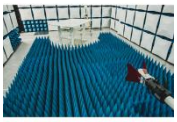
ELEMENT WASHINGTON DC LLC
7185 Oakland Mills Road, Columbia, MD 21046 USA
Tel. 410.290.6652 / Fax 410.290.6654
http://www.element.com



PART 20 & 30 MEASUREMENT REPORT

Applicant Name:
Pivotal Commware
10801 120th Ave NE #200,
Kirkland, WA 98033
United States

Date of Testing:
02/23/2023-03/28/2023
Test Report Issue Date:
04/05/2023
Test Site/Location:
Element Lab., Columbia, MD, USA
Test Report Serial No.:
1M2302160010-01.2AUVU

FCC ID:	**2AUVU-5620-12-28**
APPLICANT:	**Pivotal Commware**

Application Type:	Certification
Model:	5620-12-28
EUT Type:	5G mmWave Repeater
FCC Classification(s):	Part 20 Industrial Booster (CMRS) (B2I)
FCC Rule Part(s):	2, 20, 30
Test Procedure(s):	ANSI C63.26-2015, KDB 842590 D01 v01r02, KDB 935210 D02 v04r02, KDB 935210 D05 v01r04

This equipment has been shown to be capable of compliance with the applicable technical standards as indicated in the measurement report and was tested in accordance with the measurement procedures specified in §2.947. Test results reported herein relate only to the item(s) tested.

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

RJ Ortanez
Executive Vice President

ACCREDITED
CERT #2041.01

TABLE OF CONTENTS

PART 20 & 30 MEASUREMENT REPORT

Band	Antenna	Bandwidth [MHz]	Tx Frequency [MHz]	CCs Active	Mode	Modulation	EIRP		Emission Designator
							Max Power [W]	Max Power [dBm]	
n261	H-UL	50	27525 - 28325	1	SISO	QPSK	15.382	41.87	46M2G7D
					SISO	16-QAM	7.638	38.83	46M2W7D
		100	27550 - 28300	4	SISO	QPSK	11.194	40.49	397MG7D
					SISO	16-QAM	10.423	40.18	397MW7D
n261	V-UL	50	27525 - 28325	1	SISO	QPSK	13.709	41.37	46M4G7D
					SISO	16-QAM	11.169	40.48	46M4W7D
		100	27550 - 28300	4	SISO	QPSK	9.162	39.62	397MG7D
					SISO	16-QAM	8.913	39.50	398MW7D
n261	MIMO	50	27525 - 28325	1	SISO	QPSK	28.249	44.51	-
					SISO	16-QAM	18.793	42.74	-
		100	27550 - 28300	4	SISO	QPSK	20.370	43.09	-
					SISO	16-QAM	19.320	42.86	-

EUT Overview (Band n261)

1.0 INTRODUCTION

1.1 Scope

Measurement and determination of electromagnetic emissions (EMC) of radio frequency devices including intentional and/or unintentional radiators for compliance with the technical rules and regulations of the Federal Communications Commission.

1.2 Element Test Location

These measurement tests were conducted at the Element Laboratory located at 7185 Oakland Mills Road, Columbia, MD 21046. The measurement facility is compliant with the test site requirements specified in ANSI C63.4-2014.

1.3 Test Facility / Accreditations

Measurements were performed at Element Lab located in Columbia, MD 21046, U.S.A.

- Element Washington DC LLC is an ISO 17025-2017 accredited test facility under the American Association for Laboratory Accreditation (A2LA) with Certificate number 2041.01 for Specific Absorption Rate (SAR), Hearing Aid Compatibility (HAC) testing, where applicable, and Electromagnetic Compatibility (EMC) testing for FCC and Innovation, Science, and Economic Development Canada rules.

- Element Washington DC LLC TCB is a Telecommunication Certification Body (TCB) accredited to ISO/IEC 17065-2012 by A2LA (Certificate number 2041.03) in all scopes of FCC Rules and ISED Standards (RSS).

- Element Washington DC LLC facility is a registered (2451B) test laboratory with the site description on file with ISED.

- Element Washington DC LLC is a Recognized U.S. Certification Assessment Body (CAB # US0110) for ISED Canada as designated by NIST under the U.S. and Canada Mutual Recognition Agreement.

2.0 PRODUCT INFORMATION

2.1 Equipment Description

The Equipment Under Test (EUT) is the **Pivotal Commware 5G mmWave Repeater FCC ID: 2AUVU-5620-12-28.** The test data contained in this report pertains only to the emissions due to the 5G mmWave operation of the Donor Unit.

The EUT is part of a two-unit repeater system consisting of a Donor Unit (DU) and a Service Unit (SU). Each unit is mounted on a pole and aligned to properly receive and boost 5G signals from a gNodeB. Both units are required for operation as neither can be operated in a standalone mode.

Both units are capable of transmitting boosted 5G mmWave signals. For transmission of such signals, the DU is installed and configured to communicate with a gNodeB. The SU receives the signal from the DU via an RF cable and then re-transmits the signal to provide 5G coverage to a target area. For each unit, the antenna configuration is comprised of two separate linearly polarized antenna feeds: one for horizontally polarized transmission and one for vertically polarized transmission.

Both the DU and the SU were fitted with RF connectors to allow for conducted measurements to compare with the FCC Part 30 limits. Throughout this report, the output data for the DU are labelled as “V-UL” and “H-UL” to represent the vertical and horizontal transmission components of the output.

The EUT does not generate its own RF. The EUT supports any combination of bandwidths, number of carriers, and modulations as input signals from a signal generator connected to its input. The EUT will transmit all signals within the 5G NR n261 band that are received.

Test Device Serial No.: 600024, 700027

2.2 Device Capabilities

This device contains the following capabilities:

5G FR2 (NR Band n261, NR Band 257), LTE (B2, B4, B12 & B13)

2.3 Test Configuration

The EUT was tested per the guidance of ANSI C63.26-2015 and KDB 842590 D01 and KDB 935210 D05. See Section 7.0 of this test report for a description of the conducted and radiated tests.

All conducted testing was performed using a signal generator connected via coaxial cable to waveguide adapters on the input port of the system and measured via adapter connected to coaxial cable from the output port of the DU. All radiated testing was performed by using a signal generator connected to the RF conducted input of the SU which provides, via RF cable connection, the RF signal that is radiated from the DU.

For both conducted and radiated testing, the signal generator was set to transmit representative 5G mmWave NR signals in various sized bandwidths and modulations.

2.4 Software and Firmware

The test was conducted with firmware version 0.3.1 installed on the EUT.

2.5 EMI Suppression Device(s)/Modifications

No EMI suppression device(s) were added and no modifications were made during testing.

3.0 DESCRIPTION OF TESTS

3.1 Measurement Procedure

The measurement procedures described in the document titled "American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services" (ANSI C63.26-2015) and the guidance provided in KDB 842590 D01 v01r02 were used in the measurement of the EUT. KDB 935210 D05 v01r04 was referenced for testing the EUT as well.

3.2 Radiated Power and Radiated Spurious Emissions

The radiated test facilities consisted of an indoor 3 meter semi-anechoic chamber used for final measurements and exploratory measurements, when necessary for radiated emissions measurements in the spurious domain. The measurement area is contained within the semi-anechoic chamber which is shielded from any ambient interference. The test site inside the chamber is a 6m x 5.2m elliptical, obstruction-free area in accordance with Figure 5.7 of Clause 5 in ANSI C63.4-2014. Absorbers are arranged on the floor between the turn table and the antenna mast in such a way so as to maximize the reduction of reflections for measurements above 1GHz. For measurements below 1GHz, the absorbers are removed. A raised turntable is used for radiated measurement. The turn table is a continuously rotatable, remote-controlled, metallic turntable and 2 meters (6.56 ft.) in diameter. The turn table is flush with the raised floor of the chamber in order to maintain its function as a ground plane. An 80cm tall test table made of Styrodur is placed on top of the turn table. A Styrodur pedestal is placed on top of the test table to bring the total table height to 1.5m for measurements above 1GHz.

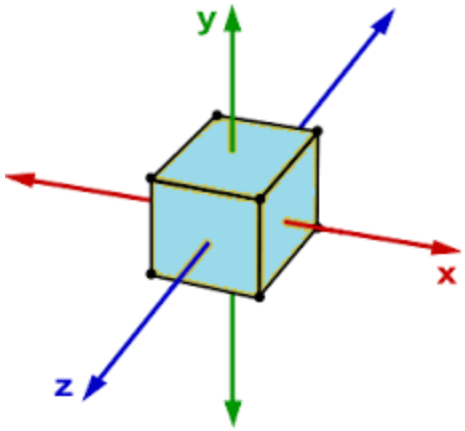


Figure 3-1. Rotation of the EUT Through Three Orthogonal Planes

The equipment under test was transmitting while connected to its antenna and is placed on a test table. The measurement antenna is in the far field of the EUT per formula $2D^2/\lambda$ where D is the larger between the dimension of the measurement antenna and the transmitting antenna of the EUT. In this case, for RSE measurements, "D" is the largest dimension of the EUT which was roughly 29cm x 29cm x 7cm. The measurement antenna and harmonic mixer were manipulated around all faces and edges of the EUT to determine location of worst-case emissions.

Frequency Range (GHz)	Wavelength (cm)	Far Field Distance (m)	Measurement Distance (m)
18-40	0.749	0.54	2.00
40-60	0.06	1.44	2.00
60-90	0.04	0.96	2.00
90-140	0.026	1.493	2.00

Table 3-1. Far-Field Distance & Measurment Distance per Frequency Range

Effective Isotropic Radiated Power Sample Calculation

The measured e.i.r.p is converted to E-field in V/m. Then, the distance correction is applied before converting back to calculated e.i.r.p, as explained in ANSI C63.26-2015.

Field Strength [dBµV/m] = Measured Value [dBm] + AFCL [dB/m] + 107

= - 32.74 dBm + (40.7dB/m + 8.78dB) + 107 = 123.74dBuV/m

= 10^(123.74/20)/1000000 = 1.54 V/m

e.i.r.p. [dBm] = 10 * log((E-Field*D_m)^2/30) + 30dB

= 10*log((1.54V/m * 1.00m)^2/30) + 30dB

= 18.98 dBm e.i.r.p.

3.3 Industrial Booster Test Cases

Per the requirements of KDB 935210 D05 v01r04, the following test cases shall be investigated for Industrial Boosters under FCC Part 20.21:

1. AGC Threshold Level
2. Out-of-Band Rejection
3. Input-versus-Output Signal Comparison
4. Mean Output Power and Amplifier/Booster Gain
5. Out-of-Band/Out-of-Block Emissions and Spurious Emissions
6. Frequency Stability
7. Radiated Spurious Emissions

3.4 Environmental Conditions

The temperature is controlled within range of 15°C to 35°C. The relative humidity is controlled within range of 10% to 75%. The atmospheric pressure is monitored within the range 86-106kPa (860-1060mbar).

4.0 MEASUREMENT UNCERTAINTY

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.4-2014. All measurement uncertainty values are shown with a coverage factor of k = 2 to indicate a 95% level of confidence. The measurement uncertainty shown below meets or exceeds the U_{CISPR} measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

Contribution	Expanded Uncertainty (±dB)
Conducted Bench Top Measurements	1.13
Radiated Disturbance (<1GHz)	4.98
Radiated Disturbance (>1GHz)	5.07
Radiated Disturbance (>18GHz)	5.09

5.0 TEST EQUIPMENT CALIBRATION DATA

Test Equipment Calibration is traceable to an accredited ISO/IEC 17025 calibration facility. Measurements antennas used during testing were calibrated in accordance to the requirements of ANSI C63.5-2017.

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
-	AP2-001	EMC Cable and Switch System	1/11/2023	Annual	1/11/2024	AP2-001
-	AP2-002	EMC Cable and Switch System	1/11/2023	Annual	1/11/2024	AP2-002
-	WL40-1	WLAN Cable Set (40GHz)	1/12/2023	Annual	1/12/2024	WL40-1
-	WL40-2	WLAN Cable Set (40GHz)	1/12/2023	Annual	1/12/2024	WL40-2
EMCO	3115	Horn Antenna (1-18GHz)	8/8/2022	Biennial	8/8/2024	9203-2178
EMCO	3116	Horn Antenna (18-40GHz)	7/20/2021	Biennial	7/20/2023	9704-5182
ESPEC	SU-241	Temperature Chamber	11/10/2022	Annual	11/10/2023	93011064
Narda	180-422-KF	Horn (Small)	8/30/2022	Biennial	8/30/2024	170WX50922
OML, Inc.	M08RH	Horn Antenna, 90 to 140 GHz	9/28/2022	Biennial	9/28/2024	180914-1
OML, Inc.	M12RH	Horn Antenna, 60 to 90 GHz	10/4/2022	Biennial	10/4/2024	18073001
OML, Inc.	M19RH	Horn Antenna, 40 to 60 GHz	10/5/2022	Biennial	10/5/2024	190823-1
Rohde & Schwarz	FSV40-N	Spectrum Analyzer	6/7/2022	Annual	6/7/2023	161616
Rohde & Schwarz	FSW67	Signal / Spectrum Analyzer	1/13/2023	Annual	1/13/2024	101639
Rohde & Schwarz	ESU26	EMI Test Receiver (26.5GHz)	8/29/2022	Annual	8/29/2023	103187
Rohde & Schwarz	ESU40	EMI Test Receiver (40GHz)	8/25/2022	Annual	8/25/2023	101299
Rohde & Schwarz	SMW200A	Vector Signal Generator	8/16/2022	Biennial	8/16/2024	102130
Schwarzbeck	VULB 9162	Bilog; Attenuator	7/27/2022	Annual	7/27/2023	304
Virginia Diodes, Inc.	SAX679	SAX Module (40 - 60GHz)	11/21/2022	Biennial	11/21/2024	SAX679
Virginia Diodes, Inc.	SAX680	SAX Module (60 - 90GHz)	11/21/2022	Biennial	11/21/2024	SAX680
Virginia Diodes, Inc.	SAX681	SAX Module (90 - 140GHz)	11/21/2022	Biennial	11/21/2024	SAX681

Table 5-1. Test Equipment

6.0 SAMPLE CALCULATIONS

Emission Designator

π/2 BPSK/ QPSK Modulation

Emission Designator = 800MG7D

BW = 800 MHz
G = Phase Modulation
7 = Quantized/Digital Info
D = Data transmission, telemetry, telecommand

QAM Modulation

Emission Designator = 802MW7D

BW = 802 MHz
W = Amplitude/Angle Modulated
7 = Quantized/Digital Info
D = Data transmission, telemetry, telecommand

7.0 TEST RESULTS

7.1 Summary

Company Name: Pivotal Commware

FCC ID: 2AUVU-5620-12-28

FCC Classification(s): Part 20 Industrial Booster (CMRS) (B2I)

Mode(s): TDD

FCC Part Section(s)	KDB 935210 D05 Section(s)	Test Description	Test Limit	Test Condition	Test Result	Reference
2.1049, 20.21	3.4	Input-Versus-Output Signal Comparison	N/A	CONDUCTED	PASS	Section 7.2
20.21	3.3	Out-of-band Rejection	N/A		PASS	Section 7.3
2.1046, 20.21	3.2, 3.5	Measuring AGC Threshold Level, Mean Output Power & Amplifier/Booster Gain	N/A		PASS	Section 7.4
2.1049	-	Occupied Bandwidth	N/A		PASS	Section 7.5
2.1046, 30.202(c)	-	Conducted Power & Equivalent Isotropic Radiated Power	≤ 55 dBm		PASS	Section 7.6
2.1051, 20.21, 30.203	3.6	Band Edge / Out-of-Band Emissions	≤ -5dBm/MHz from the band edge up to 10% of the channel BW ≤-13dBm/MHz for all out-of-band emissions		PASS	Section 7.8
2.1055, 20.21	3.7	Frequency Stability	Fundamental emissions stay within authorized frequency block		PASS	Section 7.9
2.1051, 20.21, 30.203	3.8	Radiated Spurious Emissions	≤ -13 dBm/MHz for spurious emissions	RADIATED	PASS	Section 7.7

Table 7-1. Summary of Radiated Test Results

Notes:

1. Per 2.1057(a)(2), spurious emissions were investigated up to 100GHz.

2. Testing was completed with a signal generator creating a representative mmWave 5G NR signal, using DFT-s-OFDM and CP-OFDM schemes, various modulations including QPSK, and QAM, 120kHz subcarrier spacing, 50MHz-single carrier, 50MHz-dual carrier, and 100MHz-four carrier bandwidths, and full and single resource block allocations.

3. The input signal was fed from the signal generator to the EUT via a coaxial cable and it was set at a level so as to produce the maximum output power of the AGC range.

4. Based upon investigations of all possible modulations, testing was mainly performed with QPSK modulation.

5. Unless otherwise specified, triggering from the signal generator was used in order to more accurately gate on the TDD signal with the analyzer.

6. For conducted testing only, the EUT was fitted with waveguide-to-coax RF adapters that allowed for direct measurements. With the exception of radiated spurious emissions, all measurements were performed in a conducted test setup.

7. Some RSE measurements required use of TRP test methods in order to demonstrate compliance. The Two-Cut TRP method was applied as specified in Section 4.4.3.3 of KDB 842590 D01.

7.2 Input-Versus-Output Signal Comparison

Test Overview

The Input-versus-Output Signal Comparison checks for the change in occupied bandwidth of the output signal from the booster at 3dB above the AGC threshold level and just below the AGC threshold level while not more than 0.5dB below the threshold level. All modes of operation were investigated and the worst case configuration results are reported in this section. Per KDB 935210 D05 clause 3.4, this is to be measured on both the input signal and the output signal.

Test Procedure Used

ANSI C63.26-2015 – Section 5.4.3
KDB 935210 D05 – Section 3.4

Test Settings

1. The signal analyzer's automatic bandwidth measurement capability was used to perform the 99% occupied bandwidth. The bandwidth measurement was not influenced by any intermediate power nulls in the fundamental emission.
2. RBW = 1 – 5% of the expected OBW
3. VBW ≥ 3 x RBW
4. Detector = Peak
5. Trace mode = max hold
6. Sweep = auto couple
7. The trace was allowed to stabilize

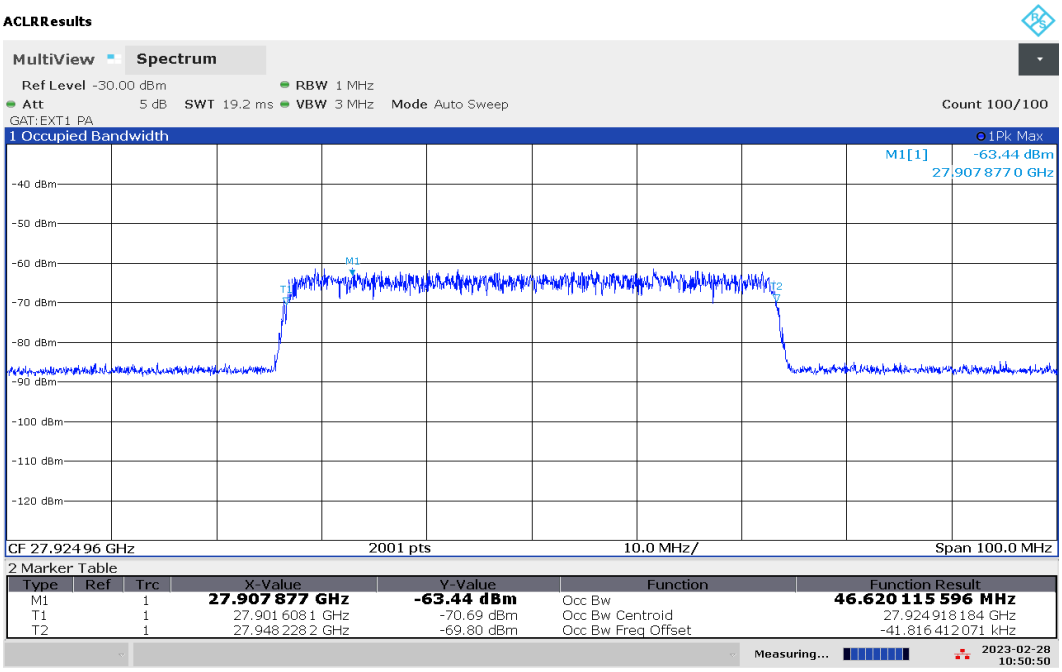
Test Notes

Per previous guidance from FCC specifically to Element lab, a 50MHz 5G NR mmWave signal was used as the input signal as opposed to the 4.1MHz AWGN required in KDB 935210 D05.

Band n261

AGC Threshold Level	EUT Antenna Polarization	Channel	Bandwidth [MHz]	Modulation	Input OBW [MHz]	Output OBW [MHz]
0.5dB below Threshold	H-UL	Mid	50	QPSK	46.62	46.12
3dB above Threshold	H-UL	Mid	50	QPSK	46.17	46.08
0.5dB below Threshold	V-UL	Mid	50	QPSK	46.21	46.28
3dB above Threshold	V-UL	Mid	50	QPSK	46.32	46.13

Table 7-2. n261 Occupied Bandwidth by AGC Threshold Level



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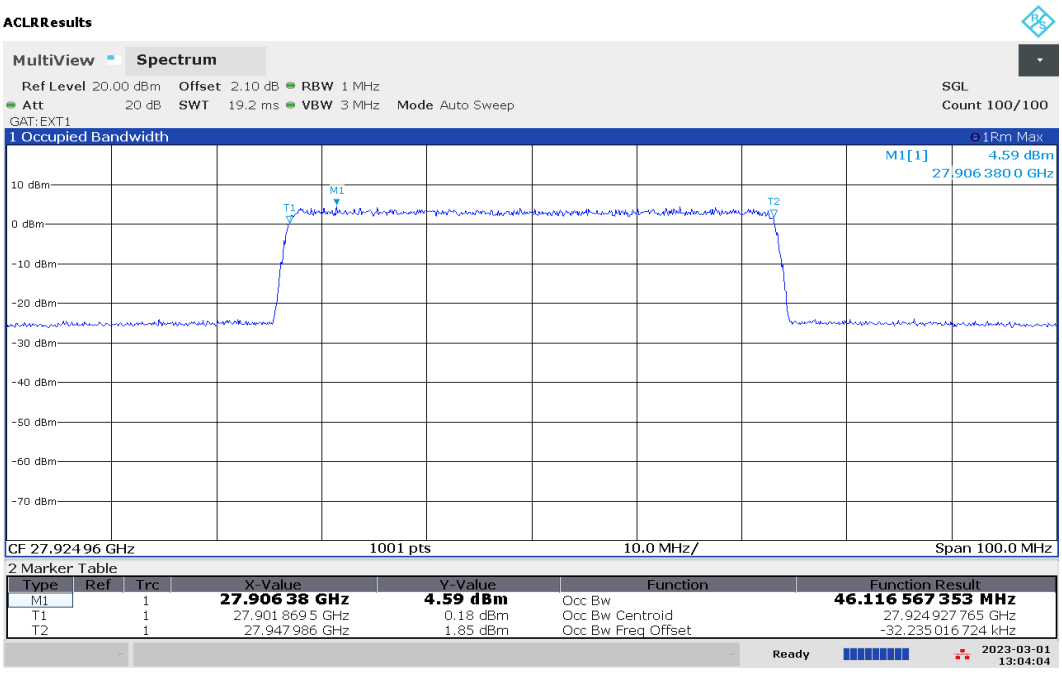
Plot 7-1. Occupied Bandwidth Input at 0.5dB below AGC Threshold – DU – H-UL Polarization.



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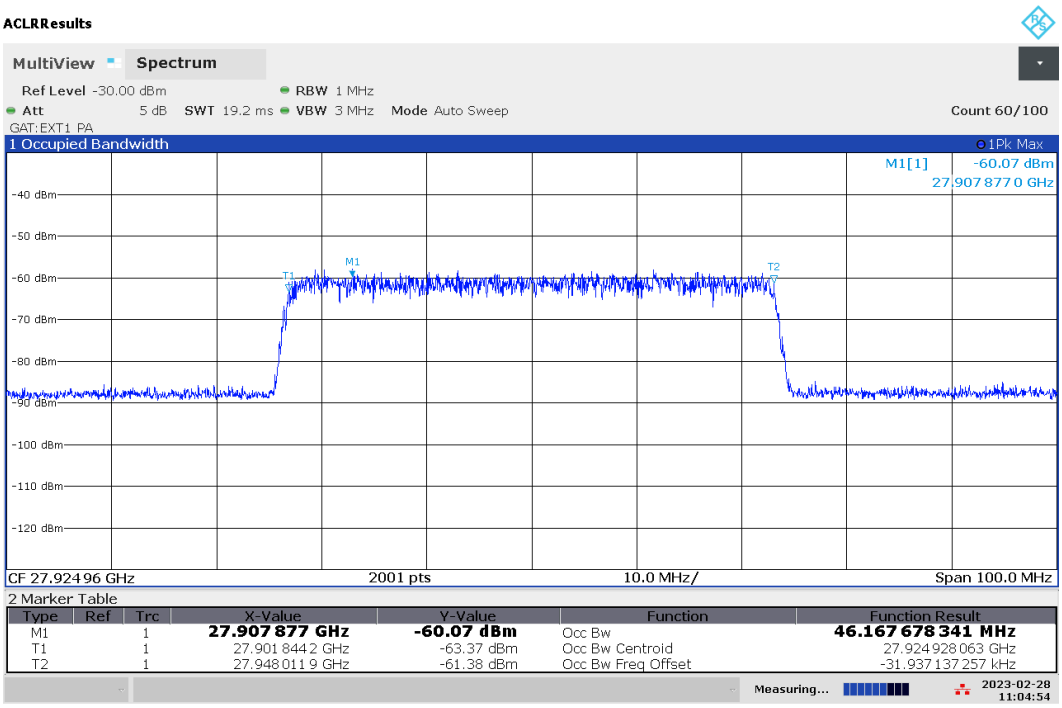
Plot 7-2. Occupied Bandwidth Output at 0.5dB below AGC Threshold – DU – H-UL Polarization.



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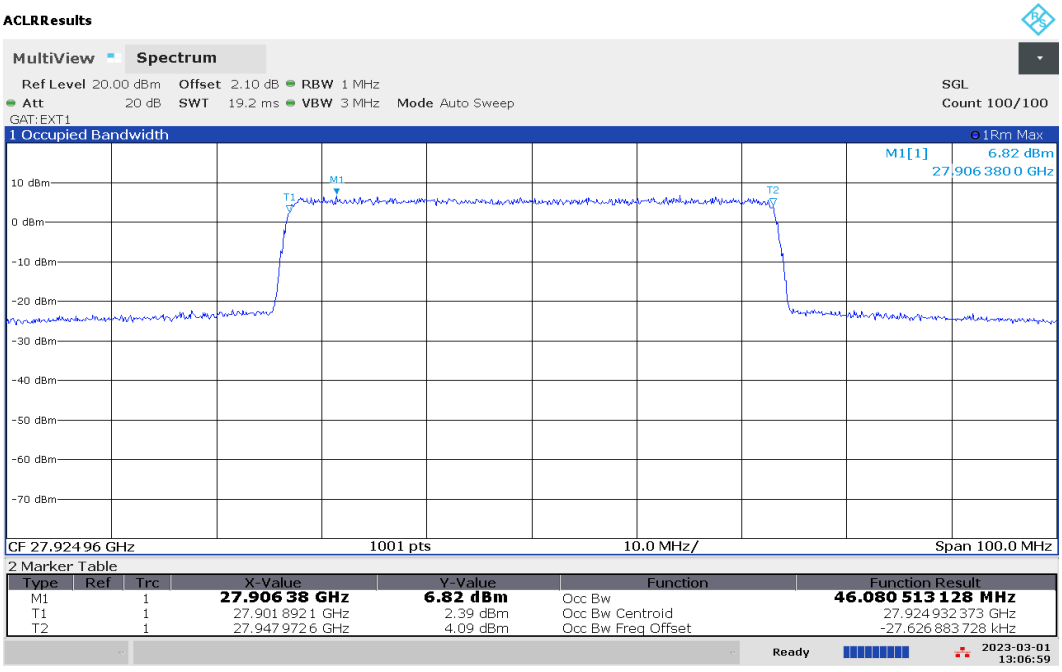
Plot 7-3. Occupied Bandwidth Input at 3dB above AGC Threshold – DU – H-UL Polarization.



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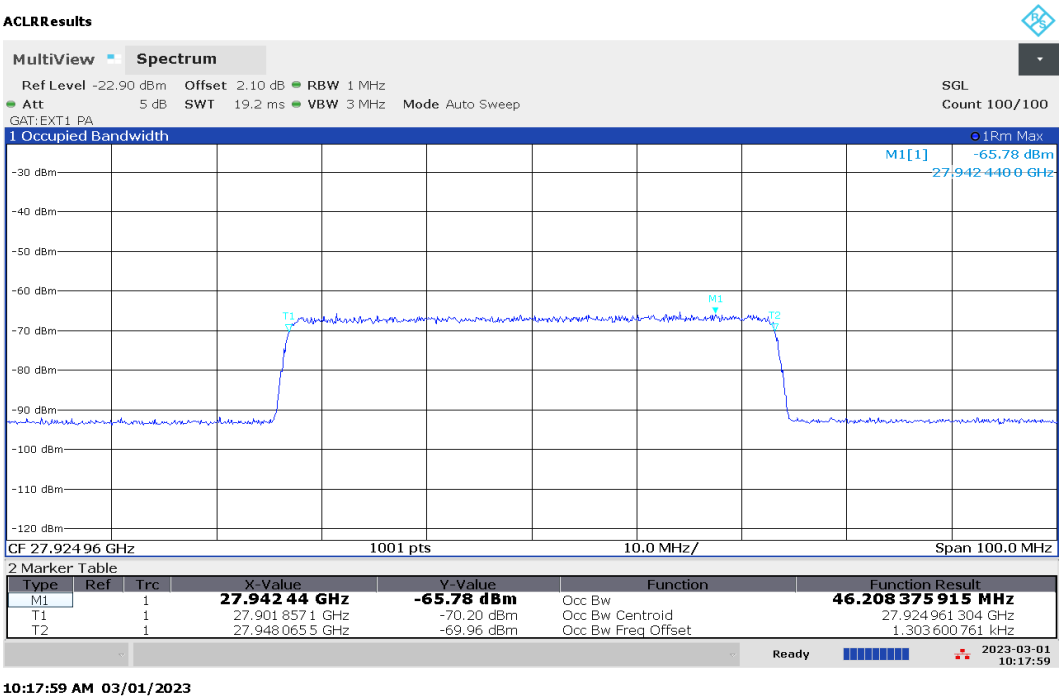
Plot 7-4. Occupied Bandwidth Output at 3dB above AGC Threshold – DU – H-UL Polarization.



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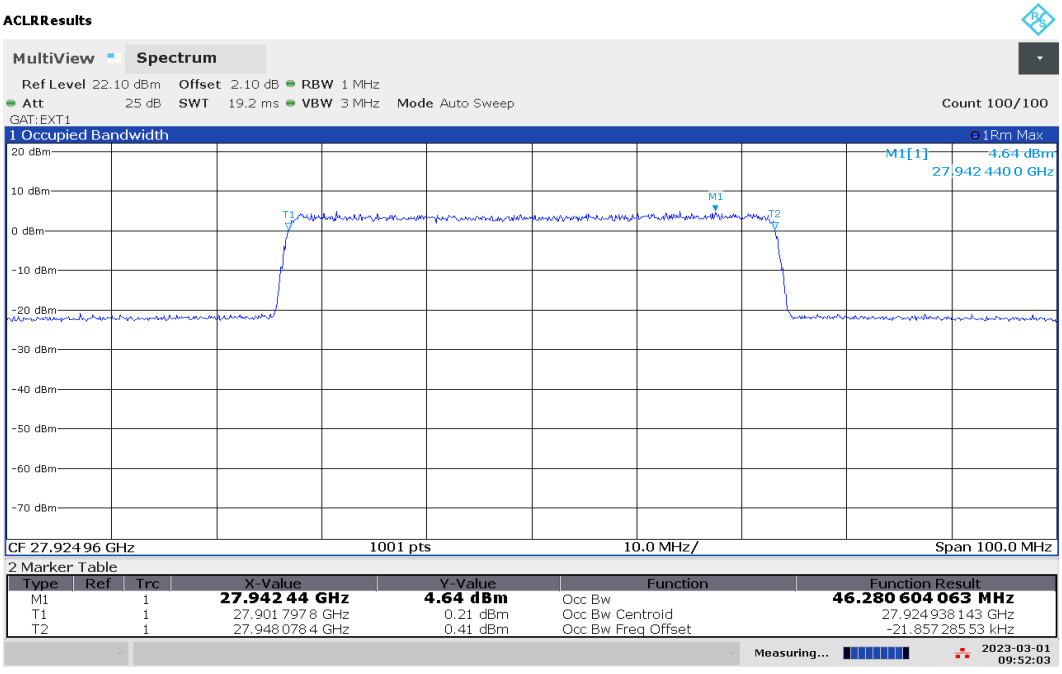
Plot 7-5. Occupied Bandwidth Input at 0.5dB below AGC Threshold – DU – V-UL Polarization.



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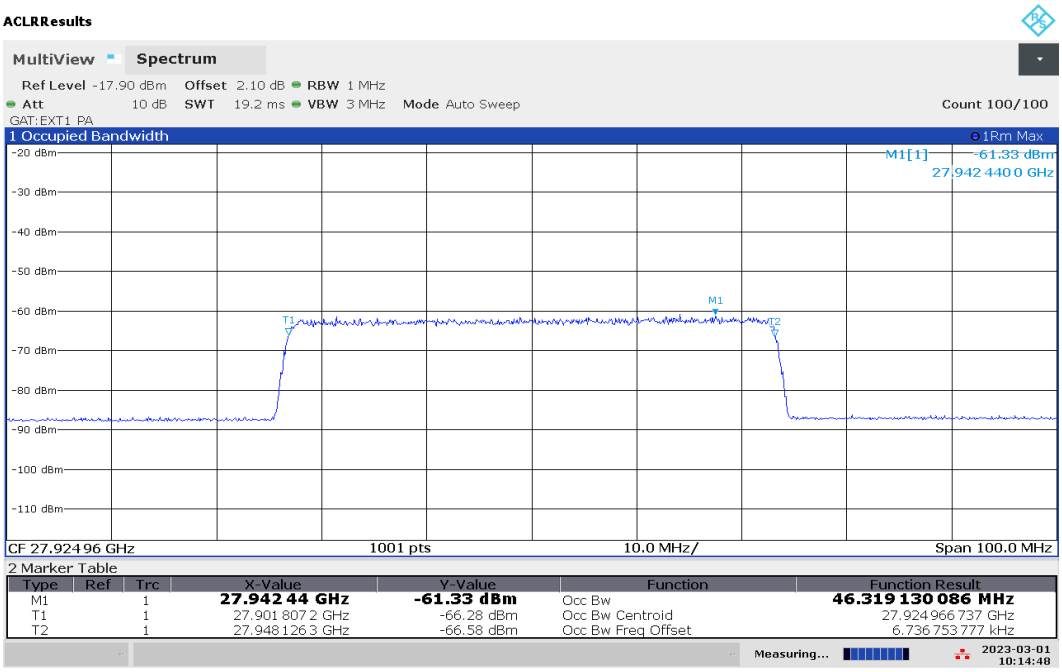
Plot 7-6. Occupied Bandwidth Output at 0.5dB below AGC Threshold – DU – V-UL Polarization.



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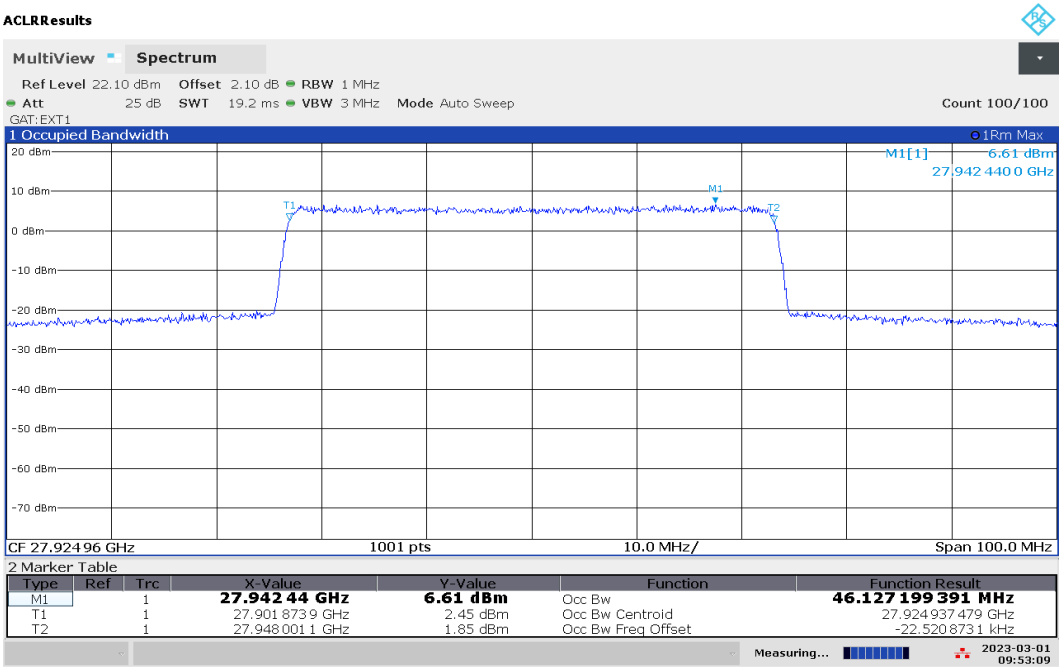
Plot 7-7. Occupied Bandwidth Input at 3dB above AGC Threshold – DU – V-UL Polarization.



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Plot 7-8. Occupied Bandwidth Output at 3dB above AGC Threshold – DU – V-UL Polarization.

7.3 Out-of-band Rejection

Test Overview

A signal generator is connected to the input port of the EUT, and the output of the EUT shall be connected to a spectrum analyzer. Per KDB 935210 D05 Section 3.3, the signal generator will sweep a CW signal to ± 250 % of the passband. Per FCC Part 20, an industrial booster shall have its 20dB bandwidth analyzed in order to assess the pass band of the booster.

Test Procedure Used

KDB 935210 D05 v01r04 – Section 3.3

Test Settings

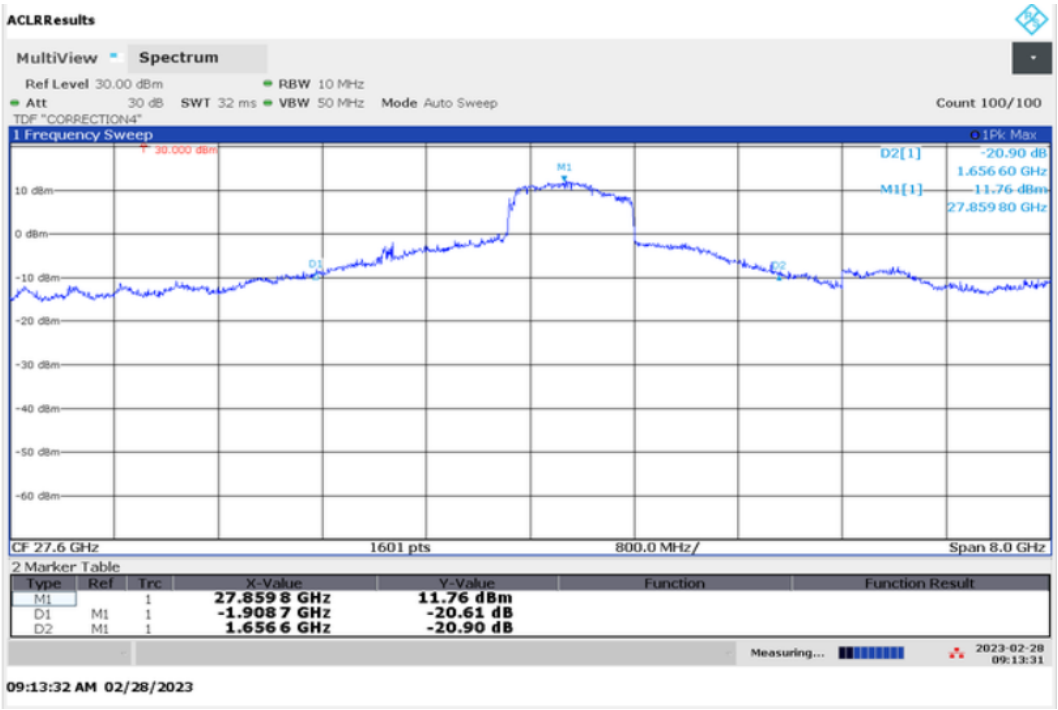
1. Start and stop frequency of the signal generator shall be ± 250 % of the passband, for each applicable CMRS band
2. Span same as the frequency range of the signal generator
3. RBW ≥ 1 % to 5 % of the EUT passband
4. VBW ≥ 3 x RBW
5. Detector = Peak/Max Hold
6. Number of sweep points ≥ 2 x Span/RBW
7. Trace mode = trace average for continuous emissions, max hold for pulse emissions
8. Sweep time = auto couple
9. The trace was allowed to stabilize

Test Notes

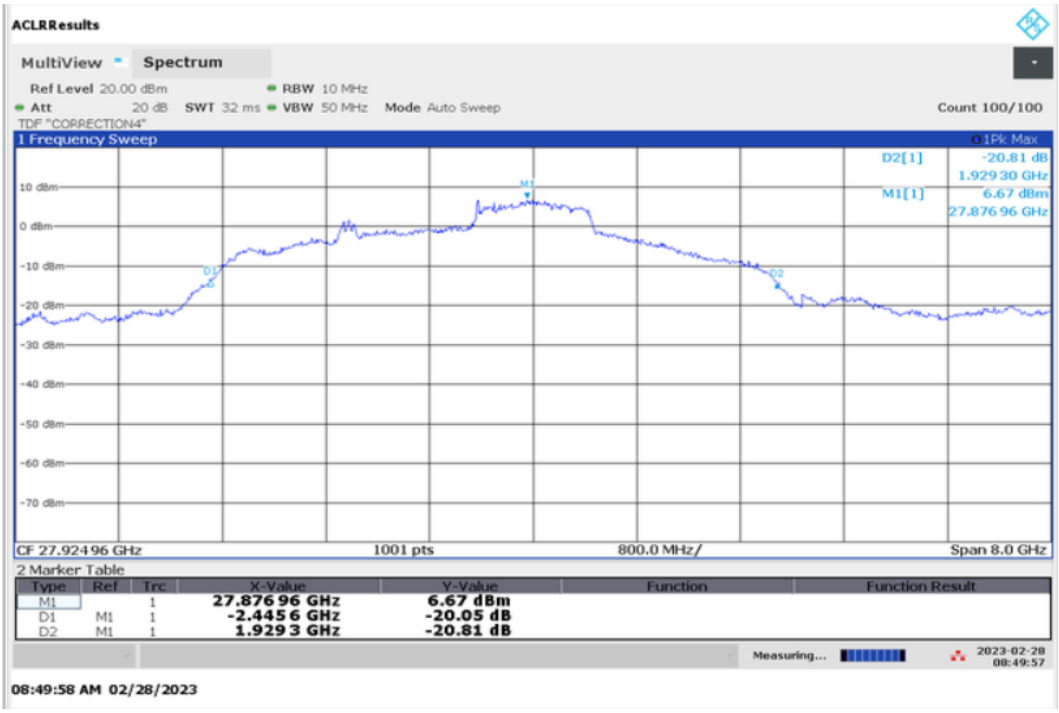
1. The spectrum plots in this section show a CW signal sweeping across each input feed of each unit of the EUT. Per the guidance from Section 3.3 of KDB 935210 D05, the frequency range of the sweep should be from 25.375GHz to 30.475GHz [250% x (28.35GHz–27.5GHz) = 2.125GHz below and above lower and upper band edges, respectively]. However, in order to more clearly display the 20dB bandwidth, a larger frequency range is displayed in the these plots.

2. In each plot, the marker “M1” is used to display the peak of the output frequency response. The “D1” and “D2” markers are provided to indicate the approximate lower and upper bounds of the 20dB bandwidth of the output frequency response.

Band n261 - DU



Plot 7-9. Out-Of-Band Rejection – DU – H-UL Polarization



Plot 7-10. Out-Of-Band Rejection – DU – V-UL Polarization

7.4 Measuring AGC Threshold Level, Mean Output Power & Amplifier/Booster Gain

Test Overview

A signal generator supplies a 5G NR mmWave signal directly into the input port of the system. The output port of the EUT is connected to the input of a signal analyzer. The AGC threshold level is measured by output power of the EUT until a 1dB increase in the input signal power no longer causes a 1dB increase in the output signal power. The Booster Gain is measured by calculating the gain between the input and the output power of the EUT at the signal generator level just below the AGC threshold level, but not more than 0.5dB below.

Test Procedures Used

KDB 935210 D05 V01R04 – Section 3.2 - Measuring AGC threshold level
KDB 935210 D05 V01R04 – Section 3.5 - Mean output power and amplifier/booster gain

Test Settings

1. Conducted power measurements are performed using the signal analyzer's "channel power" measurement capability for signals with continuous operation.
2. RBW = 1 – 5% of the expected OBW, not to exceed 1MHz
3. VBW ≥ 3 x RBW
4. Span = 2x to 3x the OBW
5. No. of sweep points > 2 x span / RBW
6. Detector = RMS
7. The integration bandwidth was roughly set equal to the measured OBW of the signal for signals with continuous operation.
8. Trace mode = trace averaging (RMS) over 100 sweeps

Test Notes

Per previous guidance from FCC specifically to Element lab, a 50MHz 5G NR mmWave signal was used as the input signal as opposed to the 4.1MHz AWGN required in KDB 935210 D05.

Band n261 - DU

Bandwidth [MHz]	Frequency [MHz]	Channel	Modulation	RB Size / Offset	EUT Input Power Level [dBm]	Conducted Power [dBm]	Output Power Step [dB]	Calculated Gain [dB]
50	27924.96	Mid	QPSK	1 RB	-51.20	16.50	0.98	67.70
50	27924.96	Mid	QPSK	1 RB	-50.20	17.46	0.96	67.66
50	27924.96	Mid	QPSK	1 RB	-49.20	18.43	0.97	67.63
50	27924.96	Mid	QPSK	1 RB	-48.20	18.50	0.07	66.70
50	27924.96	Mid	QPSK	1 RB	-47.20	18.52	0.02	65.72
50	27924.96	Mid	QPSK	1 RB	-46.20	18.61	0.09	64.81
50	27924.96	Mid	QPSK	1 RB	-45.20	18.43	-0.18	63.63
50	27924.96	Mid	QPSK	1 RB	-44.20	18.42	-0.01	62.62
50	27924.96	Mid	QPSK	1 RB	-43.20	18.92	0.50	62.12
50	27924.96	Mid	QPSK	1 RB	-42.20	18.90	-0.02	61.10
50	27924.96	Mid	QPSK	1 RB	-41.20	18.46	-0.44	59.66

Table 7-3. Full RB AGC Threshold and Booster Gain – 50MHz 1CC – DU – H-UL Polarization

Note: AGC Threshold is found at **-48.20dBm** EUT Input Power Level.

Bandwidth [MHz]	Frequency [MHz]	Channel	Modulation	RB Size / Offset	EUT Input Power Level [dBm]	Conducted Power [dBm]	Output Power Step [dB]	Calculated Gain [dB]
100	27924.96	Mid	QPSK	1 RB	-51.20	15.27	0.88	66.47
100	27924.96	Mid	QPSK	1 RB	-50.20	16.17	0.90	66.37
100	27924.96	Mid	QPSK	1 RB	-49.20	17.07	0.90	66.27
100	27924.96	Mid	QPSK	1 RB	-48.20	17.92	0.85	66.12
100	27924.96	Mid	QPSK	1 RB	-47.20	18.72	0.80	65.92
100	27924.96	Mid	QPSK	1 RB	-46.20	18.80	0.08	65.00
100	27924.96	Mid	QPSK	1 RB	-45.20	19.11	0.31	64.31
100	27924.96	Mid	QPSK	1 RB	-44.20	18.82	-0.29	63.02
100	27924.96	Mid	QPSK	1 RB	-43.20	18.78	-0.04	61.98
100	27924.96	Mid	QPSK	1 RB	-42.20	19.04	0.26	61.24
100	27924.96	Mid	QPSK	1 RB	-41.20	19.12	0.08	60.32

Table 7-4. Full RB AGC Threshold and Booster Gain – 100MHz 4CC – DU – H-UL Polarization

Note: AGC Threshold is found at **-46.20dBm** EUT Input Power Level.

Bandwidth [MHz]	Frequency [MHz]	Channel	Modulation	RB Size / Offset	EUT Input Power Level [dBm]	Conducted Power [dBm]	Output Power Step [dB]	Calculated Gain [dB]
50	27924.96	Mid	QPSK	1 RB	-51.20	13.93	0.97	65.13
50	27924.96	Mid	QPSK	1 RB	-50.20	14.91	0.98	65.11
50	27924.96	Mid	QPSK	1 RB	-49.20	15.86	0.95	65.06
50	27924.96	Mid	QPSK	1 RB	-48.20	16.84	0.98	65.04
50	27924.96	Mid	QPSK	1 RB	-47.20	16.80	-0.04	64.00
50	27924.96	Mid	QPSK	1 RB	-46.20	17.29	0.49	63.49
50	27924.96	Mid	QPSK	1 RB	-45.20	17.22	-0.07	62.42
50	27924.96	Mid	QPSK	1 RB	-44.20	17.64	0.42	61.84
50	27924.96	Mid	QPSK	1 RB	-43.20	17.19	-0.45	60.39
50	27924.96	Mid	QPSK	1 RB	-42.20	17.63	0.44	59.83
50	27924.96	Mid	QPSK	1 RB	-41.20	17.04	-0.59	58.24
50	27924.96	Mid	QPSK	1 RB	-40.20	17.28	0.24	57.48

Table 7-5. Full RB AGC Threshold and Booster Gain – 50MHz 1CC – DU – V-UL Polarization

Note: AGC Threshold is found at **-47.20dBm** EUT Input Power Level.

Bandwidth [MHz]	Frequency [MHz]	Channel	Modulation	RB Size / Offset	EUT Input Power Level [dBm]	Conducted Power [dBm]	Output Power Step [dB]	Calculated Gain [dB]
100	27924.96	Mid	QPSK	1 RB	-51.20	13.18	0.84	64.38
100	27924.96	Mid	QPSK	1 RB	-50.20	14.06	0.88	64.26
100	27924.96	Mid	QPSK	1 RB	-49.20	14.95	0.89	64.15
100	27924.96	Mid	QPSK	1 RB	-48.20	15.78	0.83	63.98
100	27924.96	Mid	QPSK	1 RB	-47.20	16.63	0.85	63.83
100	27924.96	Mid	QPSK	1 RB	-46.20	17.50	0.87	63.70
100	27924.96	Mid	QPSK	1 RB	-45.20	17.14	-0.36	62.34
100	27924.96	Mid	QPSK	1 RB	-44.20	17.54	0.40	61.74
100	27924.96	Mid	QPSK	1 RB	-43.20	17.45	-0.09	60.65
100	27924.96	Mid	QPSK	1 RB	-42.20	17.39	-0.06	59.59
100	27924.96	Mid	QPSK	1 RB	-41.20	17.84	0.45	59.04
100	27924.96	Mid	QPSK	1 RB	-40.20	17.81	-0.03	58.01

Table 7-6. Full RB AGC Threshold and Booster Gain – 100MHz 4CC – DU – V-UL Polarization

Note: AGC Threshold is found at **-45.20dBm** EUT Input Power Level.

7.5 Occupied Bandwidth

Test Overview

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers measured are each equal to 0.5 percent of the total mean power measured for a given emission. All modes of operation were investigated and the worst case configuration results are reported in this section.

Test Procedure Used

ANSI C63.26-2015 – Section 5.4.3

Test Settings

1. The signal analyzer's automatic bandwidth measurement capability was used to perform the 99% occupied bandwidth. The bandwidth measurement was not influenced by any intermediate power nulls in the fundamental emission.
2. RBW = 1 – 5% of the expected OBW
3. VBW ≥ 3 x RBW
4. Detector = Peak
5. Trace mode = max hold
6. Sweep = auto couple
7. The trace was allowed to stabilize
8. If necessary, steps 2 – 7 were repeated after changing the RBW such that it would be within 1 – 5% of the 99% occupied bandwidth observed in Step 7

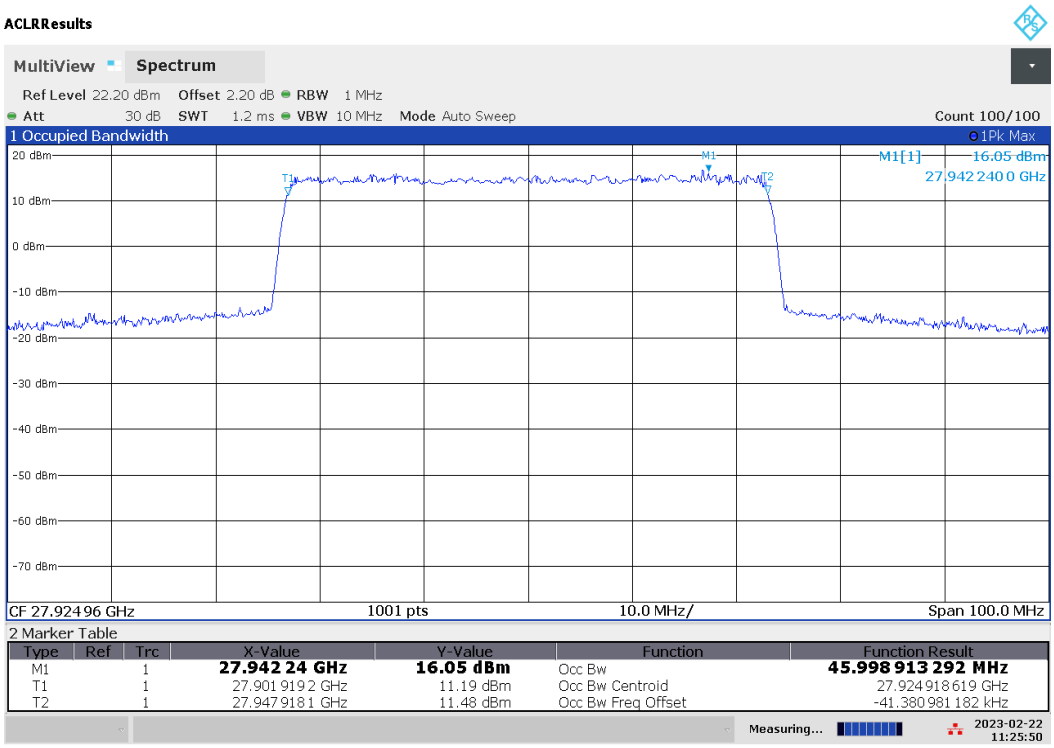
Test Notes

1. The OBW was measured for multiple transmission schemes and modulations and the worst case results have been included in the report.
2. The plots shown in this section include the appropriate offsets to correct for the frequency-dependent cable loss of the coaxial cable that connects the output port of the EUT to the spectrum analyzer.

Band n261 - DU (DFT-s-OFDM)

Antenna	Bandwidth [MHz]	CCs Active	Transmission Scheme	Modulation	OBW [MHz]
H_UL	50	1	DFT-s-OFDM	QPSK	46.00
			DFT-s-OFDM	16QAM	46.05
		2	DFT-s-OFDM	QPSK	96.40
			DFT-s-OFDM	16QAM	96.37
	100	4	DFT-s-OFDM	QPSK	393.39
			DFT-s-OFDM	16QAM	394.22
V_UL	50	1	DFT-s-OFDM	QPSK	46.24
			DFT-s-OFDM	16QAM	46.26
		2	DFT-s-OFDM	QPSK	96.17
			DFT-s-OFDM	16QAM	95.85
	100	4	DFT-s-OFDM	QPSK	396.00
			DFT-s-OFDM	16QAM	397.04

Table 7-7. Summary of DU Occupied Bandwidths



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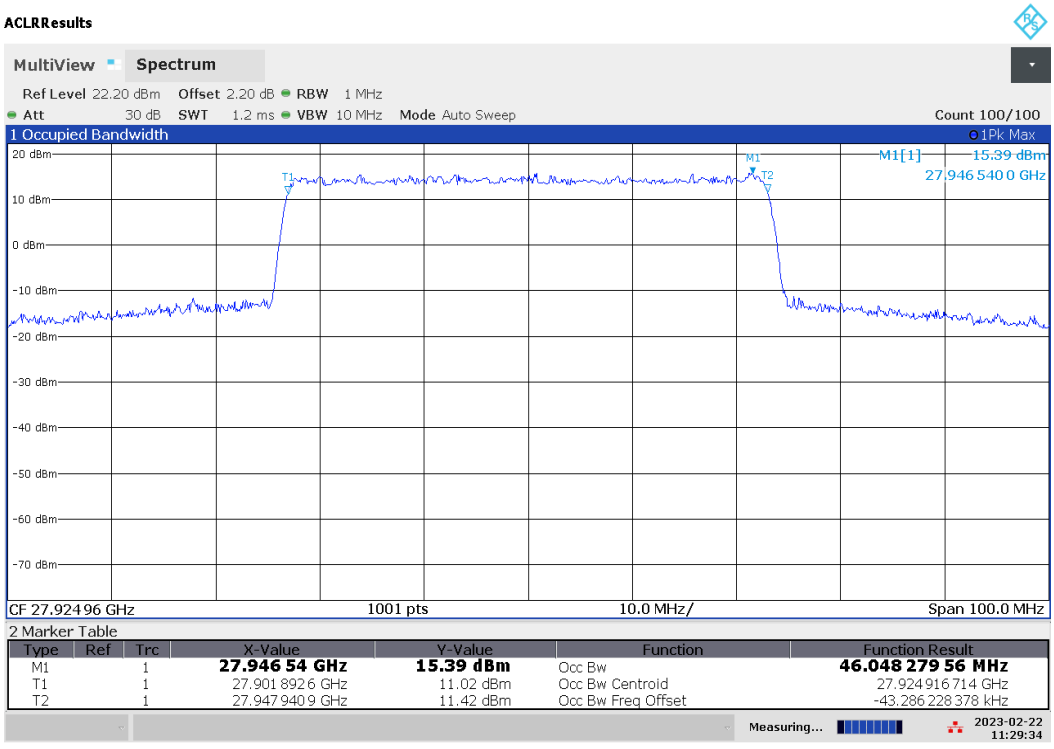
Plot 7-11. Occupied Bandwidth Plot – DU – H-UL Polarization (50MHz-1CC – QPSK – Mid Channel)



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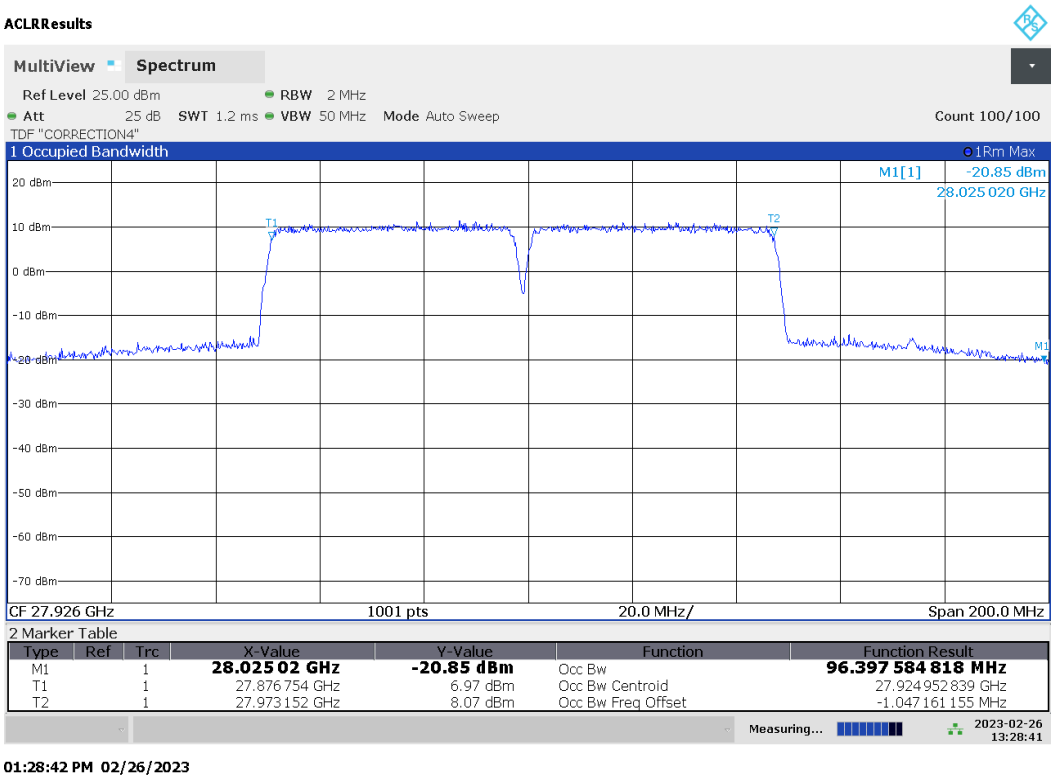
Plot 7-12. Occupied Bandwidth Plot – DU – H-UL Polarization (50MHz-1CC – 16QAM – Mid Channel)



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Plot 7-13. Occupied Bandwidth Plot – DU – H-UL Polarization (50MHz-2CC – QPSK – Mid Channel)

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Plot 7-14. Occupied Bandwidth Plot – DU – H-UL Polarization (50MHz-2CC – 16QAM – Mid Channel)

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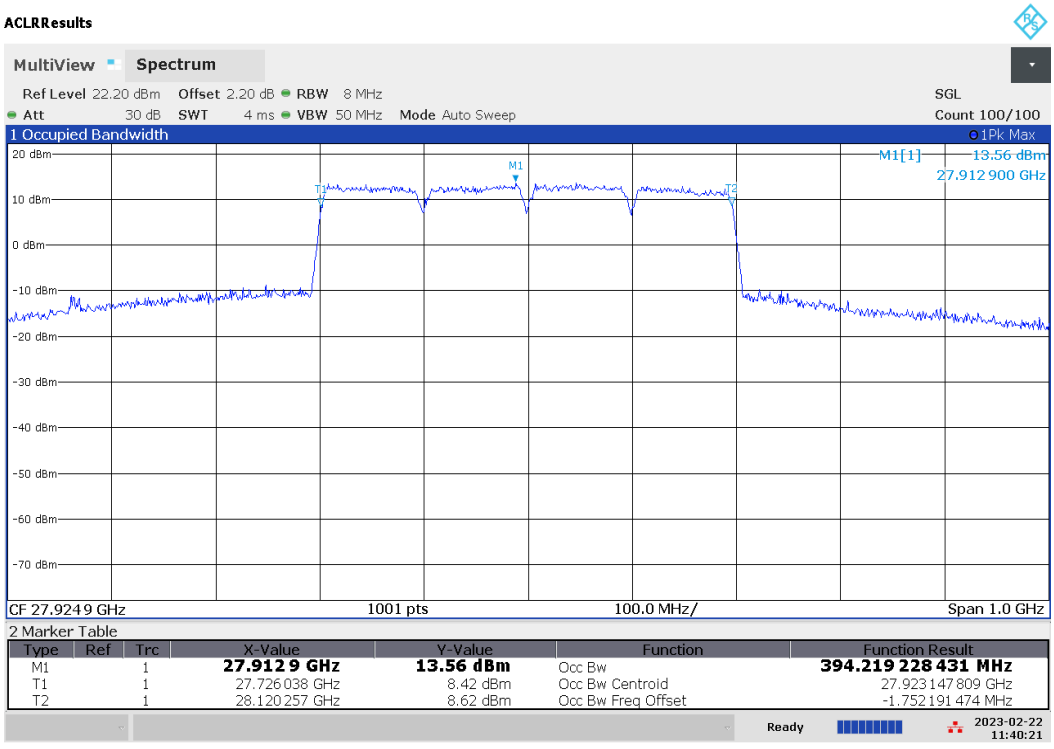
Plot 7-15. Occupied Bandwidth Plot – DU – H-UL Polarization (100MHz-4CC – QPSK – Mid Channel)



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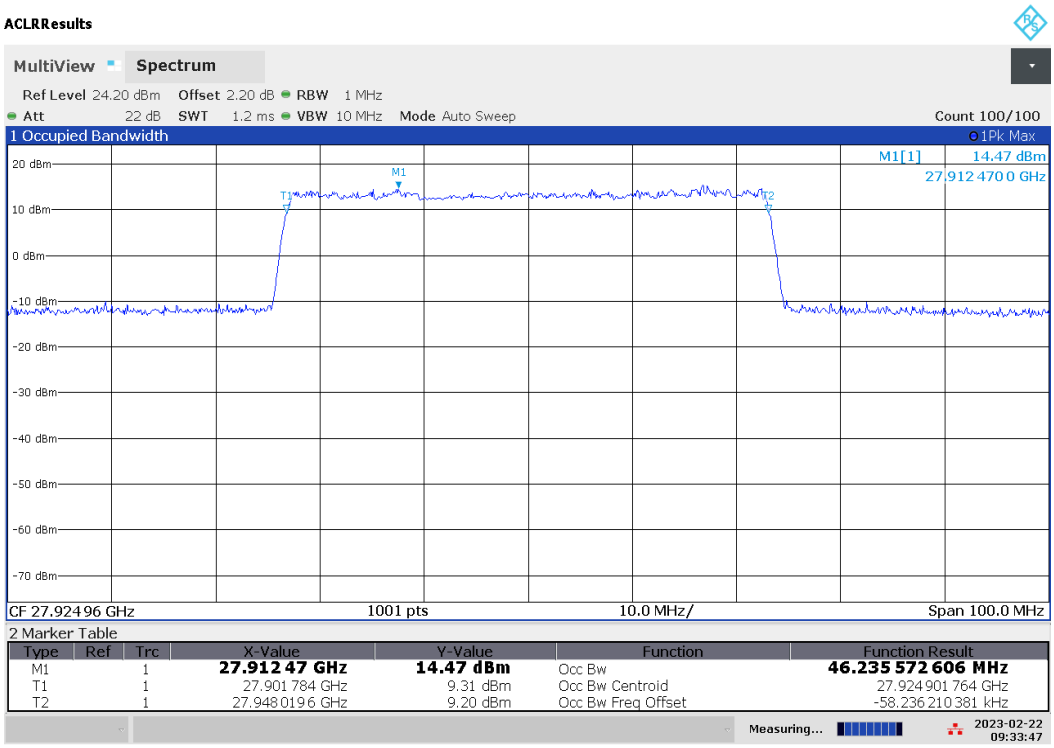
Plot 7-16. Occupied Bandwidth Plot – DU – H-UL Polarization (100MHz-4CC – 16QAM – Mid Channel)



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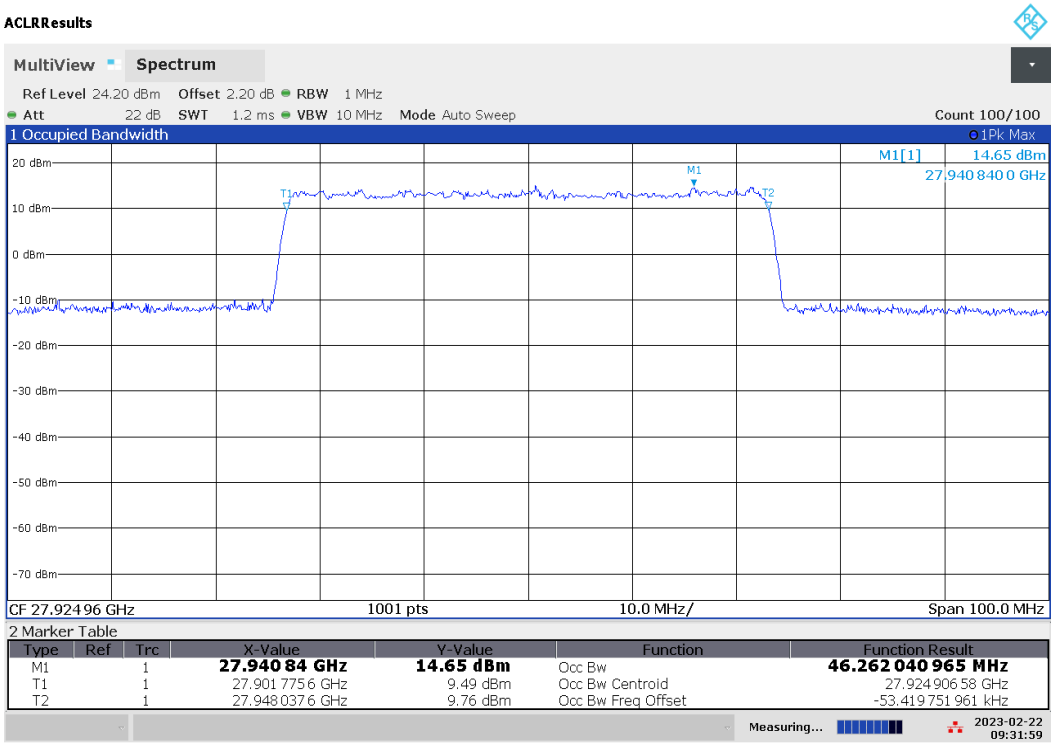
Plot 7-17. Occupied Bandwidth Plot – DU – V-UL Polarization (50MHz-1CC – QPSK – Mid Channel)



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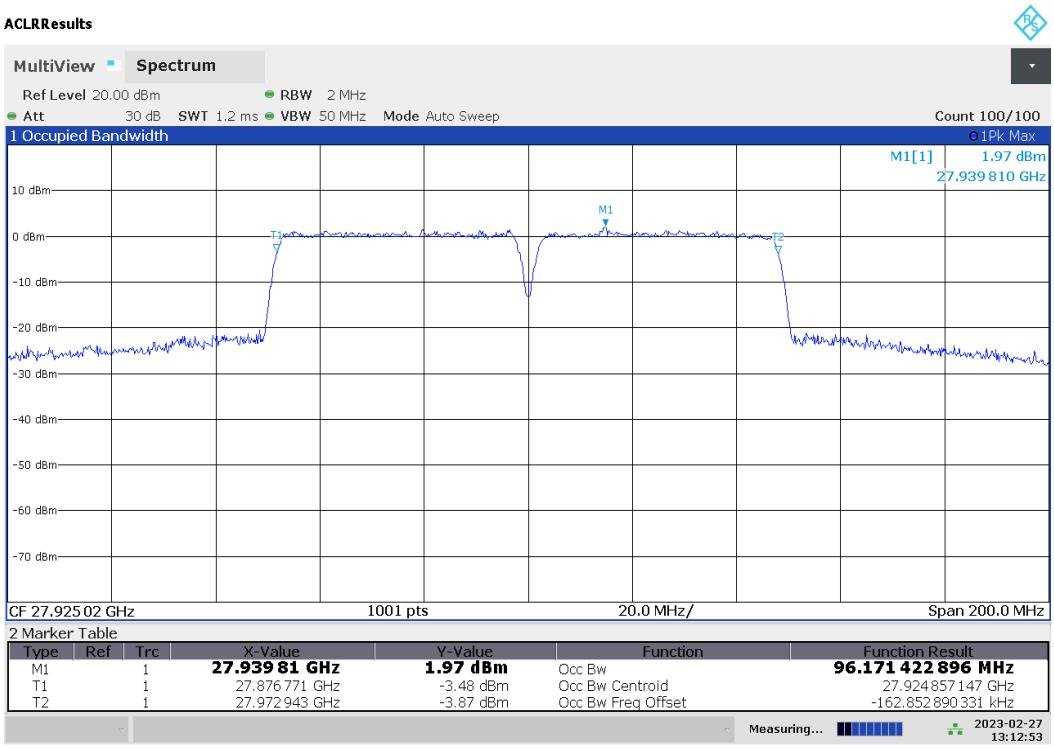
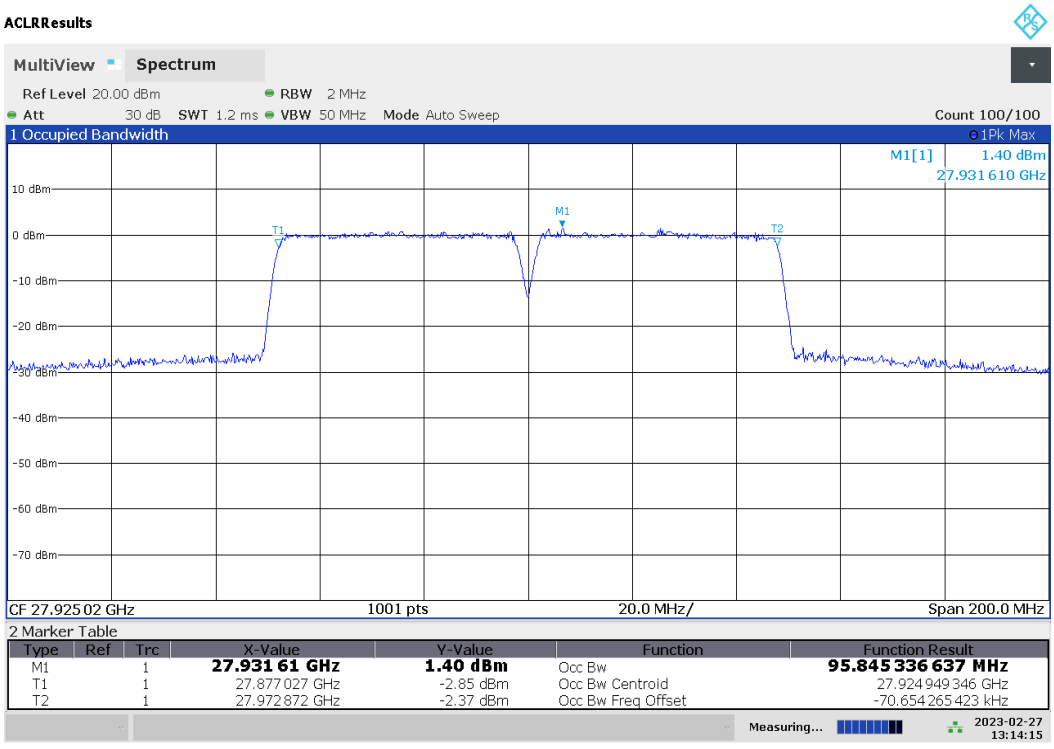
Plot 7-18. Occupied Bandwidth Plot – DU – V-UL Polarization (50MHz-1CC – 16QAM – Mid Channel)



01:12:54 PM 02/27/2023

Plot 7-19. Occupied Bandwidth Plot – DU – V-UL Polarization (50MHz-2CC – QPSK – Mid Channel)



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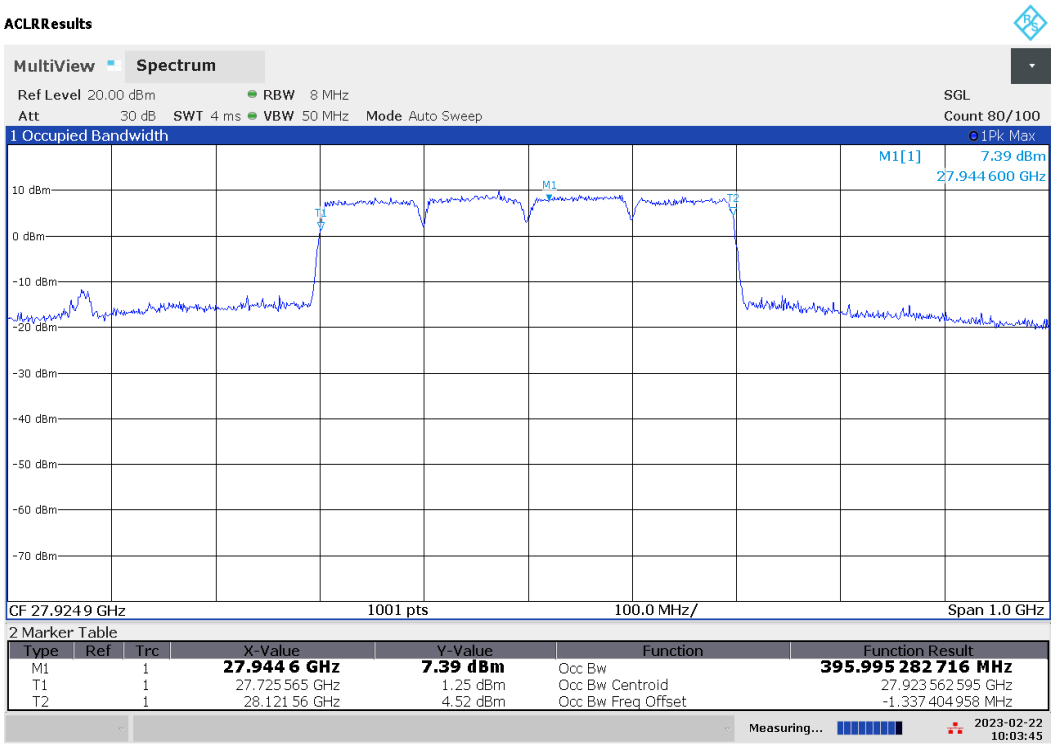
Plot 7-20. Occupied Bandwidth Plot – DU – V-UL Polarization (50MHz-2CC – 16QAM – Mid Channel)



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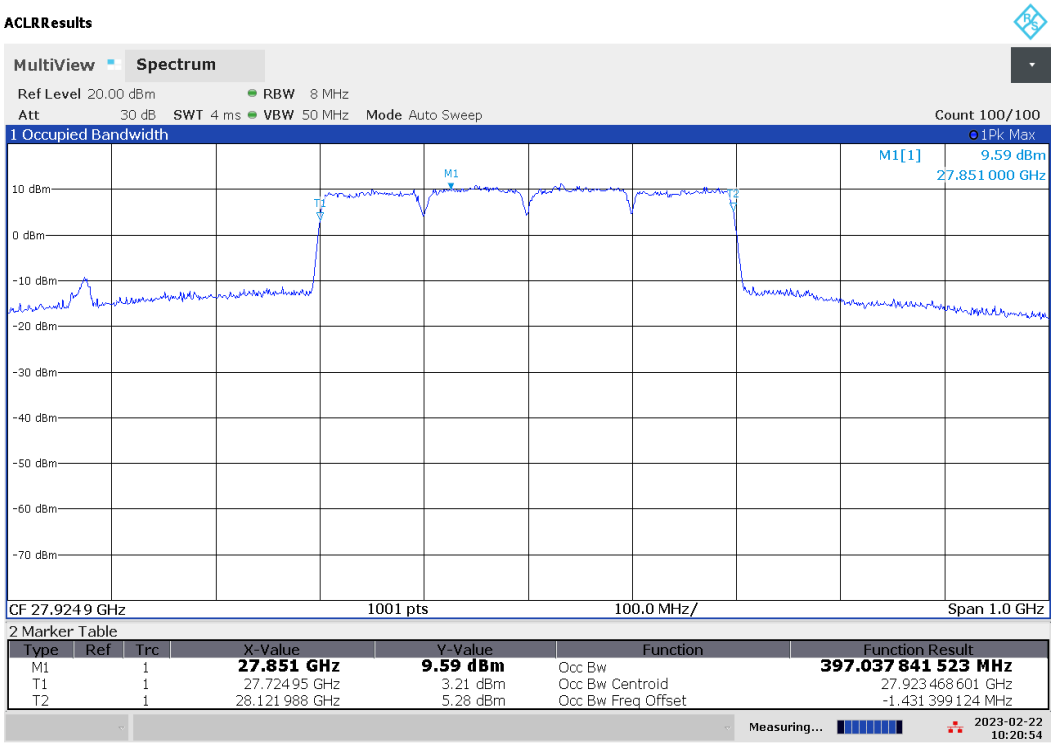
Plot 7-21. Occupied Bandwidth Plot – DU – V-UL Polarization (100MHz-4CC – QPSK – Mid Channel)



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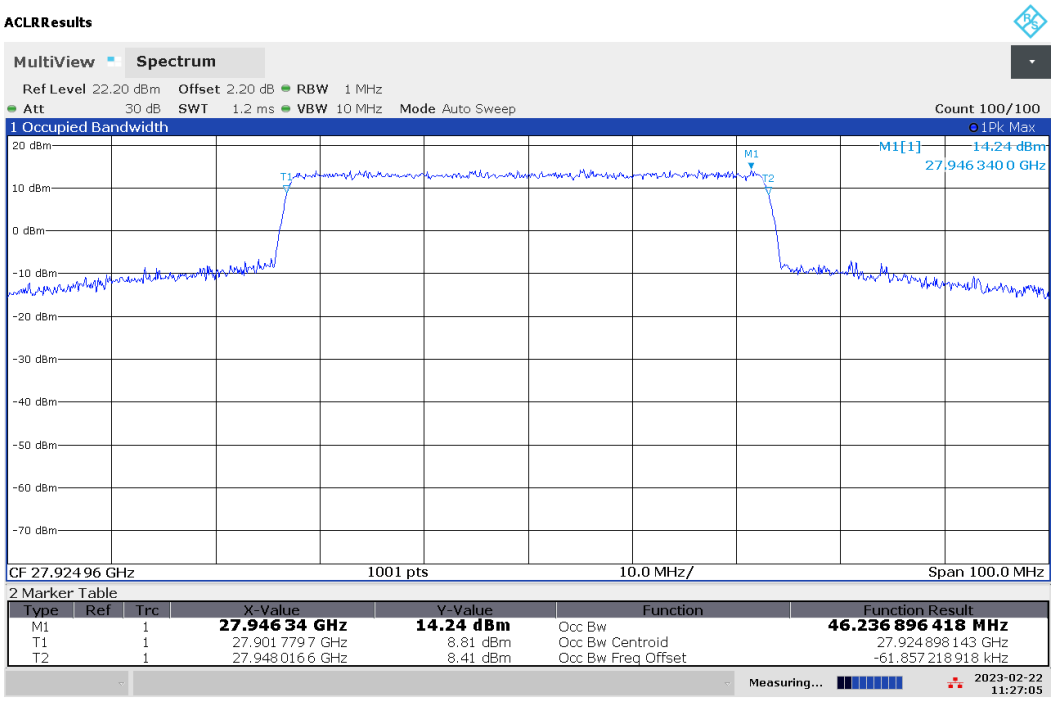
Plot 7-22. Occupied Bandwidth Plot – DU – V-UL Polarization (100MHz-4CC – 16QAM – Mid Channel)

Band n261 - DU (CP-OFDM)

Antenna	Bandwidth [MHz]	CCs Active	Transmission Scheme	Modulation	OBW [MHz]
H_UL	50	1	CP-OFDM	QPSK	46.24
			CP-OFDM	16QAM	46.23
		2	CP-OFDM	QPSK	96.69
			CP-OFDM	16QAM	96.66
	100	4	CP-OFDM	QPSK	396.89
			CP-OFDM	16QAM	397.01
V_UL	50	1	CP-OFDM	QPSK	46.36
			CP-OFDM	16QAM	46.39
		2	CP-OFDM	QPSK	95.99
			CP-OFDM	16QAM	96.12
	100	4	CP-OFDM	QPSK	397.21
			CP-OFDM	16QAM	398.41

Table 7-8. Summary of DU Occupied Bandwidths



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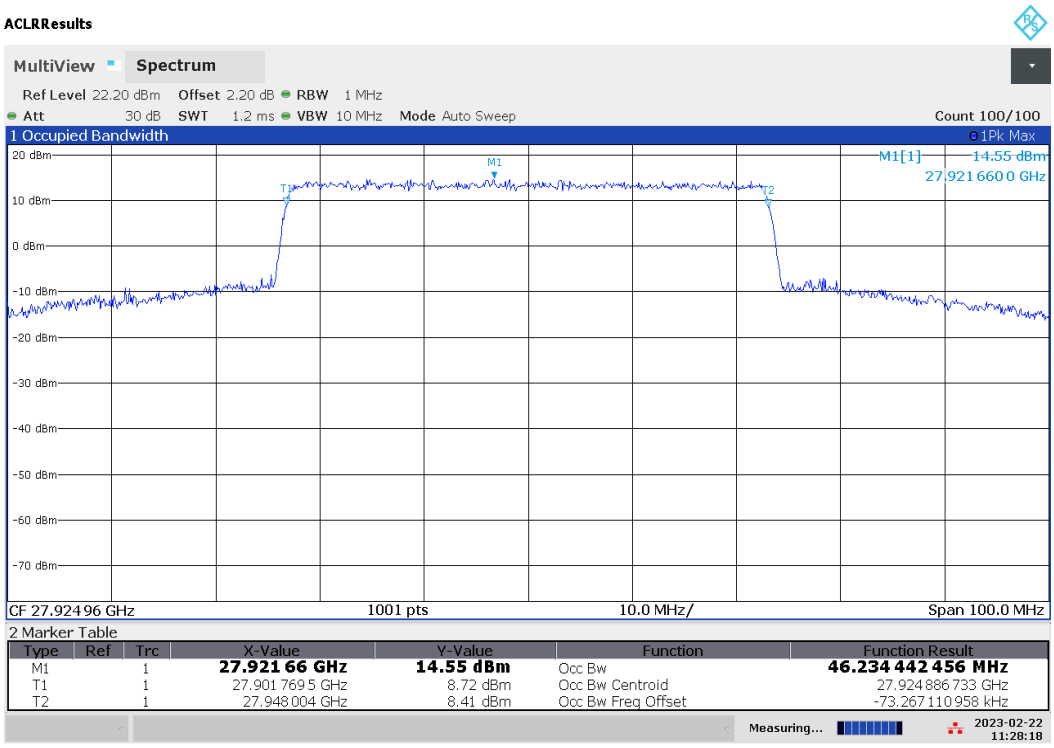
Plot 7-23. Occupied Bandwidth Plot – DU – H-UL Polarization (50MHz-1CC – QPSK – Mid Channel)



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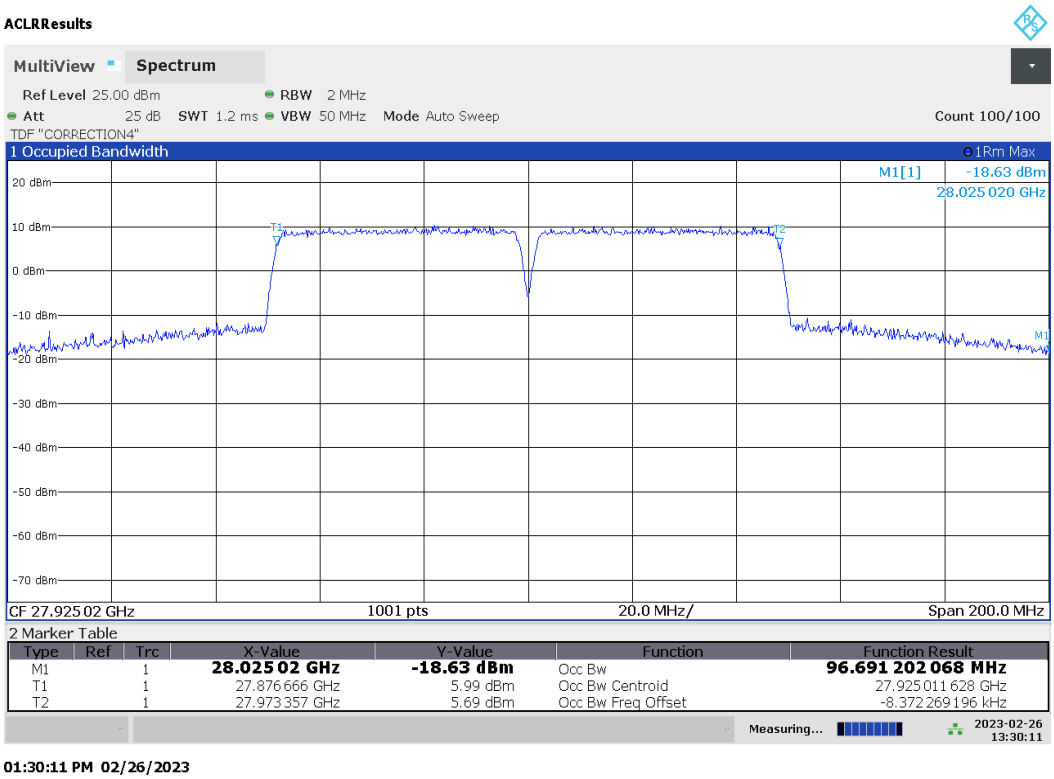
Plot 7-24. Occupied Bandwidth Plot – DU – H-UL Polarization (50MHz-1CC – 16QAM – Mid Channel)



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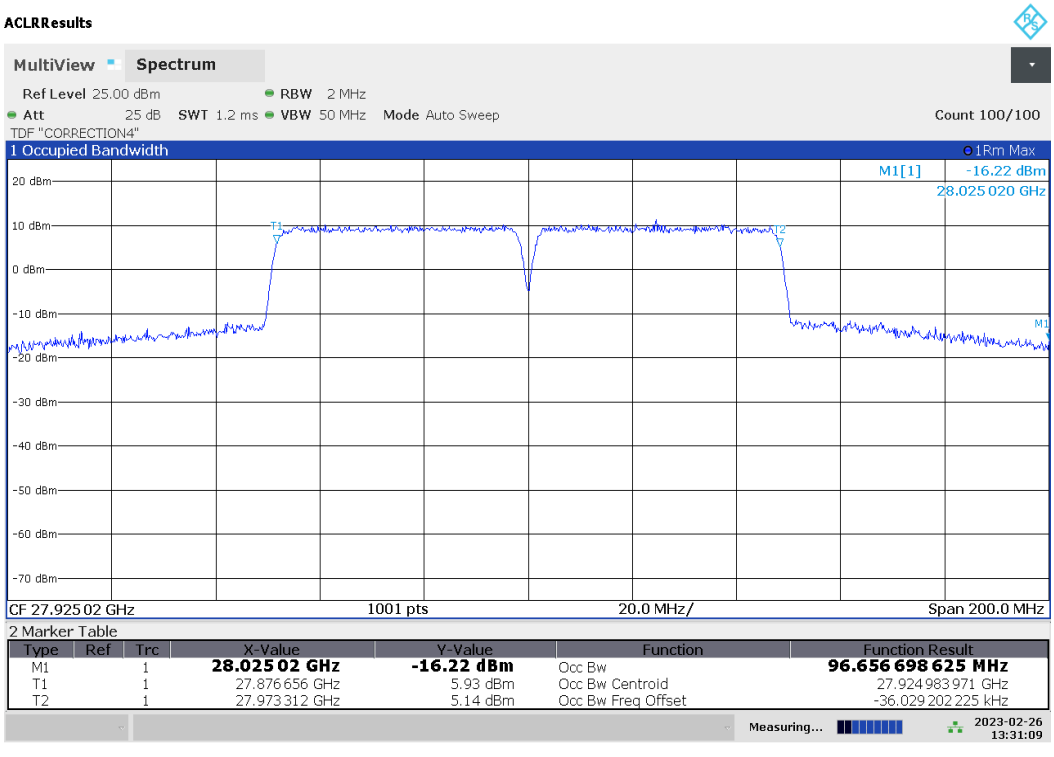
Plot 7-25. Occupied Bandwidth Plot – DU – H-UL Polarization (50MHz-2CC – QPSK – Mid Channel)



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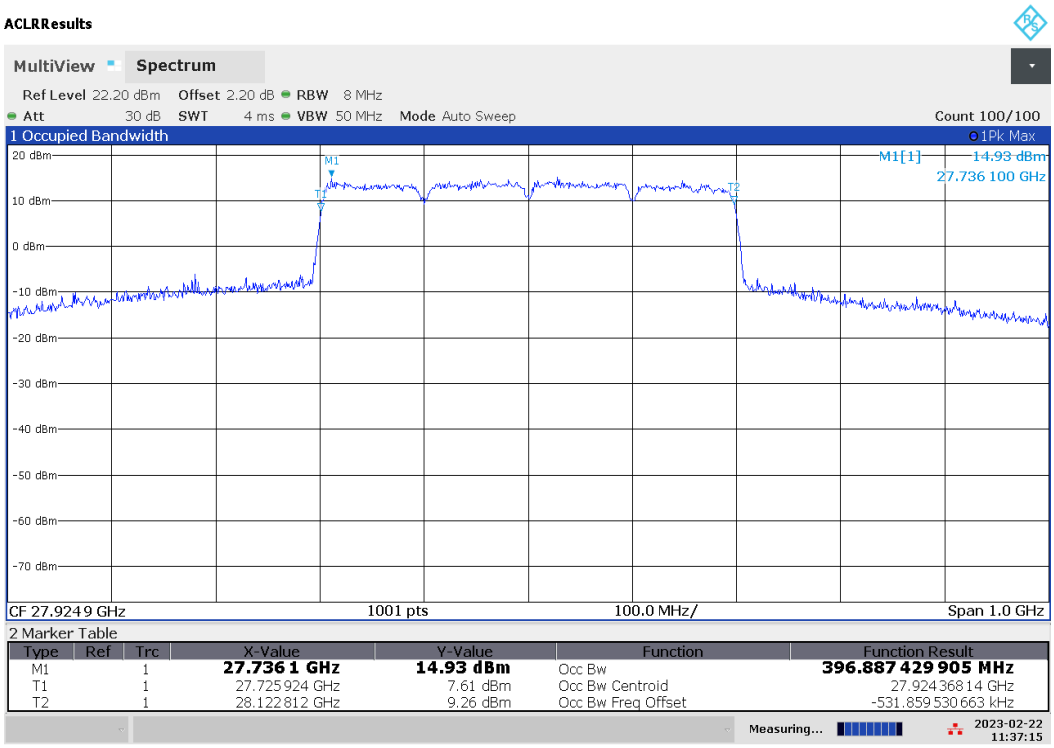
Plot 7-26. Occupied Bandwidth Plot – DU – H-UL Polarization (50MHz-2CC – 16QAM – Mid Channel)



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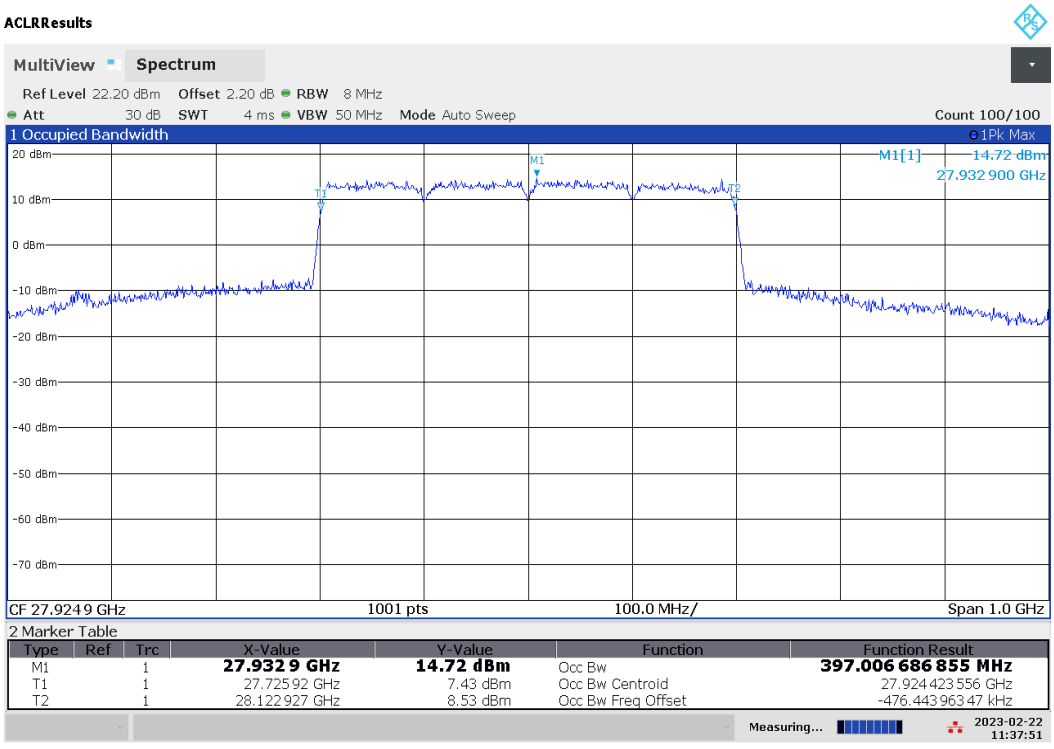
Plot 7-27. Occupied Bandwidth Plot – DU – H-UL Polarization (100MHz-4CC – QPSK – Mid Channel)



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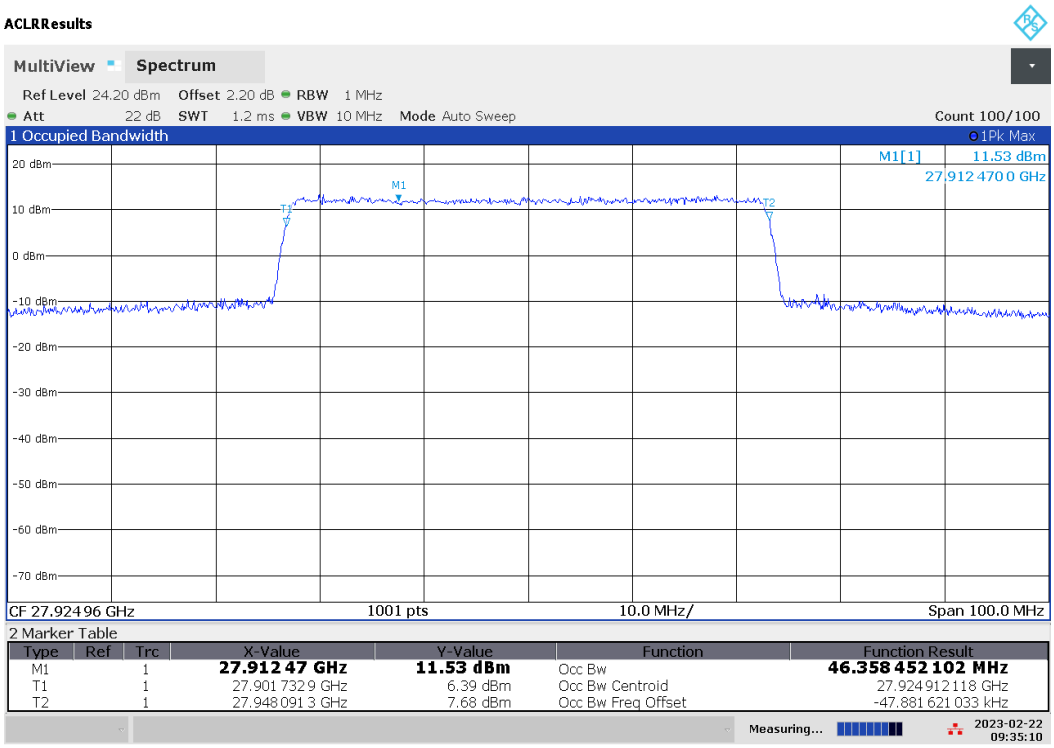
Plot 7-28. Occupied Bandwidth Plot – DU – H-UL Polarization (100MHz-4CC – 16QAM – Mid Channel)



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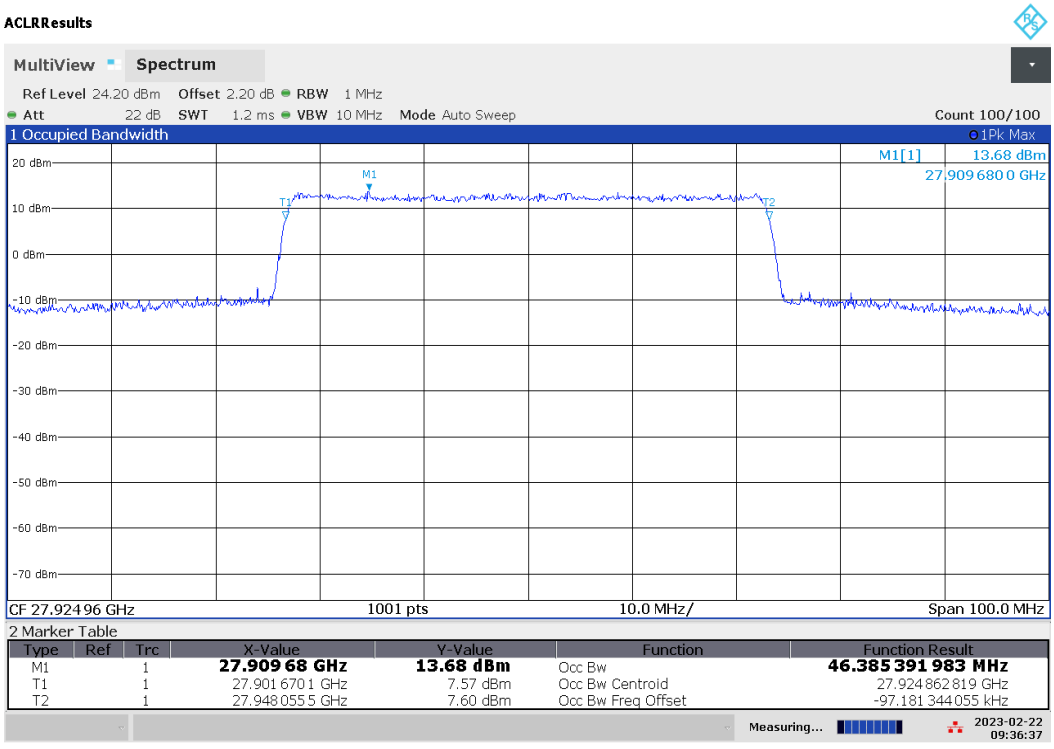
Plot 7-29. Occupied Bandwidth Plot – DU – V-UL Polarization (50MHz-1CC – QPSK – Mid Channel)



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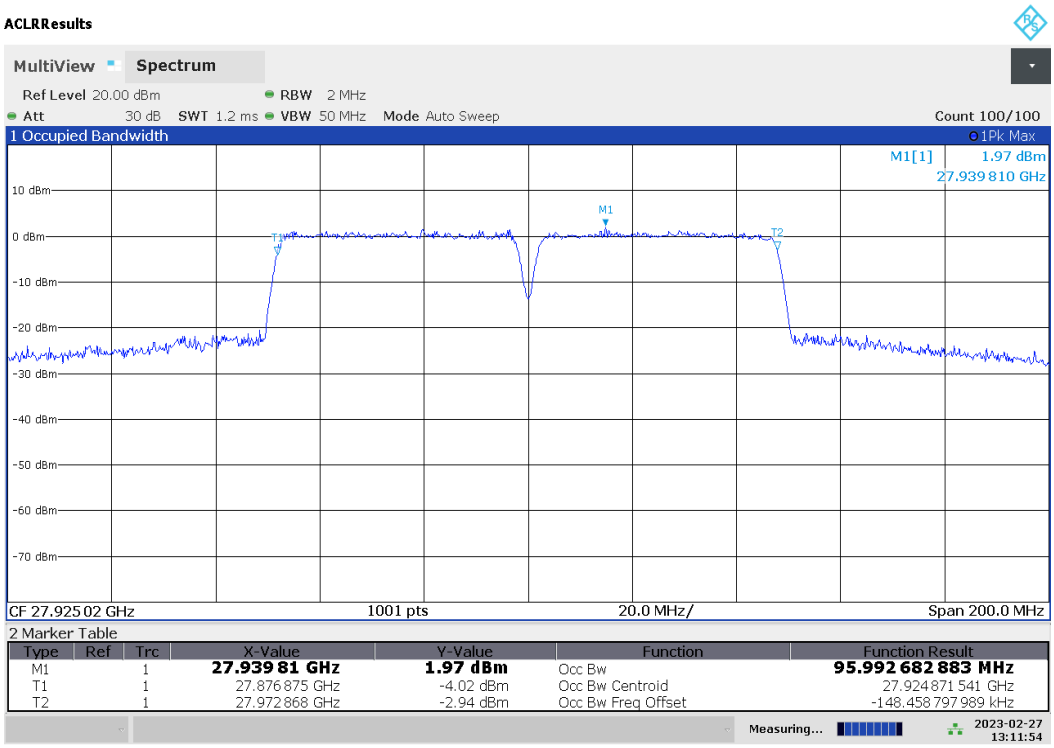
Plot 7-30. Occupied Bandwidth Plot – DU – V-UL Polarization (50MHz-1CC – 16QAM – Mid Channel)



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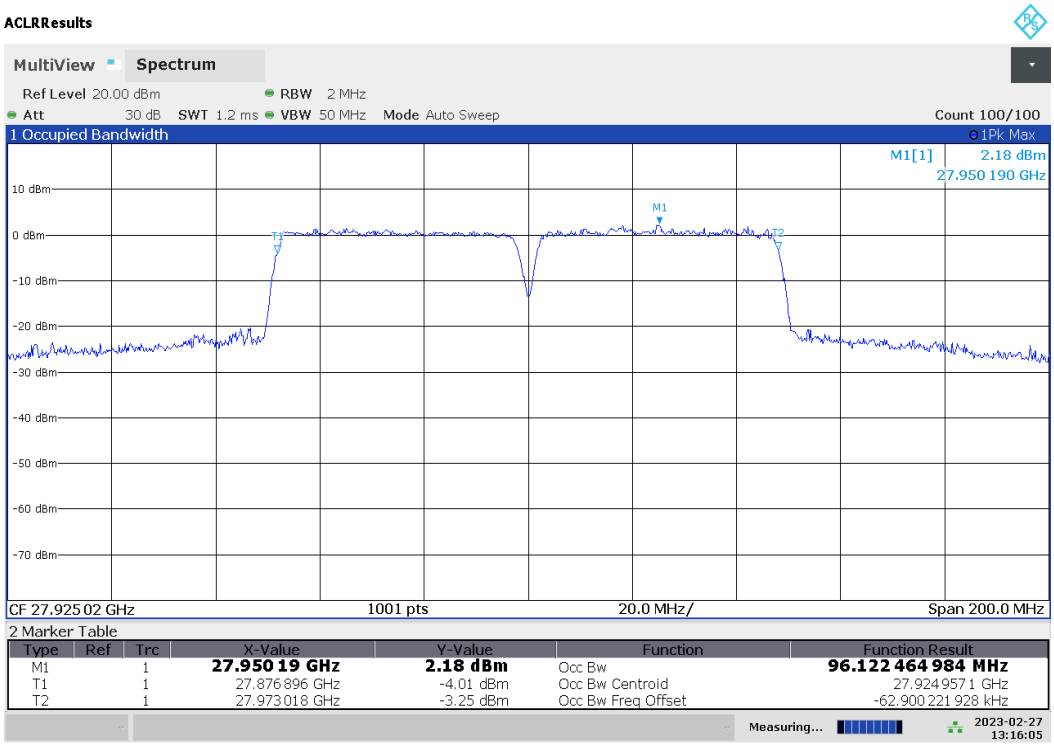
Plot 7-31. Occupied Bandwidth Plot – DU – V-UL Polarization (50MHz-2CC – QPSK – Mid Channel)



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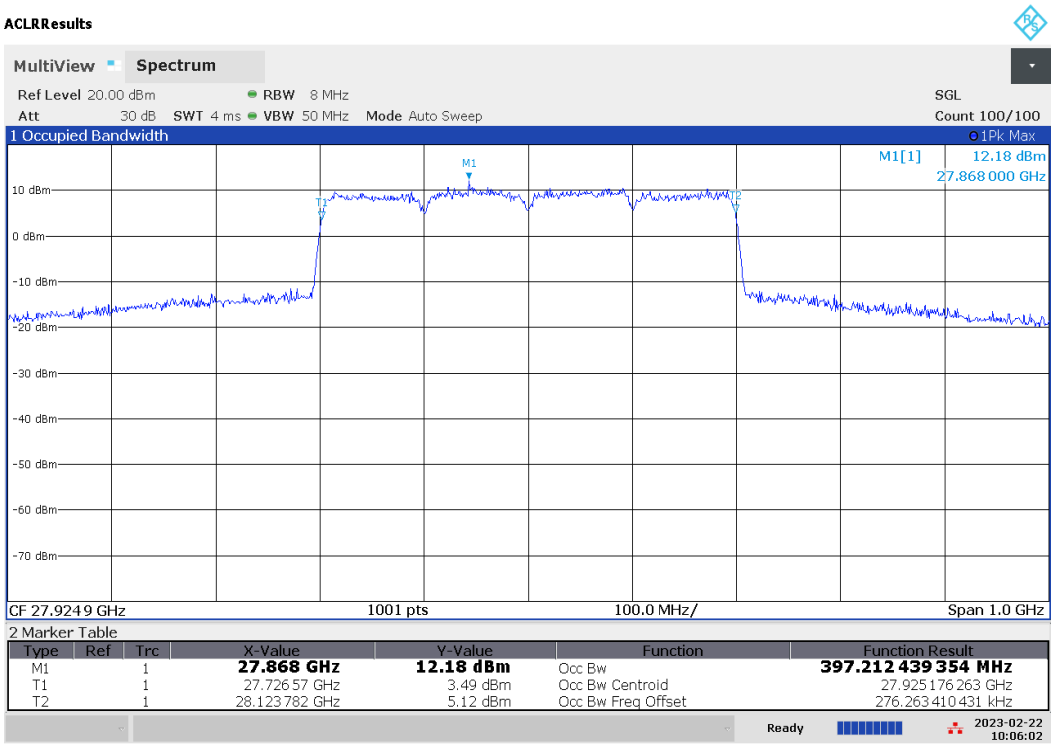
Plot 7-32. Occupied Bandwidth Plot – DU – V-UL Polarization (50MHz-2CC – 16QAM – Mid Channel)



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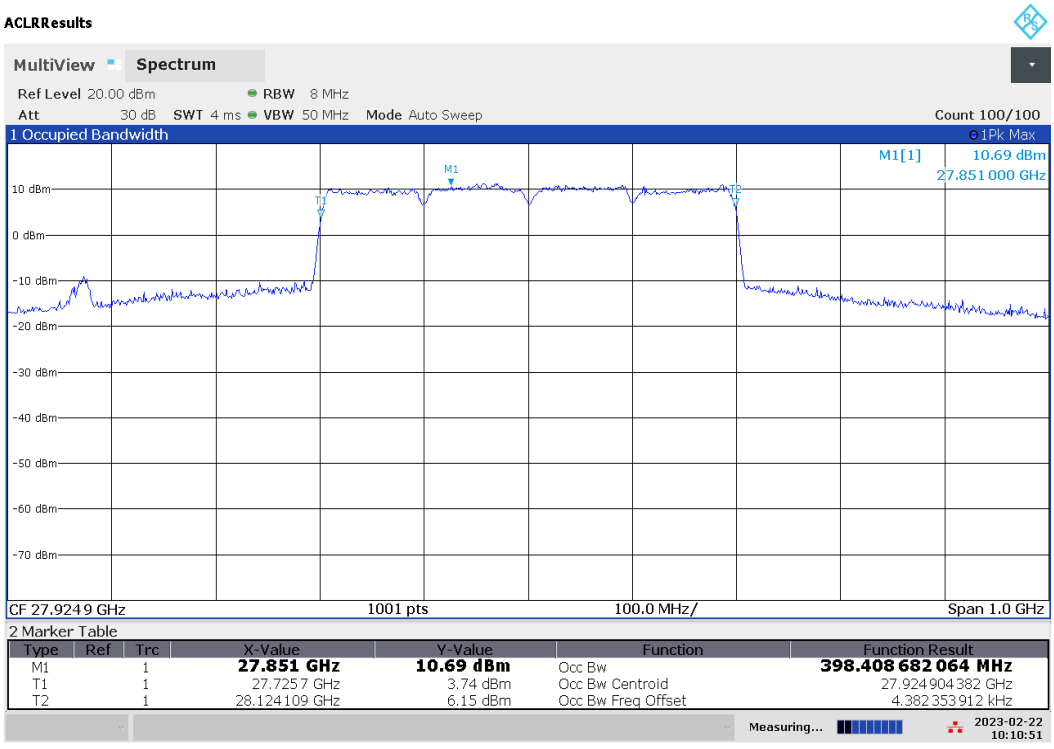
Plot 7-33. Occupied Bandwidth Plot – DU – V-UL Polarization (100MHz-4CC – QPSK – Mid Channel)



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Plot 7-34. Occupied Bandwidth Plot – DU – V-UL Polarization (100MHz-4CC – 16QAM – Mid Channel)

7.6 Conducted Power & Equivalent Isotropic Radiated Power

Test Overview

A transmitter port of the EUT is connected to the input of a signal analyzer. A signal generator supplies a 5G NR signal directly into the input port of the system. All measurements are performed as RMS average measurements while the EUT is operating at the appropriate frequencies with the max power condition as specified by the AGC software of the EUT. The Equivalent Isotripic Radiated Power (EIRP) is then calculated using these conducted power measurements.

The average power of the sum of all antenna elements is limited to a maximum EIRP of +55 dBm.

Test Procedures Used

ANSI C63.26-2015 Section 5.2.4.4.1

Test Settings

1. Conducted power measurements are performed using the signal analyzer's "channel power" measurement capability.
2. For pulsed signals, triggering was set to enable measurements only during full power bursts, with the sweep time set less than or equal to the transmission burst duration. For continuously transmitted signals, triggering was set to Free Run.
3. RBW = 1 – 5% of the expected OBW, not to exceed 1MHz
4. VBW ≥ 3 x RBW
5. Span = 2x to 3x the OBW
6. No. of sweep points ≥ 2 x span / RBW
7. Detector = RMS
8. The integration bandwidth was roughly set equal to the measured OBW of the signal for signals with continuous operation.
9. Trace mode = trace averaging (RMS) over 100 sweeps
10. The trace was allowed to stabilize.

Test Notes

1) The EUT was tested with all possible input signal configurations. The worst case emissions are reported with the regards to modulations, RB sizes and offsets, and channel bandwidth configurations as shown in the tables below. It was determined that full RB allocations provided the worst case results.

2) The power levels of the DU, which is designed to boost 5G NR uplink signals, were investigated with both CP-OFDM and DFT-s-OFDM transmission schemes.

3) The input signal to the EUT was set in order to produce the maximum power allowed by the AGC software of the EUT.

4) The MIMO Conducted Powers were calculated by using the "measure and sum the spectral maxima across the outputs" technique specified in Section 6.4.3.2.3 of ANSI C63.26-2015. The spectra were summed linearly and converted to dBm for comparison with the limit.

5) The MIMO Conducted Powers shown in the tables in this section are the mathematical summations (in linear units) of the measured conducted powers of the horizonally polarized and vertically polarized antenna feeds of an individual unit (i.e DU).

6) The single-polarization EIRP levels shown in the tables in this section are the mathematical summations (in linear units) of the corresponding single-polarization conducted powers and the gain of the transmit antenna for that polarization.

7) Per the guidance of ANSI C63.26-2015 Section 6.4.5.3.3(a) for cross-polarized antennas, the MIMO EIRP levels shown in the tables in this section are the mathematical summations (in linear units) of the corresponding MIMO conducted powers and the gain of an individual transmit antenna.

8) The gain of the transmit antenna for each unit is provided by the manufacturer.

9) The conducted power plots shown in this section include the appropriate offsets to correct for the frequency-dependent cable loss of the coaxial cable that connects the output port of the EUT to the spectrum analyzer.

Sample Conducted MIMO Calculation:

Antenna 1 + Antenna 2 = MIMO

(21.32dBm + 21.39dBm) = (135.52mW + 137.72mW) = 273.24mW = 24.37dBm

Sample EIRP Calculation:

Conducted Power + Antenna Gain = EIRP

12.57dBm + 10.50dBi = 23.07dBm

Band n261 - DU

Center Frequency [MHz]	Ant.Pol.	Transmission Scheme	Modulation	Bandwidth [MHz]	# of Carriers [CCs]	RB Size/Offset	Conducted Power [dBm]	Tx Ant Gain [dBi]	EIRP [dBm]
27525.00	H-UL	DFT-s-OFDM	QPSK	50	1	Full	20.48	21.00	41.48
27924.96	H-UL	DFT-s-OFDM	QPSK	50	1	Full	20.87	21.00	41.87
27924.96	H-UL	DFT-s-OFDM	QPSK	50	1	1 / 31	17.82	21.00	38.82
28324.92	H-UL	DFT-s-OFDM	QPSK	50	1	Full	19.23	21.00	40.23
27924.96	H-UL	DFT-s-OFDM	16-QAM	50	1	Full	17.83	21.00	38.83
27700.02	H-UL	DFT-s-OFDM	QPSK	100	4	Full	19.49	21.00	40.49
27924.96	H-UL	DFT-s-OFDM	QPSK	100	4	Full	19.20	21.00	40.20
27700.02	H-UL	DFT-s-OFDM	QPSK	100	4	1 / 33	18.22	21.00	39.22
28150.02	H-UL	DFT-s-OFDM	QPSK	100	4	Full	19.04	21.00	40.04
27700.02	H-UL	DFT-s-OFDM	16-QAM	100	4	Full	19.18	21.00	40.18

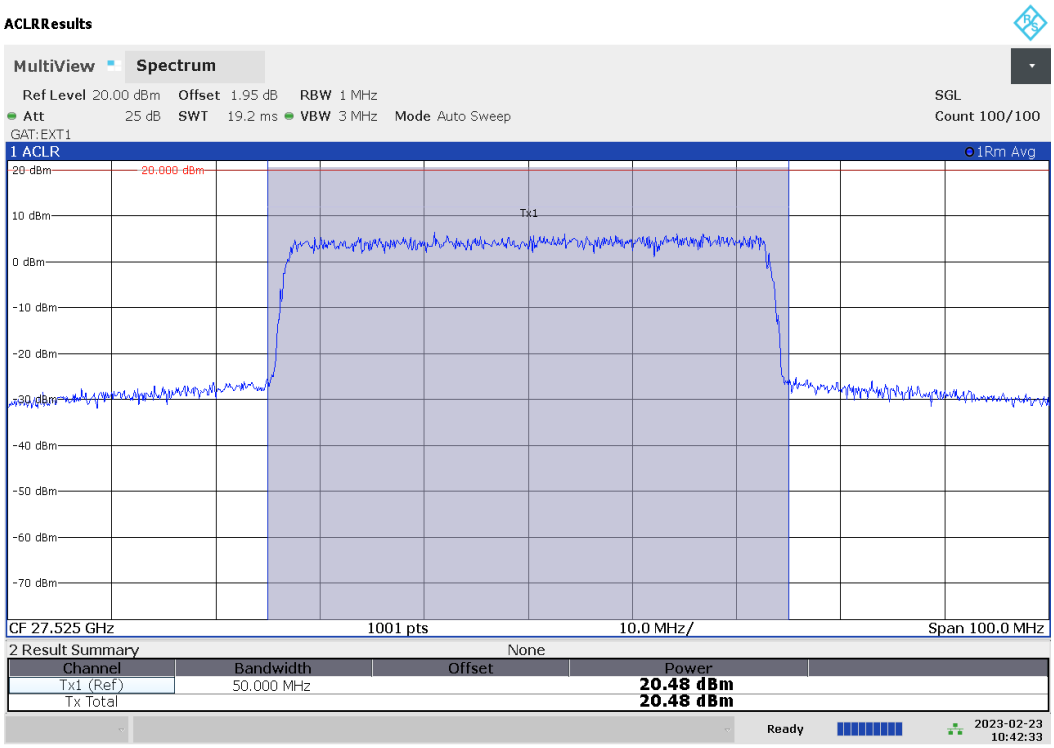
Table 7-9. NR Band n261 - Conducted Power and EIRP – DU – H-UL Polarization

Center Frequency [MHz]	Ant.Pol.	Transmission Scheme	Modulation	Bandwidth [MHz]	# of Carriers [CCs]	RB Size/Offset	Conducted Power [dBm]	Tx Ant Gain [dBi]	EIRP [dBm]
27525.00	V-UL	DFT-s-OFDM	QPSK	50	1	Full	20.37	21.00	41.37
27924.96	V-UL	DFT-s-OFDM	QPSK	50	1	Full	20.09	21.00	41.09
27525.00	V-UL	DFT-s-OFDM	QPSK	50	1	1 / 12	16.93	21.00	37.93
28324.92	V-UL	DFT-s-OFDM	QPSK	50	1	Full	19.38	21.00	40.38
27525.00	V-UL	DFT-s-OFDM	16-QAM	50	1	Full	19.48	21.00	40.48
27700.02	V-UL	DFT-s-OFDM	QPSK	100	4	Full	18.62	21.00	39.62
27924.96	V-UL	DFT-s-OFDM	QPSK	100	4	Full	18.61	21.00	39.61
27700.02	V-UL	DFT-s-OFDM	QPSK	100	4	1 / 33	17.05	21.00	38.05
28150.02	V-UL	DFT-s-OFDM	QPSK	100	4	Full	18.34	21.00	39.34
27700.02	V-UL	DFT-s-OFDM	16-QAM	100	4	Full	18.50	21.00	39.50

Table 7-10. NR Band n261 - Conducted Power and EIRP – DU – V-UL Polarization

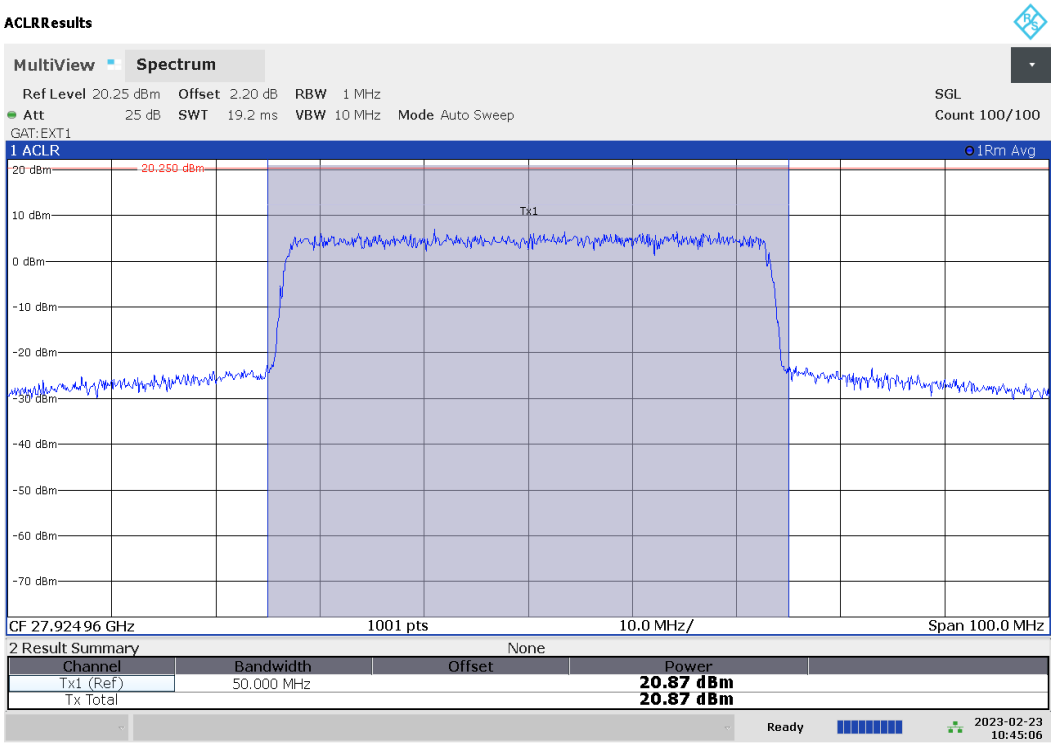
Center Frequency [MHz]	Ant.Pol.	Transmission Scheme	Modulation	Bandwidth [MHz]	# of Carriers [CCs]	RB Size/Offset	MIMO Conducted Power [dBm]	Tx Ant Gain [dBi]	MIMO EIRP [dBm]
27525.00	MIMO	DFT-s-OFDM	QPSK	50	1	Full	23.44	21.00	44.44
27924.96	MIMO	DFT-s-OFDM	QPSK	50	1	Full	23.51	21.00	44.51
27924.96	MIMO	DFT-s-OFDM	QPSK	50	1	1 / 31	20.41	21.00	41.41
28324.92	MIMO	DFT-s-OFDM	QPSK	50	1	Full	22.32	21.00	43.32
27924.96	MIMO	DFT-s-OFDM	16-QAM	50	1	Full	21.74	21.00	42.74
27700.02	MIMO	DFT-s-OFDM	QPSK	100	4	Full	22.09	21.00	43.09
27924.96	MIMO	DFT-s-OFDM	QPSK	100	4	Full	21.93	21.00	42.93
27700.02	MIMO	DFT-s-OFDM	QPSK	100	4	1 / 33	20.68	21.00	41.68
28150.02	MIMO	DFT-s-OFDM	QPSK	100	4	Full	21.71	21.00	42.71
27700.02	MIMO	DFT-s-OFDM	16-QAM	100	4	Full	21.86	21.00	42.86

Table 7-11. NR Band n261 - Conducted Power – DU – MIMO



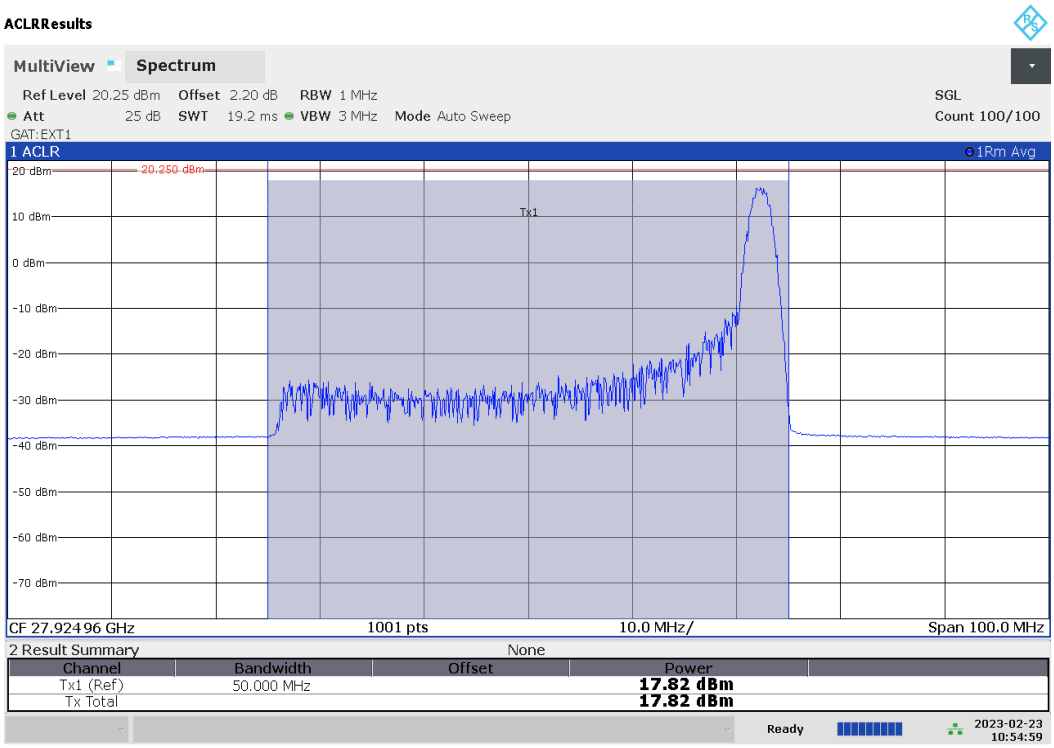
10:42:33 AM 02/23/2023

Plot 7-35. Conducted Power Plot – DU – H-UL Polarization (50MHz-1CC − QPSK – Low Ch. – Full RB)



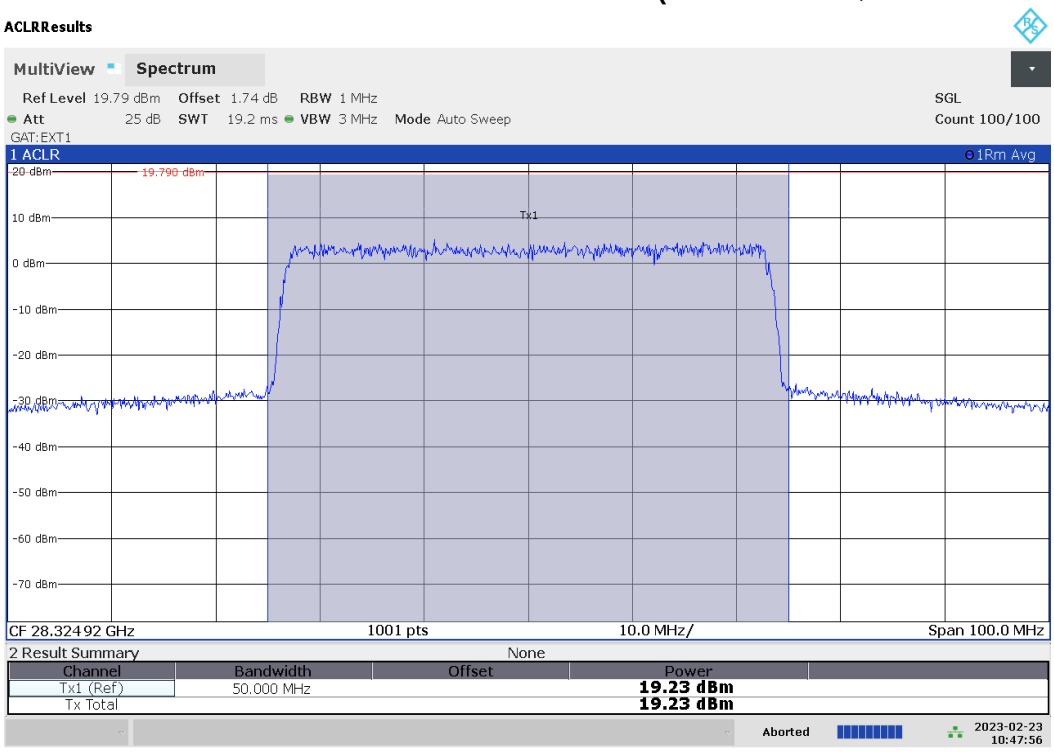
10:45:07 AM 02/23/2023

Plot 7-36. Conducted Power Plot – DU – H-UL Polarization (50MHz-1CC − QPSK – Mid Ch. – Full RB)



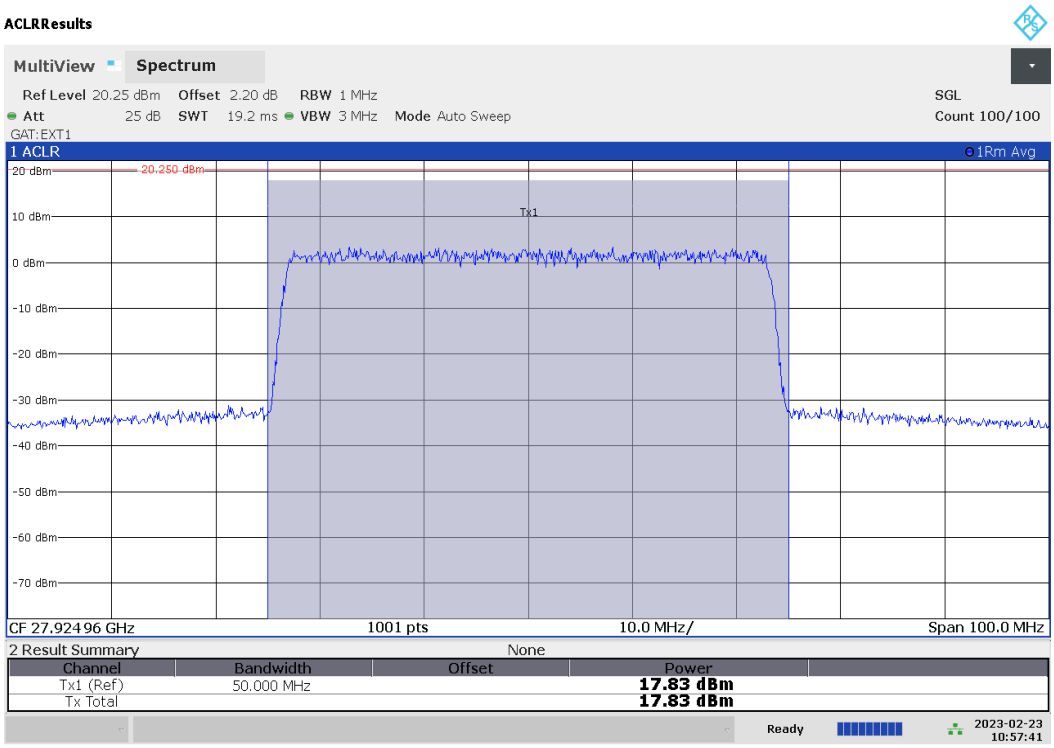
10:55:00 AM 02/23/2023

Plot 7-37. Conducted Power Plot – DU – H-UL Polarization (50MHz-1CC − QPSK – Mid Ch. – 1RB)



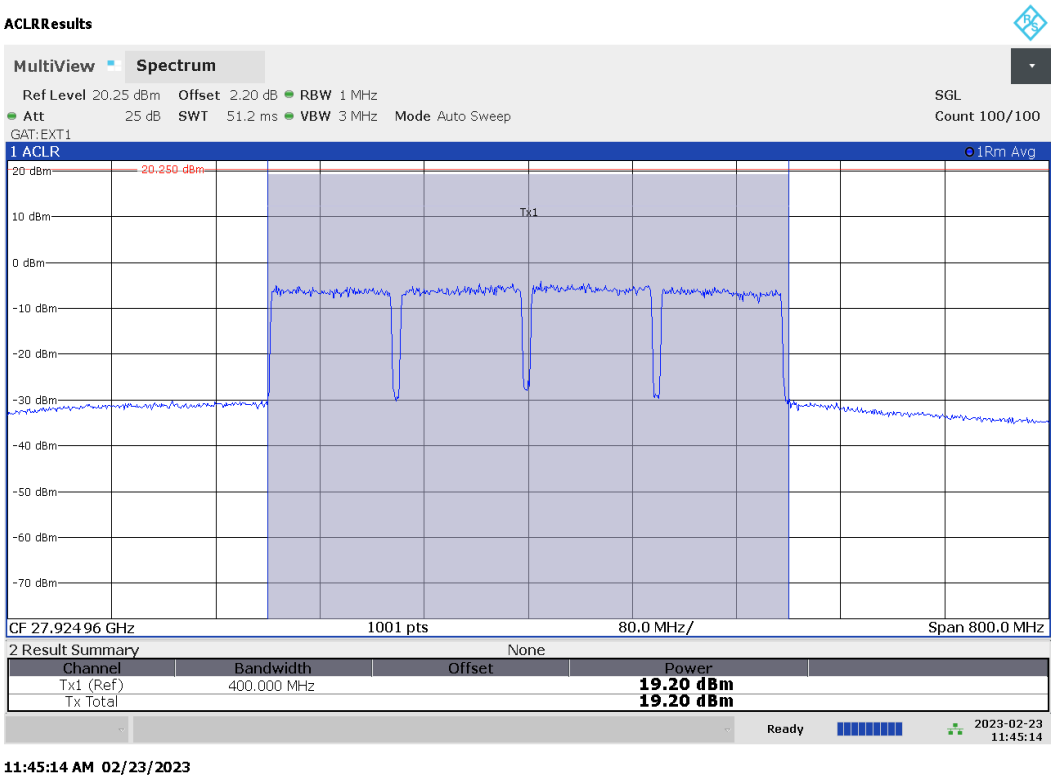
10:47:57 AM 02/23/2023

Plot 7-38. Conducted Power Plot – DU – H-UL Polarization (50MHz-1CC − QPSK – High Ch. – Full RB)

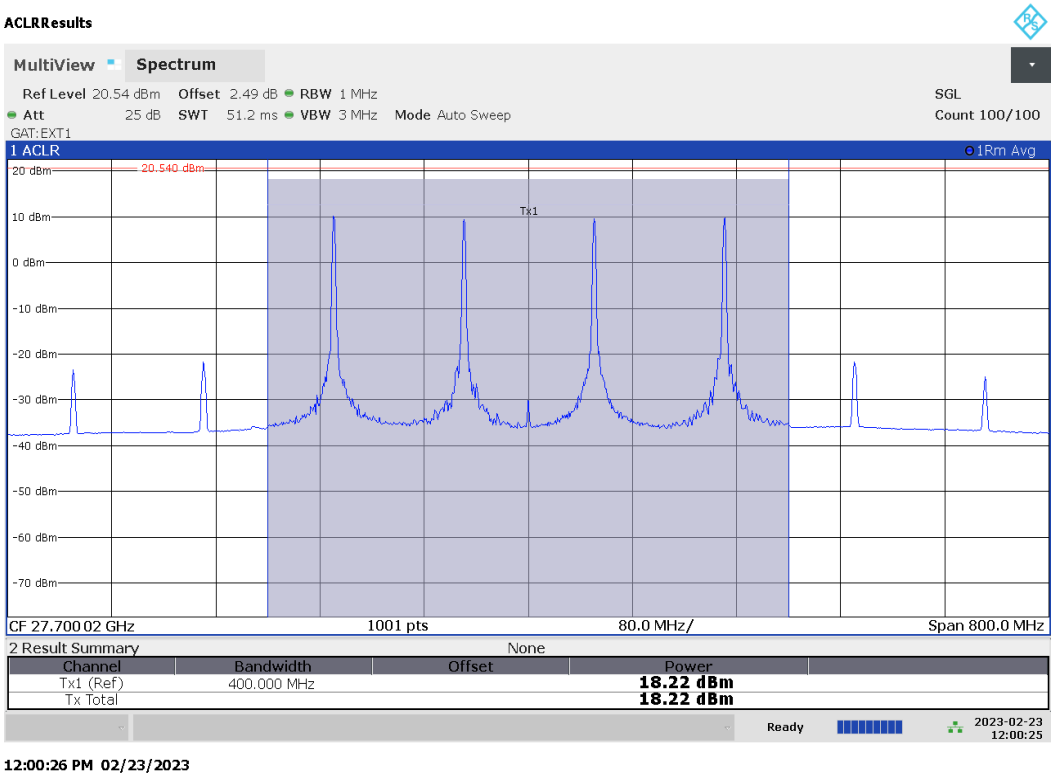


Plot 7-39. Conducted Power Plot – DU – H-UL Polarization (50MHz-1CC – 16QAM – Mid Ch. – Full RB)

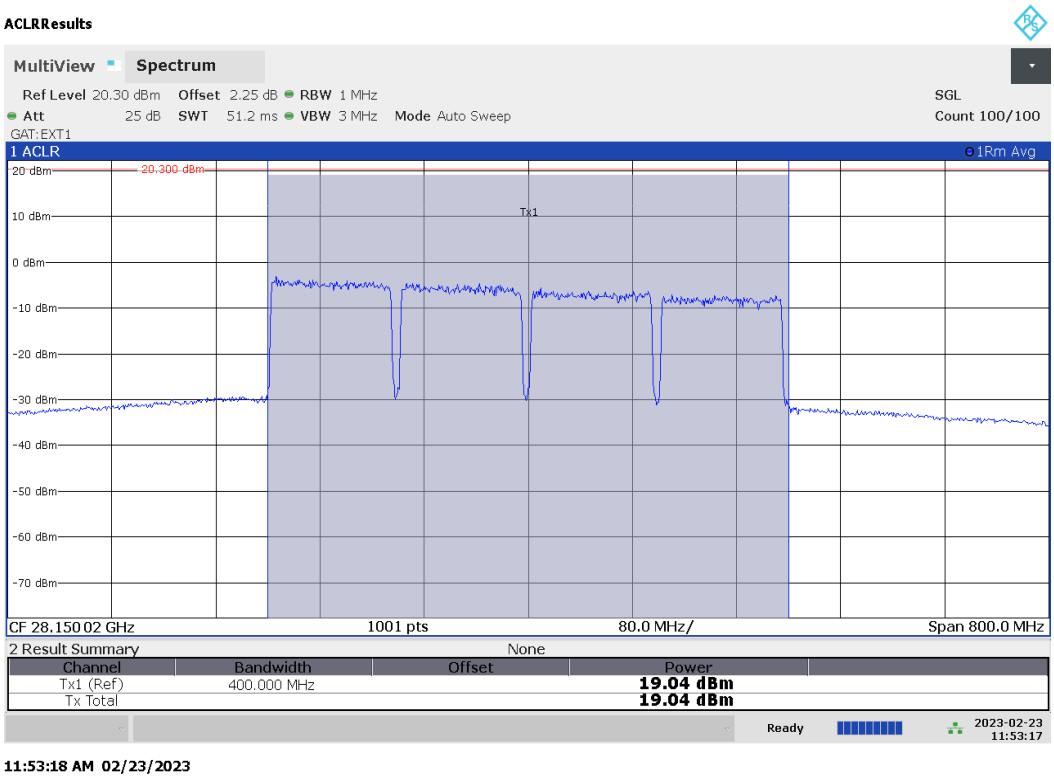
Plot 7-40. Conducted Power Plot – DU – H-UL Polarization (100MHz-4CC − QPSK – Low Ch. – Full RB)



Plot 7-41. Conducted Power Plot – DU – H-UL Polarization (100MHz-4CC − QPSK – Mid Ch. – Full RB)



Plot 7-42. Conducted Power Plot – DU – H-UL Polarization (100MHz-4CC − QPSK – Low Ch. – 1RB)

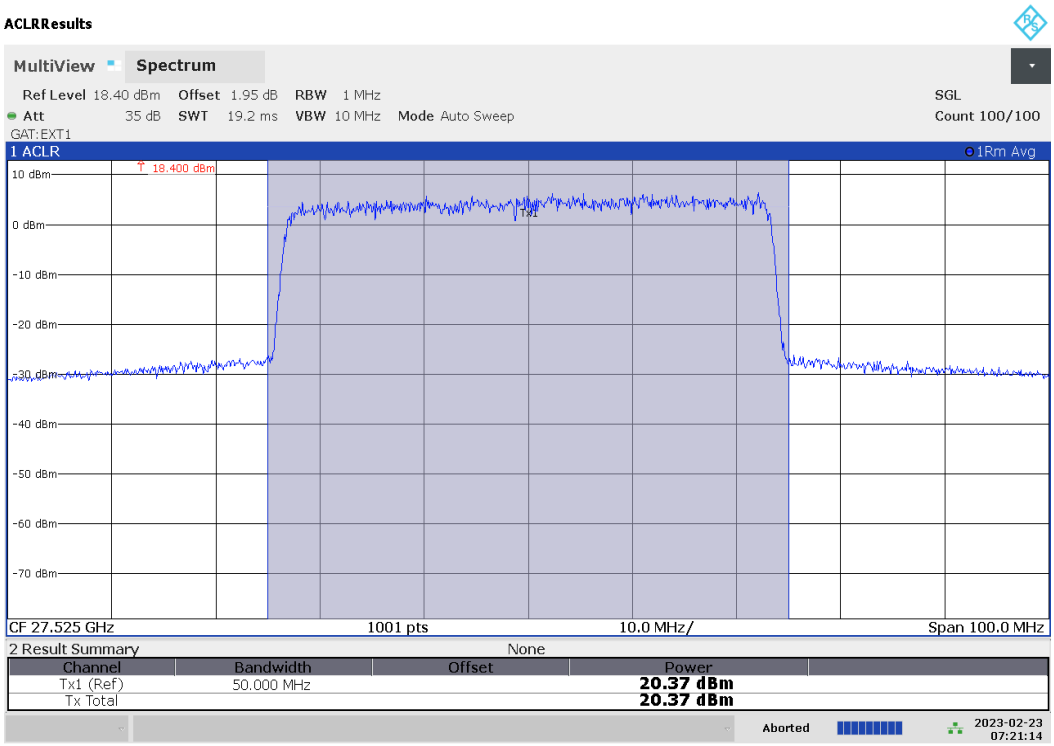


11:53:18 AM 02/23/2023

Plot 7-43. Conducted Power Plot – DU – H-UL Polarization (100MHz-4CC − QPSK – High Ch. – Full RB)

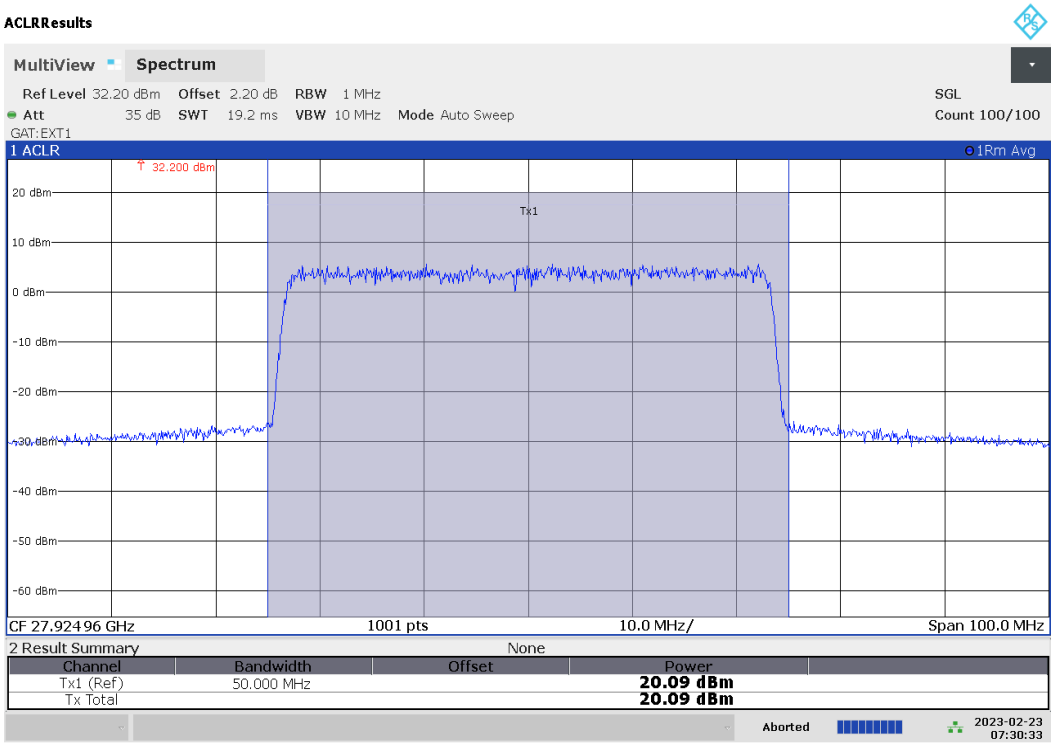
12:05:38 PM 02/23/2023

Plot 7-44. Conducted Power Plot – DU – H-UL Polarization (100MHz-4CC – 16QAM – High Ch. – Full RB)



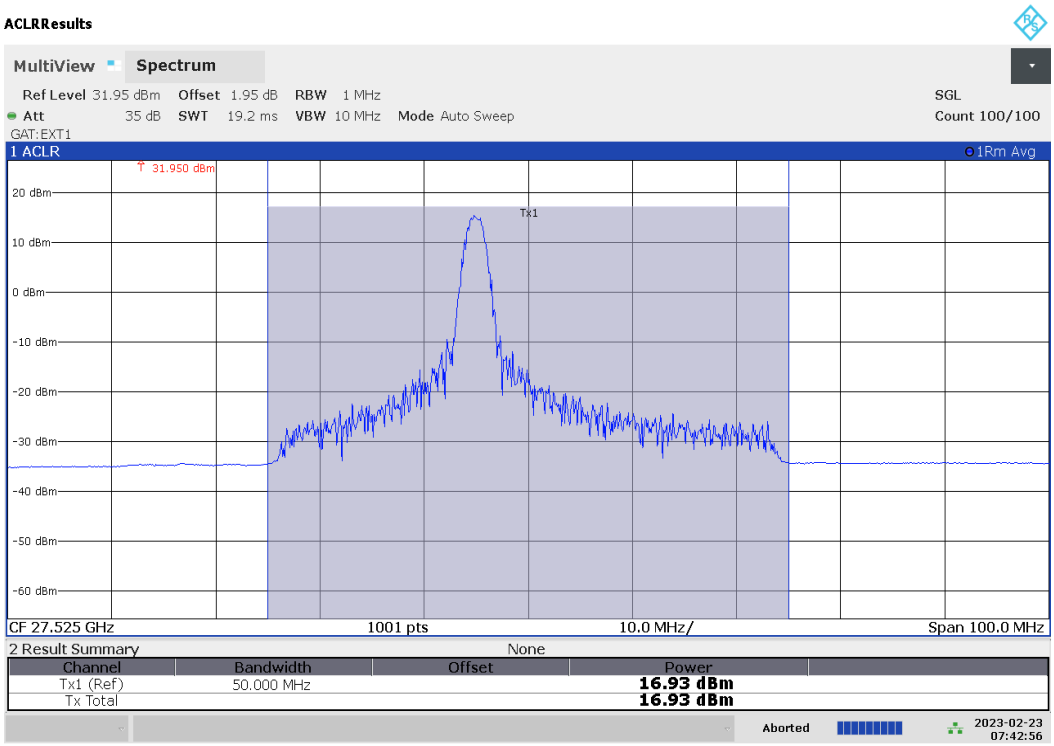
07:21:15 AM 02/23/2023

Plot 7-45. Conducted Power Plot – DU – V-UL Polarization (50MHz-1CC − QPSK – Low Ch. – Full RB)



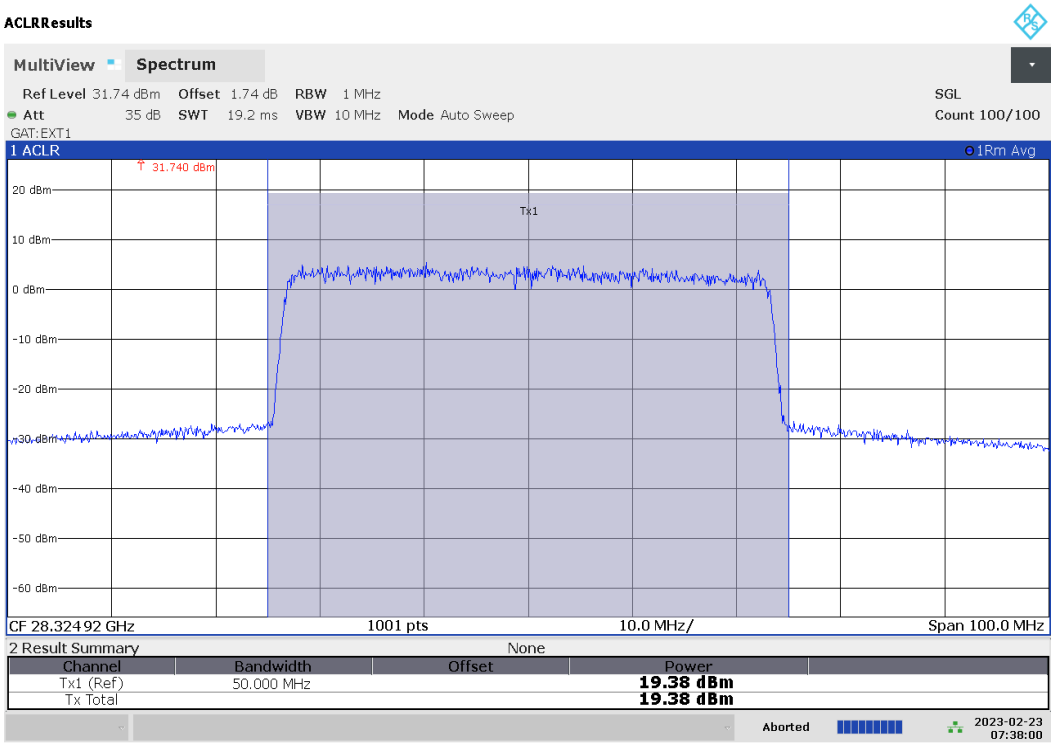
07:30:33 AM 02/23/2023

Plot 7-46. Conducted Power Plot – DU – V-UL Polarization (50MHz-1CC − QPSK – Mid Ch. – Full RB)



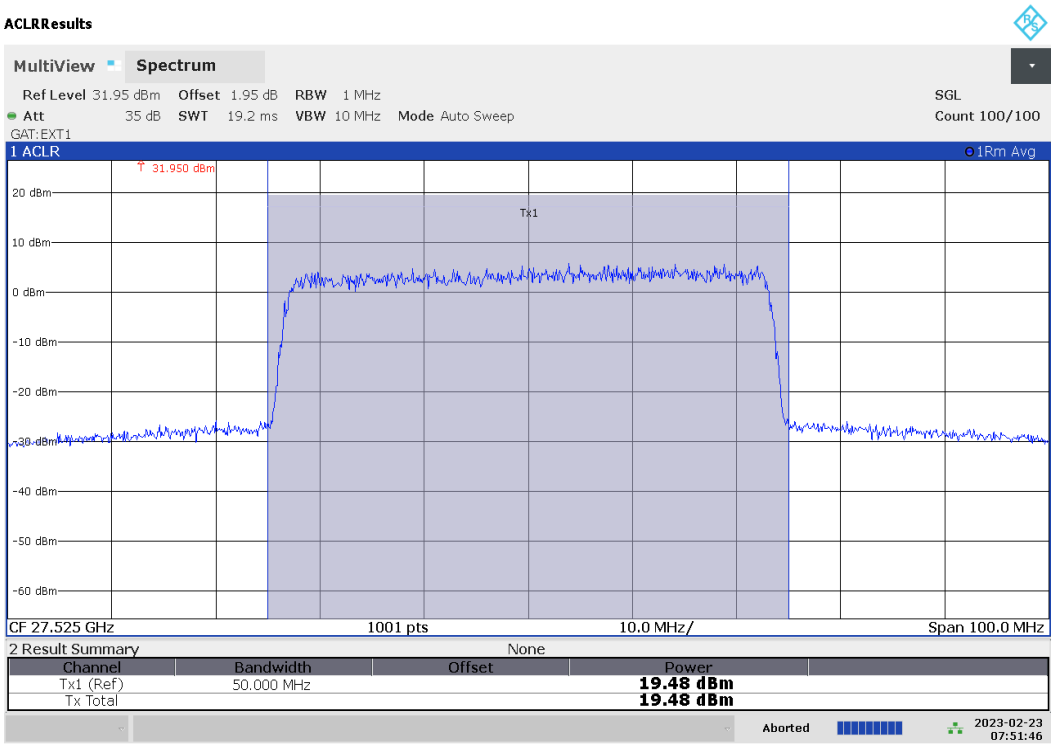
07:42:57 AM 02/23/2023

Plot 7-47. Conducted Power Plot – DU – V-UL Polarization (50MHz-1CC − QPSK – Low Ch. – 1RB)



07:38:00 AM 02/23/2023

Plot 7-48. Conducted Power Plot – DU – V-UL Polarization (50MHz-1CC − QPSK – High Ch. – Full RB)



07:51:47 AM 02/23/2023

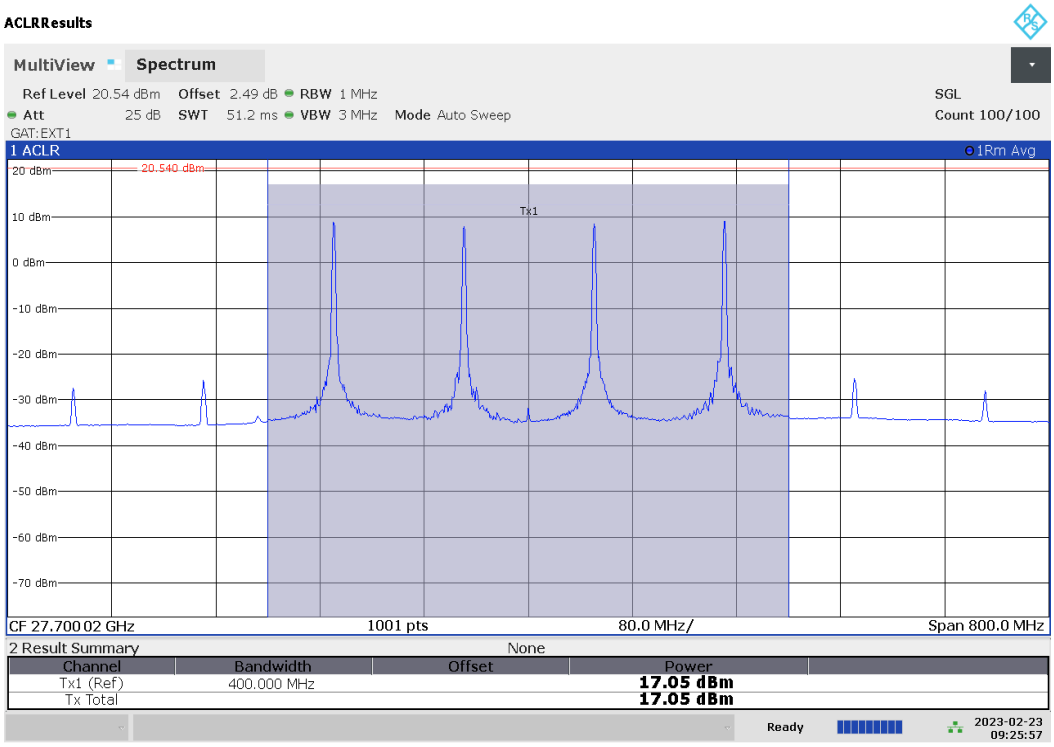
Plot 7-49. Conducted Power Plot – DU – V-UL Polarization (50MHz-1CC – 16QAM – Mid Ch. – Full RB)

09:07:45 AM 02/23/2023

Plot 7-50. Conducted Power Plot – DU – V-UL Polarization (100MHz-4CC − QPSK – Low Ch. – Full RB)

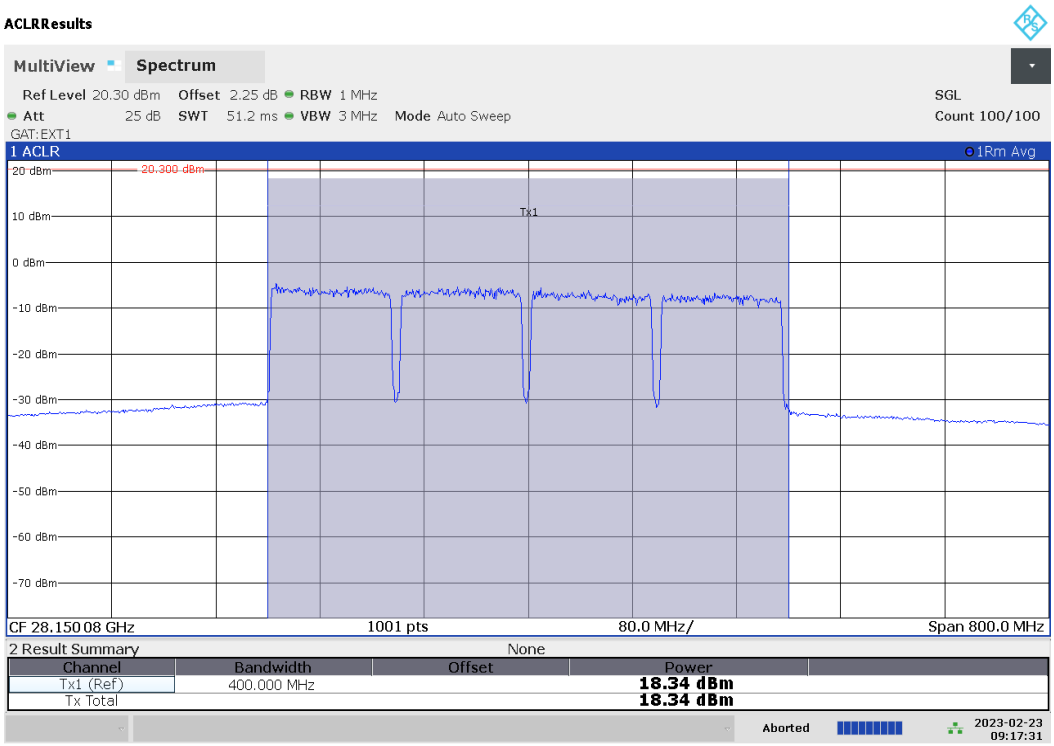
09:13:09 AM 02/23/2023

Plot 7-51. Conducted Power Plot – DU – V-UL Polarization (100MHz-4CC − QPSK – Mid Ch. – Full RB)



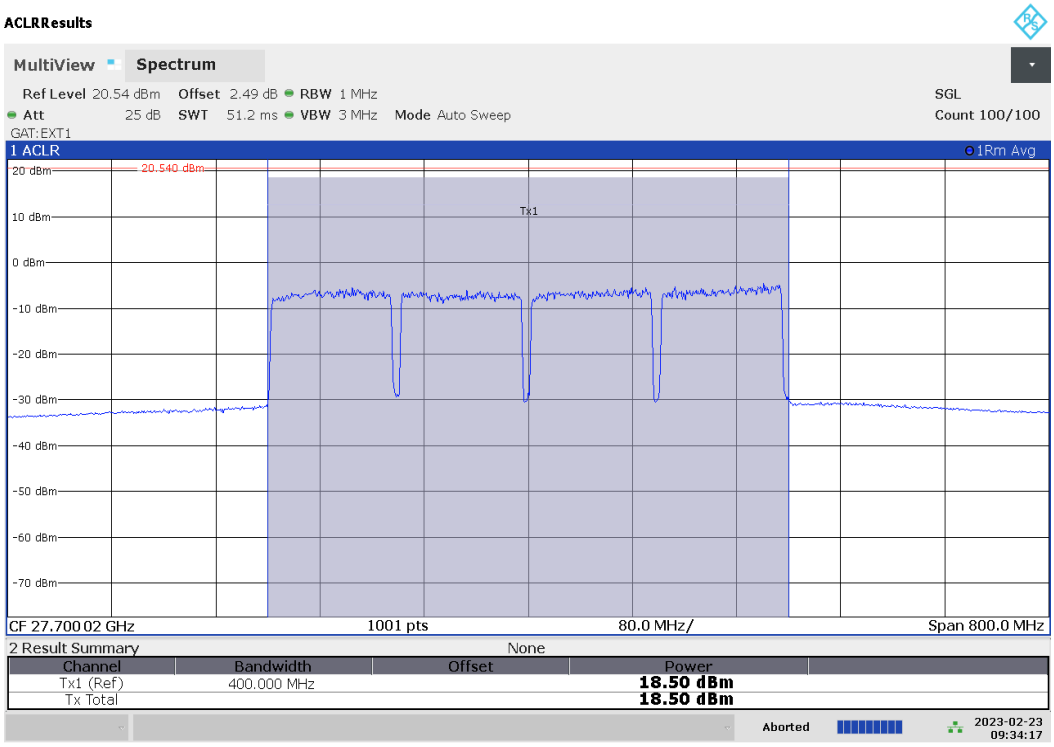
09:25:58 AM 02/23/2023

Plot 7-52. Conducted Power Plot – DU – V-UL Polarization (100MHz-4CC − QPSK – Low Ch. – 1RB)



09:17:32 AM 02/23/2023

Plot 7-53. Conducted Power Plot – DU – V-UL Polarization (100MHz-4CC − QPSK – High Ch. – Full RB)



09:34:17 AM 02/23/2023

Plot 7-54. Conducted Power Plot – DU – V-UL Polarization (100MHz-4CC – 16QAM – Low Ch. – Full RB)

7.7 Radiated Spurious and Harmonic Emissions

Test Overview

Radiated spurious emissions measurements are performed using the field strength conversion method described in ANSI C63.26-2015 with the EUT transmitting into an integral antenna. Measurements on signals operating below 1GHz are performed using hybrid (biconical/log) antennas. Measurements on signals operating above 1GHz are performed using vertically and horizontally polarized broadband horn antennas. All measurements are performed as RMS measurements while the EUT is operating at maximum power, and at the appropriate frequencies.

The conductive power or total radiated power of any emissions outside a licensee's frequency block shall be -13dBm/1MHz.

Test Procedure Used

ANSI C63.26-2015 – Section 5.5.4
KDB 842590 D01 – Section 4.4.3

Test Settings

1. Start frequency was set to 30MHz and stop frequency was set to 100 GHz . Several plots are used to show investigations in this entire span.
2. Trace / Detector = Average / RMS – for all emissions
3. For measurements made with Trace Averaging:
    a. These measurements were averaged over at least 100 traces.
    b. For signals with continuous operation, triggering was set to "free run" and the sweep time was set to "auto". For pulsed signals, triggering was set to enable measurements only during full power bursts with the sweep time set less than or equal to the transmission burst duration.
4. Number of sweep points ≥ 2 x Span/RBW
5. The trace was allowed to stabilize
6. RBW = 1MHz, VBW = 3MHz

Test Notes

1) The EUT was tested in three orthogonal planes and in all possible test configurations and positioning. The worst-case emissions are reported with the EUT positioning, modulations, RB sizes and offsets, and channel bandwidth configurations shown in the tables below. The worst case found was 50MHz-1CC bandwidth/component carrier, QPSK Modulation, with 1RB. The EUT was tested under such signaling conditions.

2) All radiated spurious emissions were measured as EIRP to compare with the §30.203 TRP limits.

3) The plots in this section were taken with the analyzer set to max hold. All final measurements shown in the tables that accompany the plots were taken with trace averaging performed over 100 sweeps while the analyzer was triggering on a specific emission of interest.

4) The plots from 1 – 100GHz show corrected average EIRP levels. The average EIRP reported below is calculated per section 5.2.7 of ANSI C63.26-2015 which states: EIRP (dBm) = E (dBμV/m) + 20log(D) − 104.8; where D is the measurement distance (in the far field region) in m. The field strength E is calculated

E (dBµV/m) = Spectrum Analyzer Level (dBm) + Antenna Factor (dB/m) + Cable Loss (dB) + Harmonic Mixer Conversion Loss (dB) + 107. All appropriate Antenna Factors and Cable Losses have been applied in the spectrum analyzer for each measurement. For measurements > 40GHz, a Harmonic Mixer Conversion Loss was also applied to the spectrum analyzer.

5) Emissions below 18GHz were measured at a 3 meter test distance, while emissions above 18GHz were measured at the appropriate far field distance. The far field of the mmWave signal is based on formula: R > 2D^2/wavelength, where D is the larger between the dimension of the measurement antenna and the transmitting antenna of the EUT. In this case, D is the dimension of the EUT which is roughly 29cm x 29cm x 7cm.

Frequency Range (GHz)	Wavelength (cm)	Far Field Distance (m)	Measurement Distance (m)
18-40	0.749	0.54	2.00
40-60	0.06	1.44	2.00
60-90	0.04	0.96	2.00
90-140	0.026	1.493	2.00

Table 7-12. Far-Field Distance & Measurement Distance per Frequency Range

6) All emissions from 30MHz - 40GHz were measured using a spectrum analyzer with an internal preamplifier. Emissions >40GHz were measured using a harmonic mixer with the spectrum analyzer.

7) To cover the simultaneous transmissions, the LTE module (FCC ID: XMR201906EG21G) was set to transmit at the same time as the mmWave functionality of the host.

8) The spectrum scan plots in this section are used for the purpose of signal identification. Each emission is subject to a unique limit based on the rule under which the transmitter operates. For instances where an emission is the product of co-located transmitters (i.e. an intermodulation product), the limit on that emission is the least strict between the rule parts under which each transmitter operates.

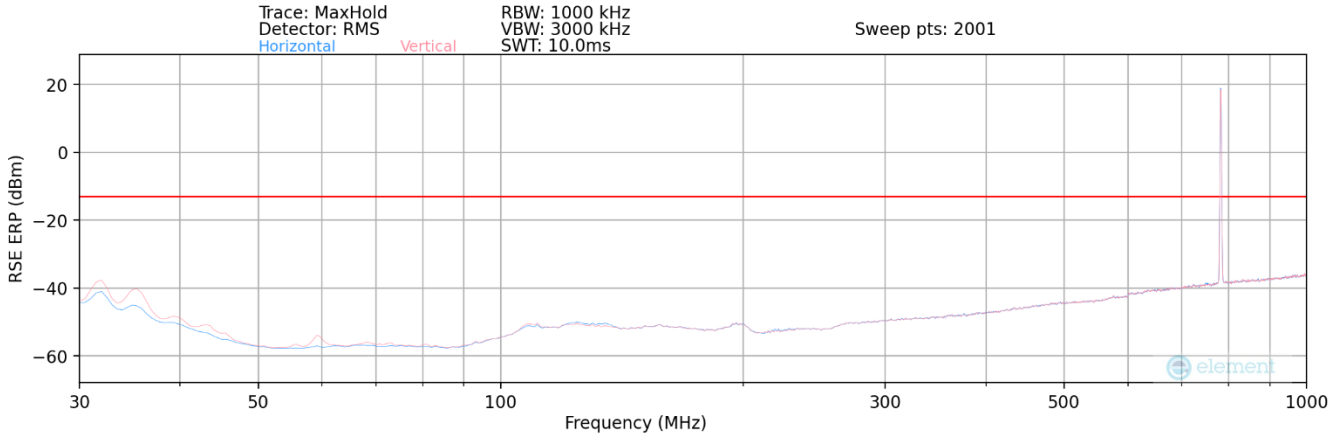
9) The limit lines on the spectrum scan plots in this section are displayed in regards to the Part 30 limits for n261 mmWave spurious emissions. The limits for spurious emissions solely due to the other transmitters are not displayed on the plots. Instead, the applicable limits are displayed in the accompanying tables.

10) The fundamental emissions from multiple co-located transmitters may appear on spectrum scan plots. These are not investigated as spurious emissions.

11) The "-" shown in the following RSE tables are used to denote a noise floor measurement.

Band n261 – DU

30MHz - 1GHz



Plot 7-55. n261 Radiated Spurious Plot (1CC QPSK Mid Channel) - DU

Spurious Emissions ERP Sample Calculation (n261)

The raw radiated spurious level is converted to field strength in dBuV/m. Then, the RSE ERP level is calculated by applying the additional factors shown below for a test distance of 3 meter.

RSE ERP (dBm) = Analyzer Level (dBm) + 107 + AFCL (dB/m) + 20Log(Dm) – 104.8 – 2.15 (dB)

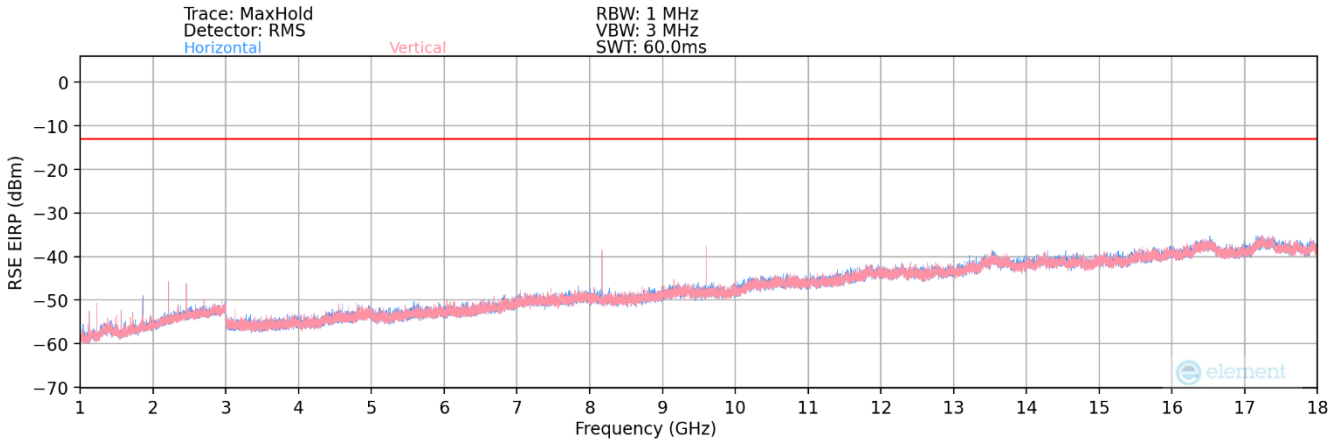
Frequency [MHz]	Channnel	Bandwidth (MHz)	EUT Beam Pol.	Modulation	Antenna Polarization [H/V]	Turntable Azimuth [degrees]	Antenna Height [cm]	Spurious Emission Level [dBm]	Limit [dBm]	Margin [dB]
33.50	Low	50	MIMO	QPSK	V	25	115	-42.58	-13.00	-29.58
36.00	Low	50	MIMO	QPSK	V	49	240	-44.24	-13.00	-31.24
70.50	Low	50	MIMO	QPSK	V	-	-	-61.56	-13.00	-48.56
200.00	Mid	50	MIMO	QPSK	V	-	-	-58.56	-13.00	-45.56
754.00	High	50	MIMO	QPSK	V	-	-	-44.97	-13.00	-31.97

Table 7-13. n261 Radiated Spurious Emissions Table (30MHz - 1GHz) - DU

Notes

The RSE ERP level is taken directly from the spectrum analyzer which includes the appropriate antenna factors, cable losses. Measurements were performed at a distance of 3 meters.

1GHz - 18GHz



Plot 7-56. n261 Radiated Spurious Plot (1CC QPSK Mid Channel) - DU

Spurious Emissions EIRP Sample Calculation (n261)

The raw radiated spurious level is converted to field strength in dBuV/m. Then, the RSE EIRP level is calculated by applying the additional factors shown below for a test distance of 3 meter.

RSE EIRP (dBm) = Analyzer Level (dBm) + 107 + AFCL (dB/m) + 20Log(Dm) – 104.8

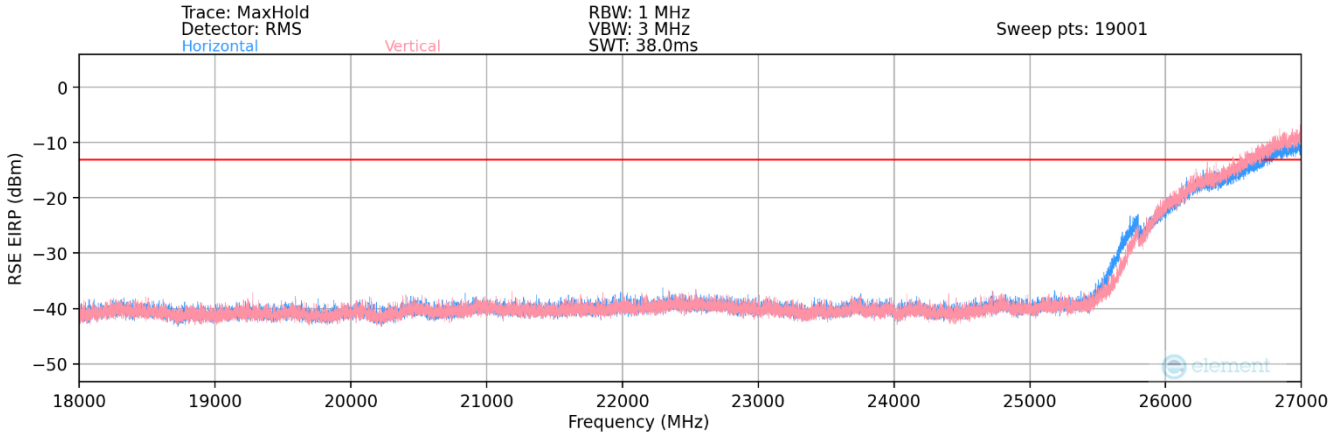
Frequency [MHz]	Channnel	Bandwidth (MHz)	EUT Beam Pol.	Modulation	Antenna Polarization [H/V]	Turntable Azimuth [degrees]	Antenna Height [cm]	Spurious Emission Level [dBm]	Limit [dBm]	Margin [dB]
1106.00	Low	50	MIMO	QPSK	H	285	94	-56.10	-13.00	-43.10
1124.50	Mid	50	MIMO	QPSK	H	144	303	-52.56	-13.00	-39.56
1564.00	High	50	MIMO	QPSK	H	150	257	-56.94	-13.00	-43.94
1720.00	High	50	MIMO	QPSK	H	147	115	-57.99	-13.00	-44.99
1860.00	High	50	MIMO	QPSK	H	121	188	-52.46	-13.00	-39.46
2211.00	High	50	MIMO	QPSK	H	155	144	-47.50	-13.00	-34.50
2457.00	High	50	MIMO	QPSK	H	169	309	-48.08	-13.00	-35.08
8168.80	High	50	MIMO	QPSK	H	155	152	-43.26	-13.00	-30.26
9600.00	High	50	MIMO	QPSK	H	54	115	-40.29	-13.00	-27.29
13450.00	High	50	MIMO	QPSK	H	-	-	-43.54	-13.00	-30.54

Table 7-14. n261 Radiated Spurious Emissions Table (1GHz - 18GHz) - DU

Notes

The RSE EIRP level is taken directly from the spectrum analyzer which includes the appropriate antenna factors, cable losses. Measurements were performed at a distance of 3 meters.

18GHz - 27GHz



Plot 7-57. n261 Radiated Spurious Plot (1CC QPSK Mid Channel) – DU

Spurious Emissions EIRP Sample Calculation (n261)

The raw radiated spurious level is converted to field strength in dBuV/m. Then, the RSE EIRP level is calculated by applying the additional factors shown below for a test distance of 2 meter.

RSE EIRP (dBm) = Analyzer Level (dBm) + 107 + AFCL (dB/m) + 20Log(Dm) – 104.8

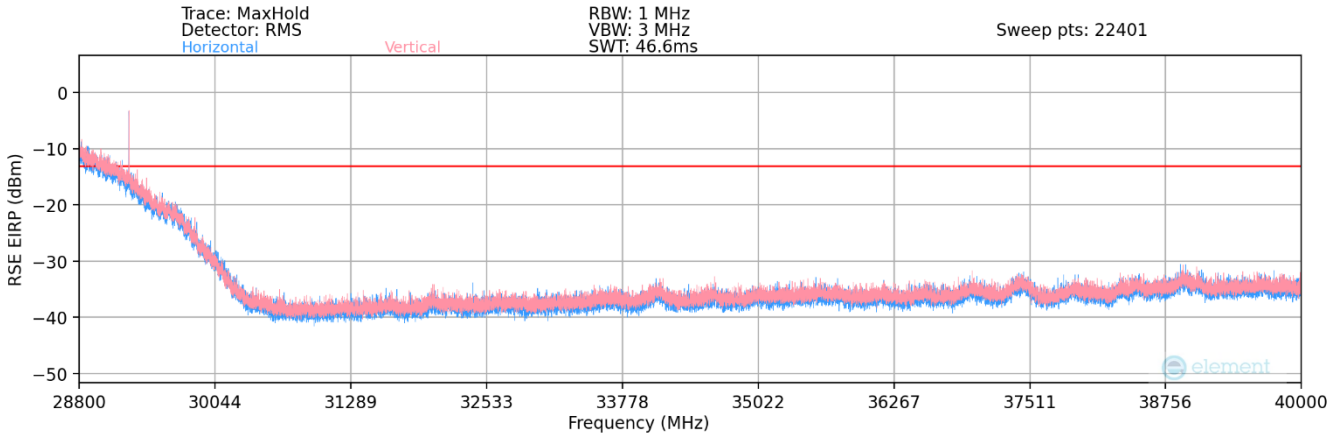
Frequency [MHz]	Channnel	Bandwidth (MHz)	EUT Beam Pol.	Modulation	Turntable Azimuth [degrees]	Antenna Polarization [degrees]	Spurious Emission Level [dBm]	Limit [dBm]	Margin [dB]
19650.00	Low	50	MIMO	QPSK	-	-	-45.78	-13.00	-32.78
22750.00	Mid	50	MIMO	QPSK	-	-	-44.98	-13.00	-31.98
26994.00	High	50	MIMO	QPSK	-	-	-15.56	-13.00	-2.56

Table 7-15. n261 Radiated Spurious Emissions Table (18GHz - 27.5GHz) - DU

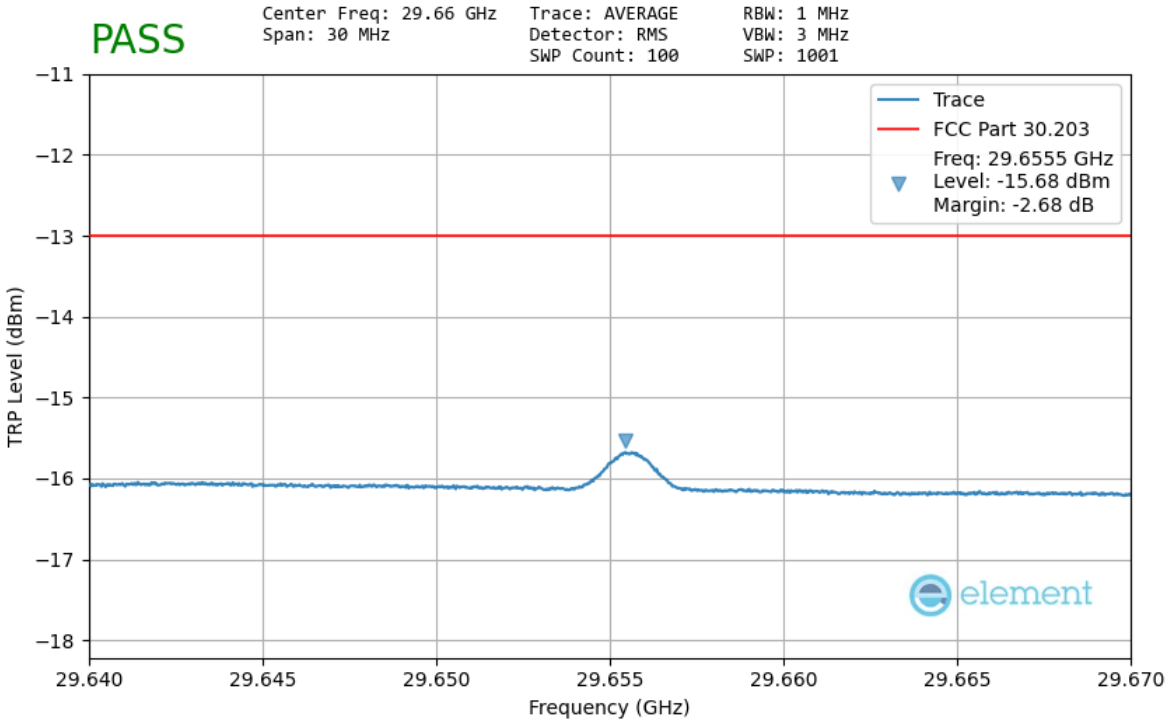
Notes

1. The RSE EIRP level is taken directly from the spectrum analyzer which includes the appropriate antenna factors, cable losses. Measurements were performed at a distance of 2 meter.
2. Even though the RSE at 26.9GHz seems to be failing on the pre-scan, when measured with Trace average and RMS, the RSE value is within limits.
3. Measurement antenna was set to height on maximum emissions as determined by manual pre-scan.

28.8GHz - 40GHz



Plot 7-58. n261 Radiated Spurious Plot (1CC QPSK Mid Channel) – DU



Plot 7-59. n261 Radiated Spurious Plot (1CC QPSK Mid Channel) - DU

Spurious Emissions EIRP Sample Calculation (n261)

The raw radiated spurious level is converted to field strength in dBuV/m. Then, the RSE EIRP level is calculated by applying the additional factors shown below for a test distance of 2 meter.

RSE EIRP (dBm) = Analyzer Level (dBm) + 107 + AFCL (dB/m) + 20Log(Dm) – 104.8

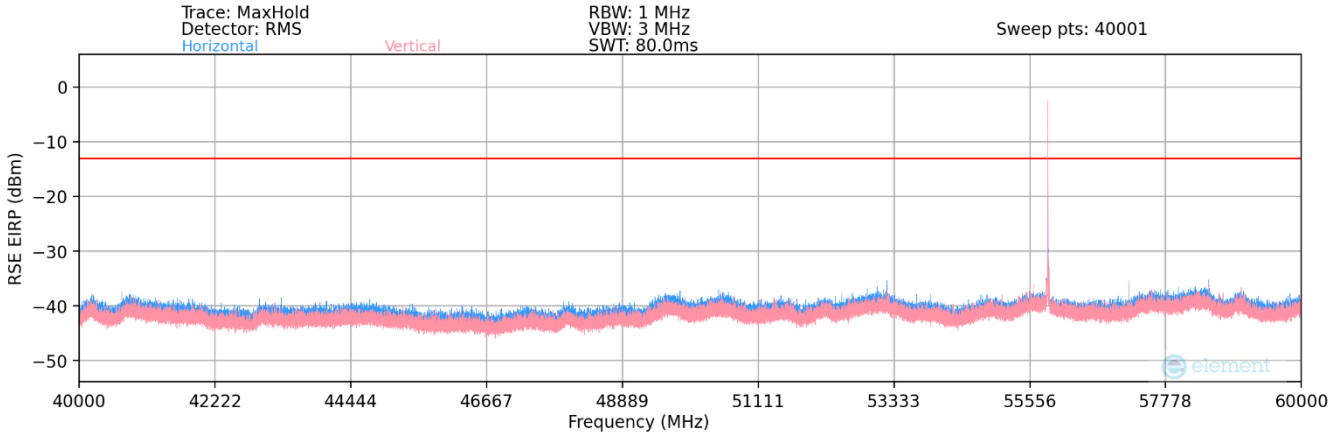
Frequency [MHz]	Channnel	Bandwidth (MHz)	EUT Beam Pol.	Modulation	Turntable Azimuth [degrees]	Antenna Polarization [degrees]	Spurious Emission Level [dBm]	Limit [dBm]	Margin [dB]
29655.00	Low	50	MIMO	QPSK	*	300	-15.68	-13.00	-2.68
29255.00	Mid	50	MIMO	QPSK	*	211	-19.90	-13.00	-6.90
28855.00	High	50	MIMO	QPSK	*	305	-17.41	-13.00	-4.41

Table 7-16. n261 Radiated Spurious Emissions Table (28.35GHz - 40GHz) - DU

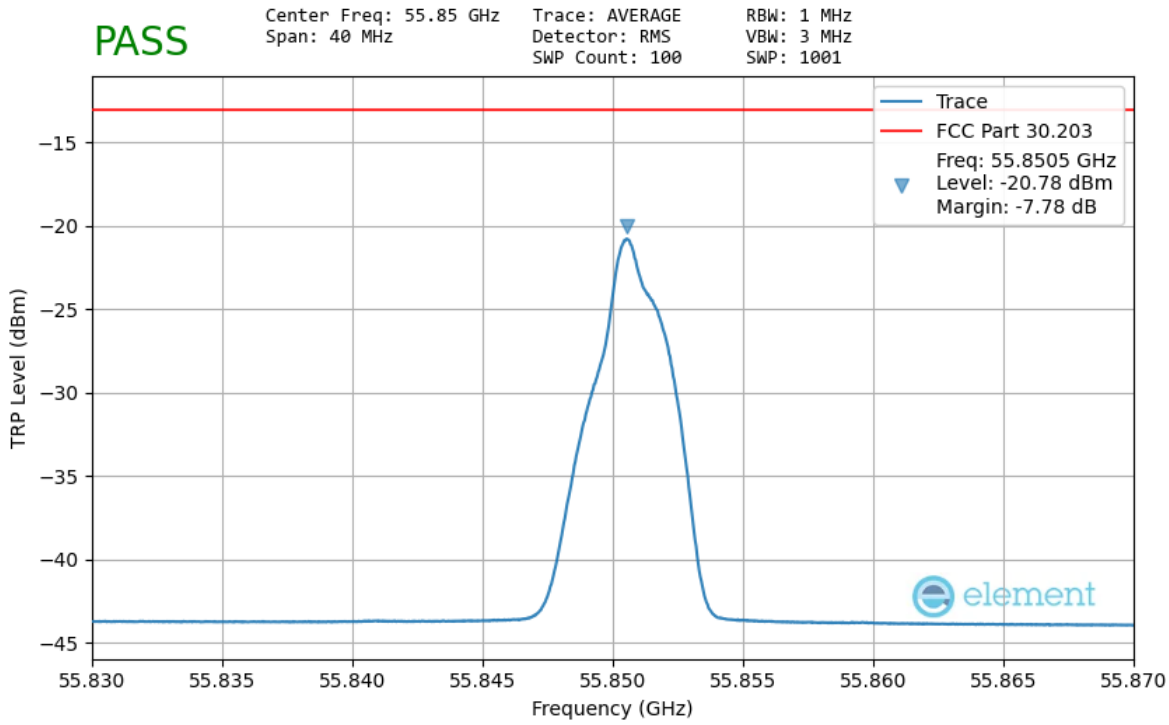
Notes

1. The TRP measurement is taken directly from the spectrum analyzer which includes the appropriate antenna factors, cable losses. Measurements were performed at a distance of 2 meter.
2. Due to failing EIRP RSE at ~29GHz shown in Plot 7-58, TRP measurements were taken and TRP Pre-scan plot for the same is included.
3. Measurement antenna was set to height on maximum emissions as determined by manual pre-scan.

40GHz - 60GHz



Plot 7-60. n261 Radiated Spurious Plot (1CC QPSK Mid Channel) – DU



Plot 7-61. n261 Radiated Spurious Plot (1CC QPSK Mid Channel) - DU

Spurious Emissions EIRP Sample Calculation (n261)

The raw radiated spurious level is converted to field strength in dBuV/m. Then, the RSE EIRP level is calculated by applying the additional factors shown below for a test distance of 2 meter.

RSE EIRP (dBm) = Analyzer Level (dBm) + 107 + AFCL (dB/m) + 20Log(Dm) – 104.8 + Harmonic Mixer Conversion Loss [dB]

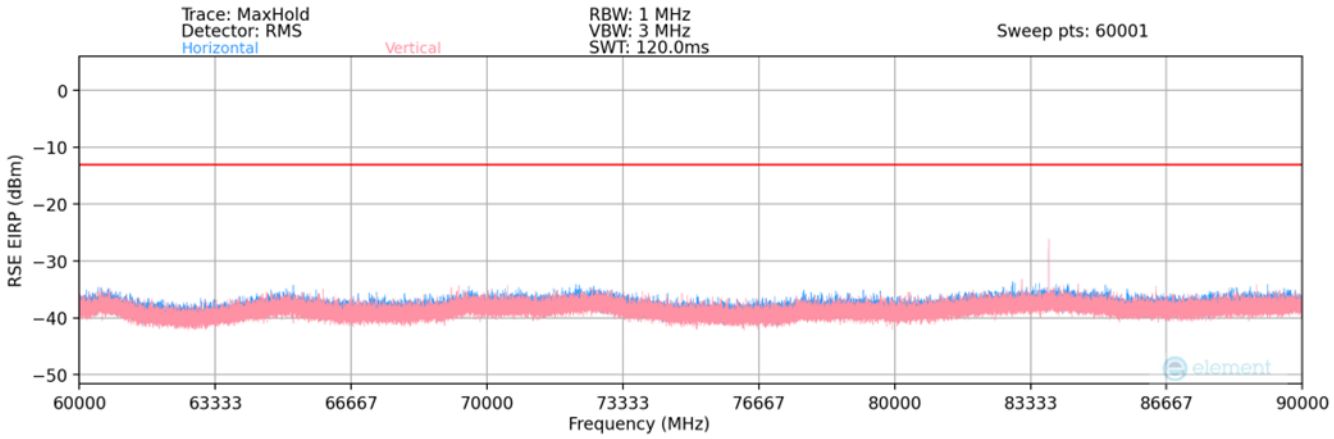
Frequency [MHz]	Channnel	Bandwidth (MHz)	EUT Beam Pol.	Modulation	Turntable Azimuth [degrees]	Antenna Polarization [degrees]	Spurious Emission Level [dBm]	Limit [dBm]	Margin [dB]
55050.00	Low	50	MIMO	QPSK	*	56	-24.73	-13.00	-11.73
55849.92	Mid	50	MIMO	QPSK	*	54	-20.78	-13.00	-7.78
56649.84	High	50	MIMO	QPSK	*	56	-23.09	-13.00	-10.09

Table 7-17. n261 Radiated Spurious Emissions Table (40GHz - 60GHz) - DU

Notes

1. The TRP measurement is taken directly from the spectrum analyzer which includes the appropriate antenna factors, cable losses. Measurements were performed at a distance of 2 meters.
2. Due to Failing RSE at ~55.85GHz, TRP measurements were taken and TRP Pre-scan plot for the same is included.
3. Measurement antenna was set to height on maximum emissions as determined by manual pre-scan.

60GHz - 90GHz



Plot 7-62. n261 Radiated Spurious Plot (1CC QPSK Mid Channel) - DU

Spurious Emissions EIRP Sample Calculation (n261)

The raw radiated spurious level is converted to field strength in dBuV/m. Then, the RSE EIRP level is calculated by applying the additional factors shown below for a test distance of 2 meter.

RSE EIRP (dBm) = Analyzer Level (dBm) + 107 + AFCL (dB/m) + 20Log(Dm) – 104.8 + Harmonic Mixer Conversion Loss [dB]

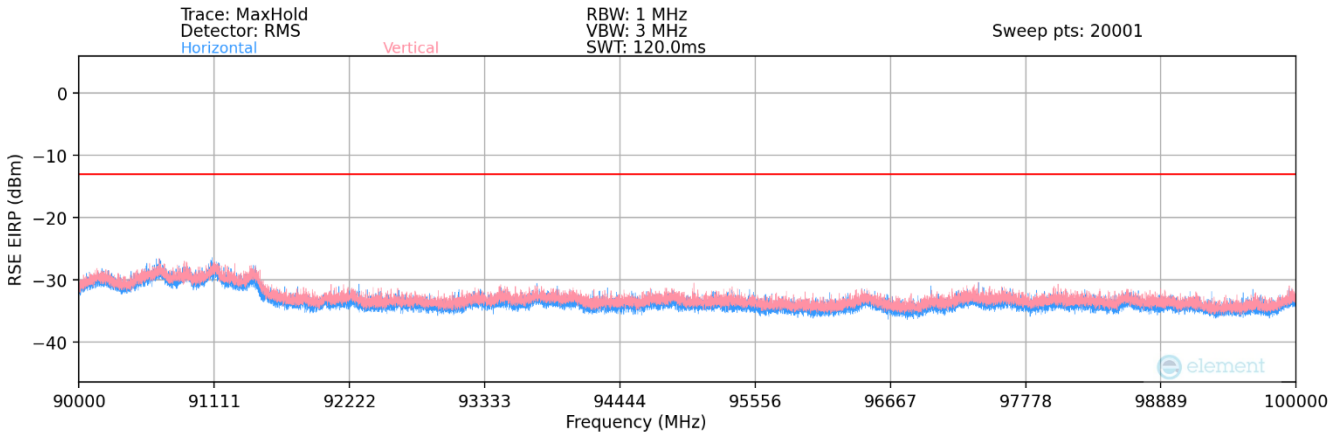
Frequency [MHz]	Channnel	Bandwidth (MHz)	EUT Beam Pol.	Modulation	Turntable Azimuth [degrees]	Antenna Polarization [degrees]	Spurious Emission Level [dBm]	Limit [dBm]	Margin [dB]
82575.00	Low	50	MIMO	QPSK	1	308	-28.68	-13.00	-15.68
83774.88	Mid	50	MIMO	QPSK	0	202	-24.05	-13.00	-11.05
84974.76	High	50	MIMO	QPSK	0	223	-23.78	-13.00	-10.78

Table 7-18. n261 Radiated Spurious Emissions Table (60GHz - 90GHz) - DU

Notes

1. The RSE EIRP level is taken directly from the spectrum analyzer which includes the appropriate antenna factors, cable losses. Measurements were performed at a distance of 2 meter.
2. Measurement antenna was set to height on maximum emissions as determined by manual pre-scan

90GHz - 100GHz



Plot 7-63. n261 Radiated Spurious Plot (1CC QPSK Mid Channel) - DU

Spurious Emissions EIRP Sample Calculation (n261)

The raw radiated spurious level is converted to field strength in dBuV/m. Then, the RSE EIRP level is calculated by applying the additional factors shown below for a test distance of 2 meter.

RSE EIRP (dBm) = Analyzer Level (dBm) + 107 + AFCL (dB/m) + 20Log(Dm) – 104.8 + Harmonic Mixer Conversion Loss [dB]

Frequency [MHz]	Channnel	Bandwidth (MHz)	EUT Beam Pol.	Modulation	Turntable Azimuth [degrees]	Antenna Polarization [degrees]	Spurious Emission Level [dBm]	Limit [dBm]	Margin [dB]
91154.00	Low	50	MIMO	QPSK	-	-	-26.22	-13.00	-13.22
95234.00	Mid	50	MIMO	QPSK	-	-	-29.51	-13.00	-16.51
99412.00	High	50	MIMO	QPSK	-	-	-30.56	-13.00	-17.56

Table 7-19. n261 Radiated Spurious Emissions Table (90GHz - 100GHz) - DU

Notes

1. The RSE EIRP level is taken directly from the spectrum analyzer which includes the appropriate antenna factors, cable losses. Measurements were performed at a distance of 2 meter.
2. Measurement antenna was set to height on maximum emissions as determined by manual pre-scan.

7.8 Band Edge / Out-of-Band Emissions

Test Overview

A signal generator is used to generate a 5G NR signal as an input to the EUT system via a coaxial cable. All out-of- band emissions are then measured in a conducted setup while the EUT is operating at its maximum power and at the appropriate frequencies. All modes of operation were investigated and the worst-case configuration results are reported in this section.

The minimum permissible attenuation level of any spurious emission is -13dBm/1MHz. However, in the bands immediately outside and adjacent to the licensee's frequency block, having a bandwidth equal to 10 percent of the channel bandwidth, the conductive power or the total radiated power of any emission shall be −5 dBm/MHz or lower.

Test Procedure Used

ANSI C63.26-2015 Section 5 and ANSI C63.26-2015 Section 6.4
KDB 842590 D01 Section 4.4.2.4
KDB 935210 D05 Section 3.6

Test Settings

1. Start and stop frequency were set such that both upper and lower band edges are measured.
2. Span was set large enough so as to capture all out of band emissions near the band edge.
3. RBW = 1MHz
4. VBW ≥ 3 x RBW
5. Detector = RMS
6. Trace mode = trace averaging (RMS) over 100 sweeps
7. Number of sweep points ≥ 2 x Span/RBW
8. Sweep time = auto couple

Test Notes

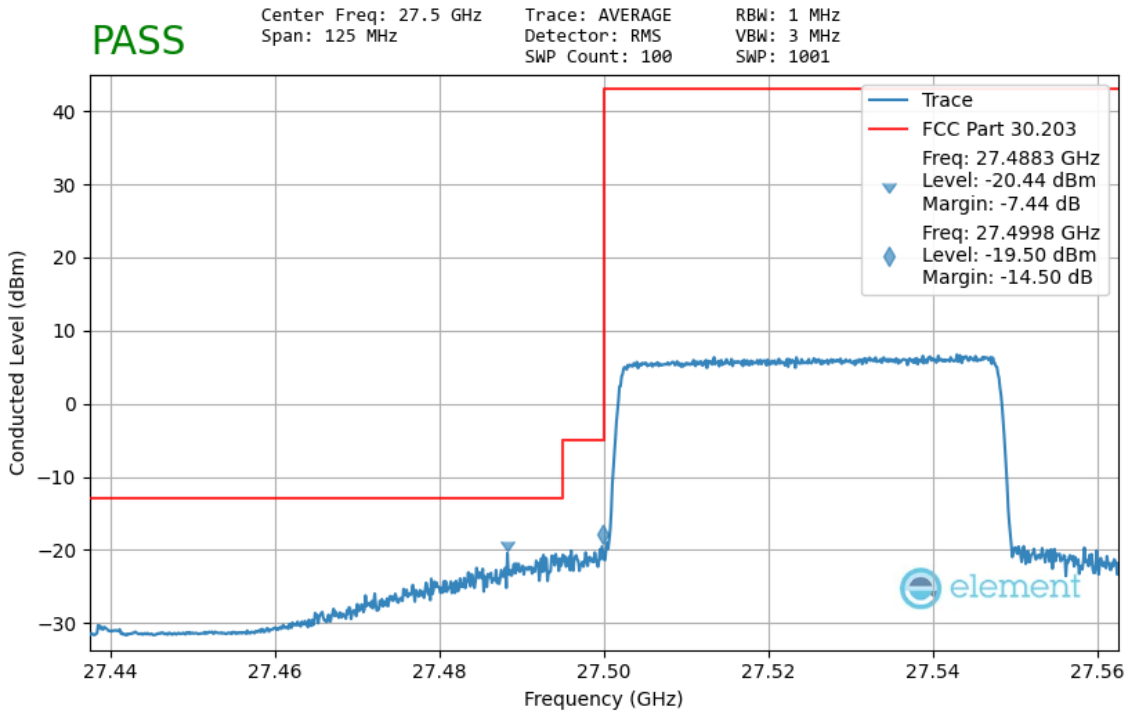
1) For FCC Part 30 compliance, all combinations of 5G NR component carriers, bandwidths, and RB allocations were fully investigated and only the worst case scenarios have been included in this section.

2) Per previous guidance from FCC specifically to Element lab, both stimulus conditions – a single test signal, and two adjacent test signals – were investigated with 50MHz 5G NR mmWave input signals as opposed to the 4.1MHz AWGN required in KDB 925210 D05.

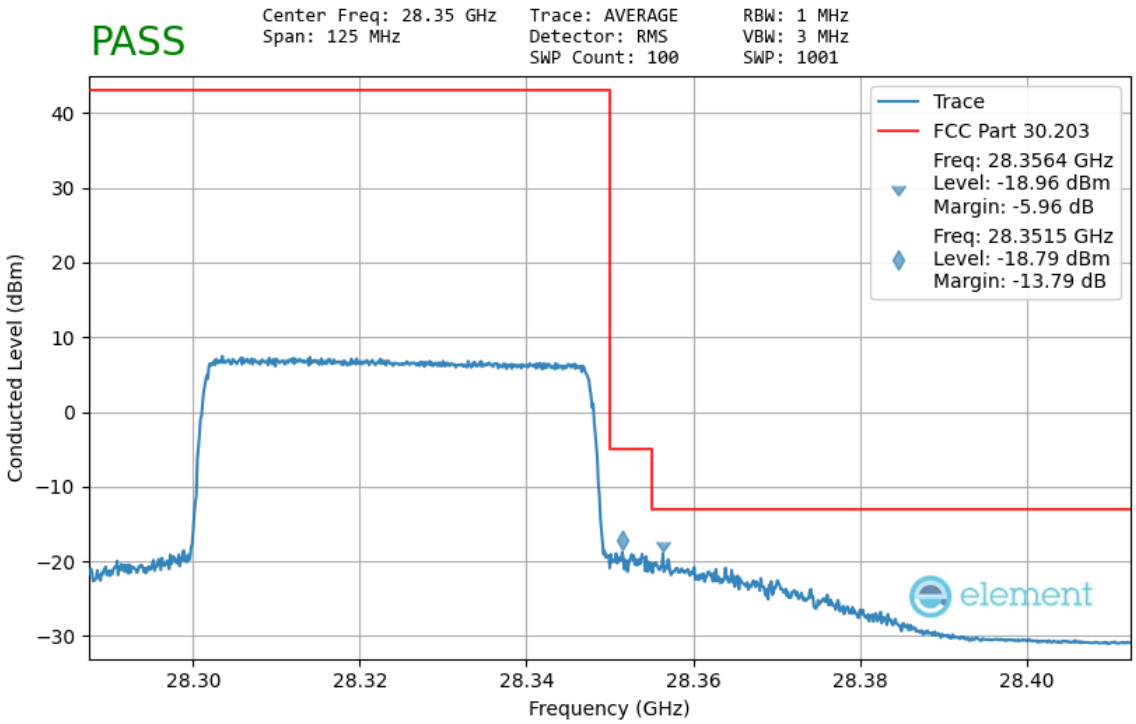
3) For all the plots in this section, appropriate frequency-varying corrections were applied to compensate for cable loss in the conducted measurement setup.

4) The band edge emission plots in this section are the spectral sums of the H and V output ports per ANSI C63.26-2015 Section 6.4.3.2.2 (measure and sum the spectra across the outputs).

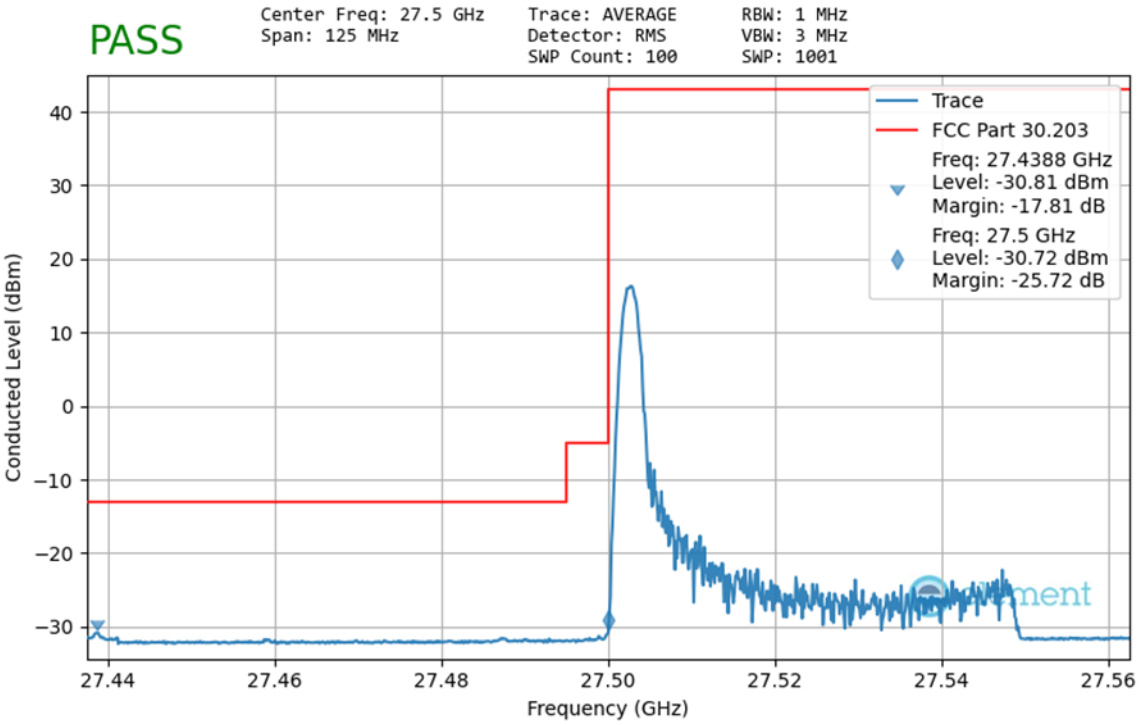
Band n261 – DU



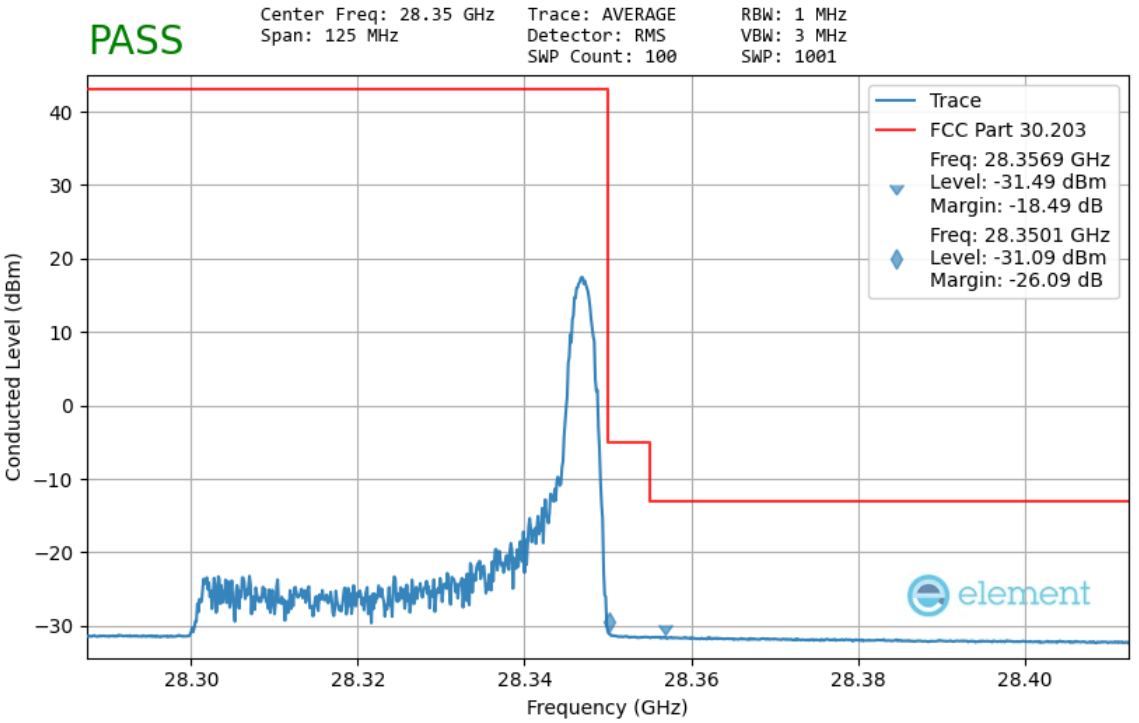
Plot 7-64. Lower Band Edge − DU – MIMO (50MHz-1CC – QPSK Full RB)



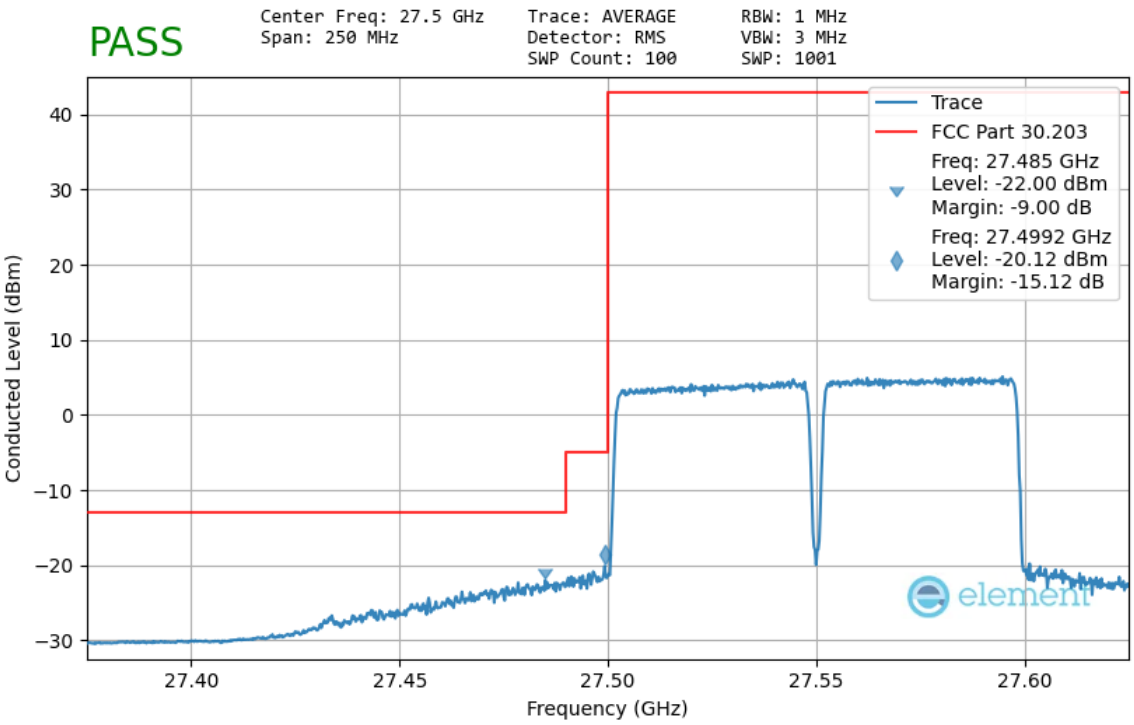
Plot 7-65. Upper Band Edge − DU – MIMO (50MHz-1CC – QPSK Full RB)



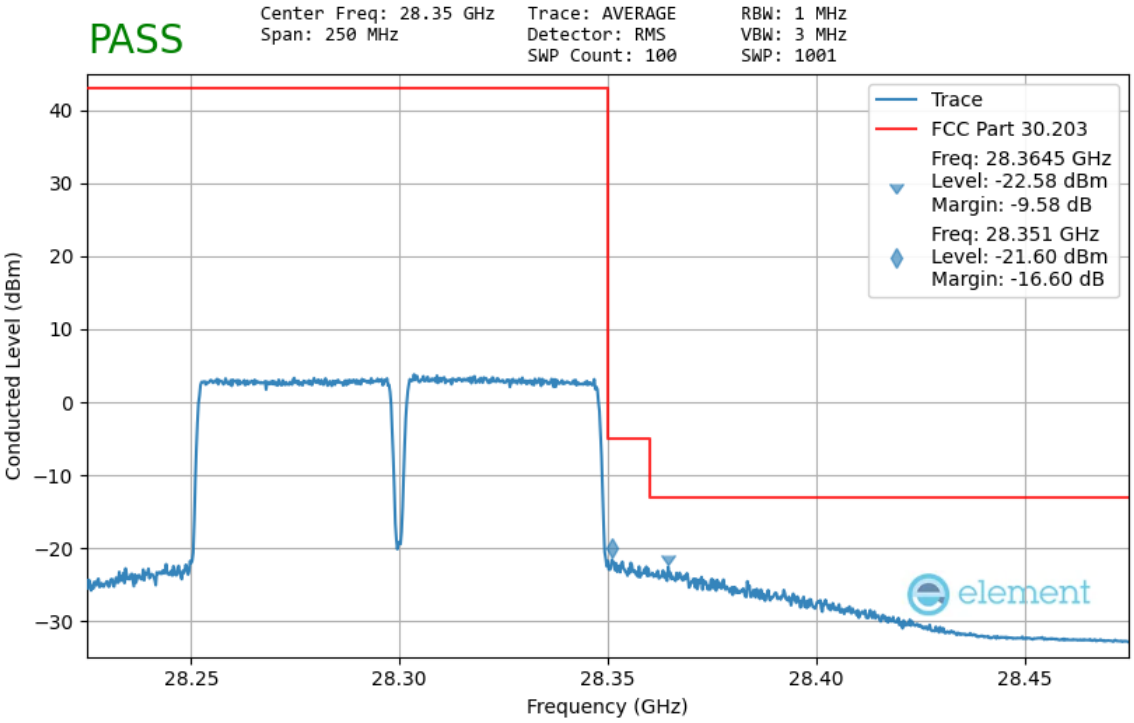
Plot 7-66. Lower Band Edge − DU – MIMO (50MHz-1CC – 1 RB)



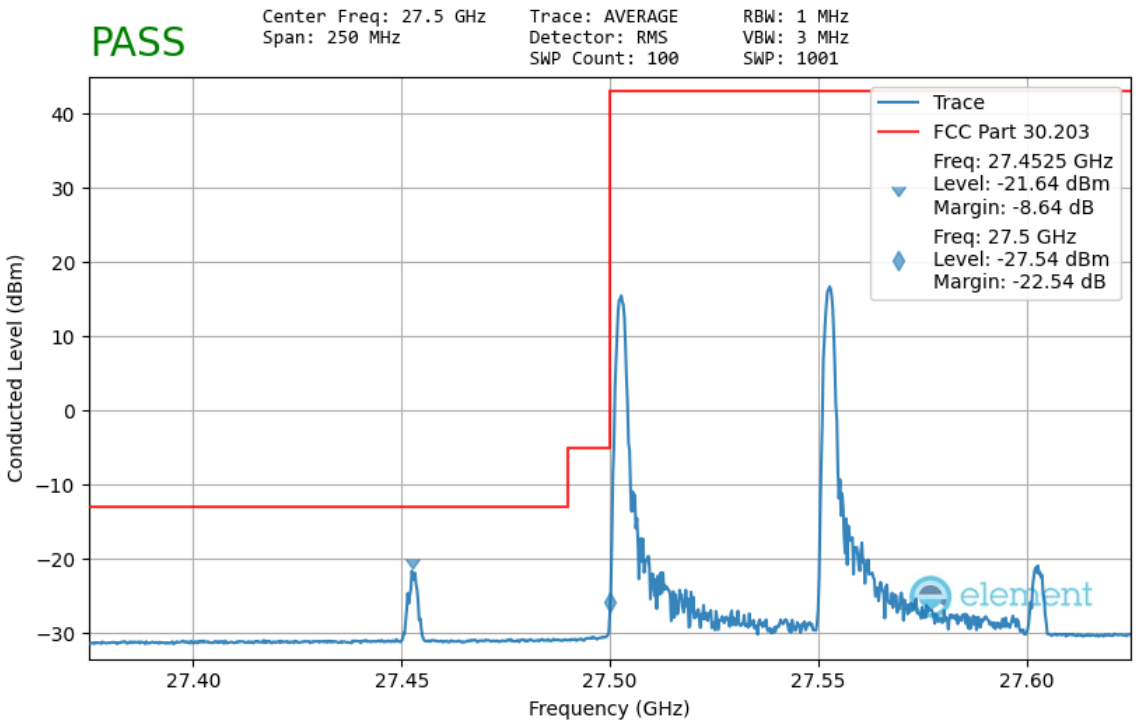
Plot 7-67. Upper Band Edge − DU – MIMO (50MHz-1CC – 1 RB)



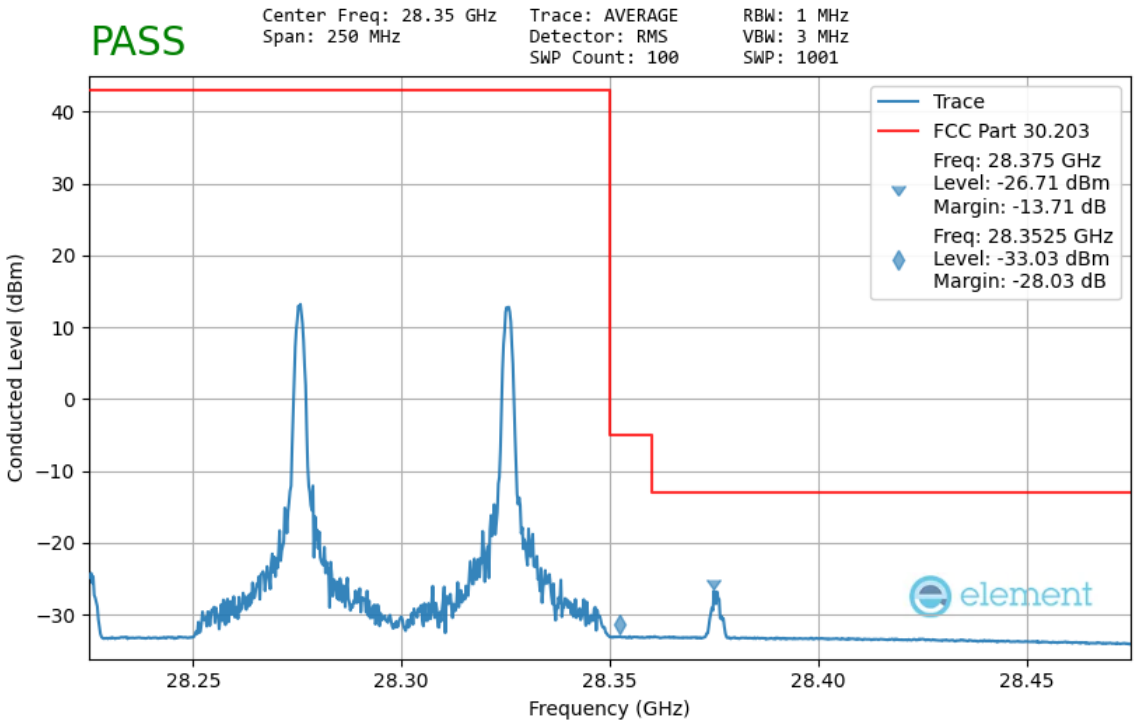
Plot 7-68. Lower Band Edge − DU – MIMO (50MHz-2CC – QPSK Full RB)



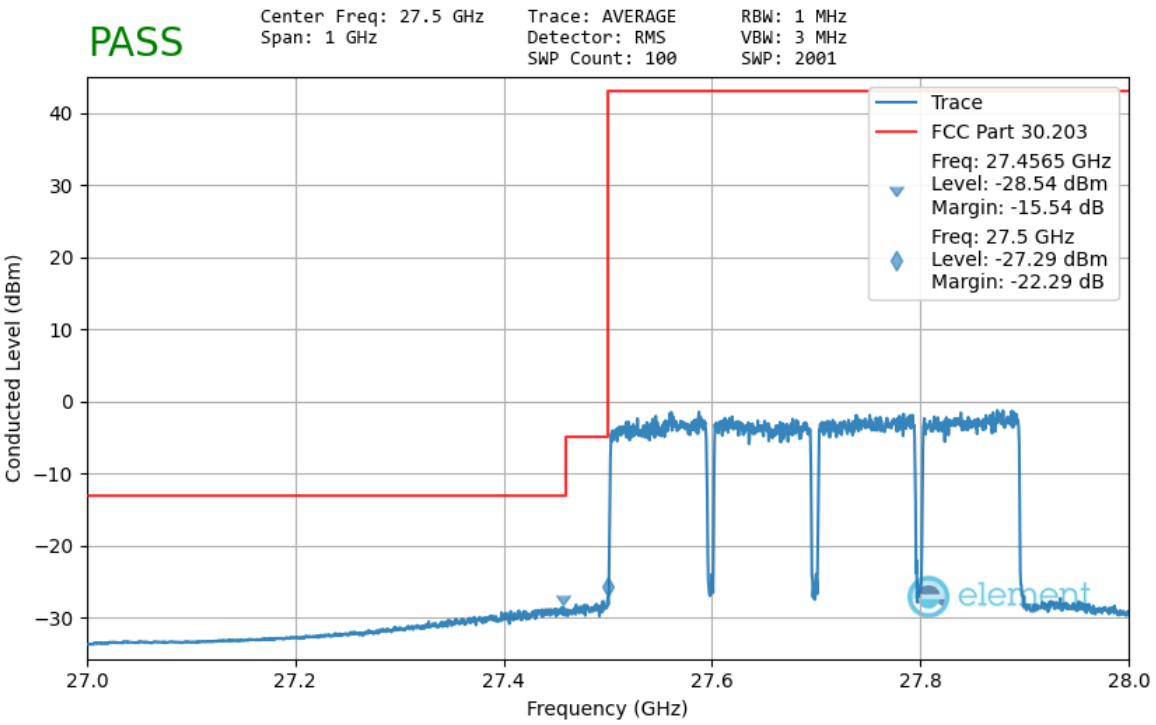
Plot 7-69. Upper Band Edge − DU – MIMO (50MHz-2CC – QPSK Full RB)



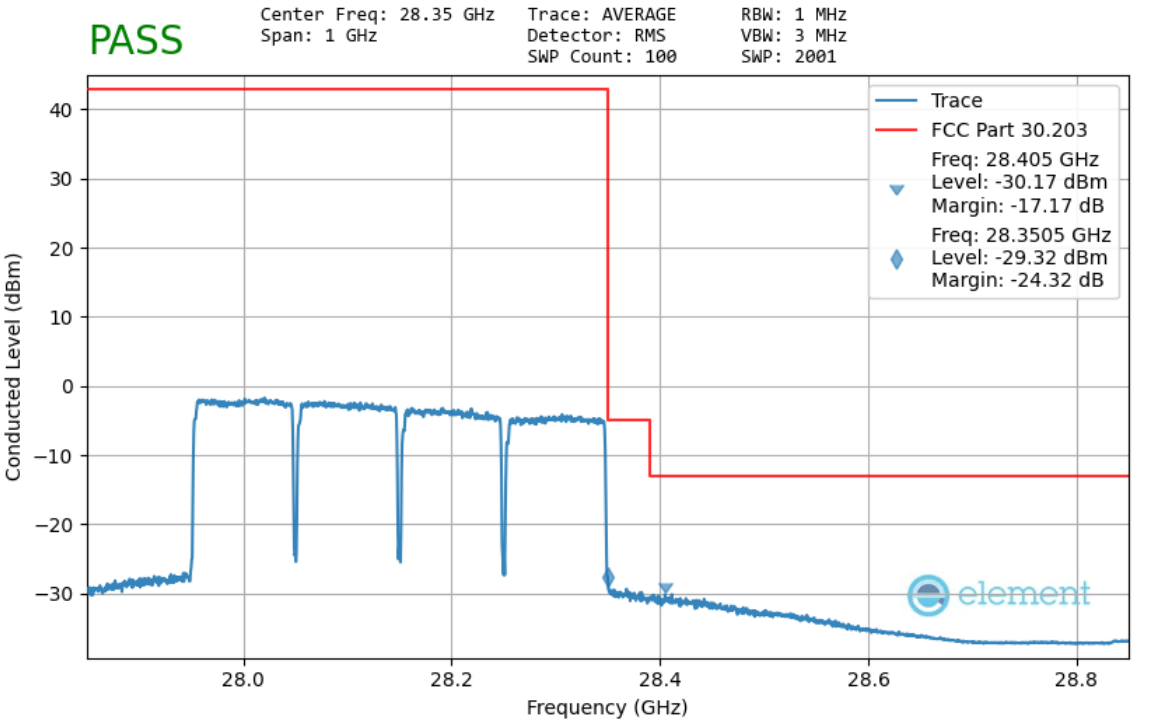
Plot 7-70. Lower Band Edge − DU – MIMO (50MHz-2CC – 1 RB)



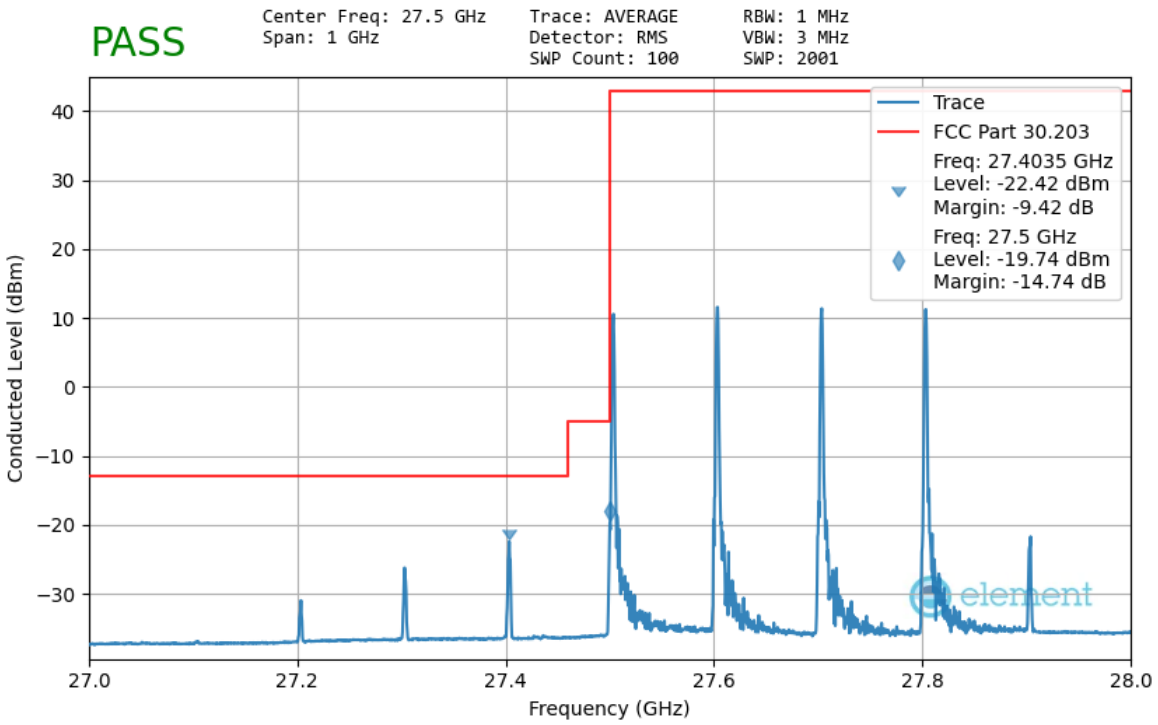
Plot 7-71. Upper Band Edge − DU – MIMO (50MHz-2CC – 1 RB)



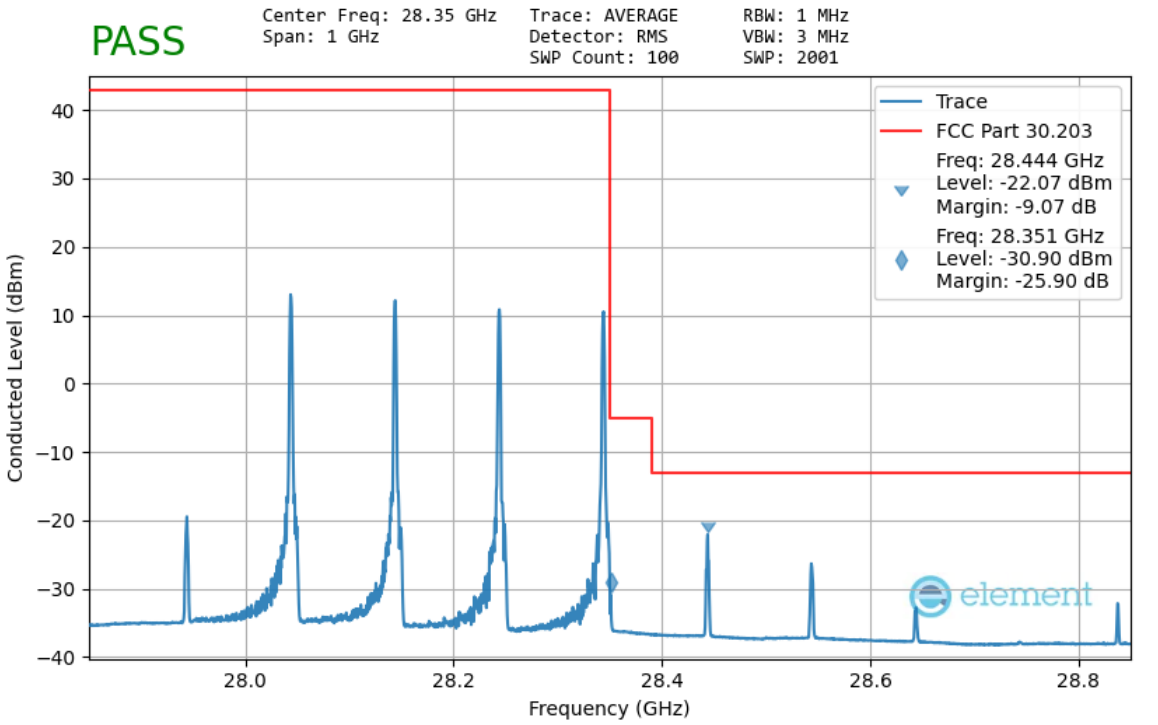
Plot 7-72. Lower Band Edge − DU – MIMO (100MHz-4CC – QPSK Full RB)



Plot 7-73. Upper Band Edge − DU – MIMO (100MHz-4CC – QPSK Full RB)



Plot 7-74. Lower Band Edge − DU – MIMO (100MHz-4CC – 1 RB)



Plot 7-75. Upper Band Edge − DU – MIMO (100MHz-4CC – 1 RB)

7.9 Frequency Stability / Temperature Variation

Test Overview and Limit

Frequency stability testing is performed in accordance with the guidelines of ANSI C63.26-2015. The frequency stability of the transmitter is measured by:

a.) **Temperature:** The temperature is varied from -30°C to +50°C in 10°C increments using an environmental chamber.

b.) **Primary Supply Voltage:** The primary supply voltage is varied from 85% to 115% of the nominal value for non hand-carried battery and AC powered equipment. For hand-carried, battery-powered equipment, primary supply voltage is reduced to the battery operating end point which shall be specified by the manufacturer.

Test Procedure Used

ANSI C63.26-2015 Section 5.6
KDB 842590 D01 v01r02 Section 4.5

Test Settings

1. The carrier frequency of the transmitter is measured at room temperature (20°C to provide a reference).
2. The equipment is turned on in a "standby" condition for fifteen minutes before applying power to the transmitter. Measurement of the carrier frequency of the transmitter is made within one minute after applying power to the transmitter.
3. Frequency measurements are made at 10°C intervals ranging from -30°C to +50°C. A period of at least one half-hour is provided to allow stabilization of the equipment at each temperature level.

Test Setup

The EUT was connected to a spectrum analyzer via a coaxial cable. The EUT was placed inside an environmental chamber, and the opening for the coaxial cable was sealed with a foam plug. The spectrum analyzer was then used to measure changes in the output fundamental frequency of the EUT as the temperature was varied.

Test Notes

The Frequency Deviation column in the table below is the amount of deviation measured from the center frequency of the indicated Reference measurement.

Band n261 - DU

OPERATING FREQUENCY:	27,924,960,000	Hz
CHANNEL:	2077915	
REFERENCE VOLTAGE:	48.00	VDC

VOLTAGE (%)	POWER (VDC)	TEMP (°C)	FREQUENCY (Hz)	Freq. Dev. (Hz)	Deviation (%)
100 %	48.00	+ 20 (Ref)	27,925,672,468	0	0.0000000
100 %		- 30	27,925,632,043	-40,425	-0.0001448
100 %		- 20	27,925,619,337	-53,131	-0.0001903
100 %		- 10	27,925,629,874	-42,594	-0.0001525
100 %		0	27,925,733,567	61,099	0.0002188
100 %		+ 10	27,925,740,187	67,719	0.0002425
100 %		+ 30	27,925,704,554	32,086	0.0001149
100 %		+ 40	27,925,704,492	32,024	0.0001147
100 %		+ 50	27,925,616,798	-55,670	-0.0001993
85 %	40.80	+ 20	27,925,648,129	-24,339	-0.0000872
115 %	55.20	+ 20	27,925,701,489	29,021	0.0001039

Table 7-20. Frequency Stability Data – DU (n261)

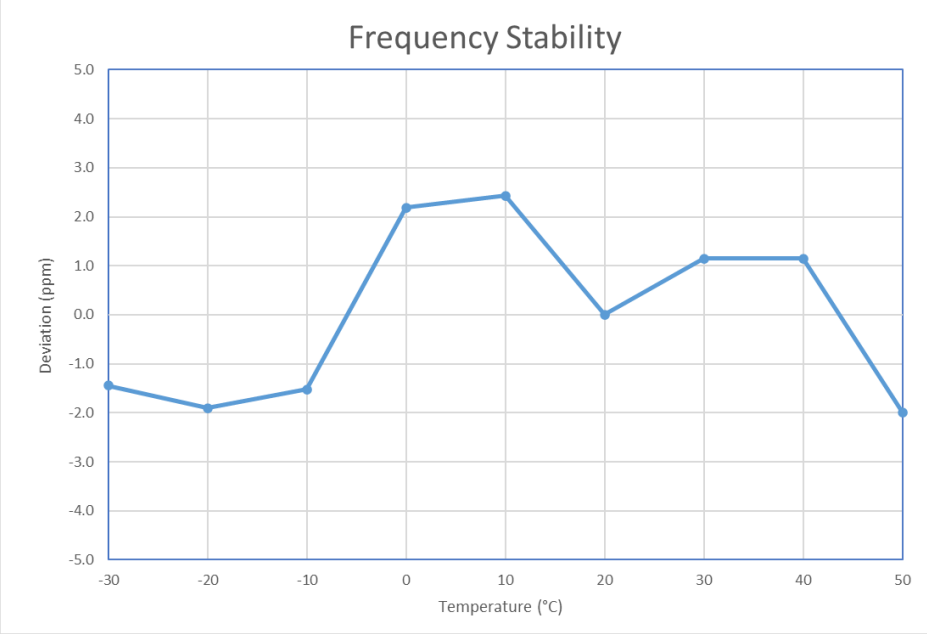


Figure 7-1. Frequency Stability Graph – DU (n261)

Note:

Based on the results of the frequency stability test at the center channel the frequency deviation results measured are very small. As such it is determined that the channels at the band edge would remain in-band when the maximum measured frequency deviation noted during the frequency stability tests is applied. Therefore the device is determined to remain operating in band over the temperature and voltage range as tested.

8.0 CONCLUSION

The data collected relate only to the item(s) tested and show that the **Pivotal Commware 5G mmWave Repeater FCC ID: 2AUVU-5620-12-28** complies with all the requirements of Part 20 and Part 30.

APPENDIX A – VDI MIXER VERIFICATION CERTIFICATE

Virginia Diodes, Inc
979 2nd St. SE
Suite 309
Charlottesville, VA 22902
Phone: 434-297-3257
Fax: 434-297-3258

Certificate of Conformance

To: Dan Pino
Element Materials Technology
7185 Oakland Mills Road
Columbia, MD 21046
United States

From: Virginia Diodes, Inc
979 2nd St. SE
Suite 309
Charlottesville, VA 22902

Packing List No: 224743 **Today's Date:** 11/21/22
Shipping Date: 11/17/22 **PO Number:** US37100165PO-1

Quantity Shipped	Unit	Description	Order-Job Number
1	EA	RETEST-VDIWR19.0SAX-M-M4 WR19SAX / SN: SAX 679	220597-01
1	EA	RETEST-VDIWR12.0SAX-M-M6 WR12SAX / SN: SAX 680	220597-02

The VDI product(s) in this shipment meet(s) the guidelines for performance specifications established in accordance with the corresponding Purchase Order. Data presented in the User Guide, where applicable, has been obtained in accordance with VDI's Quality Management System. All instruments, used to obtain data, which require calibration have been calibrated with equipment traceable to the National Institute of Standards and Technology (NIST) and through NIST to the International System of Units (SI).

Authorized Signature
Virginia Diodes, Inc

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Virginia Diodes, Inc
979 2nd St. SE
Suite 309
Charlottesville, VA 22902
Phone: 434-297-3257
Fax: 434-297-3258

Virginia Diodes, Inc.

Certificate of Conformance

To: Element Materials Technology
7185 Oakland Mills Road
Colombia, MD 21046
United States

From: Virginia Diodes, Inc
979 2nd St. SE
Suite 309
Charlottesville, VA 22902

Packing List No: 230051
Shipping Date: 01/05/23
Today's Date: 01/05/23
PO Number: US37100165PO-1

Quantity Shipped	Unit	Description	Order-Job Number
1	EA	RETEST-VDIWR8.0SAX-M-M9 WR5.1 Spectrum Analyzer Extender / SN: SAX 681	220597-03

The VDI product(s) in this shipment meet(s) the guidelines for performance specifications established in accordance with the corresponding Purchase Order. Data presented in the User Guide, where applicable, has been obtained in accordance with VDI's Quality Management System. All instruments, used to obtain data, which require calibration have been calibrated with equipment traceable to the National Institute of Standards and Technology (NIST) and through NIST to the International System of Units (SI).

Authorized Signature
Virginia Diodes, Inc

Page 1 of 1

Virginia Diodes, Inc
979 2nd St. SE
Suite 309
Charlottesville, VA 22902
Phone: 434-297-3257
Fax: 434-297-3258

Certificate of Conformance

To: Element Materials Technology
7195 Oakland Mills Road
Columbia, MD 21046
United States

From: Virginia Diodes, Inc
979 2nd St. SE
Suite 309
Charlottesville, VA 22902

Packing List No: 230941 **Today's Date:** 03/01/23
Shipping Date: 03/01/23 **PO Number:** Warranty

Quantity Shipped	Unit	Description	Order-Job Number
1	EA	REPAIR-VDIWR5.1SAX-M-M18 WR5.1SAX-M-M18 - Mini Spectrum Analyzer Extension Module / SN: SAX 682	R220106PCT-01

The VDI product(s) in this shipment meet(s) the guidelines for performance specifications established in accordance with the corresponding Purchase Order. Data presented in the User Guide, where applicable, has been obtained in accordance with VDI's Quality Management System. All instruments, used to obtain data, which require calibration have been calibrated with equipment traceable to the National Institute of Standards and Technology (NIST) and through NIST to the International System of Units (SI).

Authorized Signature
Virginia Diodes, Inc

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APPENDIX B – TEST SCOPE ACCREDITATION

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

ELEMENT MATERIALS TECHNOLOGY WASHINGTON DC LLC
(formerly PCTEST)
7185 Oakland Mills Road
Columbia, MD 21046
RJ Ortanez Phone: 410 290 6652

ELECTRICAL

Valid To: May 31, 2024 Certificate Number: 2041.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory at the location listed above, *as well as the three satellite laboratory locations listed below*[1], to perform the following Electromagnetic Compatibility, SAR, HAC, Telecommunications, OTA, Battery, RF, and Conformance and Protocol testing of wireless devices:

Test Technology:	Test Method(s)[2]:
Emissions	
Radiated and Conducted	CFR 47, FCC Part 15B (using ANSI C63.4:2014); CFR 47, FCC Part 18 (using MP-5:1986); CFR 47, FCC Parts 15/C/E (without DFS)/F/G/H (using ANSI C63.10:2013); CFR 47, FCC Part 15E (with DFS) (using FCC KDB 905462 D02 (v02)); CFR 47, FCC Part 15D (using ANSI C63.17:2013); ANSI C63.10:2020; KDB 987594; ETSI TS 134 124 Universal Mobile Telecommunications System (UMTS); (3GPP TS 34.124); (3GPP TS38.124 NR; Electromagnetic Compatibility (EMC) Requirements for Mobile Terminals and Ancillary Equipment); ETSI TS 136 124 LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); (3GPP TS 36.124); ETSI TS 151 010-1 Digital Cellular Telecommunications System (Phase 2+) (GSM); 3GPP TS 51.010-1, Section 12 (Conducted and Radiated Spurious Emissions); EN55011; EN 55032; CNS 13438 (up to 6 GHz); AS/NZS CISPR 11; IEC/CISPR 11; CISPR 32; FCC OET/MP-5; ICES-003; KS C 9811; KS C 9832; VCCI V-3(2016.11); VCCI V-3 (2015.04); VCCI 32-1: VCCI-CISPR 32

Test Technology:	Test Method(s)[2]:
Transmitter/Receiver	RSS-111; RSS-112; RSS-117; RSS-119; RSS-123; RSS-125; RSS-127; RSS-130; RSS-131; RSS-132; RSS-133; RSS-134; RSS-135; RSS-137; RSS-139; RSS-140; RSS-141; RSS-142; RSS-170; RSS-181; RSS-182; RSS-191; RSS-192; RSS-194; RSS-195; RSS-196; RSS-197; RSS-199; RSS-210; RSS-211; RSS-213; RSS-215; RSS-216; RSS-220; RSS-222; RSS-236; RSS-238; RSS-243; RSS-244; RSS-246; RSS-247; RSS-248; RSS-251; RSS-252; RSS-287; RSS-288; RSS-310; RSS-Gen
SAR/RF Exposure	IEEE 1528-2013; RSS-102; EN 50360-2017; EN 62209-1:2016; EN 62209-2:2010/A1:2019; IEC 62209-1 2nd Edition 2016; IEC 62209-2 2010; IEC PAS 63083-2017; EN 50566-2017; IEC 62209-2 AMD 1; Australian Communications Authority Radio Communications (Electromagnetic Radiation – Human Exposure) Standard 2014; ARPANSA RPS S-1(Rev.1):2021; Australia Radiocommunications Equipment (General) Rules 2021; FCC KDB 447498 D01, D02, D03 and D04; FCC KDB 616217 D04; FCC KDB 643646 D01; FCC KDB 865664 D01 and D02; FCC KDB 941225 D01, D05, D05A, D06, and D07; EN 50401:2017; EN 50385:2017; IEC 62311:2008; IEC 62479:2010; EN 62479:2010; EN 50663:2017; EN 62311:2007; EN 62232:2017; IEC 62232:2017; IEEE C95.1-1992; IEEE C95.1-2005; IEEE C95.1: 2019; IEEE C95.3-2002; IEEE C95.3-2021; IEC/IEEE 63195-1:2022; RSS-102 Measurement (SAR, RF Exp., NS, LPD;); SPR-003; SPR-002; SPR-001; SPR-004; SPR-APD; IEC TR 62630:2010; IEEE C95.3.1:2010; IEC TR 63170:2018; AS/NZS 2772.2:2016; EN 62209-3: 2019; IEC 62209-3:2019; ICNIRP (100kHz – 300 GHz):2020; IEC 62311:2019; EN 62311:2020; IEC/IEEE 62209-1528:2020; EN IEC/IEEE 62209-1528; IEC PAS 63184:2021; RRA Public Notification 2018-18, December 7, 2018 KS C 3370-1, KS C 3370-2
Hearing Aid Compatibility	ANSI C63.19:2011; ANSI C63.19:2019; CTIA Test Plan for Hearing Aid Compatibility v.3.1.1 (2017); RSS-HAC; ANSI/TIA-5050-2018
United States Radio	47 CFR FCC Parts 20, 22, 24, 25, 27, 30, 73, 74, 80, 87, 90, 95, 96, 97, 101 (using ANSI/TIA-603-E, TIA-102.CAAA-E, ANSI C63.26:2015)

Test Technology:	Test Method(s)[2]:
European Radio	ETSI EN 302 065-1; ETSI EN 302 065-2; ETSI EN 302 065-3; ETSI EN 302 065-4; ETSI EN 302 291-1; ETSI EN 302 291-2; ETSI EN 302 502; ETSI EN 302 510-1; ETSI EN 302 510-2; ETSI EN 302 537; ETSI EN 301 511; ETSI EN 301 839; ETSI EN 301 893; ETSI EN 301 893; ETSI EN 301 908-1; ETSI EN 301 908-13; ETSI EN 300 220-2; ETSI EN 300 220-3-1; ETSI EN 300 220-3-2; ETSI EN 300 220-4; ETSI EN 300 328; ETSI EN 300 328; ETSI EN 300 330; ETSI EN 300 440; ETSI EN 300 440-2
Taiwan Radio	LP0002; DGT LP0002
Korean Radio	Regulations on Radio Equipment (MSIT Ordinance MSIT No. 86, Jan. 4, 2022); Unlicensed Radio Equipment Established Without Notice (MSIT Public Notification 2022-20, May 10, 2022); Technical Requirements for the Human Protection against Electromagnetic Waves (MSIT Public Notification 2019-4, January 16, 2019); Equipment to be Subject of the Test Procedure for Electromagnetic Field Strength and Specific Absorption Rate (RRA Public Notification (2021-16, October 12, 2021); Technical Requirements for Radio Equipment for Telecommunication Services (RRA Public Notification 2022-15 July 29, 2022); Technical Requirements for Measurement and Test Procedure of Specific Absorption Rate (RRA Public Notification 2018-18, Dec 7, 2018); Technical Requirements for Measurement of Electromagnetic Field Strength (RRA Public Notification 2021-22 Nov 29, 2021); KS X 3123; KS X 3142; KS X 3270; KS X 3271
Australia/New Zealand Radio	AS/NZS 4268:2017
RF, Protocol, and RRM Conformance	
5G NR	3GPP TS 38.508-1; 3GPP TS 38.508-2; 3GPP TS 38.521-1; 3GPP TS 38.521-2; 3GPP TS 38.521-3; 3GPP TS 38.521-4; 3GPP TS 38.522; 3GPP TS 38.523-1; 3GPP TS 38.523-2; 3GPP 38.523-3; 3GPP TS 38.533; 3GPP TS 34.229-5; VZW 5G NR FR2 RFOTA; VZW 5G Protocol Pre-Conformance (TS 38.523-1); VZW 5G NR FR1 Supp RF; VZW 5G NR RF Pre Conformance (TS 38.521-3); VZW 5G NR Radio Resource Management (RRM) Pre-Conformance (TS 38.533); 5G NR FR1 Performance/DEMOD Pre Conformance (TS 38.521-4); VZW 5G NR SA Data Retry; VZW 5G NR SA Voice Services Fallback

Test Technology:	Test Method(s)[2]:
5G NR (cont.)	VZW 5G NR SA Voice, VZW Video and Messaging; VZW 5G NR SA System Selection; VZW 5G WEA TP; VZW 5G Iconography AT&T 10776 Test Plans(5G/4G/3G/2G)
LTE	3GPP TS 36.521-1; 3GPP TS 36.521-3; 3GPP TS 36.523-1; 3GPP 37.571-1; 3GPP 37.571-2; 3GPP TS 34.229-1; ETSI EN 301 908-13 Version 13.1.1 (2019-11); 3GPP Carrier Aggregation; PTCRB NAPRD.03; PTCRB PPMD; PTCRB Cat-M (per RFT132 eMTC); PVG.09 LTE Data Throughput & TR 37.901 Data Throughput Performance; PVG.04 PTCRB Radiated Spurious Emissions; Global Certification Forum (GCF-CC) Certification / LTE Field Test (TS.11); 3GPP Cat-NB & Cat-M; MetroPCS Lab Conformance; AT&T LTE Conformance; AT&T IoT Accelerator Conformance, 19263; VZW Lab Conformance; VZW Supl RF; VZW FR2 Supplementary RF, VZW FR1 Supplementary RF; VZW Supl Signaling Conformance; VZW Supl RRM; VZW LTE LBS Performance; VZW Safe for Network (SFN), VZW Phase 1, VZW Open Development and Field Interoperability Testing (FIT) [3]; VZW Network Extender; VZW PCO; VZW Data Retry; VZW Data Throughput; VZW SMS; VZW AT Commands; VZW CMAS; VZW eMBMS; VZW APN; VZW Cat-M VoLTE; Live Network Extender and Android Test Plan; USCC Lab Conformance; KDDI LTE Device Testing; SoftBank LTE Testing
WCDMA (UTRA)	3GPP TS 34.121-1; 3GPP TS 34.123-1; SoftBank Mobile WCDMA Testing
SVLTE / Multimode	E911 Data Call Processing; Stress Testing; RSSI for MM Devices; LTE LBS Performance; VZW Multimode Supl Signaling; VZW Multimode SMS; VZW Multimode Data Retry
VoLTE	IMS VoIP; Rich Communication Services (RCS); IMS Registration and Retry; ePDG Live Network; E911 for VoLTE; VZW hVoLTE; VZW VoIP and VT Performance; VZW Interband RRM and Protocol
Carrier Aggregation	VZW Carrier Aggregation Supplementary RF; VZW Carrier Aggregation Data Throughout