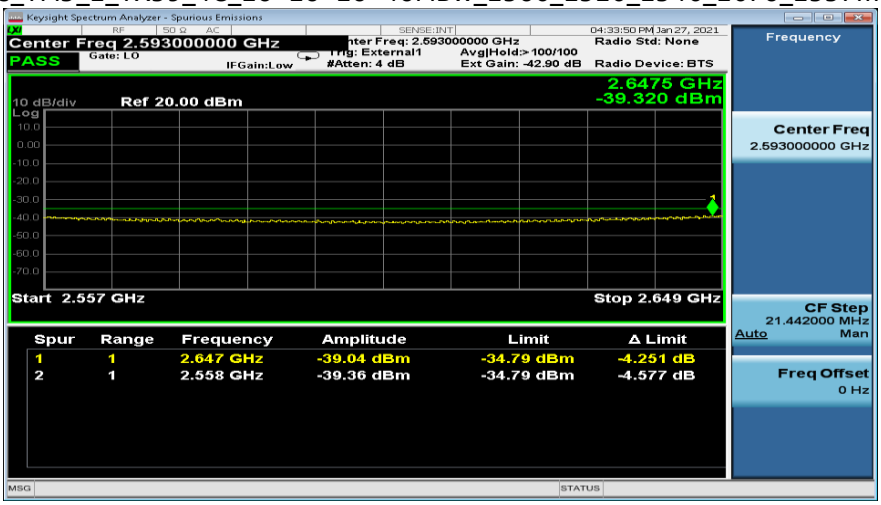
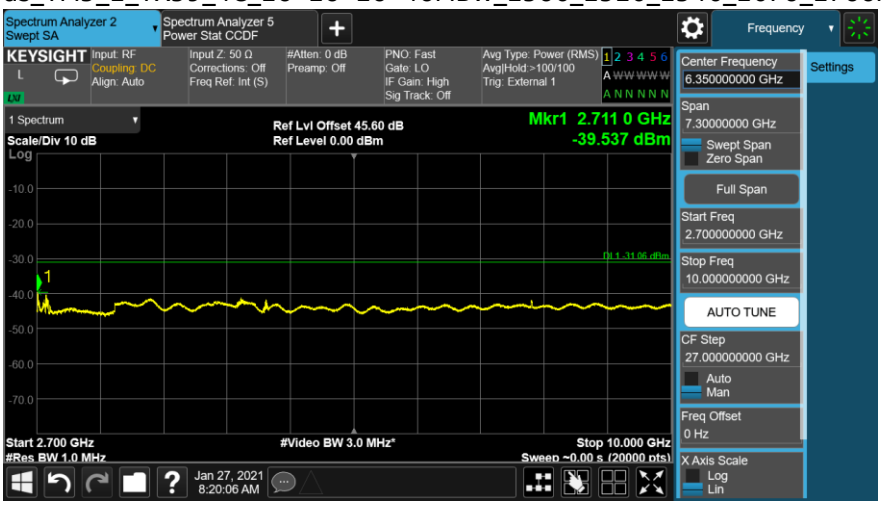


Spurious_TM3_2_TX59_4C_20+20+20+40MBW_2506_2526_2546_2670_2557m-2649m



Spurious_TM3_2_TX59_4C_20+20+20+40MBW_2506_2526_2546_2670_2700m-10g



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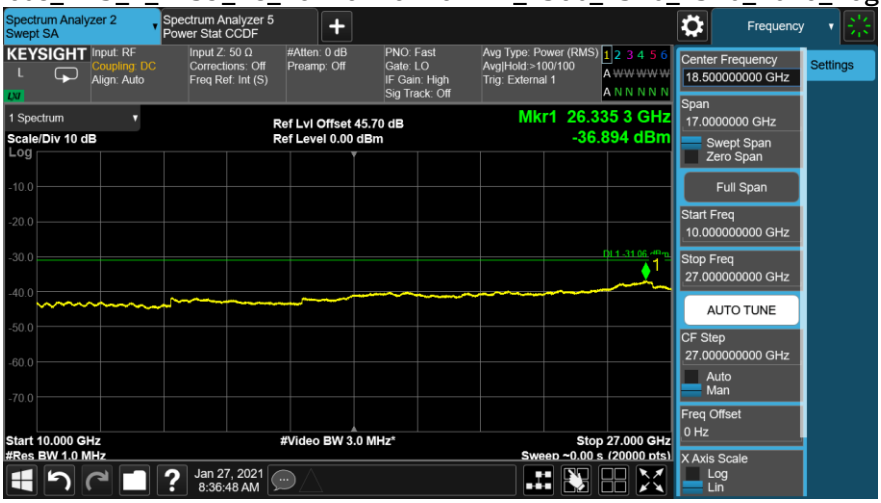
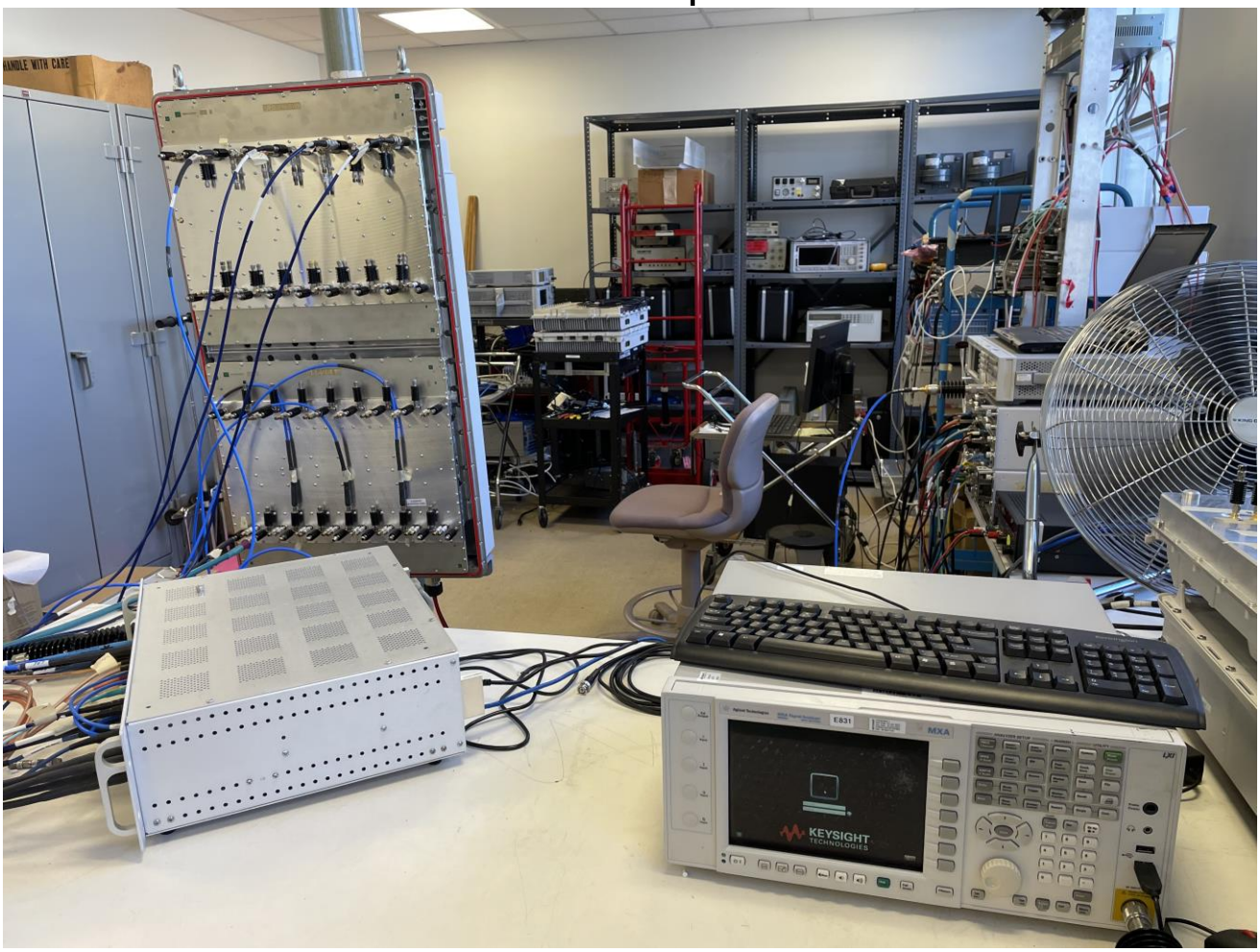


Photographs

Test Setup



Test Equipment

Asset ID	Manufacturer	Type	Description	Model	Serial	Calibration Date	Calibration Due
E831	Agilent Technologies	MXA Signal Analyzer	20Hz-26.5GHz	N9020A	MY48011791	2020-06-16	2022-06-16
E896	Agilent Technologies	Network Analyzer	10 MHz - 40 GHz	N5230C	MY49000897	2019-01-31	2021-01-31*
E1338	KeySight Technologies	MXA Signal Analyzer		N9020B	MY57430927	2019-11-14	2021-11-14
E1156	Weinschel	Attenuator	10dB 0.05GHz-26GHz 25W	74-10-12	1069	CNR-V	CNR-V
E1155	Weinschel	Attenuator	10dB 25Watt 0.05GHz - 26GHz	74-10-12	1068	CNR-V	CNR-V

* Equipment was last used on 1/27/2021

Customer Provided Equipment

Manufacturer	Type	Description	Model	Serial	Calibration Date	Calibration Due
Mini Circuit	Modular Test System	ZTM-53	ZTM-52	11701250030	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, 27 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 27 GHz), no reportable spurious emissions were detected.

7. NVLAP Certificate of Accreditation

United States Department of Commerce
National Institute of Standards and Technology

NVLAP®

ilac-MRA

Certificate of Accreditation to ISO/IEC 17025:2017

NVLAP LAB CODE: 100275-0

Nokia, Global Product Compliance Lab
Murray Hill, NJ

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

Electromagnetic Compatibility & Telecommunications

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

2020-09-25 through 2021-09-30
Effective Dates

DEPARTMENT OF COMMERCE * UNITED STATES OF AMERICA *

For the National Voluntary Laboratory Accreditation Program