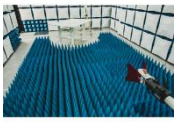
Element Materials Technology
(formerly PCTEST)
18855 Adams Court, Morgan Hill, CA 95037 USA
Tel. 408.538.5600
http://www.element.com



PART 22 MEASUREMENT REPORT

Applicant Name:
Apple Inc.
One Apple Park Way
Cupertino, CA 95014
United States

Date of Testing:
10/01/2023 - 02/13/2024
Test Report Issue Date:
3/22/2024
Test Site/Location:
Element Materials Technology Morgan Hill, CA, USA
Test Report Serial No.:
1C23311270066-07.BCG

FCC ID:	**BCGA2899**
Applicant Name:	**Apple Inc.**

Application Type:	Certification
Model:	A2899, A2900
EUT Type:	Tablet Device
FCC Classification:	PCS Licensed Transmitter (PCB)
FCC Rule Part:	22
Test Procedure(s):	ANSI C63.26-2015, TIA-603-E-2016, KDB 971168 D01 v03r01

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.

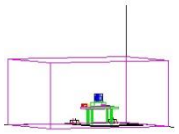
RJ Ortanez
Executive Vice President

Prepared by: WKR0000006193

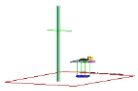
Reviewed by: WKR0000005805

ACCREDITED
CERT #2041.02

TABLE OF CONTENTS



PART 22 MEASUREMENT REPORT



Mode	Bandwidth	Modulation	Tx Frequency Range [MHz]	OBW [MHz]	ERP		Emission Designator
					Max. Power [W]	Max. Power [dBm]	
WCDMA850	5 MHz	Spread Spectrum	826.4 - 846.6	4.1787	0.140	21.45	4M18F9W
Band 5	1.4 MHz	QPSK	824.7 - 848.3	1.1031	0.131	21.16	1M10G7W
		16QAM	824.7 - 848.3	1.1083	0.108	20.33	1M11D7W
		64QAM	824.7 - 848.3	1.1127	0.085	19.30	1M11D7W
		256QAM	824.7 - 848.3	1.1046	0.044	16.40	1M10D7W
	3 MHz	QPSK	825.5 - 847.5	2.7149	0.129	21.10	2M71G7W
		16QAM	825.5 - 847.5	2.7094	0.114	20.57	2M71D7W
		64QAM	825.5 - 847.5	2.7109	0.086	19.35	2M71D7W
		256QAM	825.5 - 847.5	2.7120	0.042	16.24	2M71D7W
	5 MHz	QPSK	826.5 - 846.5	4.5271	0.136	21.33	4M53G7W
		16QAM	826.5 - 846.5	4.5301	0.114	20.55	4M53D7W
		64QAM	826.5 - 846.5	4.5296	0.087	19.40	4M53D7W
		256QAM	826.5 - 846.5	4.5435	0.042	16.27	4M54D7W
	10 MHz	QPSK	829.0 - 844.0	9.0214	0.129	21.12	9M02G7W
		16QAM	829.0 - 844.0	9.0124	0.112	20.51	9M01D7W
		64QAM	829.0 - 844.0	9.0202	0.086	19.32	9M02D7W
		256QAM	829.0 - 844.0	9.0057	0.043	16.34	9M01D7W
Band 26	1.4 MHz	QPSK	824.7 - 848.3	1.1031	0.140	21.45	1M10G7W
		16QAM	824.7 - 848.3	1.1083	0.120	20.79	1M11D7W
		64QAM	824.7 - 848.3	1.1127	0.092	19.65	1M11D7W
		256QAM	824.7 - 848.3	1.1046	0.047	16.71	1M10D7W
	3 MHz	QPSK	825.5 - 847.5	2.7149	0.140	21.45	2M71G7W
		16QAM	825.5 - 847.5	2.7094	0.120	20.78	2M71D7W
		64QAM	825.5 - 847.5	2.7109	0.093	19.68	2M71D7W
		256QAM	825.5 - 847.5	2.7120	0.047	16.70	2M71D7W
	5 MHz	QPSK	826.5 - 846.5	4.5271	0.140	21.45	4M53G7W
		16QAM	826.5 - 846.5	4.5301	0.122	20.88	4M53D7W
		64QAM	826.5 - 846.5	4.5296	0.097	19.86	4M53D7W
		256QAM	826.5 - 846.5	4.5435	0.046	16.59	4M54D7W
	10 MHz	QPSK	829.0 - 844.0	9.0214	0.140	21.45	9M02G7W
		16QAM	829.0 - 844.0	9.0124	0.121	20.84	9M01D7W
		64QAM	829.0 - 844.0	9.0202	0.095	19.80	9M02D7W
		256QAM	829.0 - 844.0	9.0057	0.045	16.58	9M01D7W
ULCA Band 5	10 + 10 MHz	QPSK	829.0 - 844.0	18.8692	0.138	21.39	18M9G7W
		16QAM	829.0 - 844.0	18.8892	0.083	19.17	18M9D7W
		64QAM	829.0 - 844.0	18.8884	0.083	19.20	18M9D7W
		256QAM	829.0 - 844.0	18.8731	0.052	17.12	18M9D7W

EUT Overview

Mode	Bandwidth	Modulation	Tx Frequency Range [MHz]	OBW [MHz]	ERP		Emission Designator
					Max. Power [W]	Max. Power [dBm]	
NR Band n5	5 MHz	π/2 BPSK	826.5 - 846.5	4.4677	0.137	21.38	4M47G7W
		QPSK	826.5 - 846.5	4.4740	0.140	21.45	4M47G7W
		16QAM	826.5 - 846.5	4.4779	0.118	20.72	4M48D7W
		64QAM	826.5 - 846.5	4.4773	0.079	18.96	4M48D7W
		256QAM	826.5 - 846.5	4.4690	0.050	16.95	4M47D7W
	10 MHz	π/2 BPSK	829.0 - 844.0	8.9311	0.137	21.36	8M93G7W
		QPSK	829.0 - 844.0	9.2958	0.139	21.42	9M30G7W
		16QAM	829.0 - 844.0	9.3149	0.110	20.43	9M31D7W
		64QAM	829.0 - 844.0	9.2958	0.075	18.73	9M30D7W
		256QAM	829.0 - 844.0	9.2582	0.050	17.01	9M26D7W
	15 MHz	π/2 BPSK	831.5 - 841.5	13.4350	0.140	21.45	13M4G7W
		QPSK	831.5 - 841.5	14.0601	0.140	21.45	14M1G7W
		16QAM	831.5 - 841.5	14.0855	0.124	20.95	14M1D7W
		64QAM	831.5 - 841.5	14.1302	0.083	19.19	14M1D7W
		256QAM	831.5 - 841.5	14.1143	0.052	17.14	14M1D7W
	20 MHz	π/2 BPSK	834.0 - 839.0	17.8906	0.138	21.41	17M9G7W
		QPSK	834.0 - 839.0	18.9375	0.140	21.45	18M9G7W
		16QAM	834.0 - 839.0	18.9053	0.119	20.74	18M9D7W
		64QAM	834.0 - 839.0	18.8983	0.085	19.29	18M9D7W
		256QAM	834.0 - 839.0	18.8932	0.053	17.26	18M9D7W
NR Band n26	5 MHz	π/2 BPSK	826.5 - 846.5	4.4677	0.138	21.39	4M47G7W
		QPSK	826.5 - 846.5	4.4740	0.138	21.41	4M47G7W
		16QAM	826.5 - 846.5	4.4779	0.115	20.61	4M48D7W
		64QAM	826.5 - 846.5	4.4773	0.090	19.52	4M48D7W
		256QAM	826.5 - 846.5	4.4690	0.052	17.13	4M47D7W
	10 MHz	π/2 BPSK	829.0 - 844.0	8.9311	0.137	21.38	8M93G7W
		QPSK	829.0 - 844.0	9.2958	0.136	21.35	9M30G7W
		16QAM	829.0 - 844.0	9.3149	0.117	20.69	9M31D7W
		64QAM	829.0 - 844.0	9.2958	0.084	19.23	9M30D7W
		256QAM	829.0 - 844.0	9.2582	0.052	17.16	9M26D7W
	15 MHz	π/2 BPSK	831.5 - 841.5	13.4350	0.139	21.43	13M4G7W
		QPSK	831.5 - 841.5	14.0601	0.140	21.45	14M1G7W
		16QAM	831.5 - 841.5	14.0855	0.117	20.70	14M1D7W
		64QAM	831.5 - 841.5	14.1302	0.084	19.26	14M1D7W
		256QAM	831.5 - 841.5	14.1143	0.053	17.27	14M1D7W
	20 MHz	π/2 BPSK	834.0 - 839.0	17.8906	0.139	21.44	17M9G7W
		QPSK	834.0 - 839.0	18.9375	0.140	21.45	18M9G7W
		16QAM	834.0 - 839.0	18.9053	0.116	20.63	18M9D7W
		64QAM	834.0 - 839.0	18.8983	0.084	19.22	18M9D7W
		256QAM	834.0 - 839.0	18.8932	0.053	17.24	18M9D7W

EUT Overview

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 and the Innovation, Science and Economic Development Canada.

1.2 Element Materials Technology Test Location

These measurement tests were conducted at the Element Materials Technology facility located at 18855 Adams Court, Morgan Hill, CA 95037. The measurement facility is compliant with the test site requirements specified in ANSI C63.4-2014 and KDB 414788 D01 v01r01.

1.3 Test Facility / Accreditations

Measurements were performed at Element Materials Technology

- Element Materials Technology is an ISO 17025-2017 accredited test facility under the American Association for Laboratory Accreditation (A2LA) with Certificate number 2041.02 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 Materials Technology 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 Materials Technology facility is a registered (22831) 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 Mutal Recognition Agreements (MRAs).

2.0 PRODUCT INFORMATION

2.1 Equipment Description

The Equipment Under Test (EUT) is the **Apple Tablet Device FCC ID: BCGA2899**. The test data contained in this report pertains only to the emissions due to the EUT's licensed transmitters that operate under the provisions of Part 22.

Test Device Serial No.: MV3WTWWGT4, VGTVQGM9J9, RX5LQRFQ9Q, DLXGYV0005D0000FH3, DLXGYV0002L0000FH3

2.2 Device Capabilities

This device contains the following capabilities:

850/1700/1900 WCDMA/HSPA, Multi-band LTE, 5G NR (FR1), 802.11b/g/n/ax WLAN, 802.11a/n/ac/ax UNII, 802.11a/ax WIFI 6E, 802.15.4, Bluetooth (1x, EDR, LE1M, LE2M, HDR4, HDR8), NB UNII (1x, HDR4, HDR8), WPT

This device supports BT Beamforming

This device supports simultaneous transmission operations, which allows for multiple transmitters to transmit simultaneously on the same antenna. The table below shows all configurations possible.

Antenna	Simultaneous Tx Config	Wifi 2GHz	Bluetooth	Thread	Wifi 5GHz	Wifi 6GHz	NB UNII	LTE/FR1 NR	LTE/FR1 NR
		802.11 b/g/n/ax	BDR, EDR, HDR4/8, LE1/2M	802.15.4	802.11 a/n/ac/ax	802.11 a/ax	BDR, HDR4/8	MB/HB	UHB
Antenna 3b	Config 1	✗	✗	✗	✓	✗	✗	✓	✗
Antenna 3b	Config 2	✗	✗	✗	✗	✓	✗	✓	✗
Antenna 3b	Config 3	✗	✗	✗	✗	✗	✓	✓	✗
Antenna 3a	Config 4	✓	✗	✗	✗	✗	✗	✗	✓
Antenna 3a	Config 5	✗	✓	✗	✗	✗	✗	✗	✓
Antenna 3a	Config 6	✗	✗	✓	✗	✗	✗	✗	✓
Antenna 1a	Config 7	✓	✗	✗	✗	✗	✗	✗	✓
Antenna 1a	Config 8	✗	✓	✗	✗	✗	✗	✗	✓
Antenna 1a	Config 9	✗	✗	✓	✗	✗	✗	✗	✓
Antenna 1b	Config 10	✗	✗	✗	✓	✗	✗	✓	✗
Antenna 1b	Config 11	✗	✗	✗	✗	✓	✗	✓	✗
Antenna 1b	Config 12	✗	✗	✗	✗	✗	✓	✓	✗

Table 2-1. Simultaneous Transmission Configurations

✓ = Support; ✗ = Not Support

Note:

All the above simultaneous transmission configurations have been tested and the worst case configuration was found to be Config 8 and reported in RF Bluetooth and RF FCC Part 96 reports.

Specific 2.4GHz Wi-Fi antenna that can only transmit simultaneously with 2.4GHz Bluetooth antenna is listed in the SAR test report. For BT (2.4GHz) in connected mode and Wi-Fi (2.4GHz) - Wi-Fi max power will not exceed minimum of (13.5dBm, SAR max cap, Reg max cap) power. For BT (2.4GHz) in disconnected mode and Wi-Fi (2.4GHz) - BT will be using iPA only and Wi-Fi max power will not exceed minimum of (SAR max cap, Reg max cap) power. Bluetooth can simultaneously transmit with IEEE 802.11a/n/ac/ax 5/6 GHz on separate antenna.

2.3 Antenna Description

The following antenna gains provided by the manufacturer were used for testing.

Band	Antenna Gain [dBi]	
	Antenna 4	Antenna 2
WCDMA 850	-2.1	-2.1
LTE Band 26/5		
NR Band n26/5		

Table 2-2. Highest Antenna Gain

2.4 Test Support Equipment

1	Apple MacBook Pro	Model:	A2141	S/N:	C02H604EQ05D
	w/AC/DC Adapter	Model:	A2166	S/N:	C4H042705ZNPM0WA6
2	Apple USB-C Cable	Model:	Spartan	S/N:	GXK1336018XKTR024
3	USB-C Cable	Model:	A246C	S/N:	DWH80115BK826GV19
	w/ AC Adapter	Model:	A2305	S/N:	C4H95160004PF4F4V
4	DC Power Supply	Model:	KPS3010D	S/N:	N/A
5	Apple Pencil	Model:	A2538	S/N:	KJ26TCFXJW

Table 2-3. Test Support Equipment

2.5 Test Configuration

The EUT was tested per the guidance of ANSI C63.26 2015, TIA-603-E-2016 and KDB 971168 D01 v03r01. See Section 7.0 of this test report for a description of the radiated and antenna port conducted emissions tests.

For emissions from 1GHz – 18GHz, low, mid, and high channels were tested with highest power and worst case configuration. The emissions below 1GHz were tested with the highest transmitting power and the worst case channel.

The EUT was manipulated through three orthogonal planes of X-orientation (flatbed), Y-orientation (landscape), and Z-orientation (portrait) during the testing. Only the worst case emissions were reported in this test report.

2.6 Software and Firmware

The test was conducted with firmware version 21E8197 installed on the EUT.

2.7 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 documents titled “American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services” (ANSI C63.26-2015 and TIA-603-E-2016) and “Procedures for Compliance Measurement of the Fundamental Emission Power of Licensed Wideband (> 1 MHz) Digital Transmission Systems” (KDB 971168 D01 v03r01) were used in the measurement of the EUT.

Deviation from Measurement Procedure……...……...None

3.2 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. 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.

The equipment under test was transmitting while connected to its integral antenna and is placed on a turntable 3 meters from the receive antenna. The receive antenna height is adjusted between 1 and 4 meter height, the turntable is rotated through 360 degrees, and the EUT is manipulated through all orthogonal planes representative of its typical use to achieve the highest reading on the receive spectrum analyzer.

For radiated spurious emissions measurements and calculations, conversion method is used per the formulas in KDB 971168 Section 5.8.4. Field Strength (EIRP) is calculated using the following formulas:

$$E_{[dB\mu V/m]} = \text{Measured amplitude level}_{[dBm]} + 107 + \text{Cable Loss}_{[dB]} + \text{Antenna Factor}_{[dB/m]}$$

And

$$EIRP_{[dBm]} = E_{[dB\mu V/m]} + 20\log D - 104.8;\ \text{where D is the measurement distance in meters.}$$

All radiated measurements are performed in a chamber that meets the site requirements per ANSI C63.4-2014.

Per KDB 414788 D01 v01r01, radiated emission test sites other than open-field test sites (e.g., shielded anechoic chambers), may be employed for emission measurements below 30MHz if characterized so that the measurements correspond to those obtained at an open-field test site. To determine test site equivalency, a reference sample transmitting at 149kHz was measured on an open field test site (asphalt with no ground plane) and then measured in the 3m semi-anechoic chamber. A calibrated 60cm loop antenna was used while the reference device was rotated through the X, Y and Z axis in order to capture the worst case level. A maximum deviation of 2.77dB at 149kHz was measured when comparing the 3 meter semi-anechoic chamber to the open field site.

Radiated spurious emission levels are investigated with the receive antenna horizontally and vertically polarized per ANSI C63.26-2015 and TIA-603-E-2016.

4.0 MEASUREMENT UNCERTAINTY

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.23-2012.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	2.07
Radiated Disturbance (<30MHz)	4.12
Radiated Disturbance (30MHz-1GHz)	4.85
Radiated Disturbance (1-18GHz)	5.08
Radiated Disturbance (>18GHz)	4.59

5.0 TEST EQUIPMENT CALIBRATION DATA

Test Equipment Calibration is traceable to the National Institute of Standards and Technology (NIST). 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
Agilent Technologies	N9030A	3Hz-44GHz PXA Signal Analyzer	6/21/2023	Annual	6/21/2024	MY49430244
ESPEC	SU-241	Tabletop Temperature Chamber	11/17/2023	Annual	11/17/2024	92009574
ETS-Lindgren	3117	Double Ridged Guide Antenna (1-18 GHz)	3/30/2023	Annual	3/30/2024	00218555
Keysight Technology	N9040B	UXA Signal Analyzer	11/5/2023	Annual	11/5/2024	MY57213068
Rohde & Schwarz	TS-PR18	Pre-Amplifier (1GHz - 18GHz)	8/31/2023	Annual	8/31/2024	100052
Rohde & Schwarz	FSV40	Signal Analyzer (10Hz-40GHz)	5/11/2023	Annual	5/11/2024	101619
Rohde & Schwarz	ESW44	EMI Test Receiver	6/6/2023	Annual	6/6/2024	101668
Rohde & Schwarz	TS-PR8	Pre-Amplifier (30MHz - 8GHz)	6/22/2023	Annual	6/22/2024	102356
Rohde & Schwarz	CMW500	Wideband Radio Communication Tester	11/30/2023	Annual	11/30/2024	161616
Rohde & Schwarz	CMW500	Wideband Radio Communication Tester	12/27/2023	Annual	12/27/2024	164715
Rohde & Schwarz	TS-PR1840	Pre-Amplifier (18GHz - 40GHz)	6/2/2023	Annual	6/2/2024	100050
Rohde & Schwarz	HFH2-Z2	Loop Antenna	5/1/2023	Annual	5/1/2024	100519
Rohde & Schwarz	FSW43	Signal Analyzer (2Hz-43.5GHz)	7/13/2023	Annual	7/13/2024	101261
Schwarzbeck	VULB 9162	Bilog Antenna (30MHz - 6GHz)	4/17/2023	Annual	4/17/2024	00304

Table 5-1. Test Equipment

Notes:

1. For equipment listed above that has a calibration date or calibration due date that falls within the test date range, care was taken to ensure that this equipment was used after the calibration date and before the calibration due date.

6.0 SAMPLE CALCULATIONS

Emission Designator

WCDMA Emission Designator

Emission Designator = 4M16F9W
WCDMA BW = 4.16 MHz
F = Frequency Modulation
9 = Composite Digital Info
W = Combination (Audio/Data)

π/2 BPSK / QPSK Modulation

Emission Designator = 8M62G7W
BW = 8.62 MHz
G = Phase Modulation
7 = Quantized/Digital Info
W = Combination of Any

QAM Modulation

Emission Designator = 8M45D7W
BW = 8.45 MHz
D = Amplitude/Angle Modulated
7 = Quantized/Digital Info
W = Combination of Any

Spurious Radiated Emission

Example: Spurious emission at 3700.40 MHz

The receive spectrum analyzer reading at 3 meters with the EUT on the turntable was –81.0 dBm. The gain of the substituted antenna is 8.1 dBi. The signal generator connected to the substituted antenna terminals is adjusted to produce a reading of –81.0 dBm on the spectrum analyzer. The loss of the cable between the signal generator and the terminals of the substituted antenna is 2.0 dB at 3700.40 MHz. So 6.1 dB is added to the signal generator reading of –30.9 dBm yielding –24.80 dBm. The fundamental EIRP was 25.50 dBm so this harmonic was 25.50 dBm – (-24.80) = 50.3 dBc.

7.0 TEST RESULTS

7.1 Summary

Company Name: Apple Inc.

FCC ID: BCGA2899

FCC Classification: PCS Licensed Transmitter (PCB)

Mode(s): WCDMA/LTE/NR

Test Condition	Test Description	FCC Part Section(s)	Test Limit	Test Result	Reference
CONDUCTED	Occupied Bandwidth	2.1049	N/A	N/A	Section 7.2
	Conducted Band Edge / Spurious Emissions	2.1051, 22.917(a)	-13 dBm at Band Edge and for all out-of-band emissions	PASS	Sections 7.3, 7.4
	Transmitter Conducted Output Power	2.1046	N/A	N/A	See RF Exposure Report
	Effective Radiated Power	22.913(a)(5)	< 7 Watts max. ERP	PASS	Section 7.5
	Frequency Stability	2.1055, 22.355	±2.5 ppm	PASS	Section 7.7
RADIATED	Radiated Spurious Emissions	2.1053, 22.917(a)	-13 dBm for all out-of-band emissions	PASS	Section 7.6

Table 7-1. Summary of Test Results

Notes:

1. All modes of operation and data rates were investigated. The test results shown in the following sections represent the worst case emissions.

2. The analyzer plots were all taken with a correction table loaded into the analyzer. The correction table was used to account for the losses of the cables, directional couplers, and attenuators used as part of the system to maintain a link between the call box and the EUT at all frequencies of interest.

3. All antenna port conducted emissions testing was performed on a test bench with the antenna port of the EUT connected to the spectrum analyzer through calibrated cables, attenuators, and couplers.

4. All conducted emissions measurements are performed with automated test software to capture the corresponding plots necessary to show compliance. The measurement software utilized is Element EMC Software Tool v1.1.

7.2 Occupied Bandwidth

§2.1049

Test Overview

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. All modes of operation were investigated and the worst case configuration results are reported in this section. All ports were tested and only the worst case data were reported.

Test Procedure Used

KDB 971168 D01 v03r01 – Section 4.2

Test Settings

1. The signal analyzer's automatic bandwidth measurement capability was used to perform the 99% occupied bandwidth and the 26dB 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 Setup

The EUT and measurement equipment were set up as shown in the diagram below.

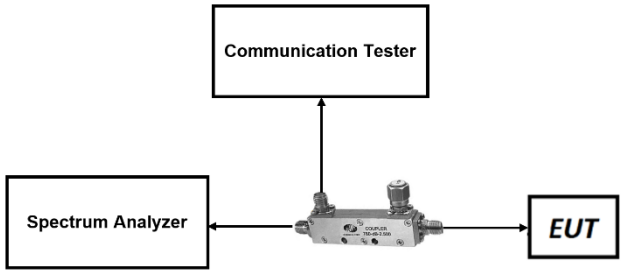
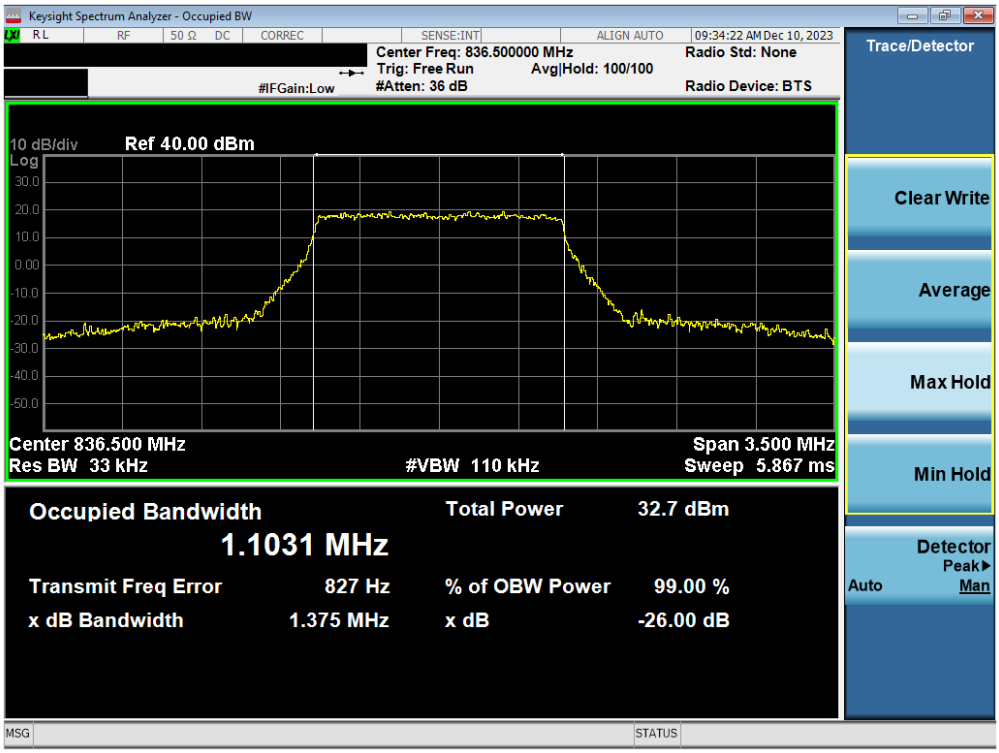


Figure 7-1. Test Instrument & Measurement Setup

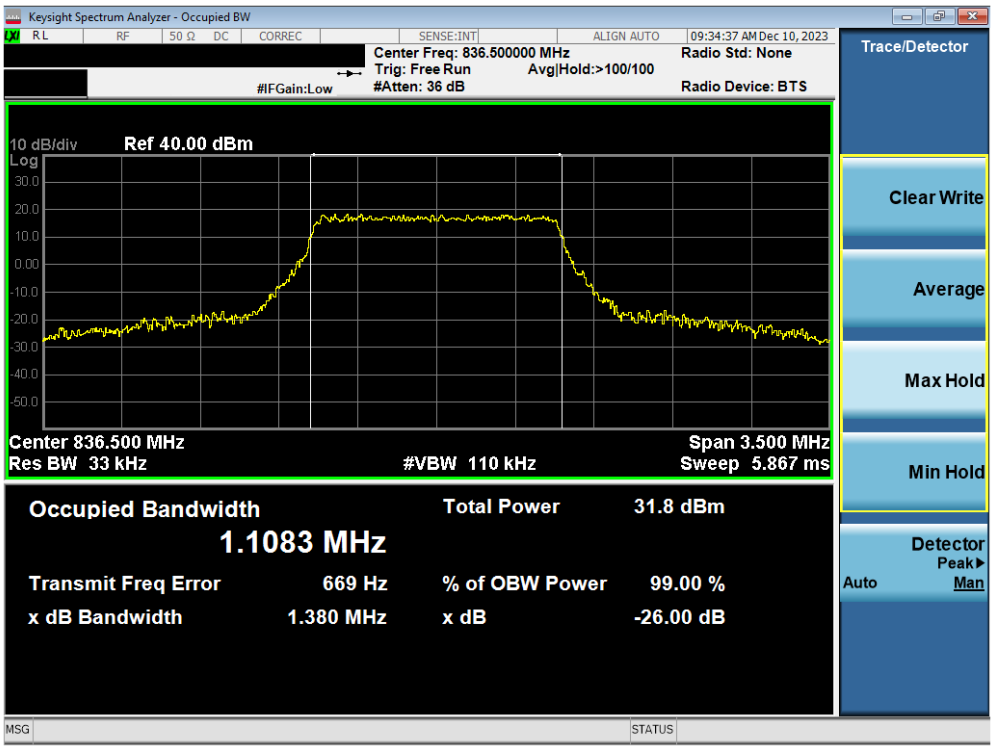
Test Notes

None.

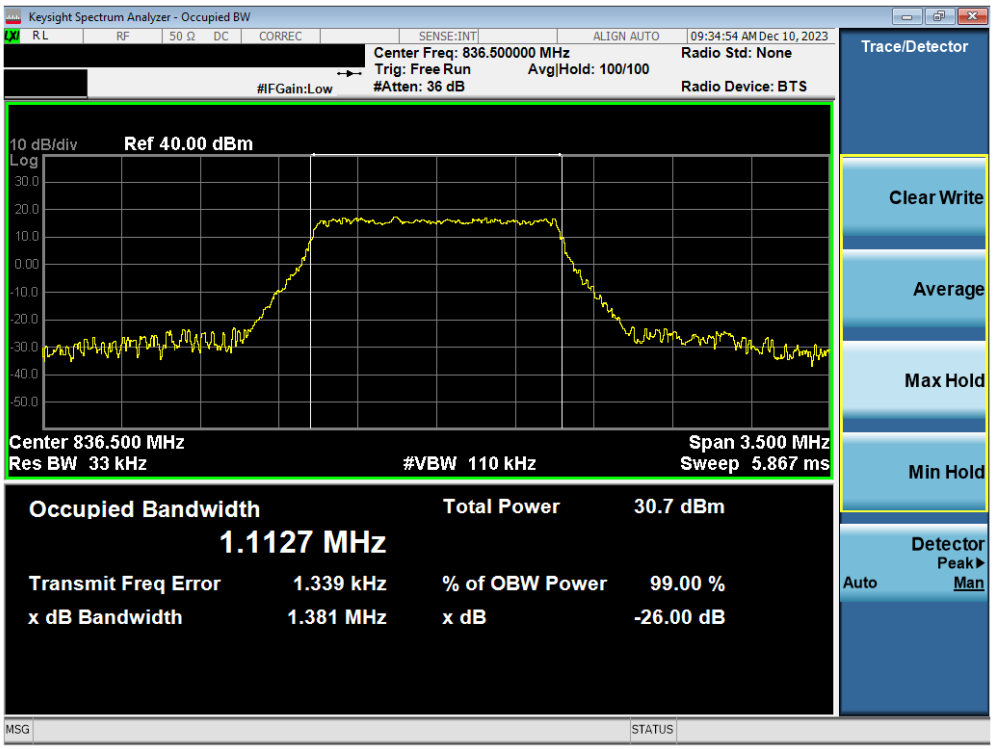
LTE Band 26/5



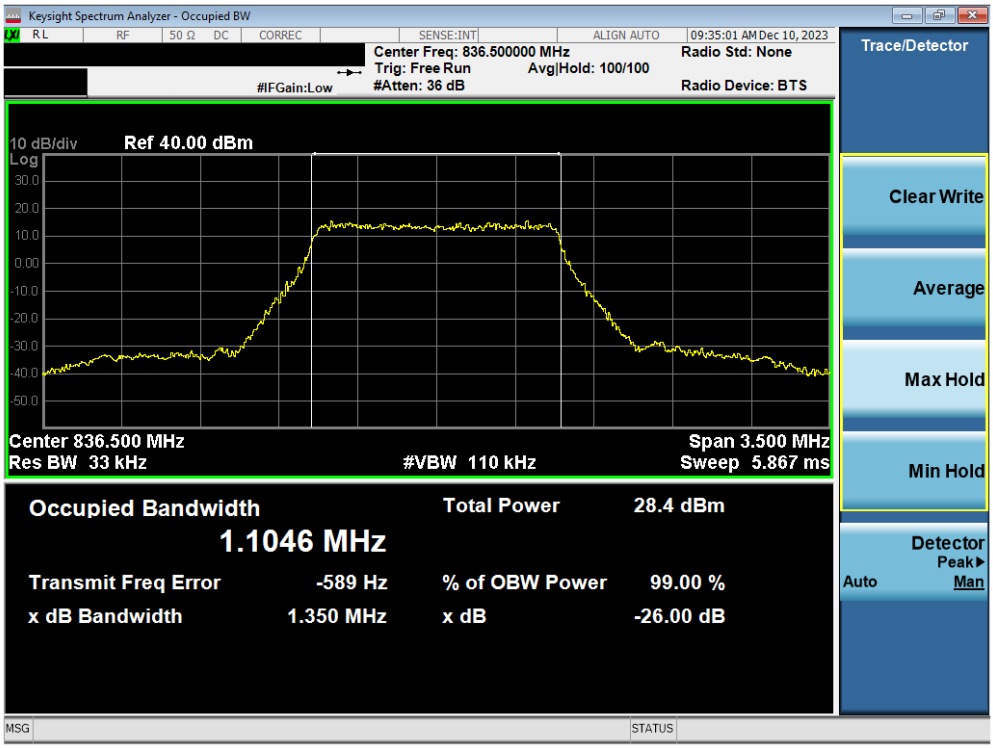
Plot 7-1. Occupied Bandwidth Plot (LTE Band 26/5 - 1.4MHz QPSK - Full RB Configuration)



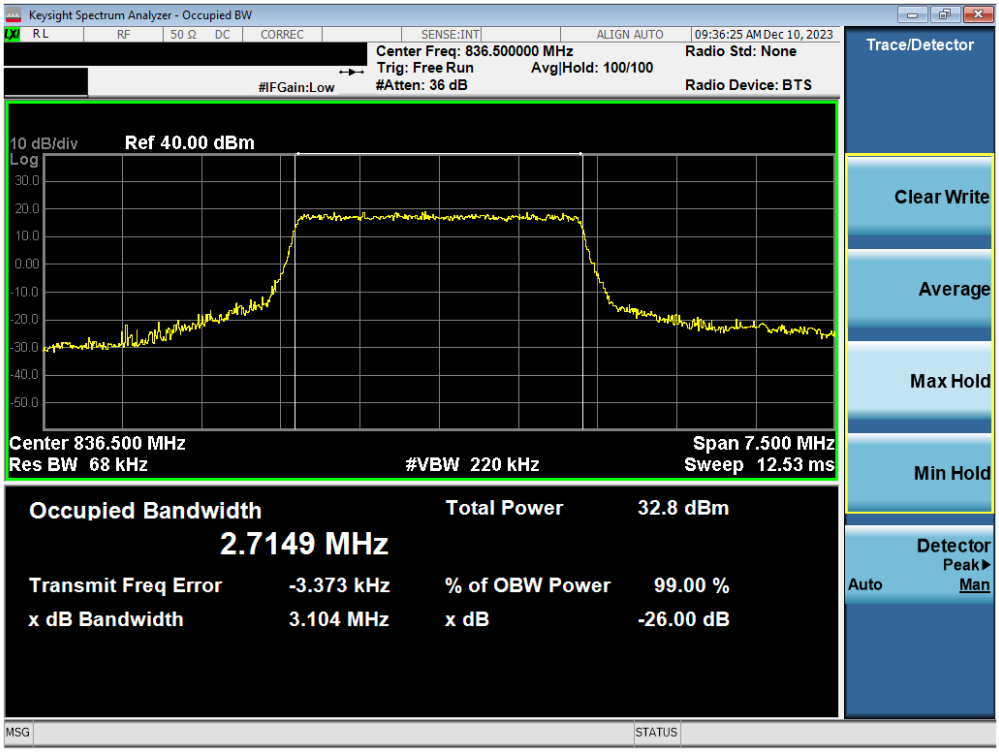
Plot 7-2. Occupied Bandwidth Plot (LTE Band 26/5 - 1.4MHz 16-QAM - Full RB Configuration)



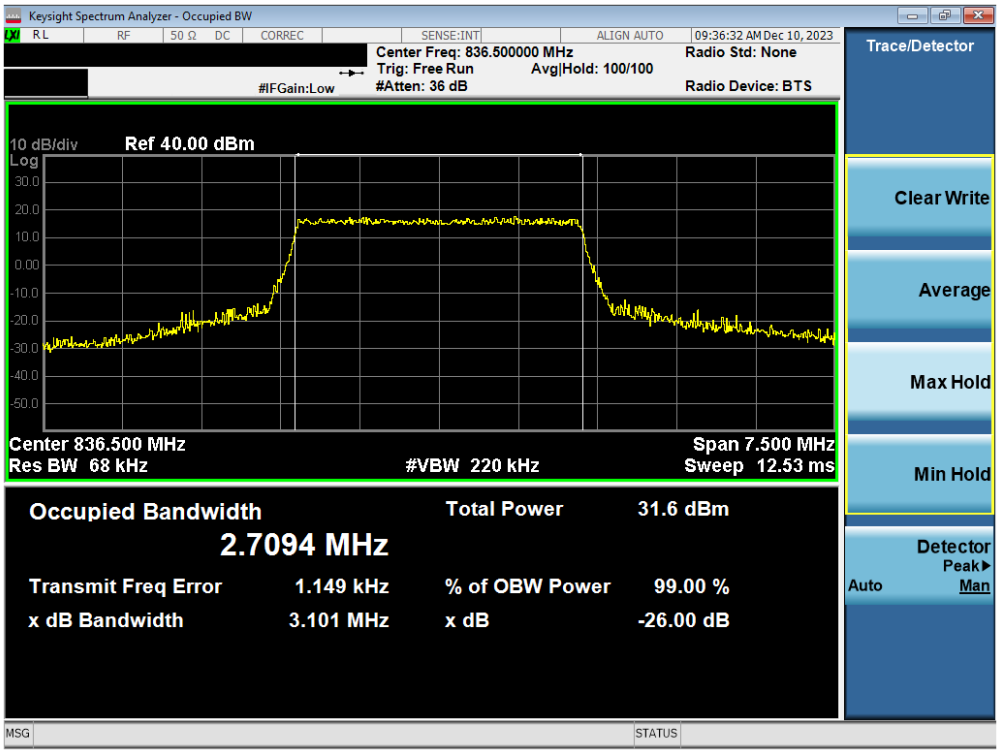
Plot 7-3. Occupied Bandwidth Plot (LTE Band 26/5 - 1.4MHz 64-QAM - Full RB Configuration)



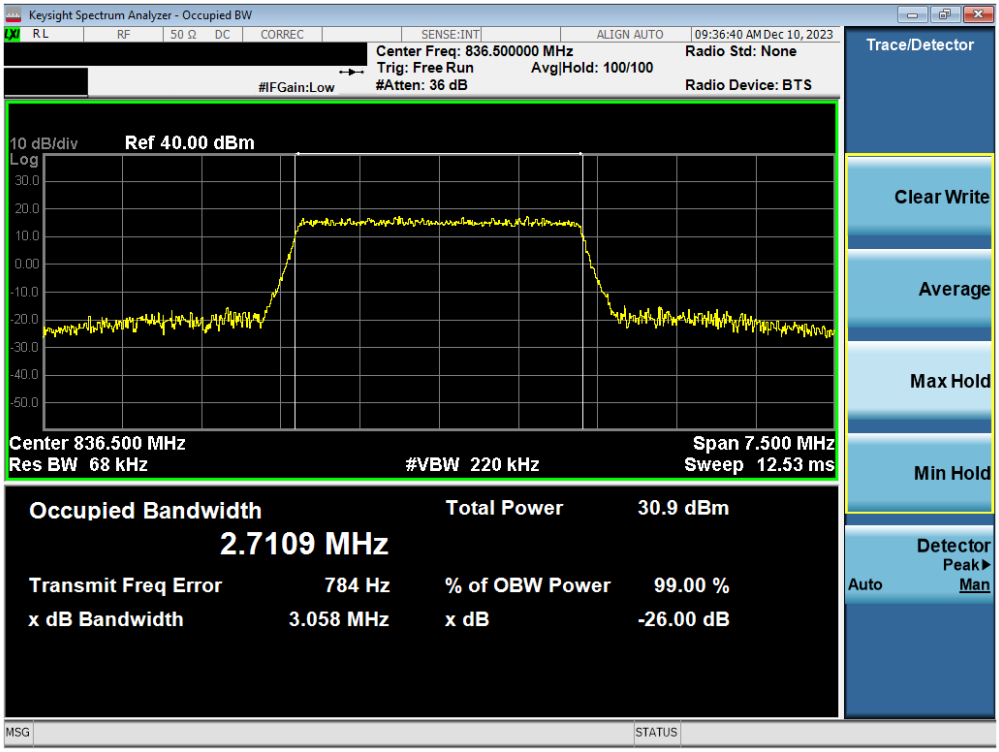
Plot 7-4. Occupied Bandwidth Plot (LTE Band 26/5 - 1.4MHz 256-QAM - Full RB Configuration)



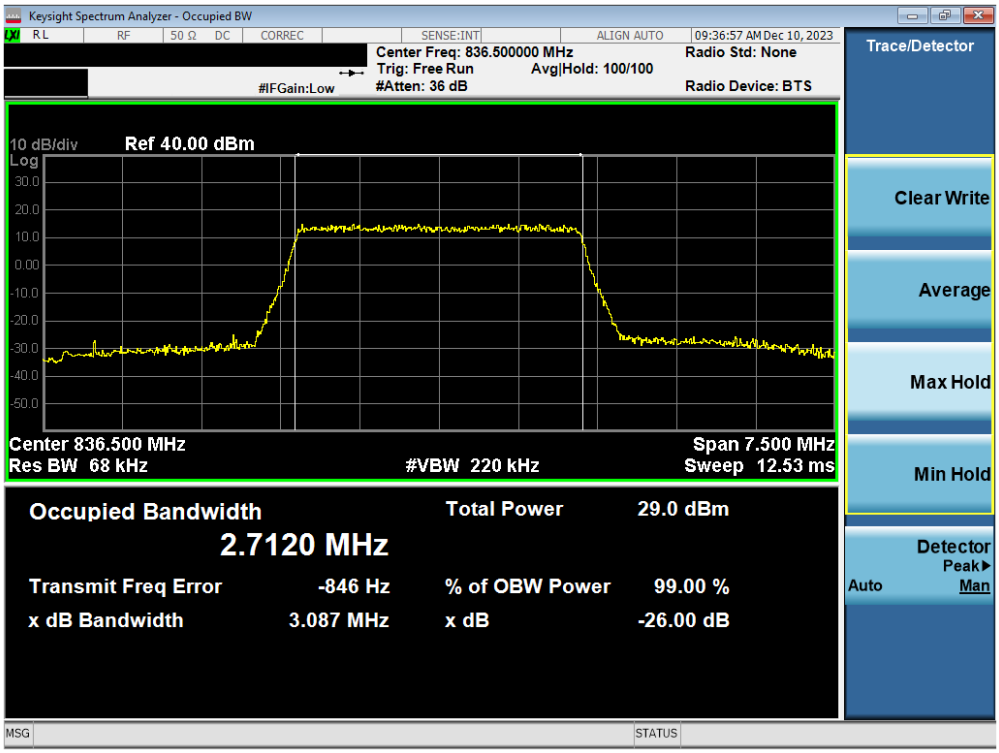
Plot 7-5. Occupied Bandwidth Plot (LTE Band 26/5 - 3MHz QPSK - Full RB Configuration)



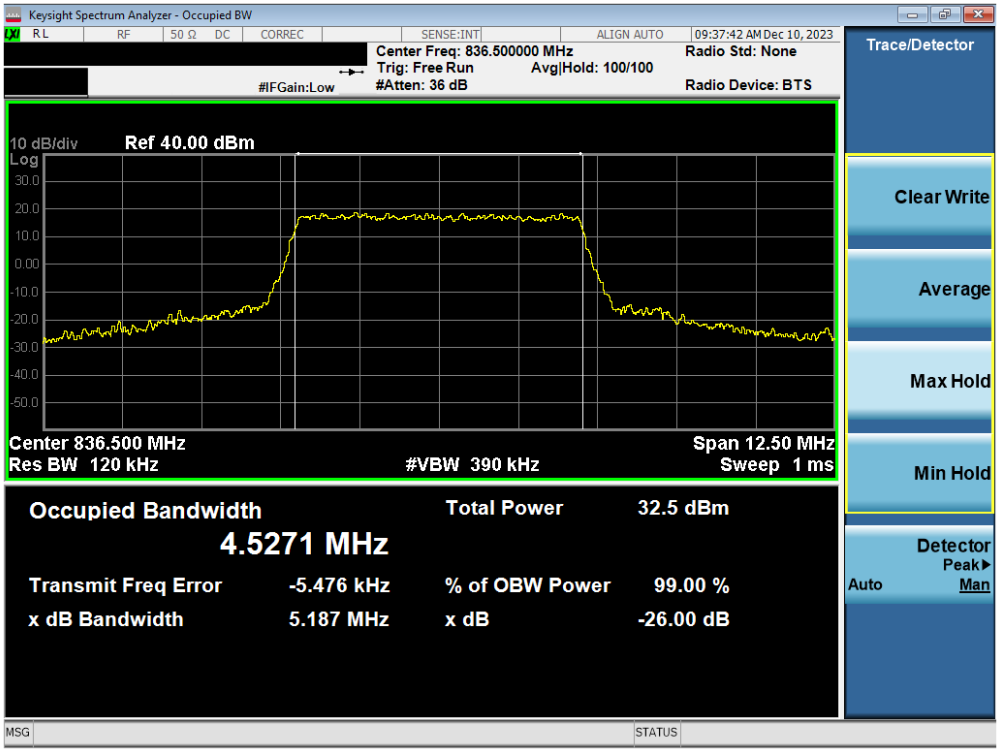
Plot 7-6. Occupied Bandwidth Plot (LTE Band 26/5 - 3MHz 16-QAM - Full RB Configuration)



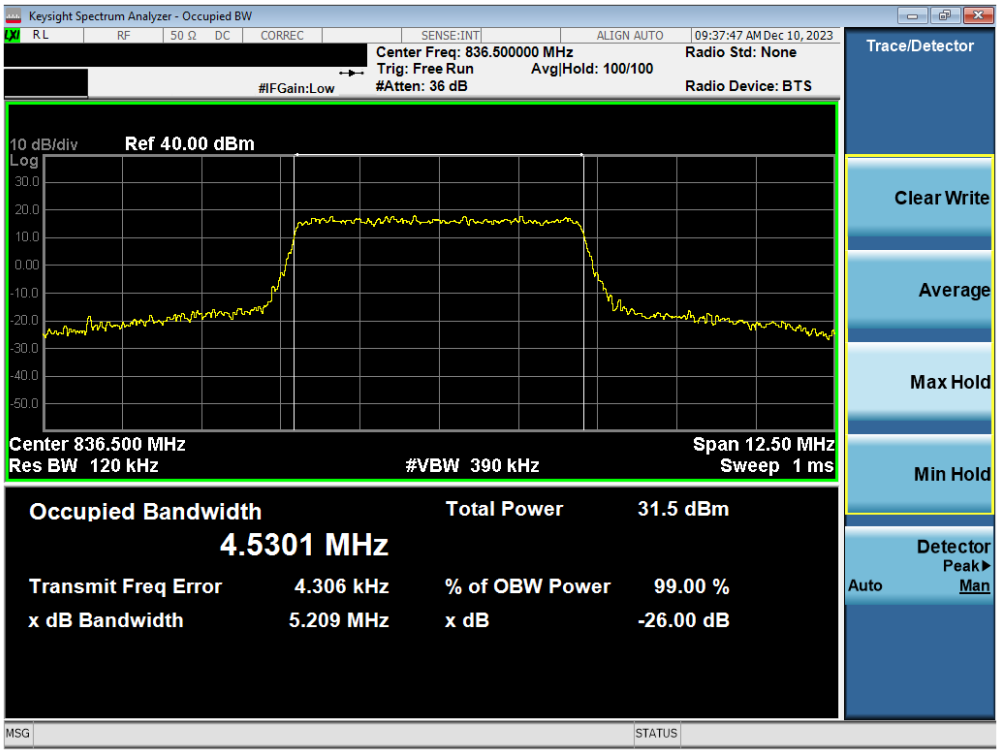
Plot 7-7. Occupied Bandwidth Plot (LTE Band 26/5 - 3MHz 64-QAM - Full RB Configuration)



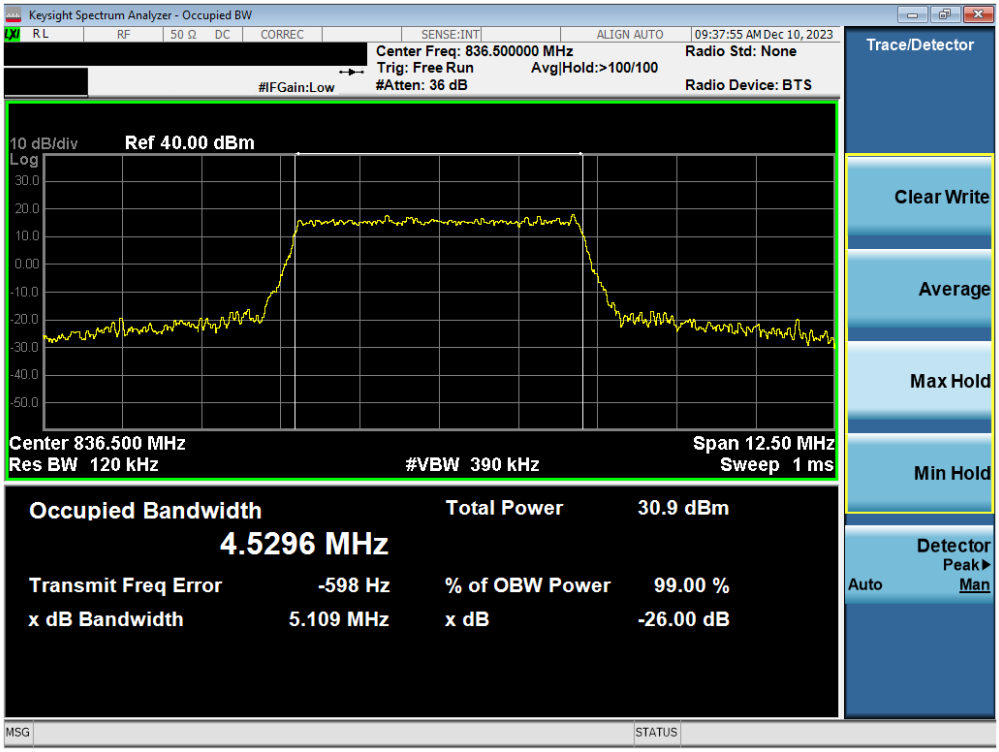
Plot 7-8. Occupied Bandwidth Plot (LTE Band 26/5 - 3MHz 256-QAM - Full RB Configuration)



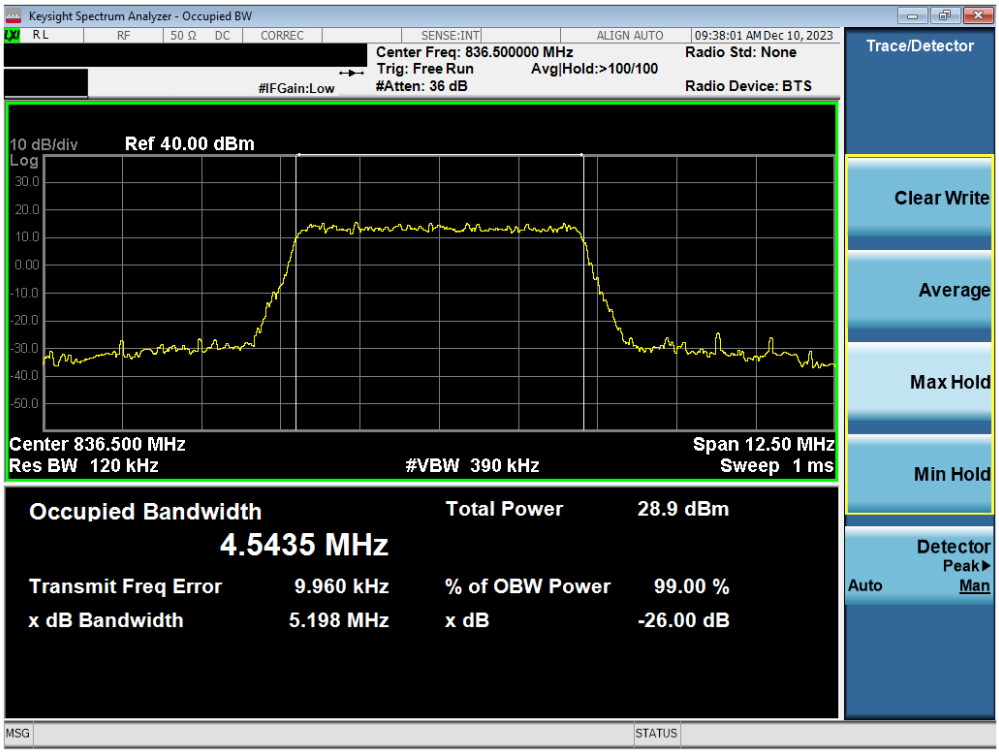
Plot 7-9. Occupied Bandwidth Plot (LTE Band 26/5 - 5MHz QPSK - Full RB Configuration)



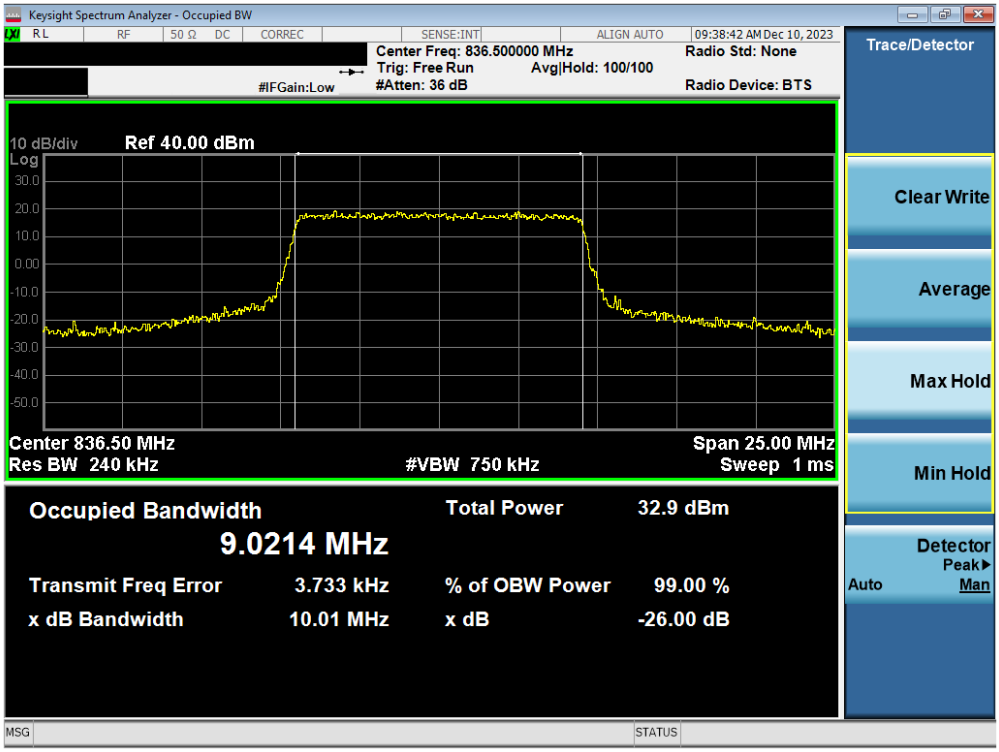
Plot 7-10. Occupied Bandwidth Plot (LTE Band 26/5 - 5MHz 16-QAM - Full RB Configuration)



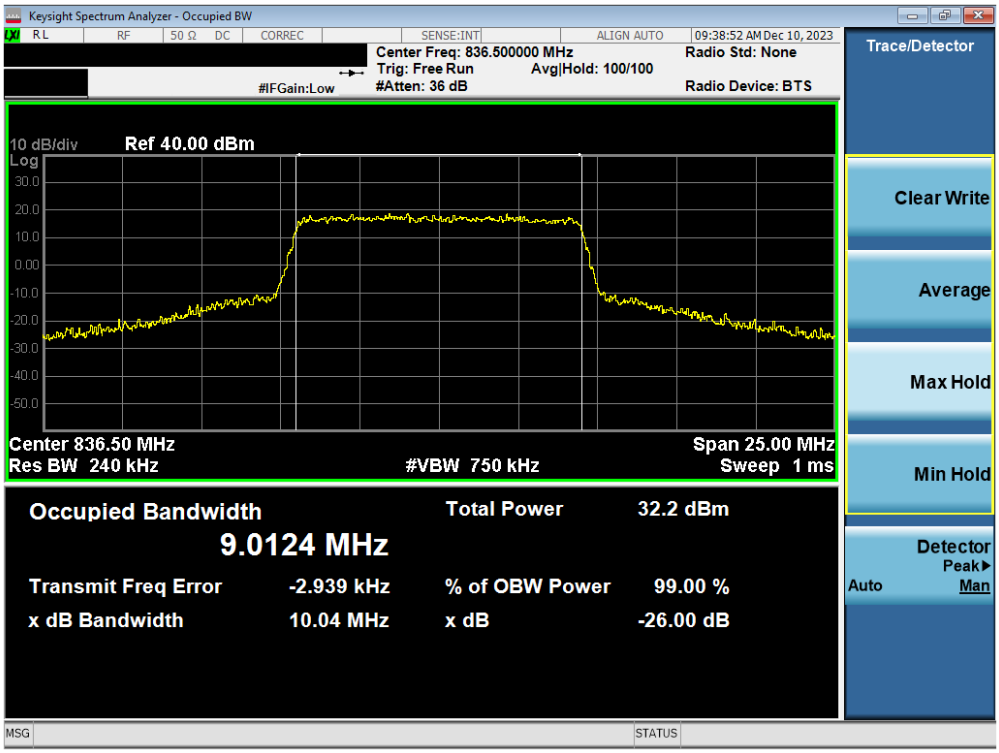
Plot 7-11. Occupied Bandwidth Plot (LTE Band 26/5 - 5MHz 64-QAM - Full RB Configuration)



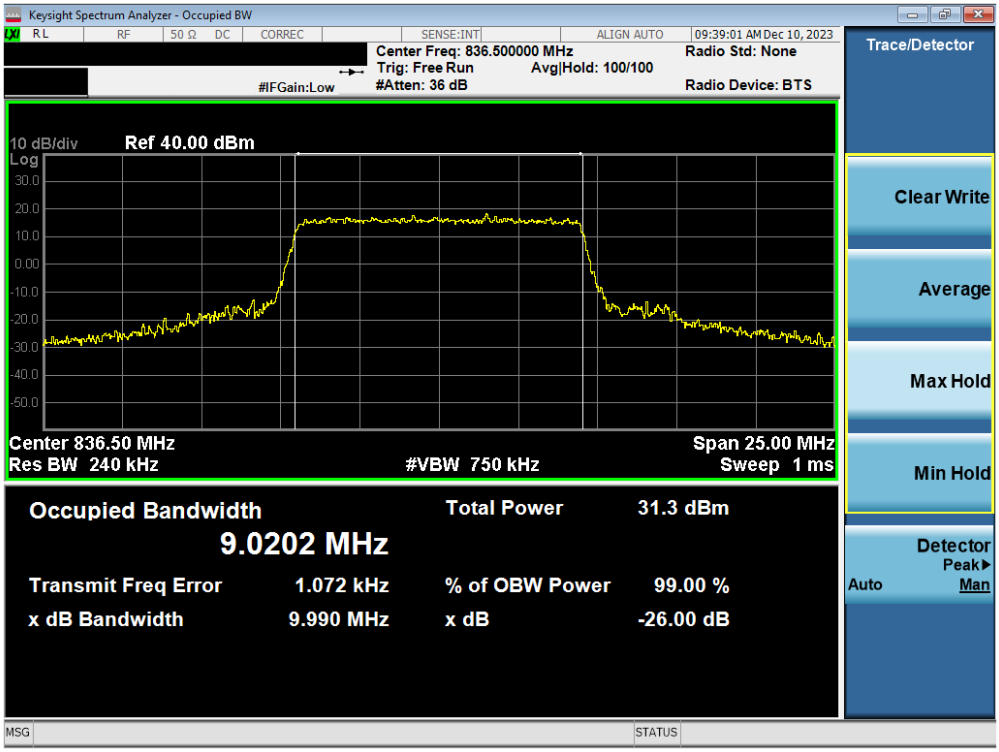
Plot 7-12. Occupied Bandwidth Plot (LTE Band 26/5 - 5MHz 256-QAM - Full RB Configuration)



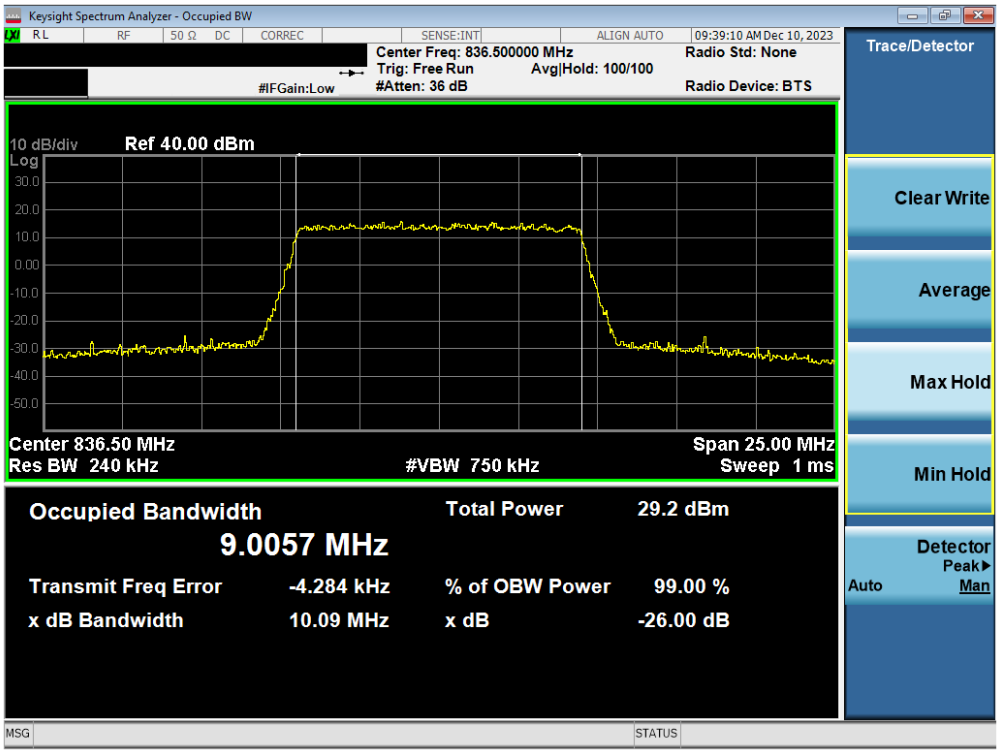
Plot 7-13. Occupied Bandwidth Plot (LTE Band 26/5 - 10MHz QPSK - Full RB Configuration)



Plot 7-14. Occupied Bandwidth Plot (LTE Band 26/5 - 10MHz 16-QAM - Full RB Configuration)



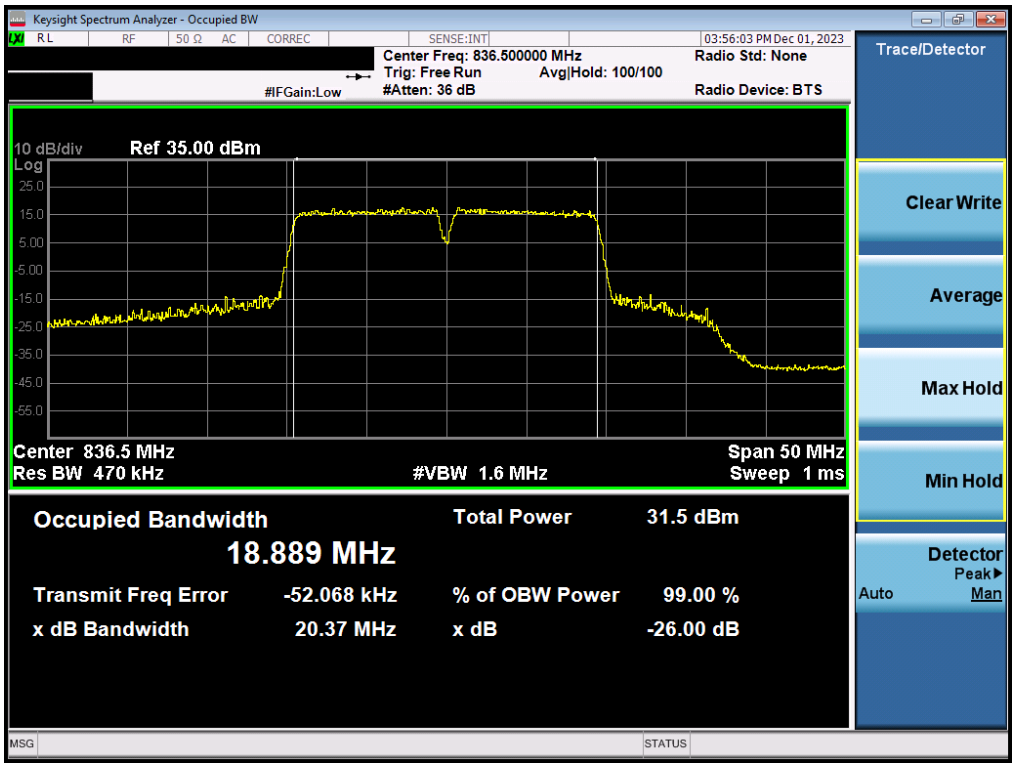
Plot 7-15. Occupied Bandwidth Plot (LTE Band 26/5 - 10MHz 64-QAM - Full RB Configuration)



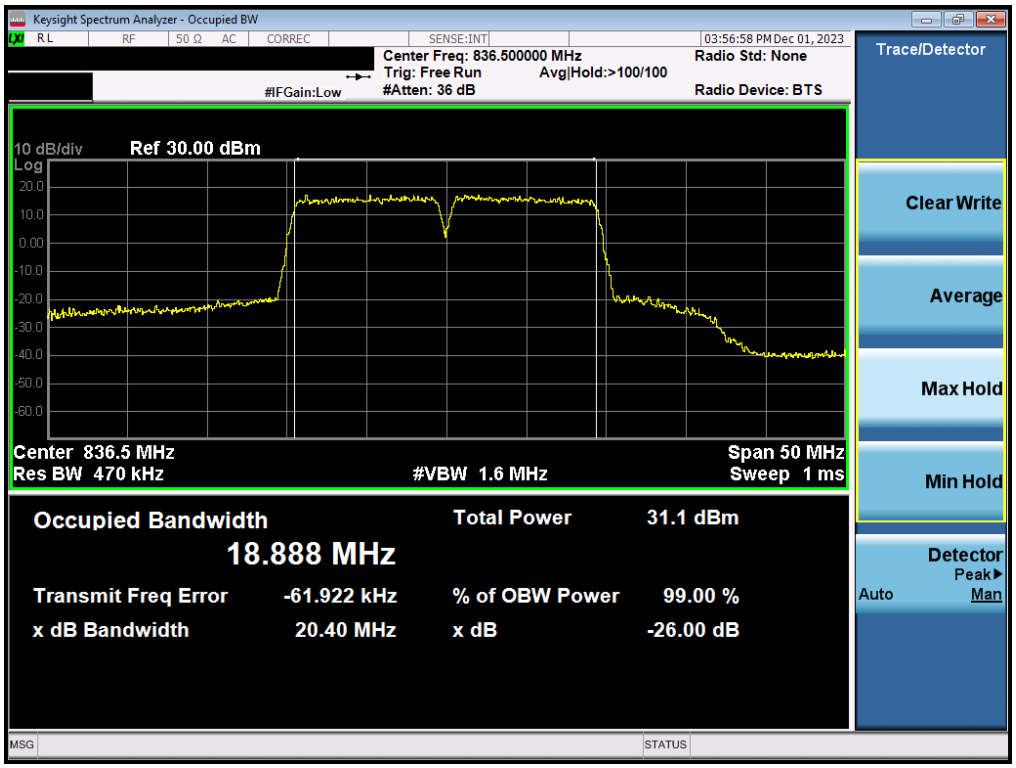
Plot 7-16. Occupied Bandwidth Plot (LTE Band 26/5 - 10MHz 256-QAM - Full RB Configuration)

ULCA – LTE Band 5

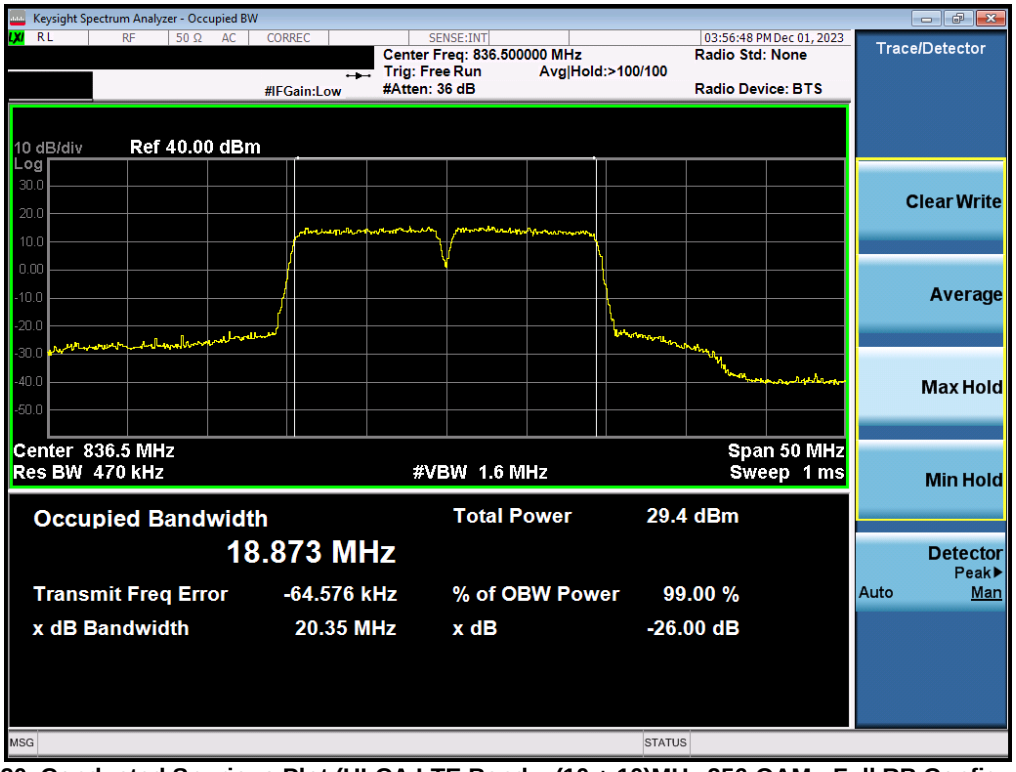
Plot 7-17. Conducted Spurious Plot (ULCA LTE Band 5 – (10 + 10)MHz QPSK - Full RB Configuration)



Plot 7-18. Conducted Spurious Plot (ULCA LTE Band 5 – (10 + 10)MHz 16-QAM - Full RB Configuration)

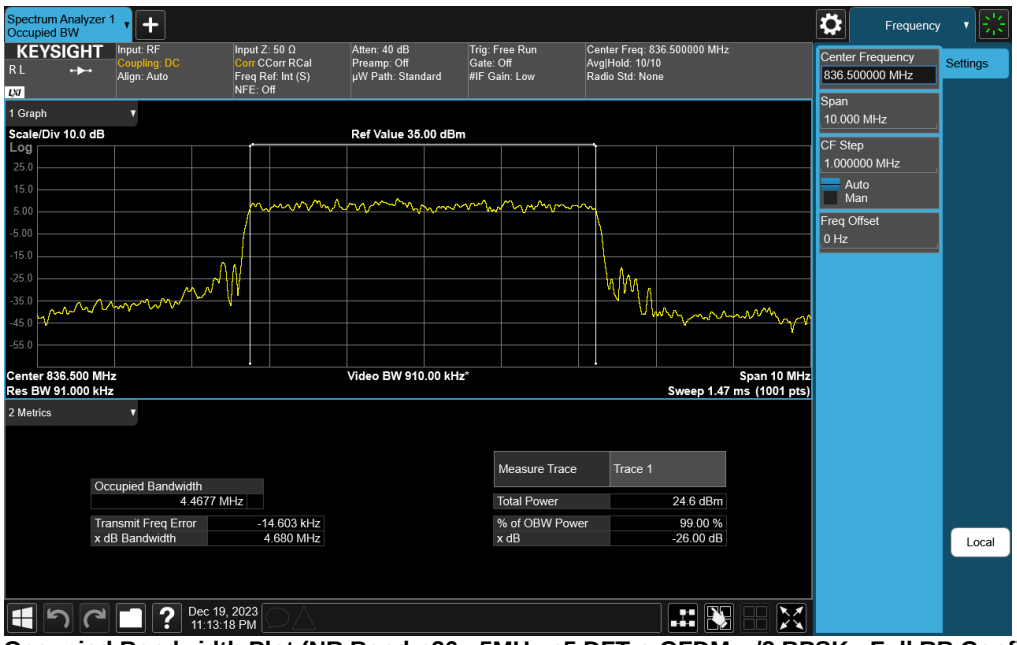


Plot 7-19. Conducted Spurious Plot (ULCA LTE Band – (10 + 10)MHz 64-QAM - Full RB Configuration)

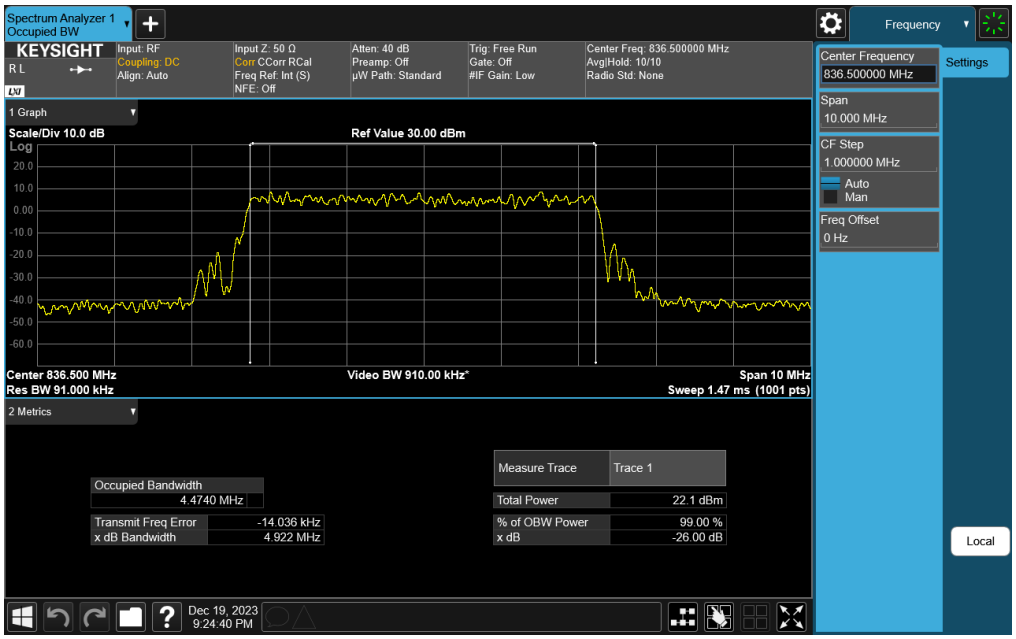


Plot 7-20. Conducted Spurious Plot (ULCA LTE Band – (10 + 10)MHz 256-QAM - Full RB Configuration)

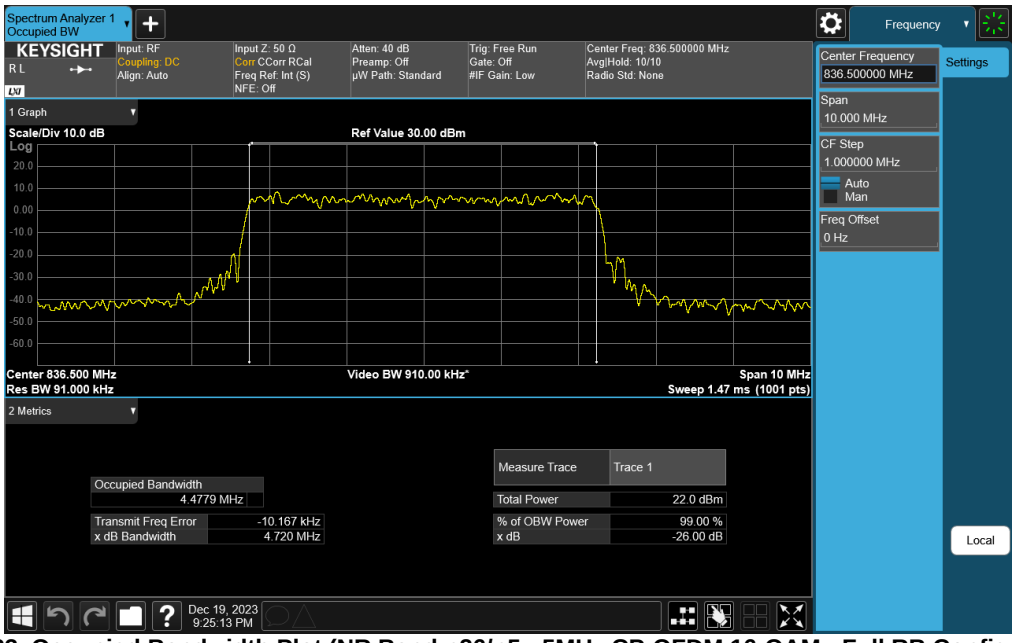
NR Band n26/n5



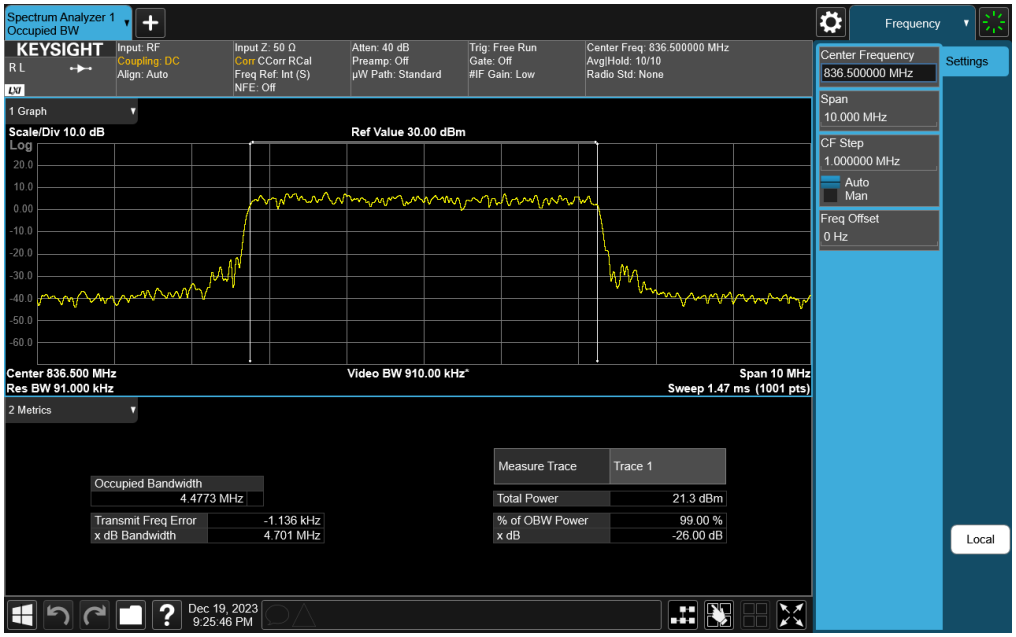
Plot 7-21. Occupied Bandwidth Plot (NR Band n26 - 5MHz n5 DFT-s-OFDM π/2 BPSK - Full RB Configuration)



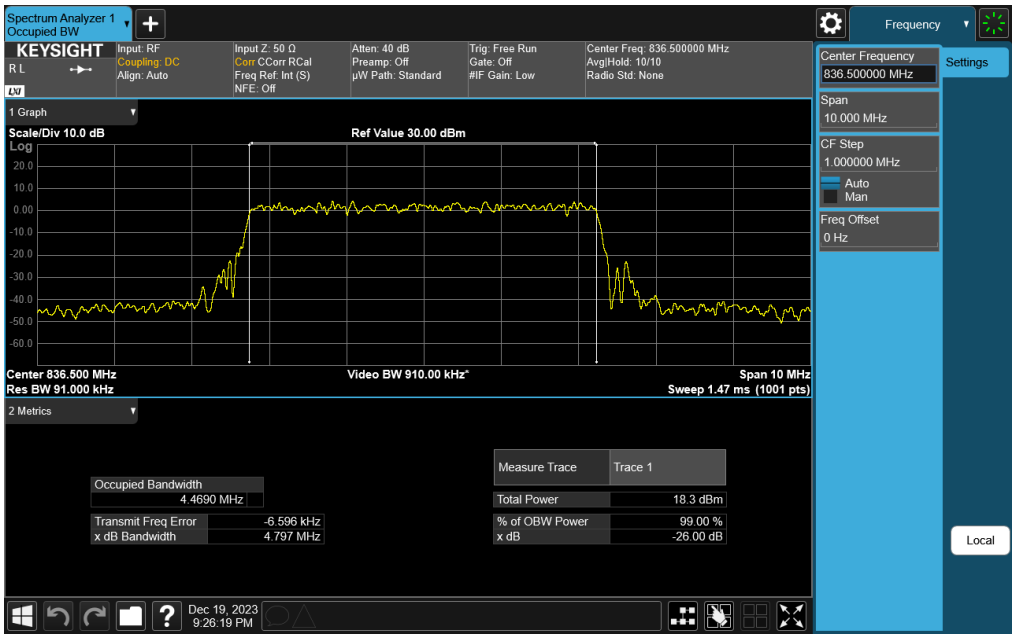
Plot 7-22. Occupied Bandwidth Plot (NR Band n26/n5 - 5MHz CP-OFDM QPSK - Full RB Configuration)



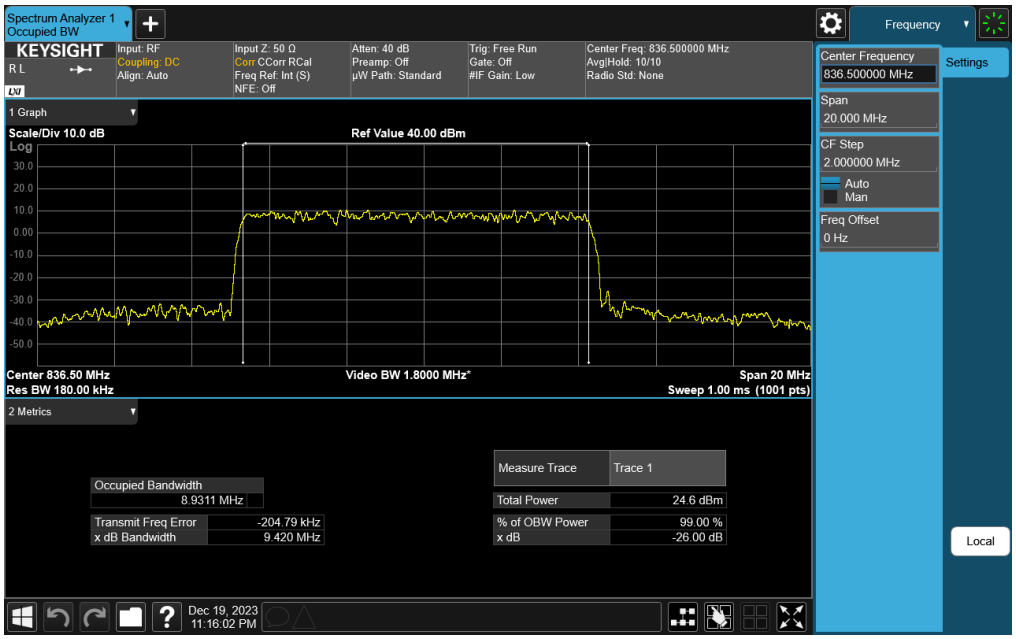
Plot 7-23. Occupied Bandwidth Plot (NR Band n26/n5 - 5MHz CP-OFDM 16-QAM - Full RB Configuration)



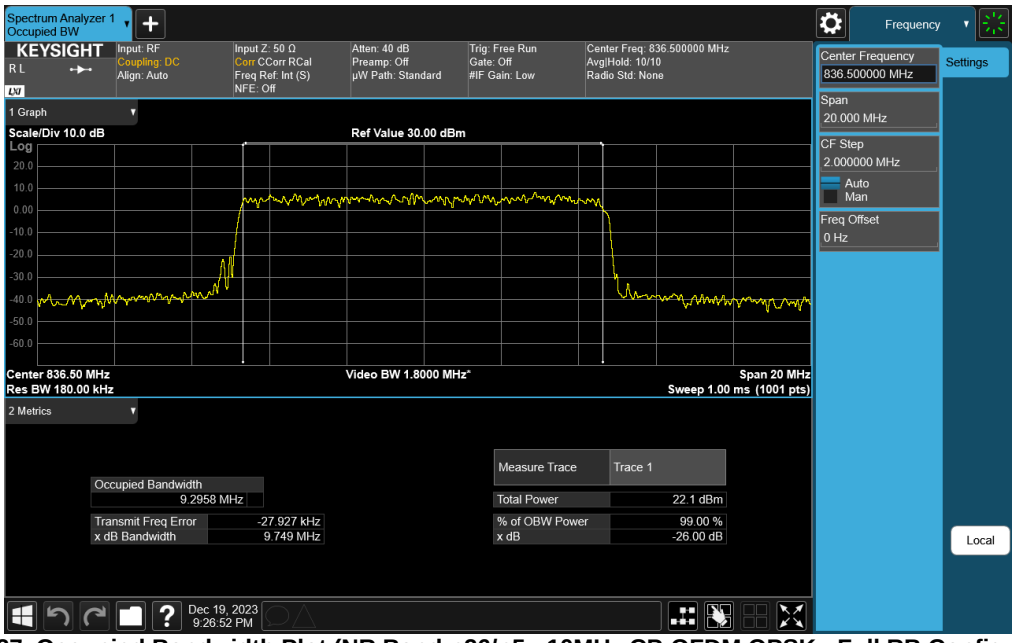
Plot 7-24. Occupied Bandwidth Plot (NR Band n26/n5 - 5MHz CP-OFDM 64-QAM - Full RB Configuration)



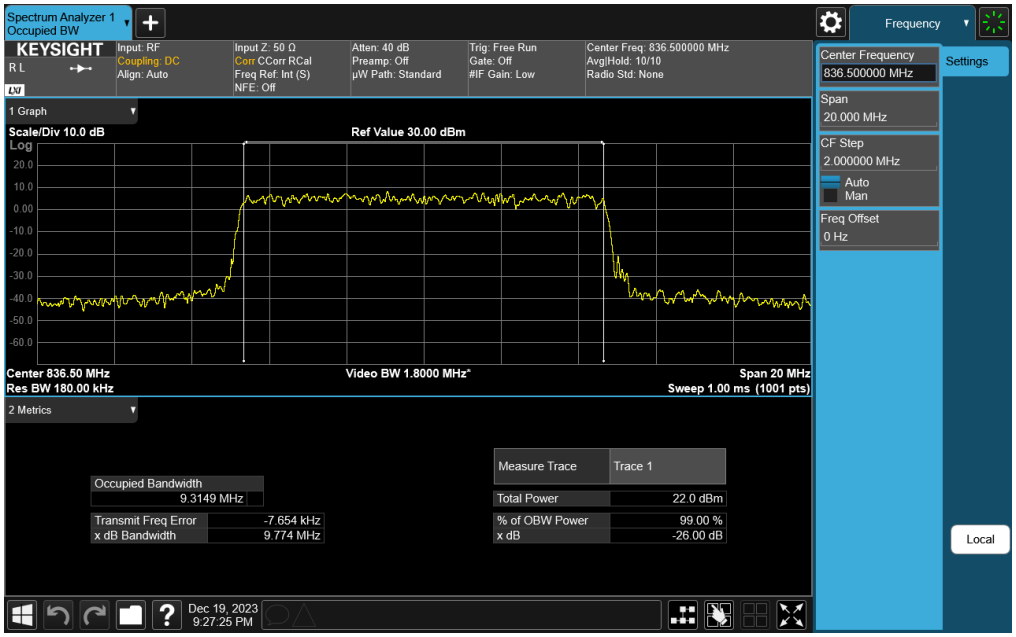
Plot 7-25. Occupied Bandwidth Plot (NR Band n26/n5 - 5MHz CP-OFDM 256-QAM - Full RB Configuration)



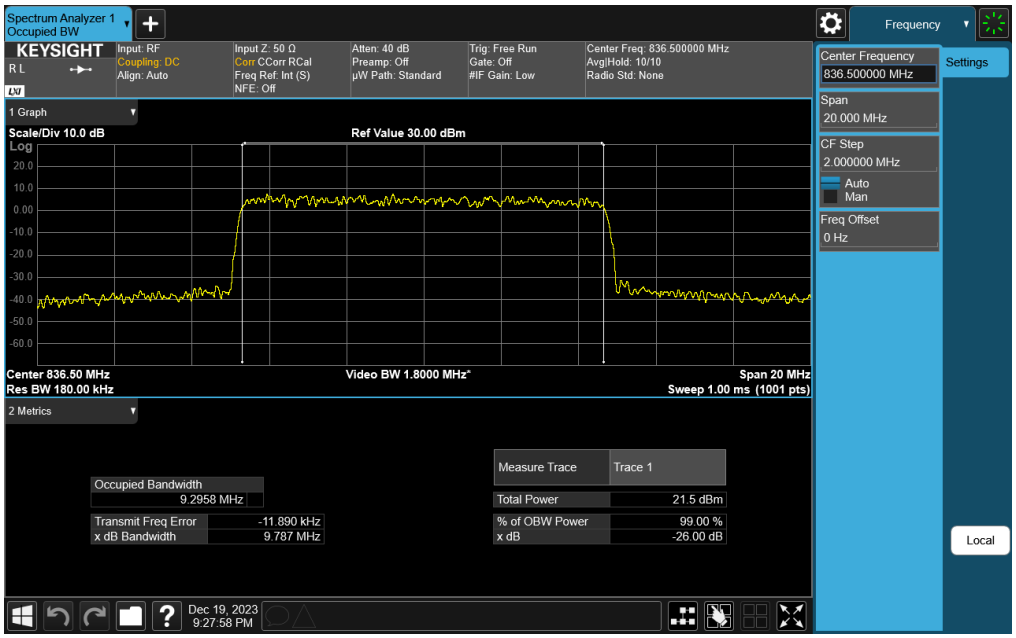
Plot 7-26. Occupied Bandwidth Plot (NR Band n26/n5 - 10MHz DFT-s-OFDM π/2 BPSK - Full RB Configuration)



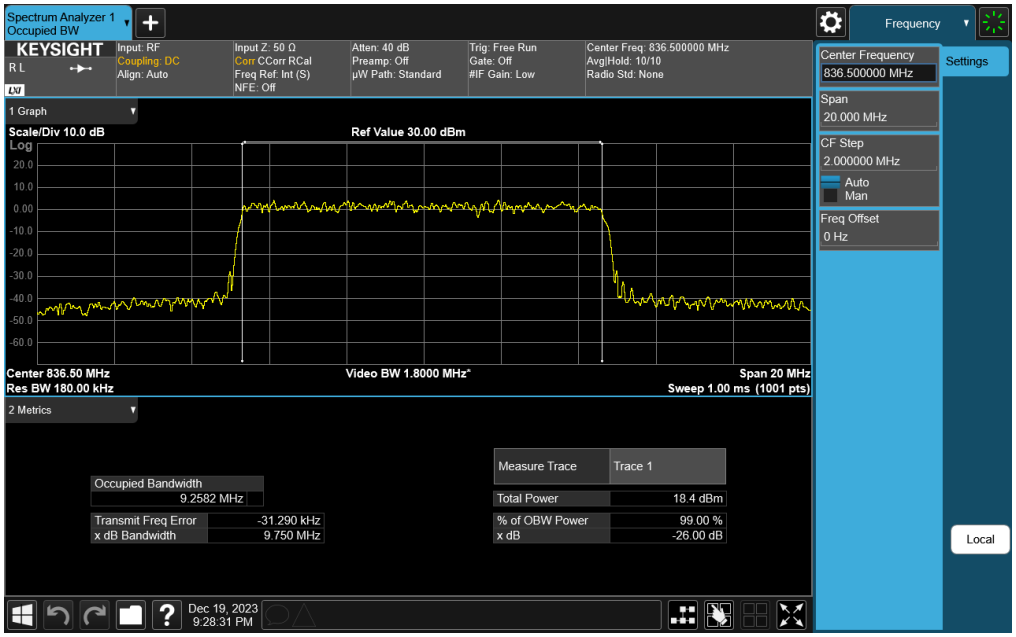
Plot 7-27. Occupied Bandwidth Plot (NR Band n26/n5 - 10MHz CP-OFDM QPSK - Full RB Configuration)



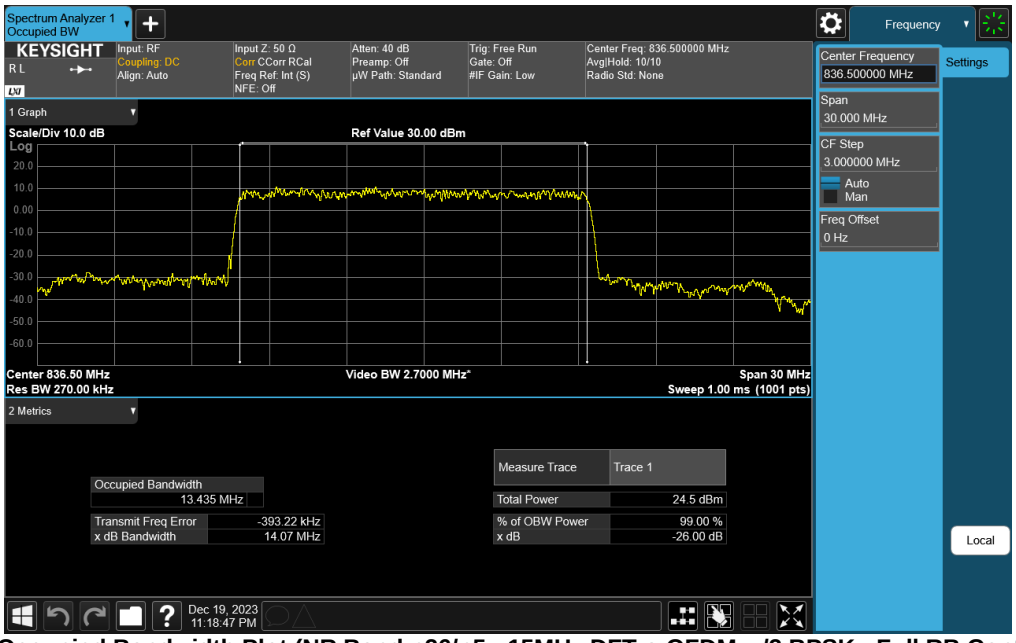
Plot 7-28. Occupied Bandwidth Plot (NR Band n26/n5 - 10MHz CP-OFDM 16-QAM - Full RB Configuration)



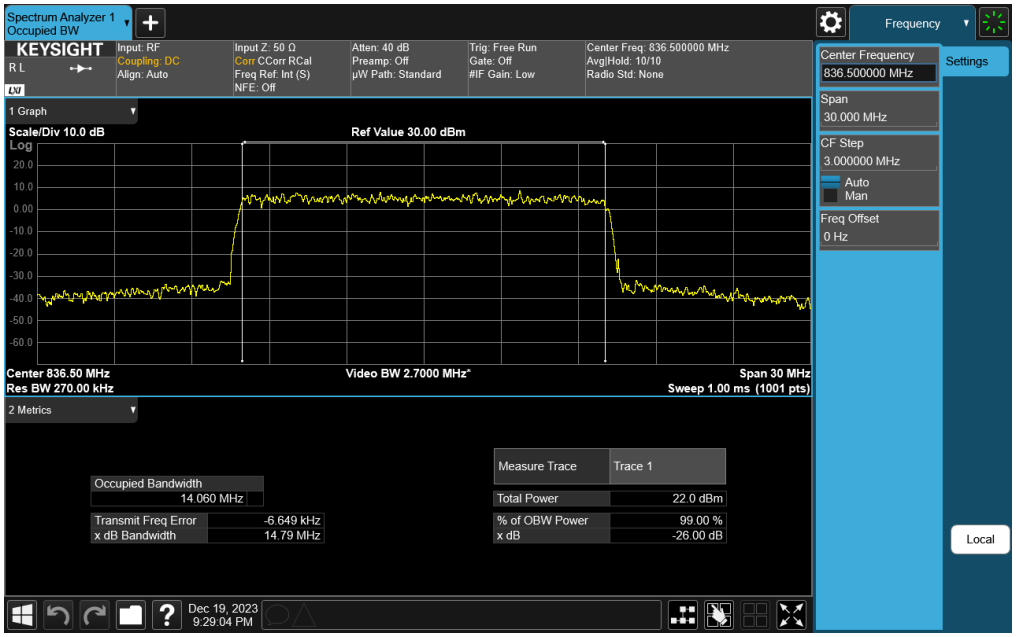
Plot 7-29. Occupied Bandwidth Plot (NR Band n26/n5 - 10MHz CP-OFDM 64-QAM - Full RB Configuration)



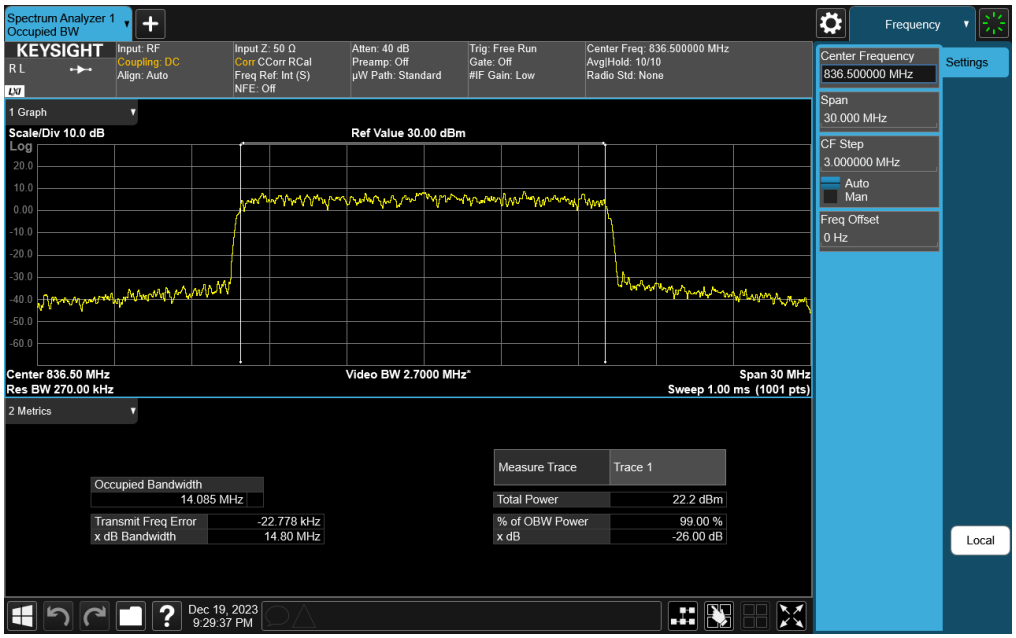
Plot 7-30. Occupied Bandwidth Plot (NR Band n26/n5 - 10MHz CP-OFDM 256-QAM - Full RB Configuration)



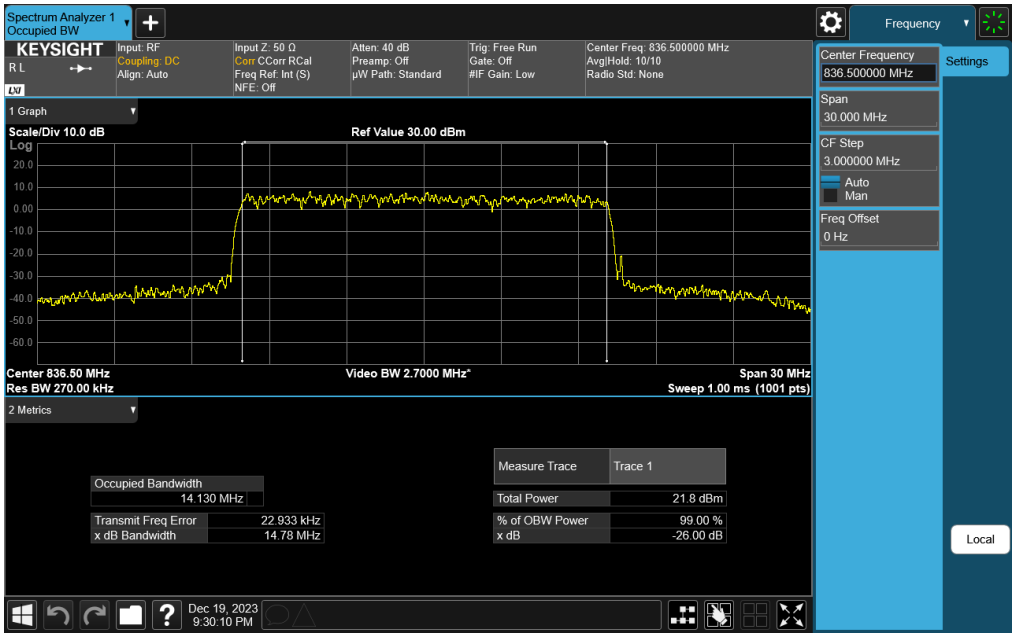
Plot 7-31. Occupied Bandwidth Plot (NR Band n26/n5 - 15MHz DFT-s-OFDM π/2 BPSK - Full RB Configuration)



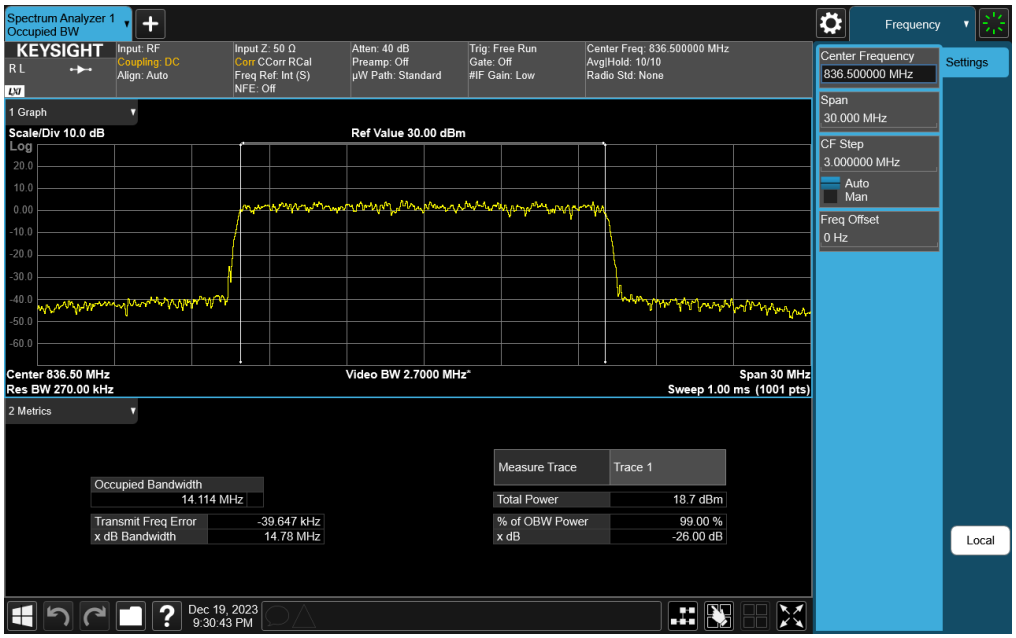
Plot 7-32. Occupied Bandwidth Plot (NR Band n26/n5 - 15MHz CP-OFDM QPSK - Full RB Configuration)



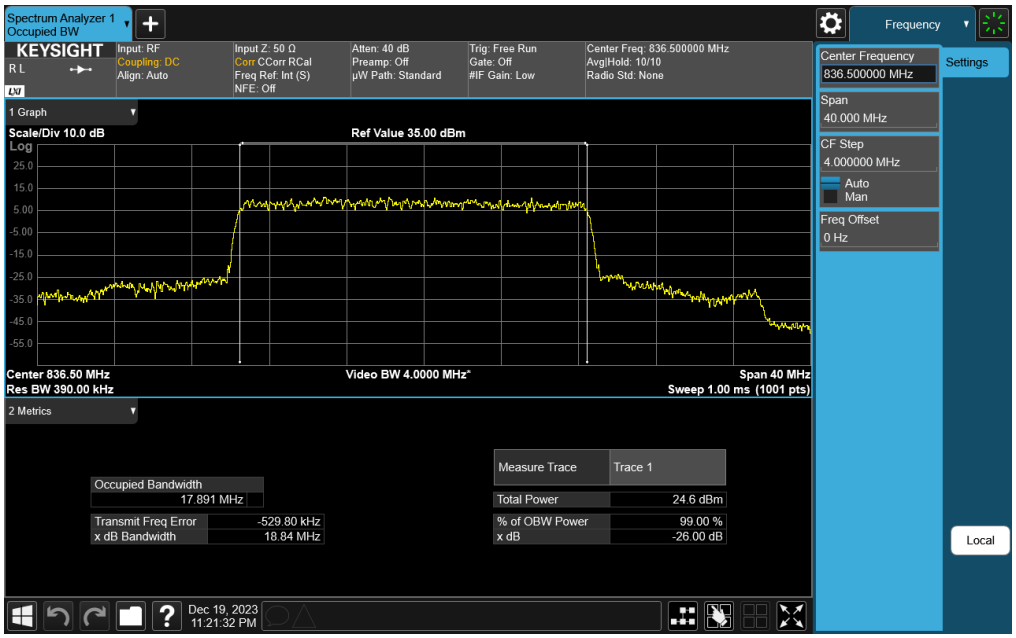
Plot 7-33. Occupied Bandwidth Plot (NR Band n26/n5 - 15MHz CP-OFDM 16-QAM - Full RB Configuration)



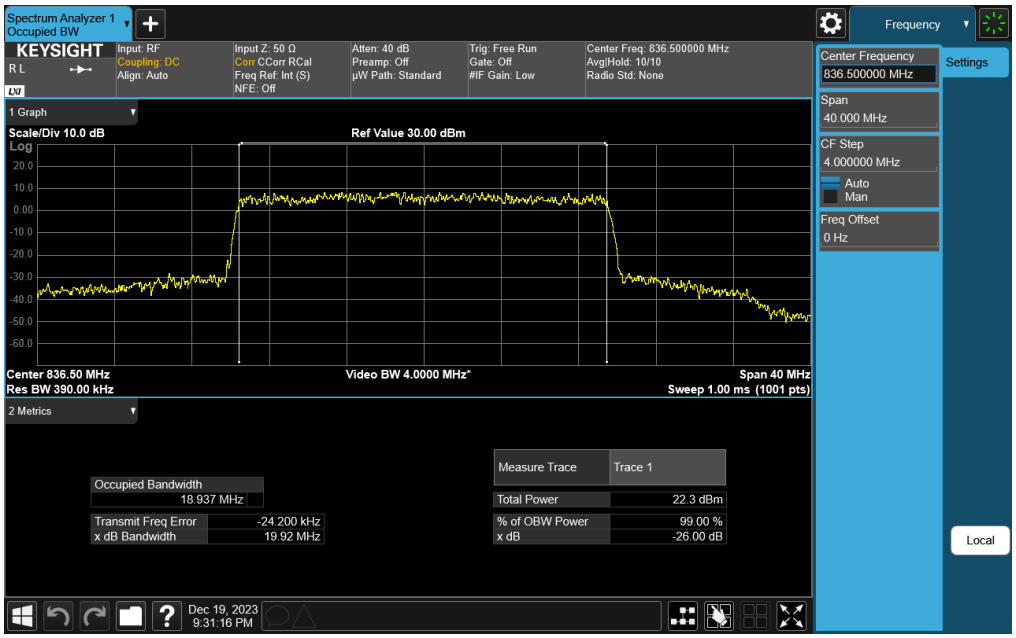
Plot 7-34. Occupied Bandwidth Plot (NR Band n26/n5 - 15MHz CP-OFDM 64-QAM - Full RB Configuration)



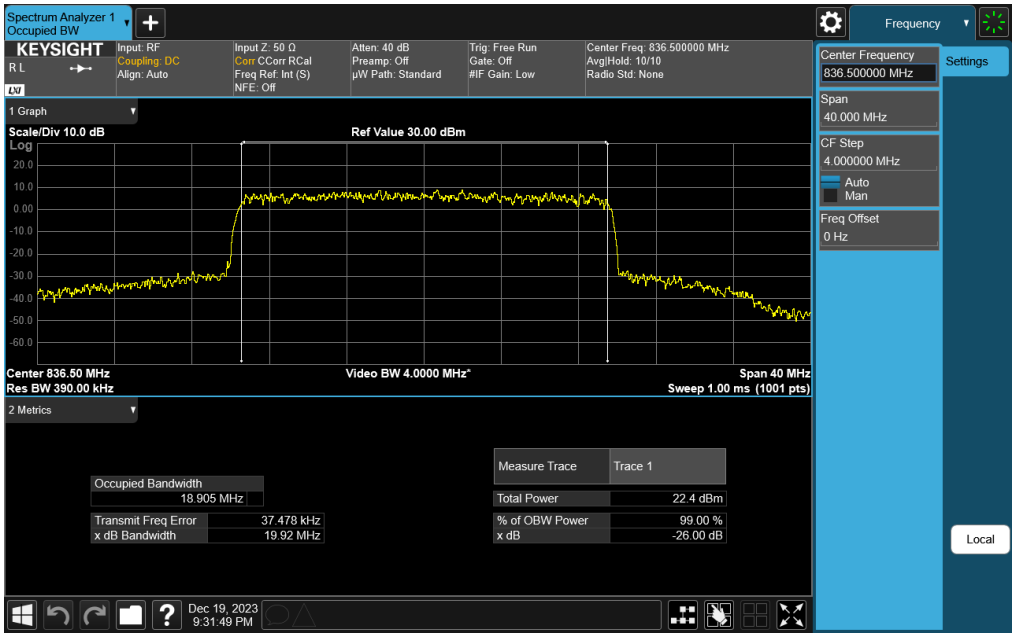
Plot 7-35. Occupied Bandwidth Plot (NR Band n26/n5 - 15MHz CP-OFDM 256-QAM - Full RB Configuration)



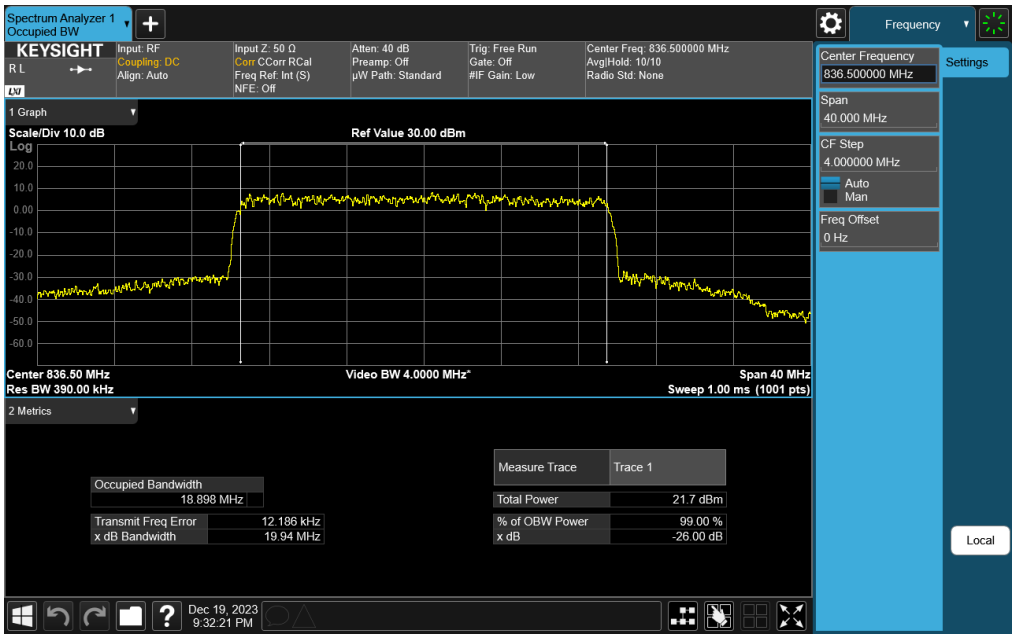
Plot 7-36. Occupied Bandwidth Plot (NR Band n26/n5 - 20MHz DFT-s-OFDM π/2 BPSK - Full RB Configuration)



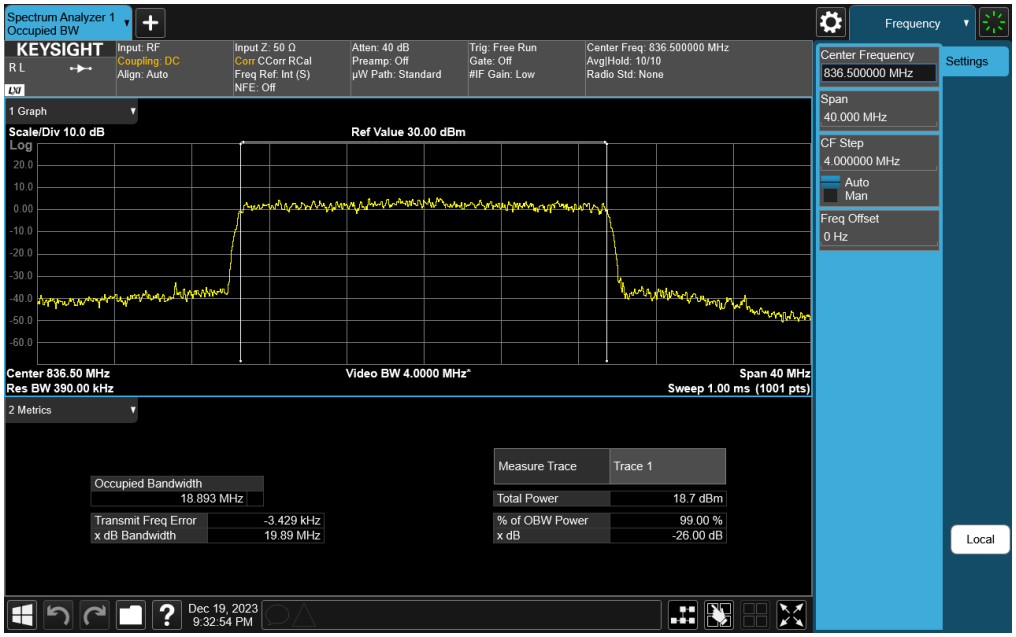
Plot 7-37. Occupied Bandwidth Plot (NR Band n26/n5 - 20MHz CP-OFDM QPSK - Full RB Configuration)



Plot 7-38. Occupied Bandwidth Plot (NR Band n26/n5 - 20MHz CP-OFDM 16-QAM - Full RB Configuration)

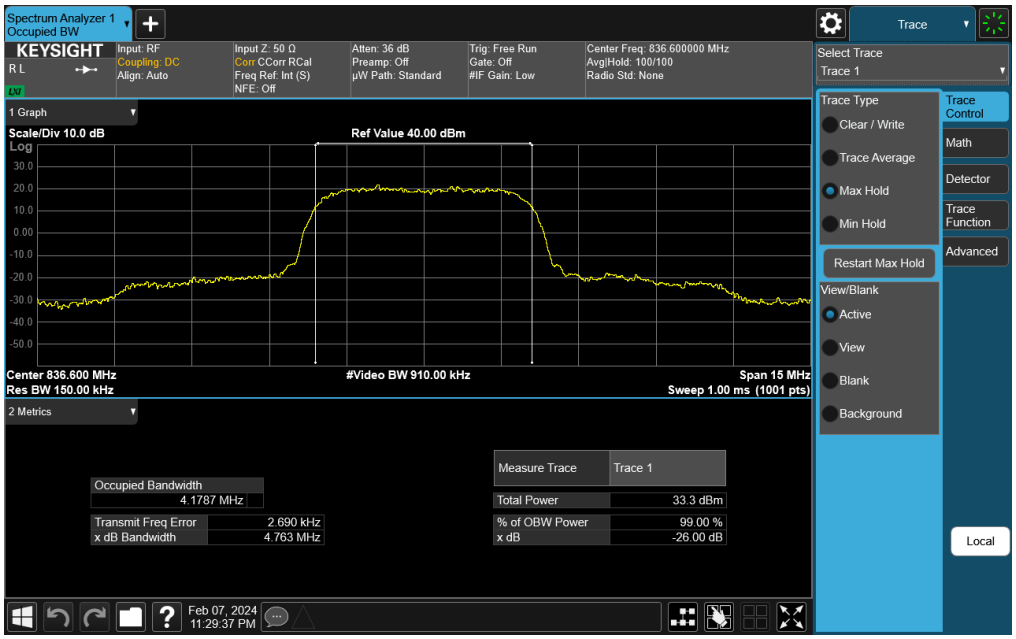


Plot 7-39. Occupied Bandwidth Plot (NR Band n26/n5 - 20MHz CP-OFDM 64-QAM - Full RB Configuration)



Plot 7-40. Occupied Bandwidth Plot (NR Band n26/n5 - 20MHz CP-OFDM 256-QAM - Full RB Configuration)

WCDMA Cell



Plot 7-41. Occupied Bandwidth Plot (WCDMA, Ch. 4183)

7.3 Spurious and Harmonic Emissions at Antenna Terminal

§2.1051, 22.917(a)

Test Overview

The level of the carrier and the various conducted spurious and harmonic frequencies is measured by means of a calibrated spectrum analyzer. The spectrum is scanned from the lowest frequency generated in the equipment up to a frequency including its 10th harmonic. All out of band emissions are measured with a spectrum analyzer connected to the antenna terminal of the EUT while the EUT is operating at maximum power, and at the appropriate frequencies. All data rates were investigated to determine the worst case configuration. All modes of operation were investigated and the worst case configuration results are reported in this section. All ports were tested and only the worst case data were reported.

The minimum permissible attenuation level of any spurious emission is 43 + 10 $log_{10}(P_{[Watts]})$, where P is the transmitter power in Watts.

Test Procedure Used

KDB 971168 D01 v03r01 – Section 6.0

Test Settings

1. Start frequency was set to 30MHz and stop frequency was set to 10GHz (separated into at least two plots per channel)
2. Detector = RMS
3. Trace mode = trace average for continuous emissions, max hold for pulse emissions
4. Sweep time = auto couple
5. The trace was allowed to stabilize
6. Please see test notes below for RBW and VBW settings

Test Setup

The EUT and measurement equipment were set up as shown in the diagram below.

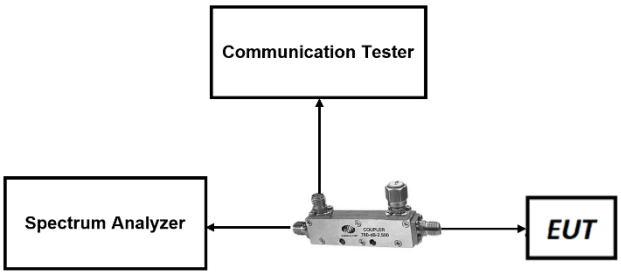


Figure 7-2. Test Instrument & Measurement Setup

Test Notes

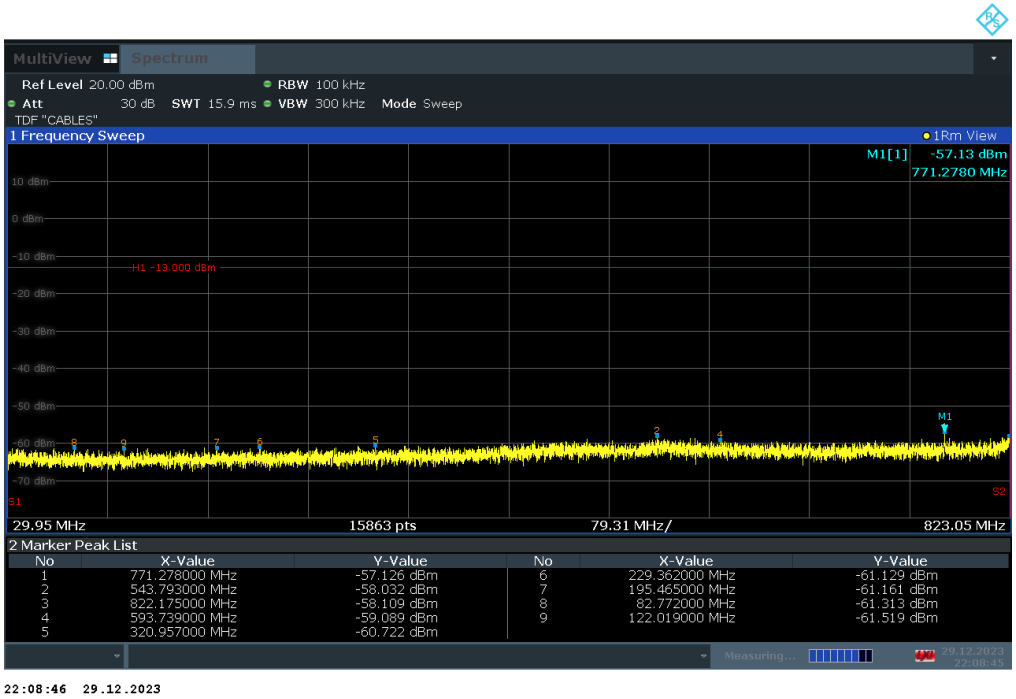
1. Per Part 22, compliance with the applicable limits is based on the use of measurement instrumentation employing a resolution bandwidth 100 kHz or greater for measurements below 1GHz. However, in the 1 MHz bands immediately outside and adjacent to the frequency block a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed. The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emission are attenuated at least 26 dB below the transmitter power.

2. For NR operation, all subcarrier spacings (SCS) and transmission schemes (e.g. CP-OFDM and DFT-s-OFDM) were investigated to determine the worst case configuration. All modes of operation were investigated and the worst case configuration results are reported in this section.

3. Uplink carrier aggregation conducted spurious emissions measurements were evaluated for the two contiguous channels using various combinations of RB size, RB offset, modulation, and channel bandwidth. The worst case (highest) powers were found while operating with QPSK modulation with both carriers set to transmit using 1RB.

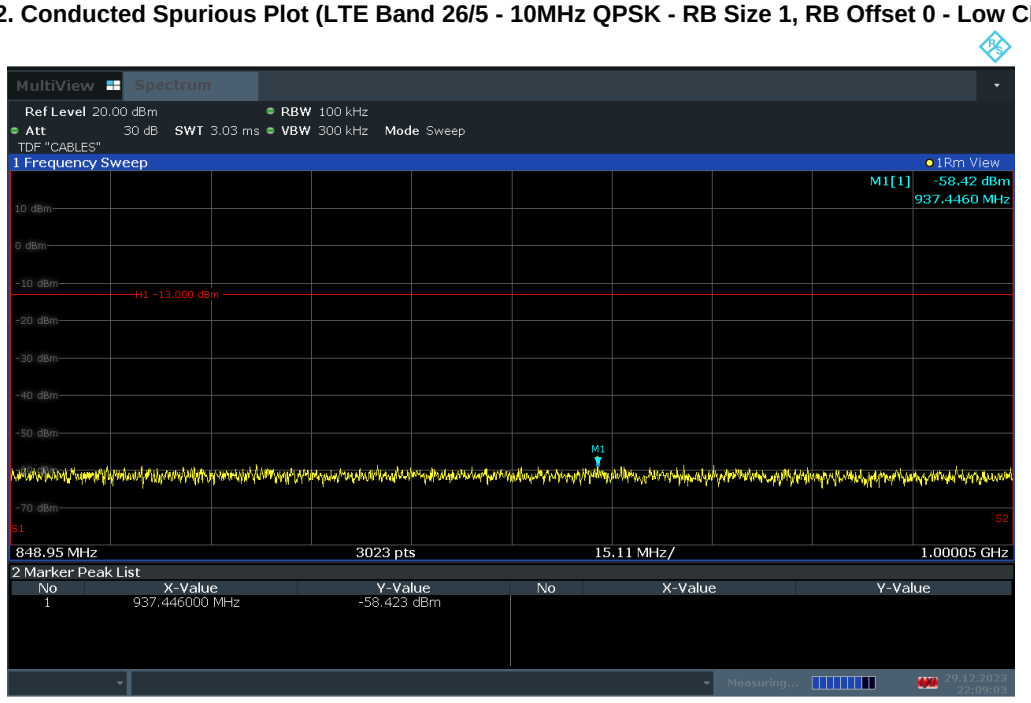
4. Uplink carrier aggregation inter-band emission was investigated and found to not be the worst case

LTE Band 26/5



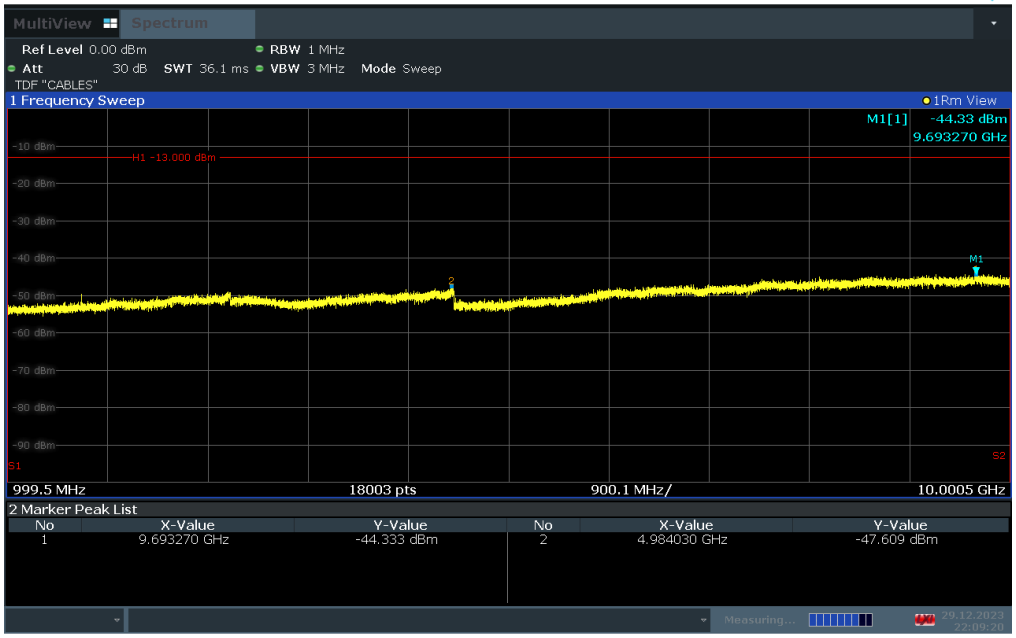
22:08:46 29.12.2023

Plot 7-42. Conducted Spurious Plot (LTE Band 26/5 - 10MHz QPSK - RB Size 1, RB Offset 0 - Low Channel)



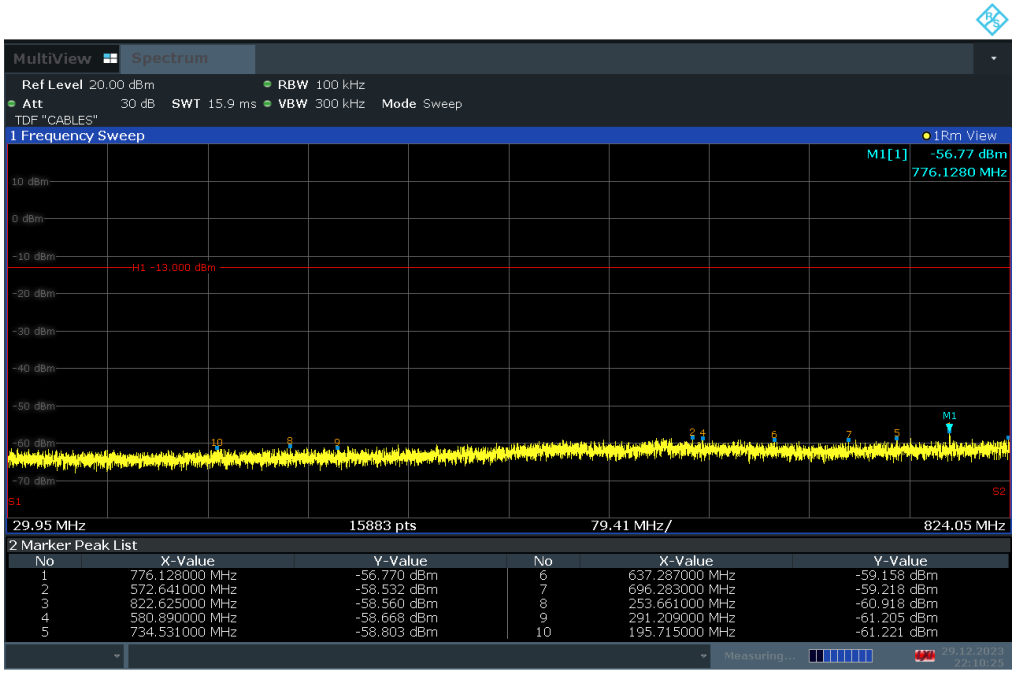
22:09:03 29.12.2023

Plot 7-43. Conducted Spurious Plot (LTE Band 26/5 - 10MHz QPSK - RB Size 1, RB Offset 0 - Low Channel)



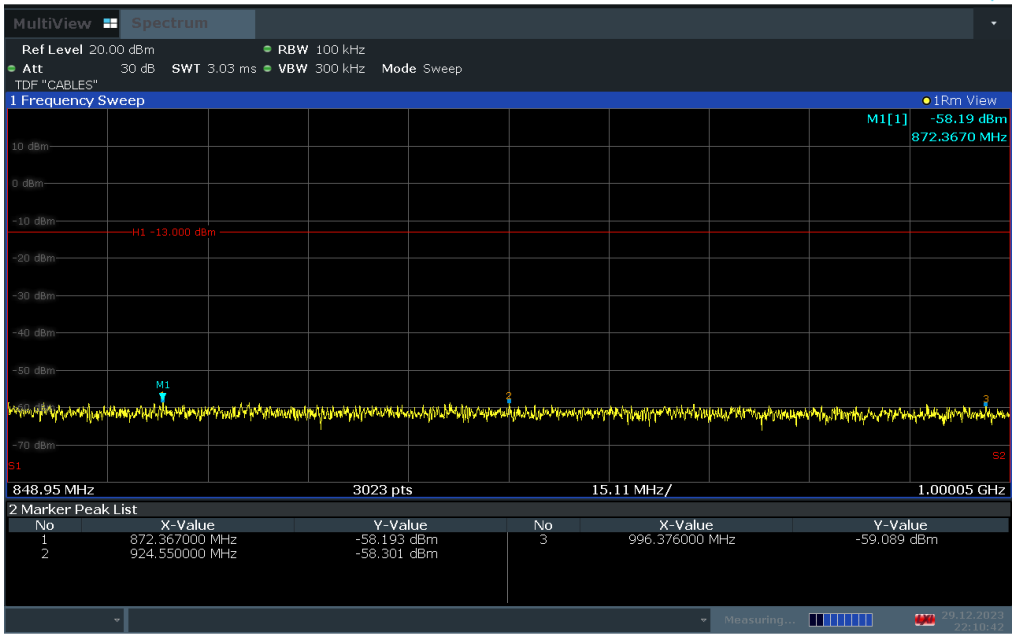
22:09:21 29.12.2023

Plot 7-44. Conducted Spurious Plot (LTE Band 26/5 - 10MHz QPSK - RB Size 1, RB Offset 0 - Low Channel)

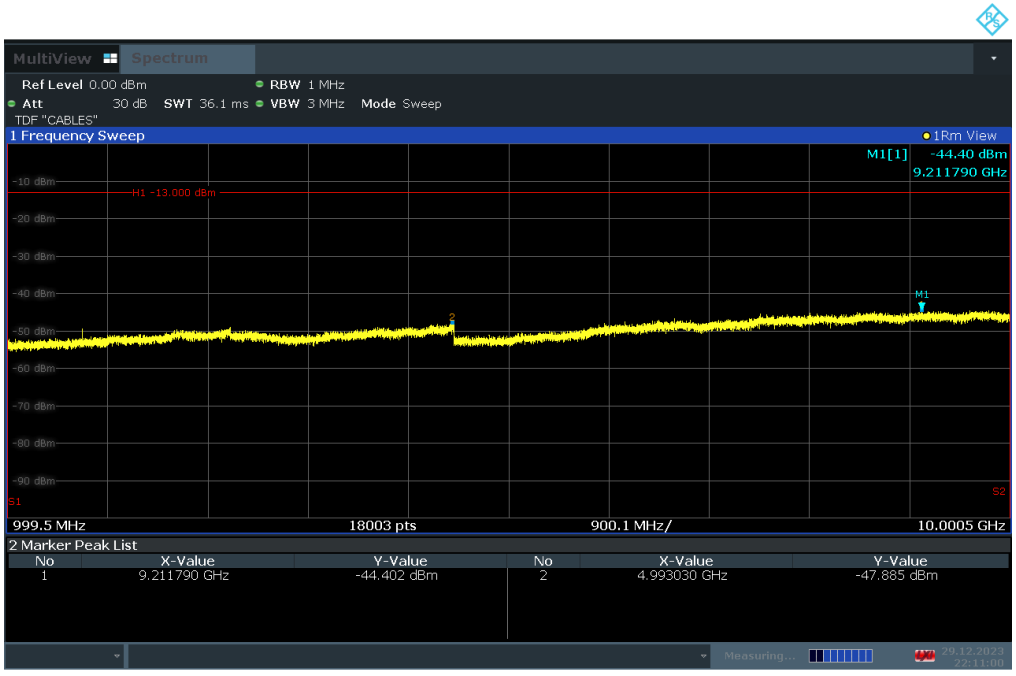


22:10:25 29.12.2023

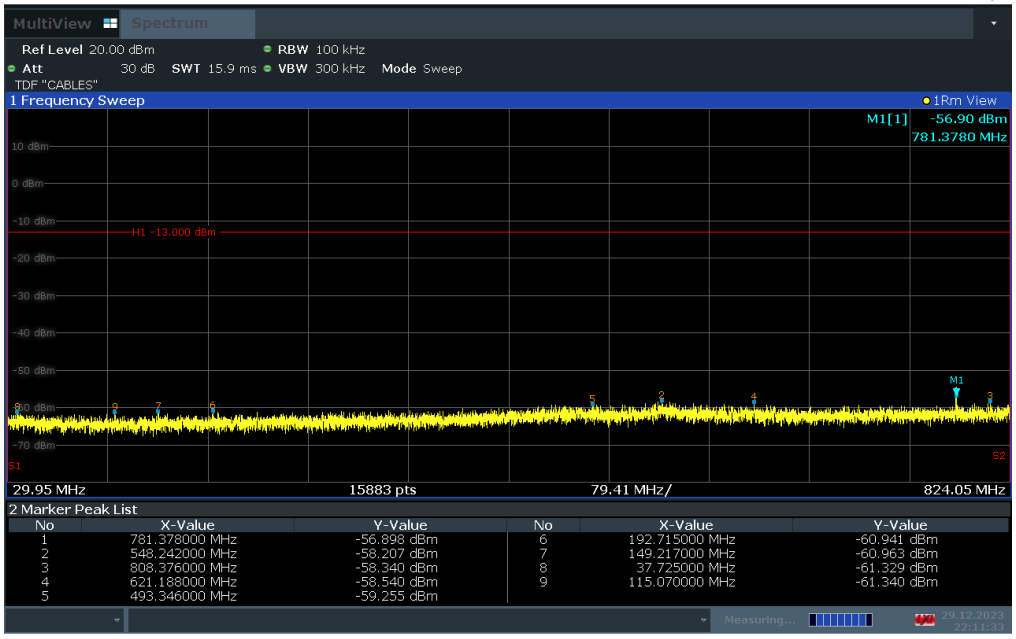
Plot 7-45. Conducted Spurious Plot (LTE Band 26/5 - 10MHz QPSK - RB Size 1, RB Offset 0 - Mid Channel)



Plot 7-46. Conducted Spurious Plot (LTE Band 26/5 - 10MHz QPSK - RB Size 1, RB Offset 0 - Mid Channel)

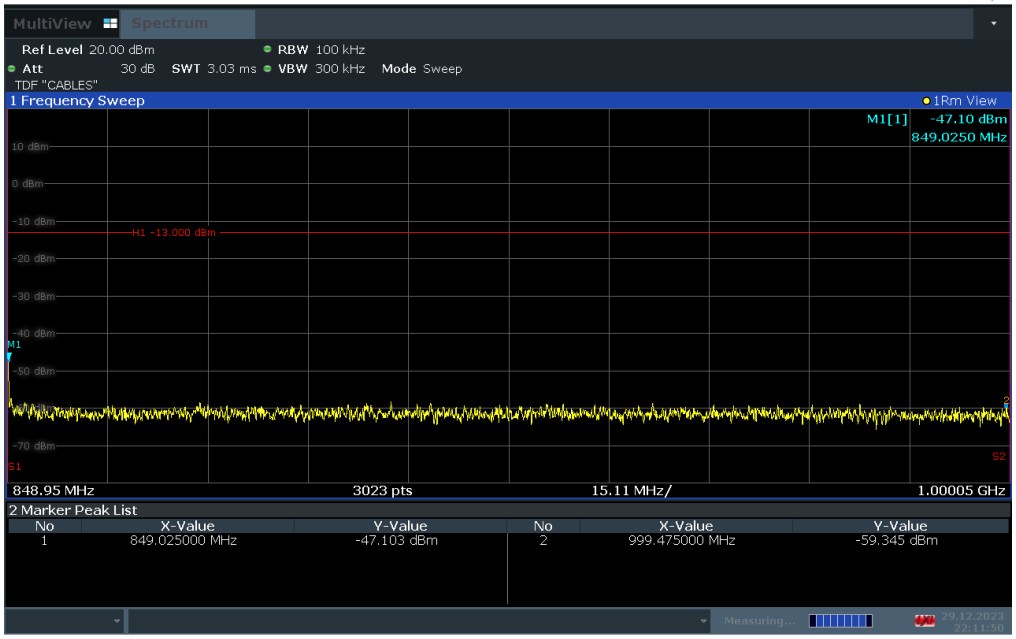


Plot 7-47. Conducted Spurious Plot (LTE Band 26/5 - 10MHz QPSK - RB Size 1, RB Offset 0 - Mid Channel)



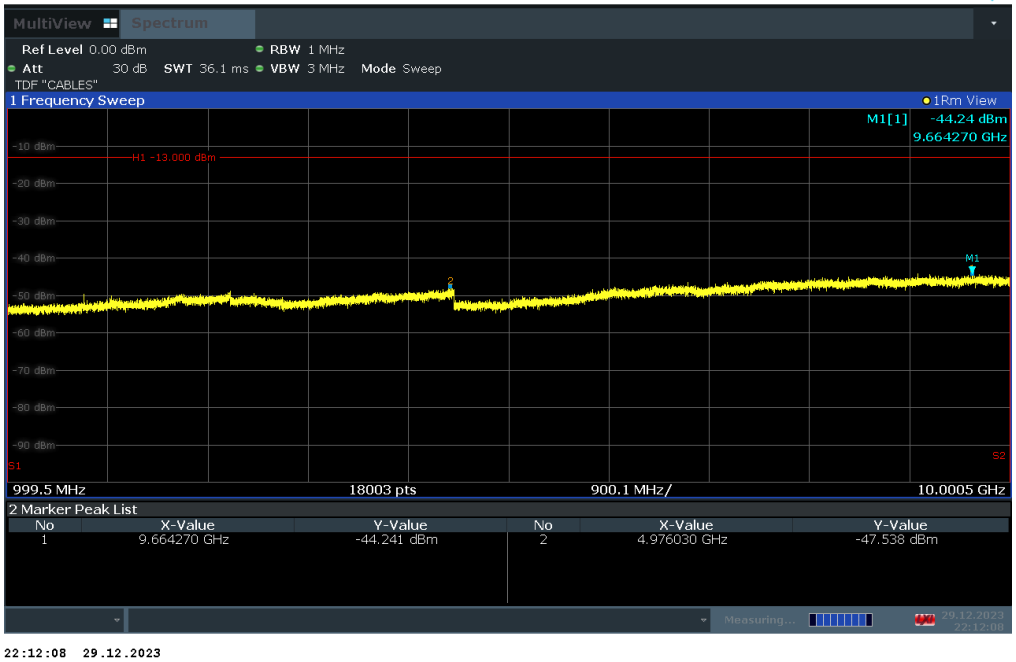
22:11:33 29.12.2023

Plot 7-48. Conducted Spurious Plot (LTE Band 26/5 - 10MHz QPSK - RB Size 1, RB Offset 0 - High Channel)



22:11:51 29.12.2023

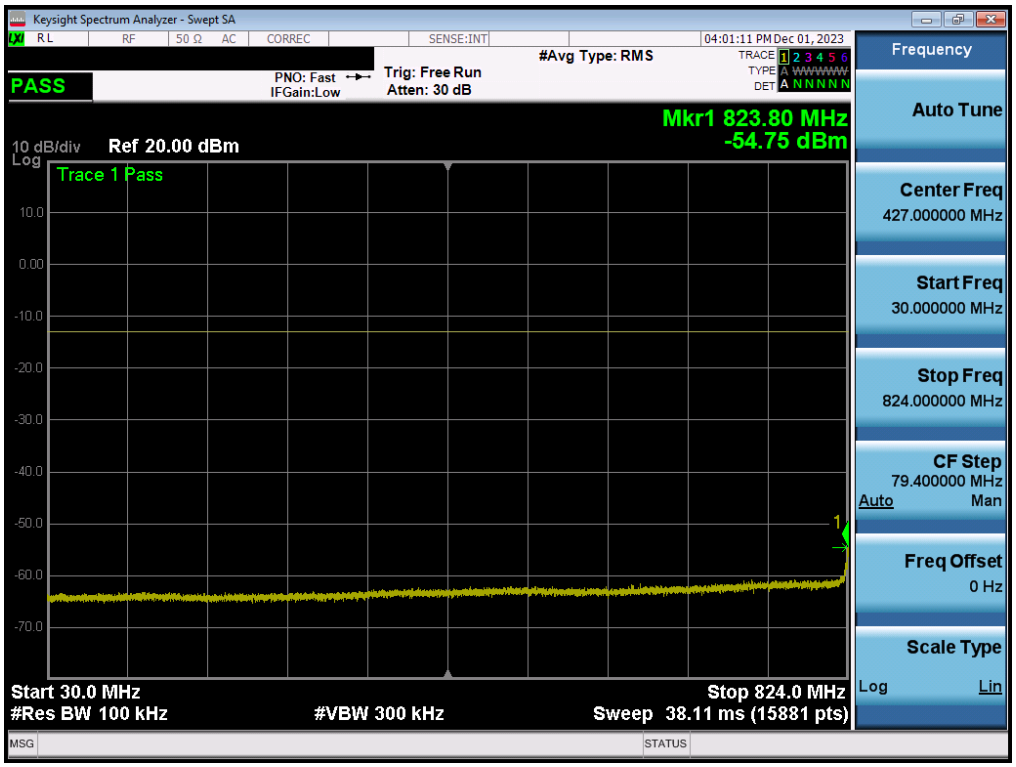
Plot 7-49. Conducted Spurious Plot (LTE Band 26/5 - 10MHz QPSK - RB Size 1, RB Offset 0 - High Channel)



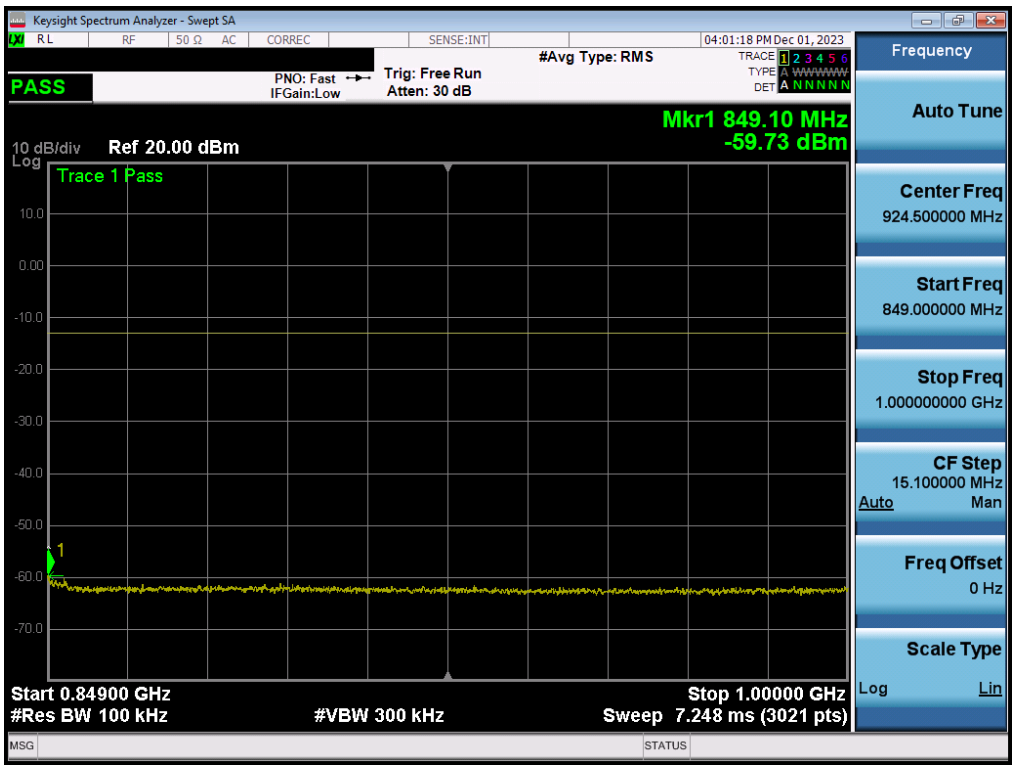
22:12:08 29.12.2023

Plot 7-50. Conducted Spurious Plot (LTE Band 26/5 - 10MHz QPSK - RB Size 1, RB Offset 0 - High Channel)

ULCA LTE Band 5

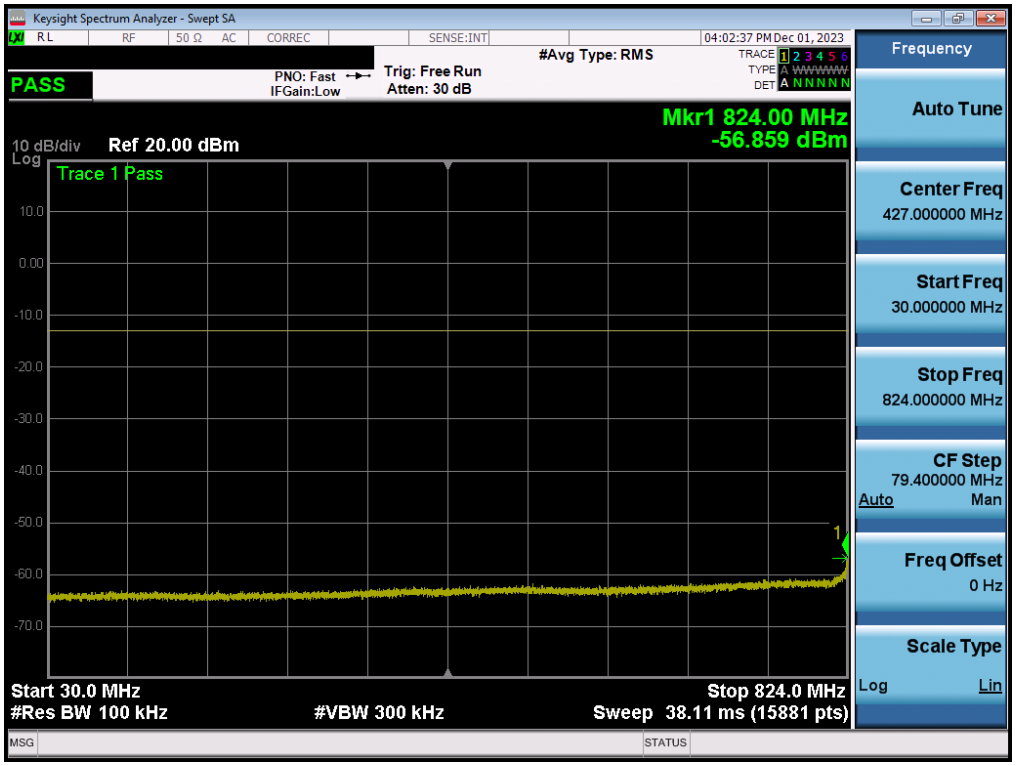


Plot 7-51. Conducted Spurious Plot (ULCA LTE Band 5 – (10 + 10)MHz QPSK – PCC 1/49 SCC 1/0 - Low Channel)

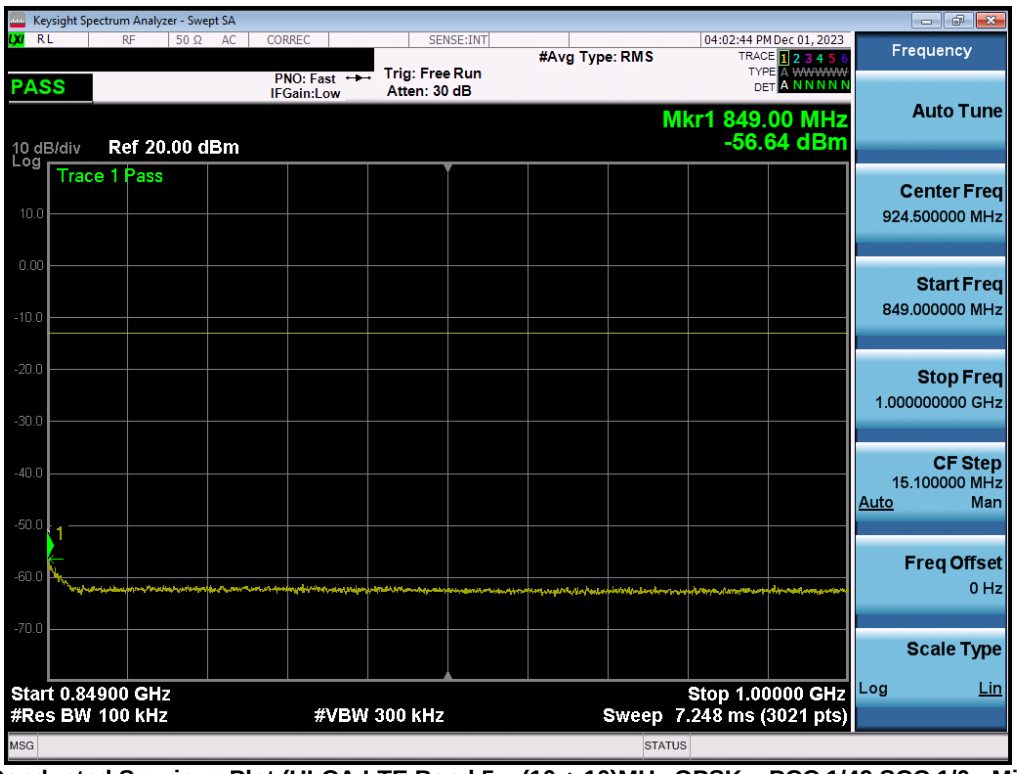


Plot 7-52. Conducted Spurious Plot (ULCA LTE Band 5 – (10 + 10)MHz QPSK – PCC 1/49 SCC 1/0 - Low Channel)

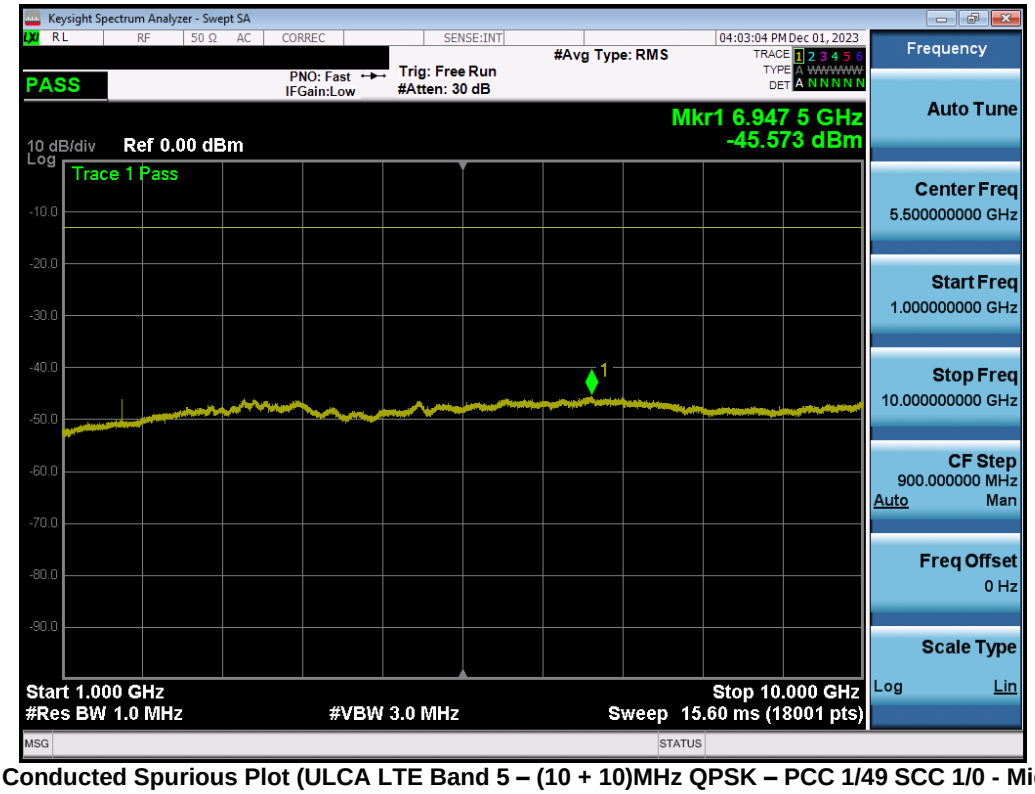
Plot 7-53. Conducted Spurious Plot (ULCA LTE Band 5 – (10 + 10)MHz QPSK – PCC 1/49 SCC 1/0 - Low Channel)



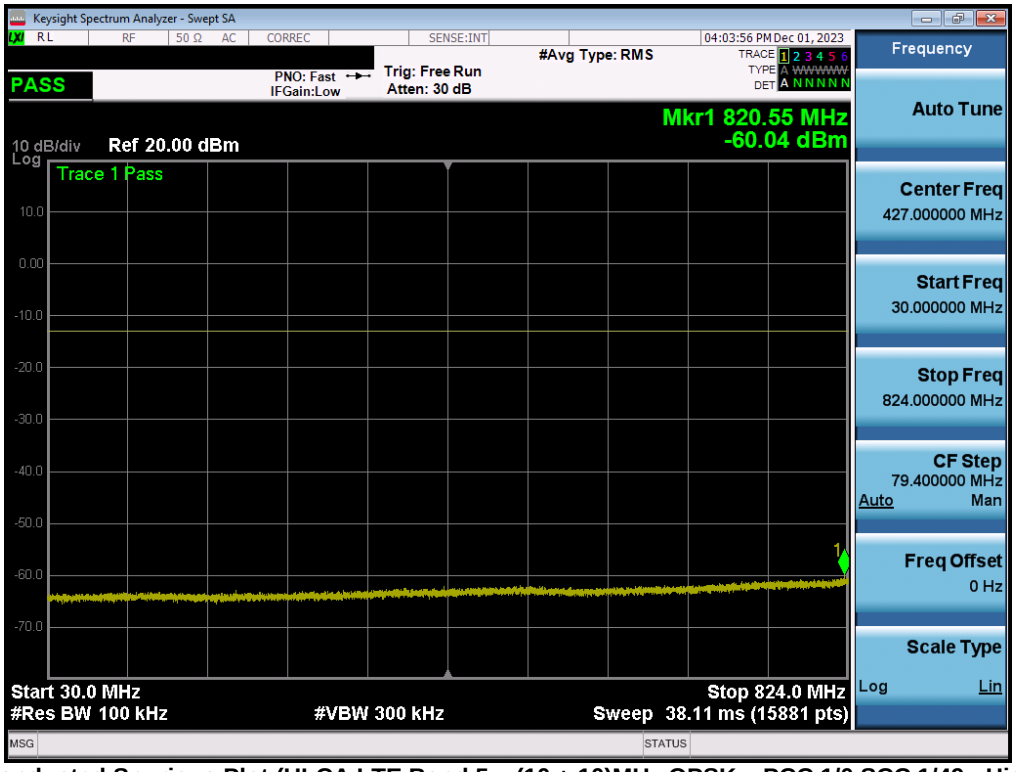
Plot 7-54. Conducted Spurious Plot (ULCA LTE Band 5 – (10 + 10)MHz QPSK – PCC 1/49 SCC 1/0 - Mid Channel)



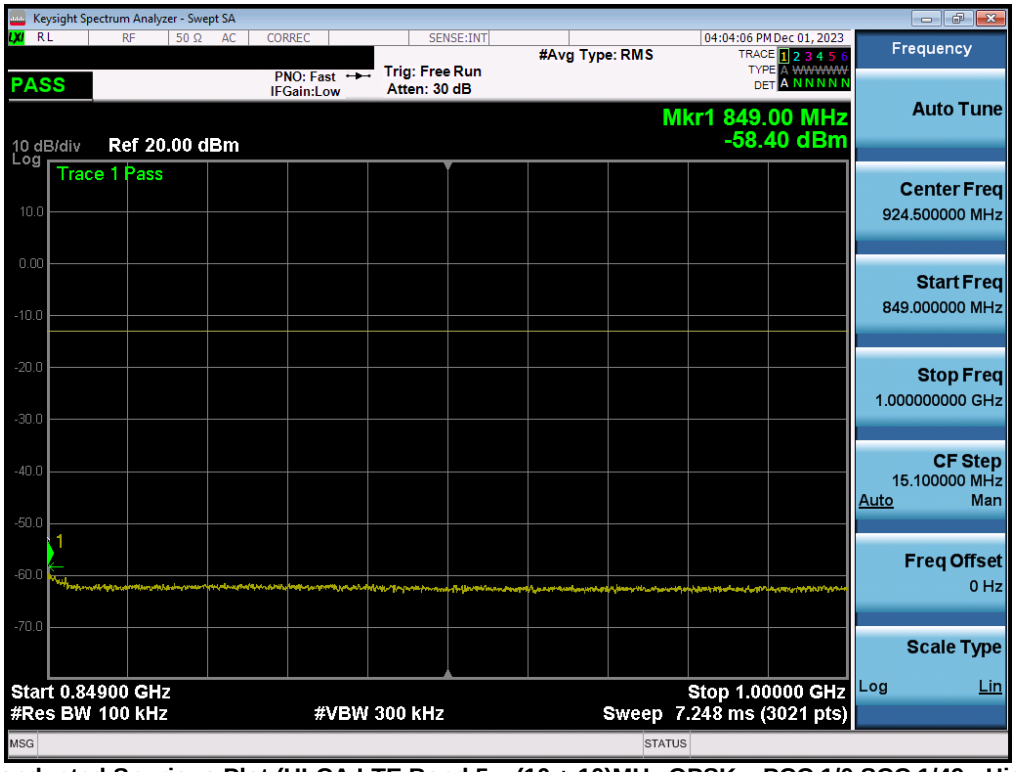
Plot 7-55. Conducted Spurious Plot (ULCA LTE Band 5 – (10 + 10)MHz QPSK – PCC 1/49 SCC 1/0 - Mid Channel)



Plot 7-56. Conducted Spurious Plot (ULCA LTE Band 5 – (10 + 10)MHz QPSK – PCC 1/49 SCC 1/0 - Mid Channel)



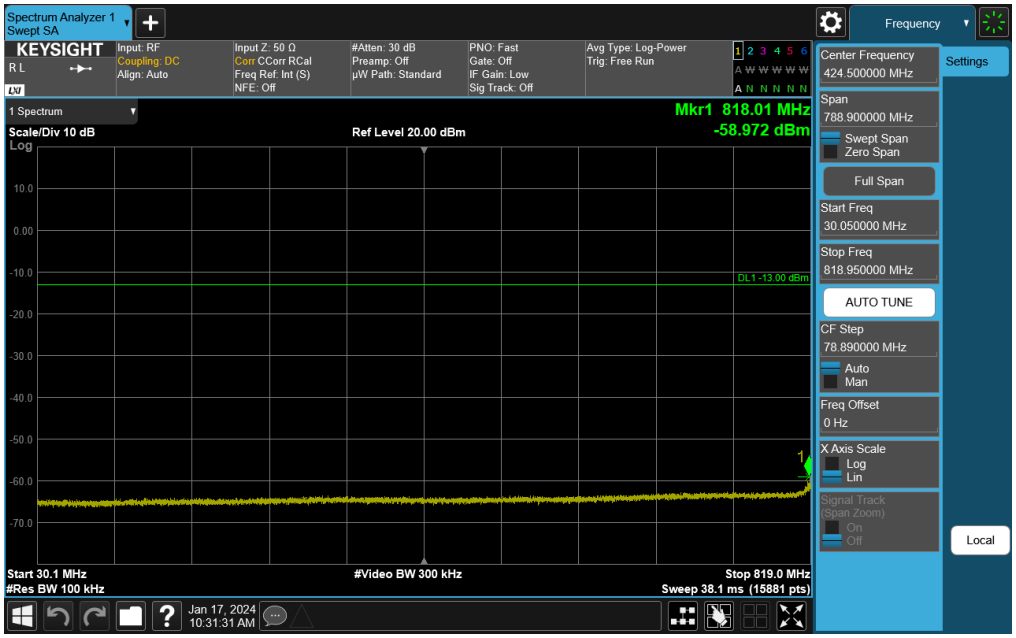
Plot 7-57. Conducted Spurious Plot (ULCA LTE Band 5 – (10 + 10)MHz QPSK – PCC 1/0 SCC 1/49 - High Channel)



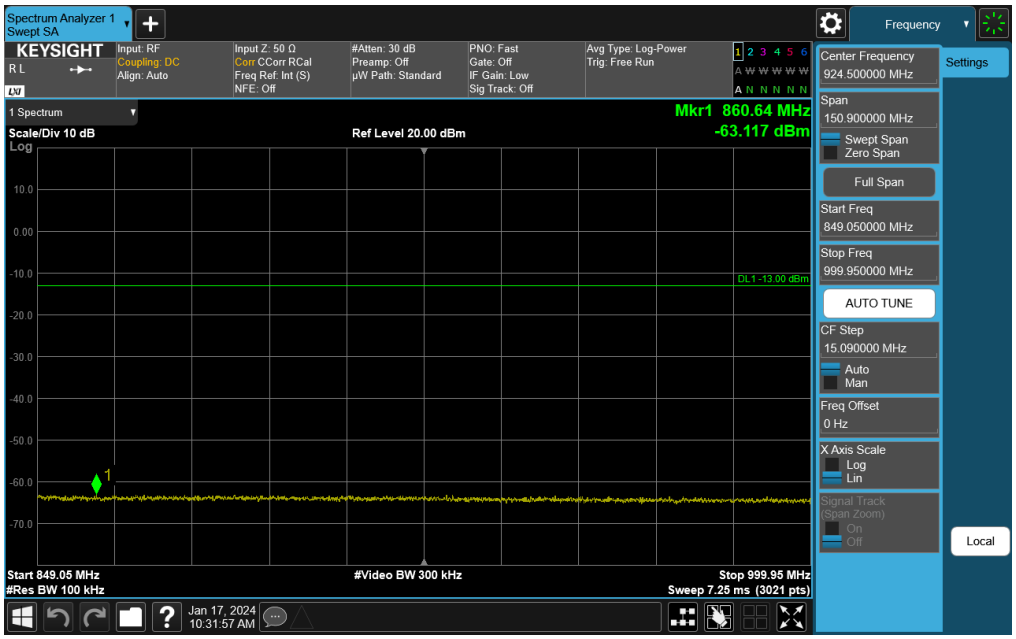
Plot 7-58. Conducted Spurious Plot (ULCA LTE Band 5 – (10 + 10)MHz QPSK – PCC 1/0 SCC 1/49 - High Channel)

Plot 7-59. Conducted Spurious Plot (ULCA LTE Band 5 – (10 + 10)MHz QPSK – PCC 1/0 SCC 1/49 - High Channel)

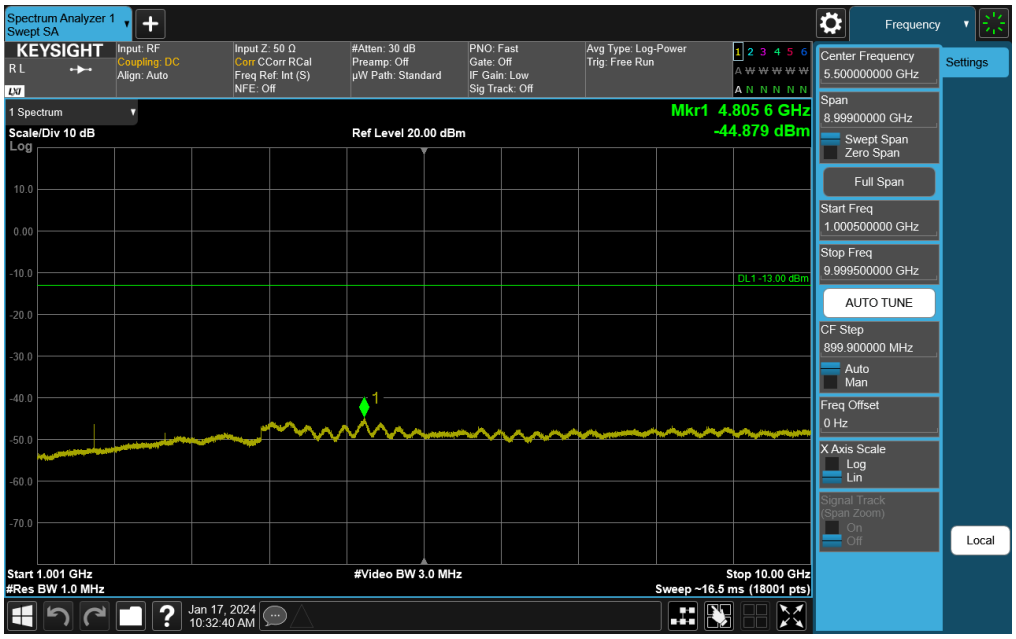
NR Band n26/n5



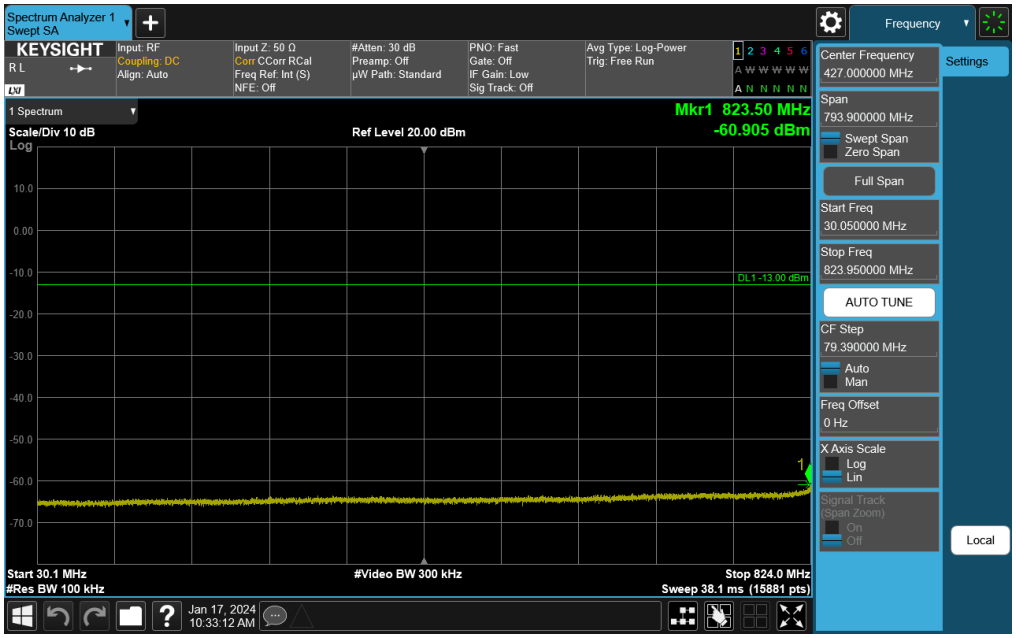
Plot 7-60. Conducted Spurious Plot (NR Band n26/n5 - 20.0MHz DFT-s-OFDM QPSK - RB Size 1, RB Offset 0 - Low Channel)



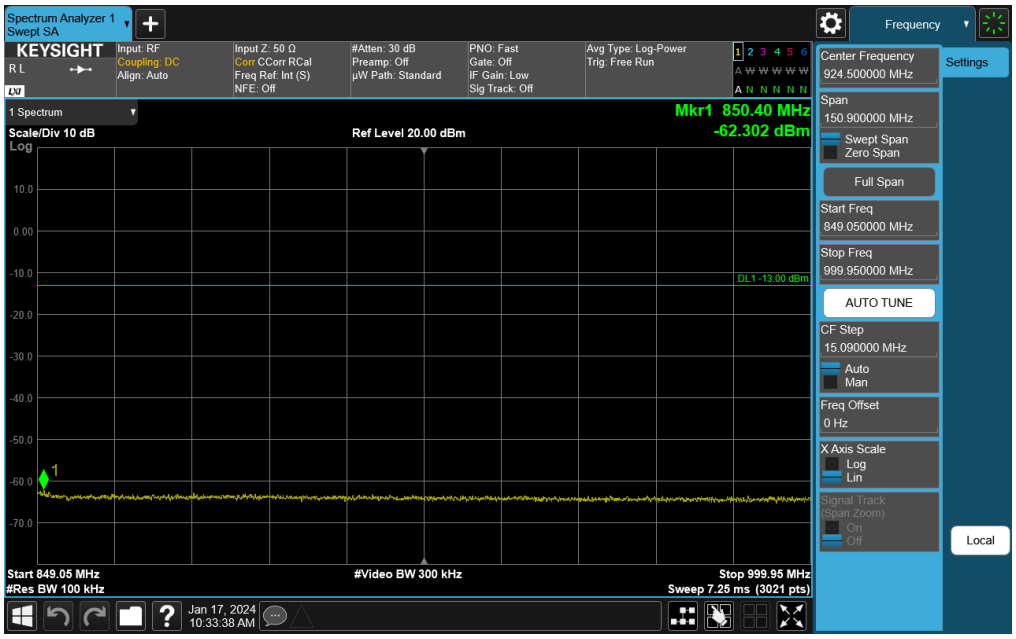
Plot 7-61. Conducted Spurious Plot (NR Band n26/n5 - 20.0MHz DFT-s-OFDM QPSK - RB Size 1, RB Offset 0 - Low Channel)



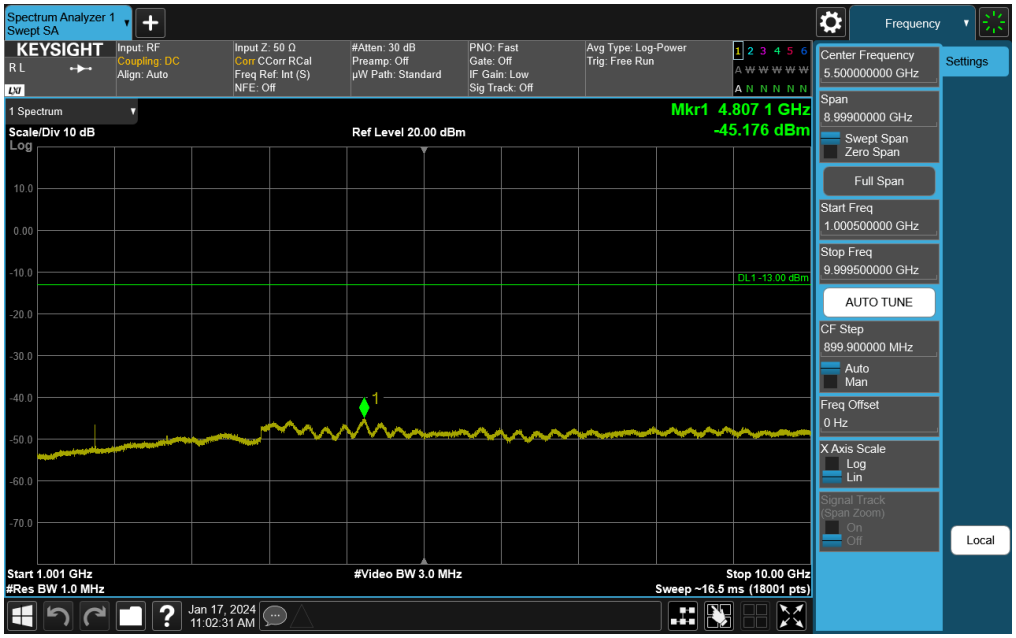
Plot 7-62. Conducted Spurious Plot (NR Band n26/n5 - 20.0MHz DFT-s-OFDM QPSK - RB Size 1, RB Offset 0 - Low Channel)



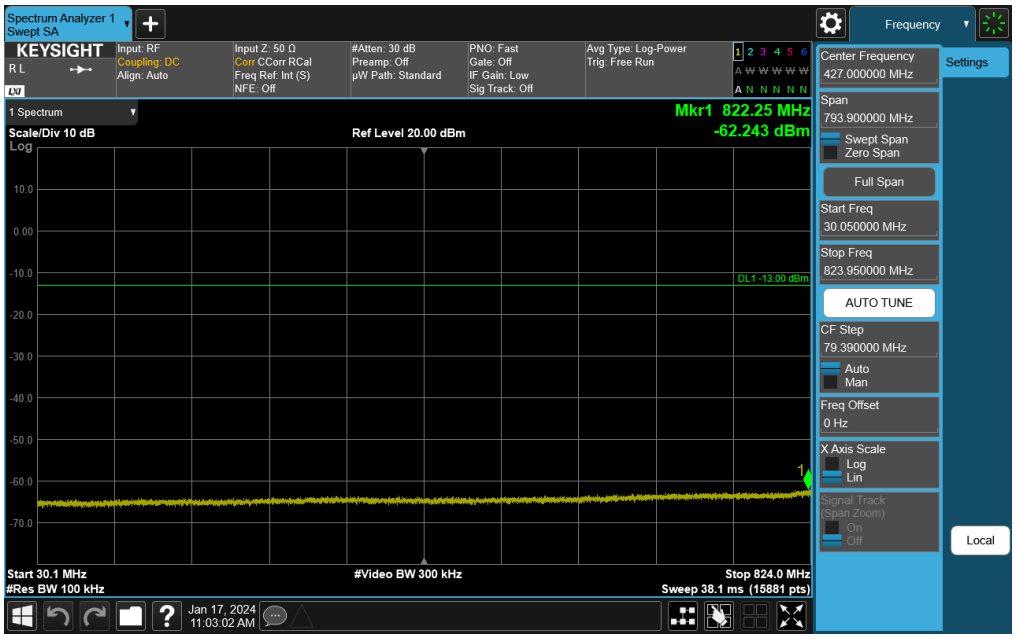
Plot 7-63. Conducted Spurious Plot (NR Band n26/n5 - 20.0MHz DFT-s-OFDM QPSK - RB Size 1, RB Offset 0 - Mid Channel)



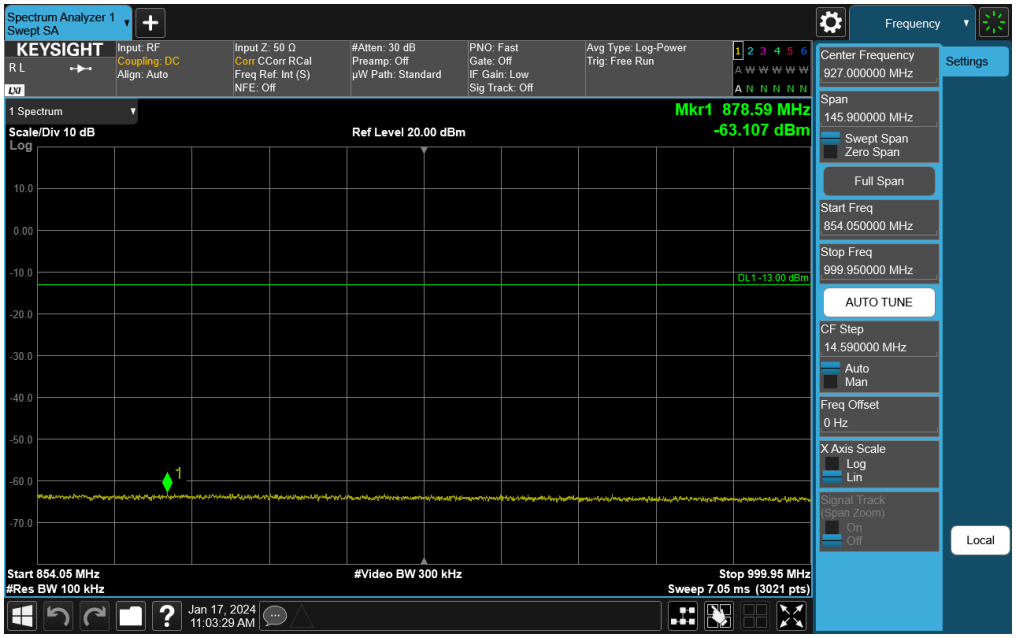
Plot 7-64. Conducted Spurious Plot (NR Band n26/n5 - 20.0MHz DFT-s-OFDM QPSK - RB Size 1, RB Offset 0 - Mid Channel)



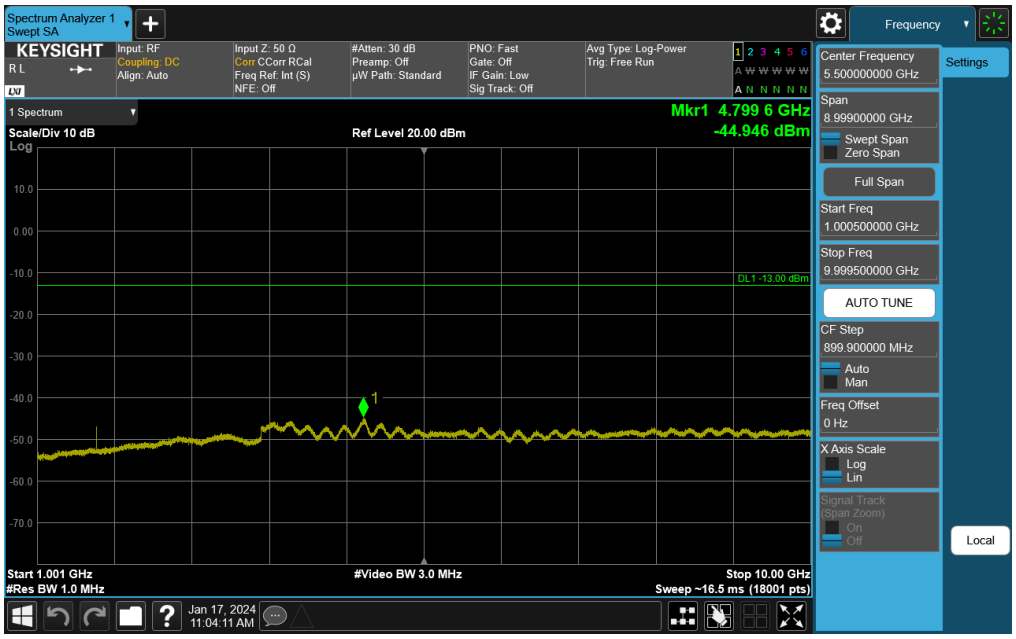
Plot 7-65. Conducted Spurious Plot (NR Band n26/n5 - 20.0MHz DFT-s-OFDM QPSK - RB Size 1, RB Offset 0 - Mid Channel)



Plot 7-66. Conducted Spurious Plot (NR Band n26/n5 - 20.0MHz DFT-s-OFDM QPSK - RB Size 1, RB Offset 0 - High Channel)

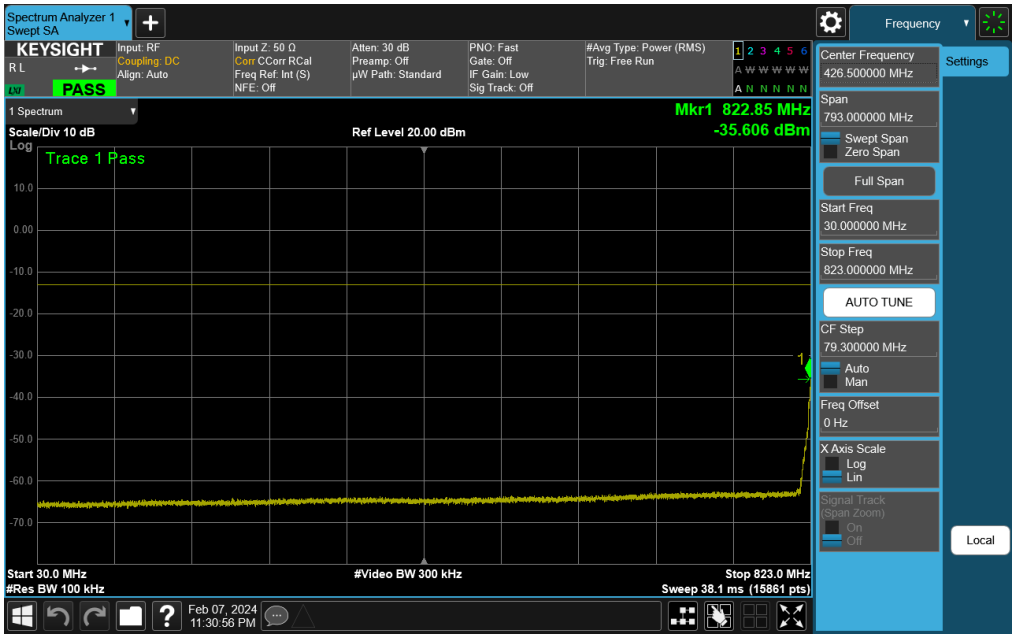


Plot 7-67. Conducted Spurious Plot (NR Band n26/n5 - 20.0MHz DFT-s-OFDM QPSK - RB Size 1, RB Offset 0 - High Channel)

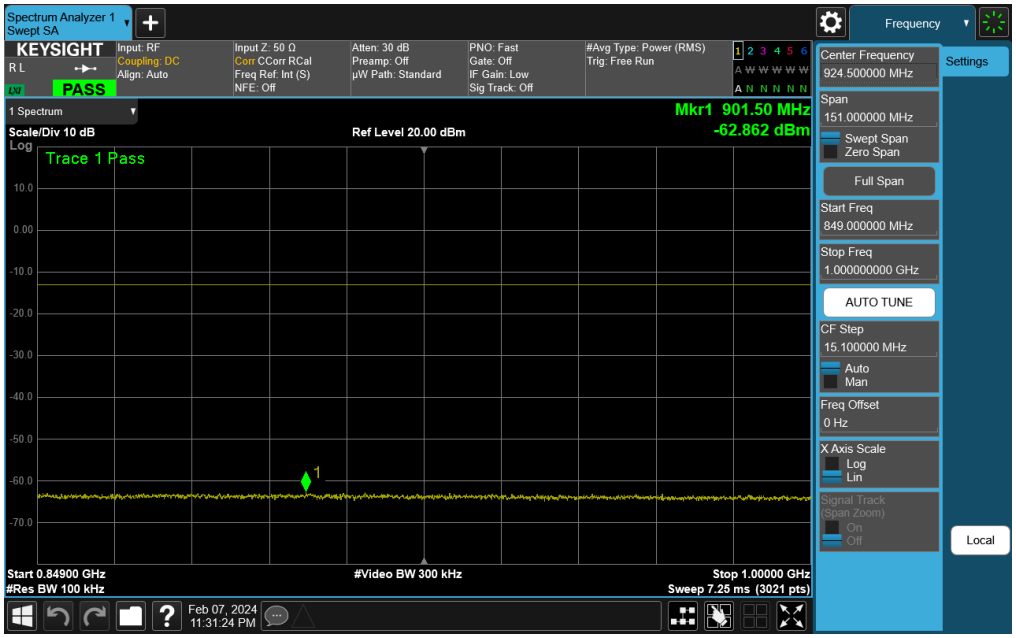


Plot 7-68. Conducted Spurious Plot (NR Band n26/n5 - 20.0MHz DFT-s-OFDM QPSK - RB Size 1, RB Offset 0 - High Channel)

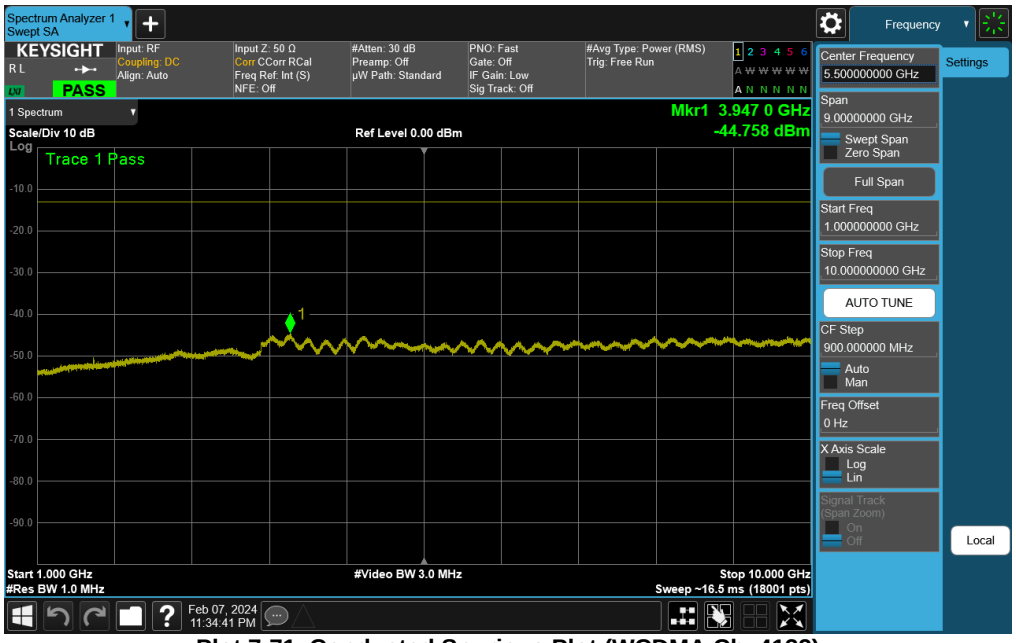
WCDMA Cell



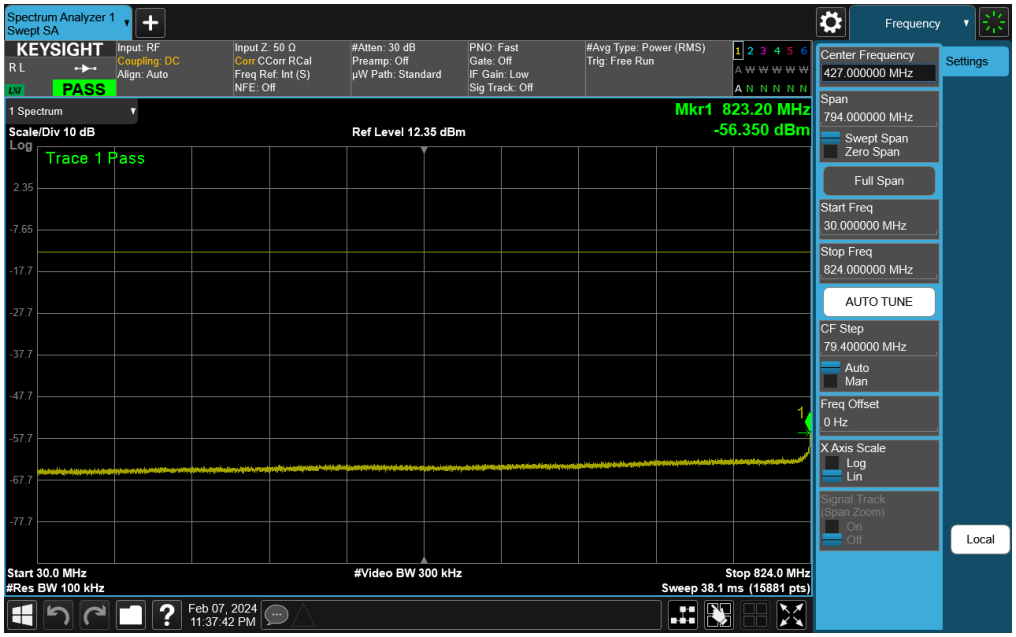
Plot 7-69. Conducted Spurious Plot (WCDMA Ch. 4132)



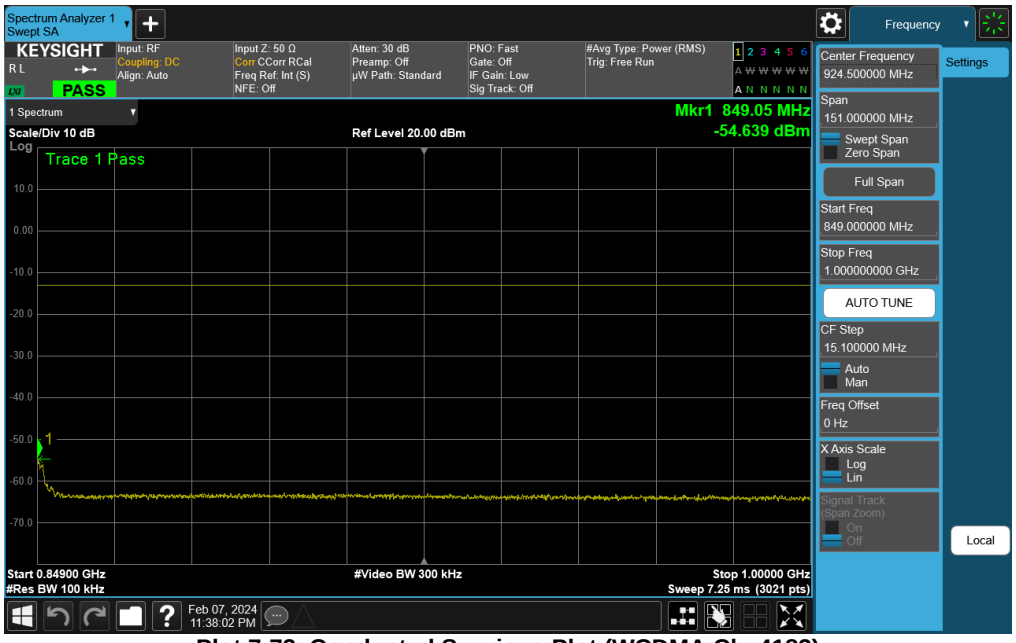
Plot 7-70. Conducted Spurious Plot (WCDMA Ch. 4132)



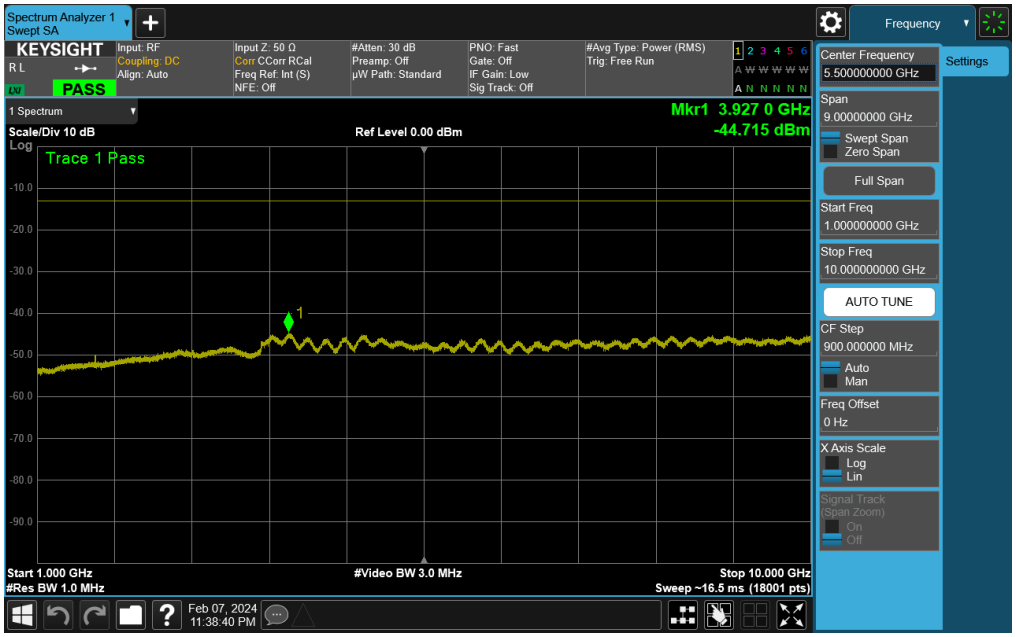
Plot 7-71. Conducted Spurious Plot (WCDMA Ch. 4132)



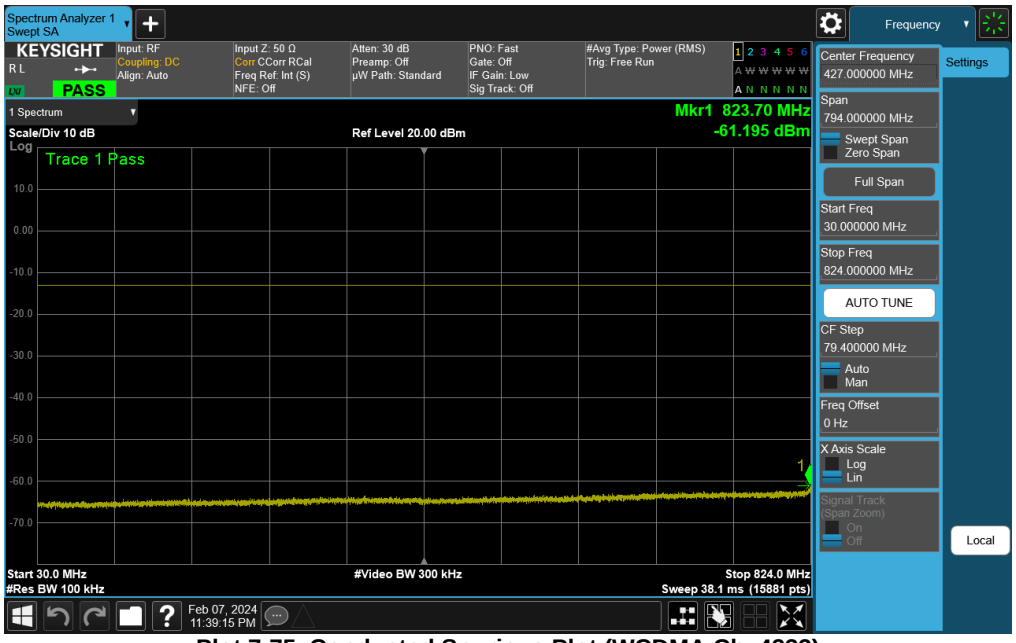
Plot 7-72. Conducted Spurious Plot (WCDMA Ch. 4183)



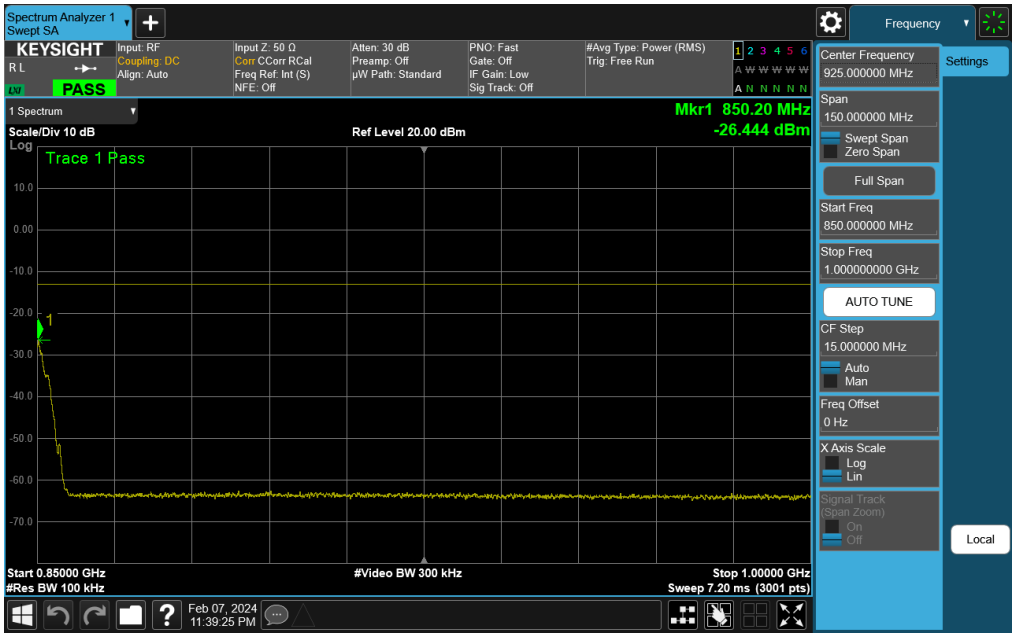
Plot 7-73. Conducted Spurious Plot (WCDMA Ch. 4183)



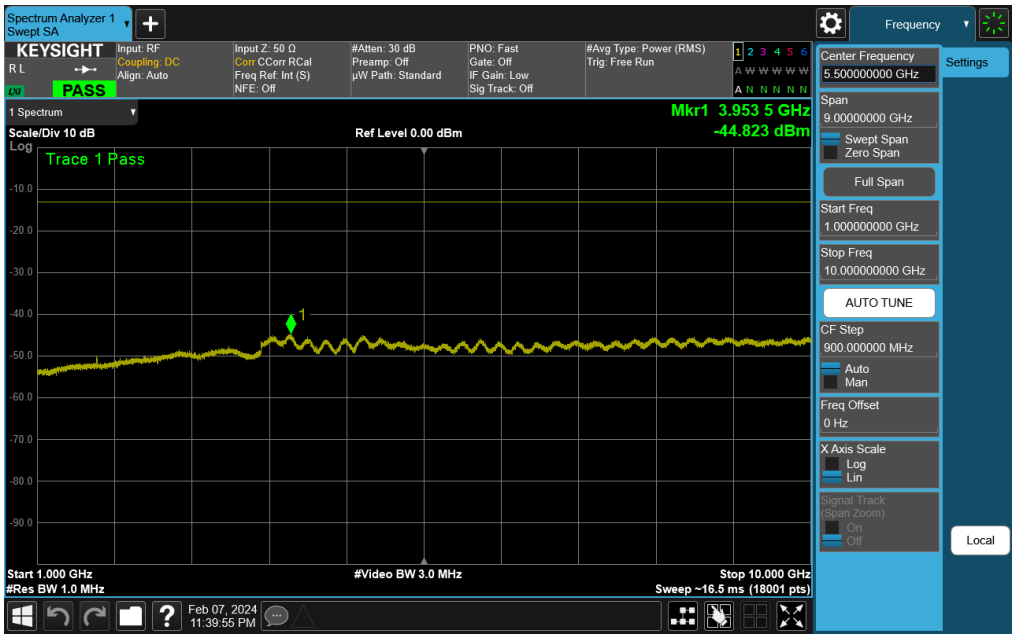
Plot 7-74. Conducted Spurious Plot (WCDMA Ch. 4183)



Plot 7-75. Conducted Spurious Plot (WCDMA Ch. 4233)



Plot 7-76. Conducted Spurious Plot (WCDMA Ch. 4233)



Plot 7-77. Conducted Spurious Plot (WCDMA Ch. 4233)

7.4 Band Edge Emissions at Antenna Terminal

§2.1051, 22.917(a)

Test Overview

All out of band emissions are measured with a spectrum analyzer connected to the antenna terminal of the EUT while the EUT is operating at maximum power, and at the appropriate frequencies. All data rates were investigated to determine the worst case configuration. All modes of operation were investigated and the worst case configuration results are reported in this section. All ports were tested and only the worst case data was reported.

The minimum permissible attenuation level of any spurious emission is 43 + 10 $log_{10}(P_{[Watts]})$, where P is the transmitter power in Watts.

Test Procedure Used

KDB 971168 D01 v03r01 – Section 6.0

Test Settings

1. Start and stop frequency were set such that the band edge would be placed in the center of the plot
2. Span was set large enough so as to capture all out of band emissions near the band edge
3. RBW $\geq$ 1% of the emission bandwidth
4. VBW $\geq$ 3 x RBW
5. Detector = RMS
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 Setup

The EUT and measurement equipment were set up as shown in the diagram below.

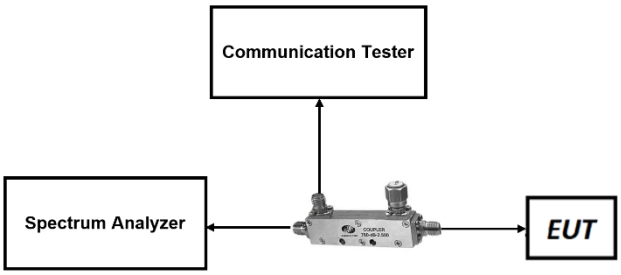


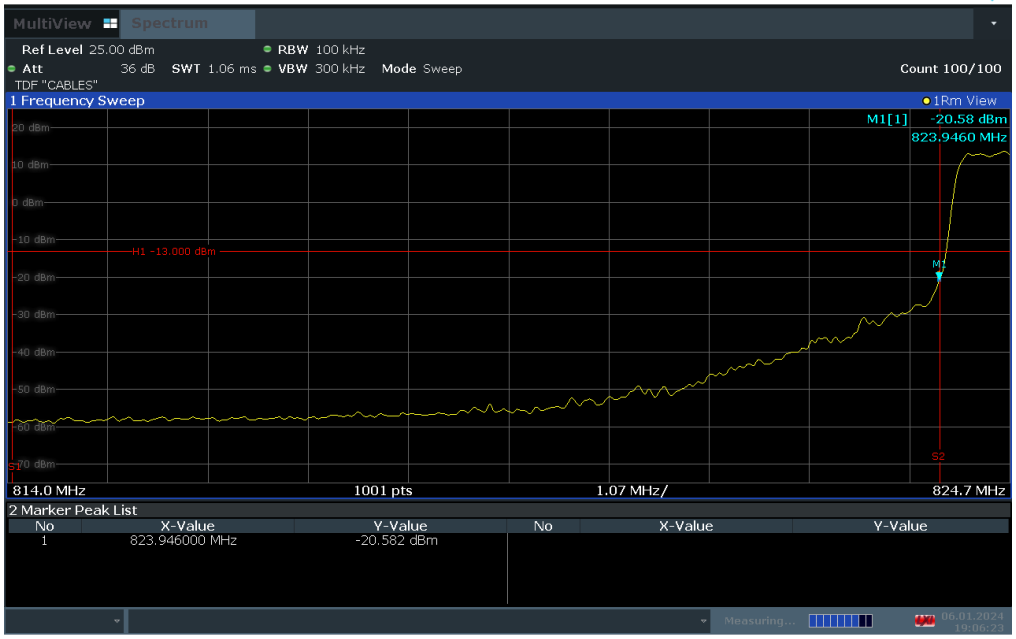
Figure 7-3. Test Instrument & Measurement Setup

Test Notes

1. Per 22.917(b), in the 1 MHz bands immediately outside and adjacent to the frequency block a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed to demonstrate compliance with the out-of-band emissions limit. The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emission are attenuated at least 26 dB below the transmitter power.

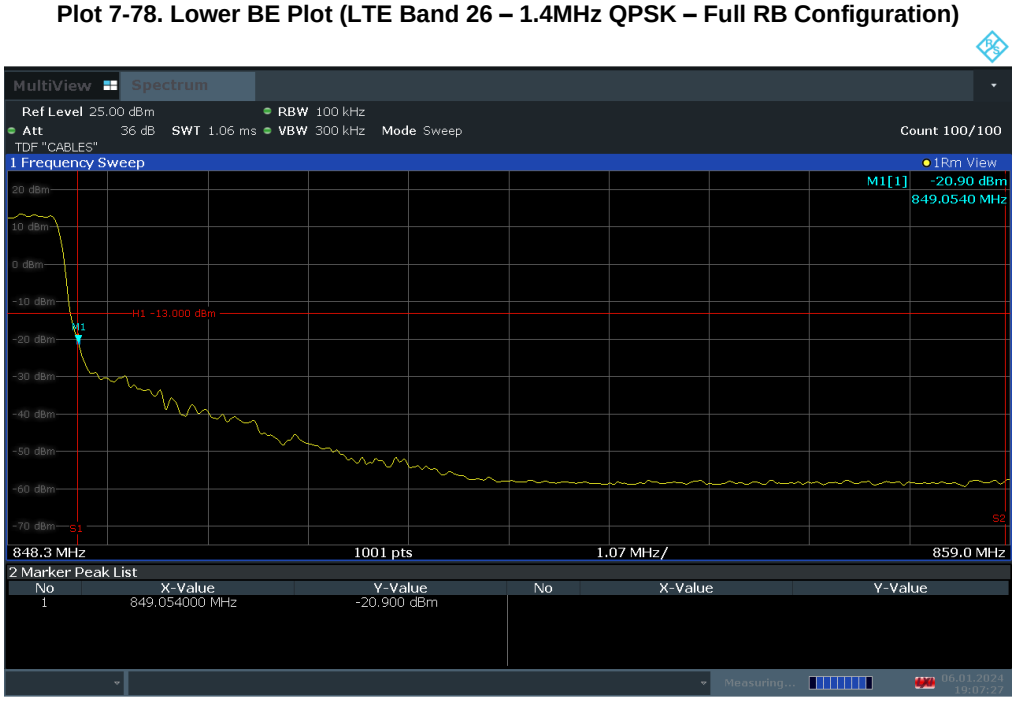
2. For NR operation, all subcarrier spacings (SCS) and transmission schemes (e.g. CP-OFDM and DFT-s-OFDM) were investigated to determine the worst case configuration. All modes of operation were investigated and the worst case configuration results are reported in this section.

LTE Band 26



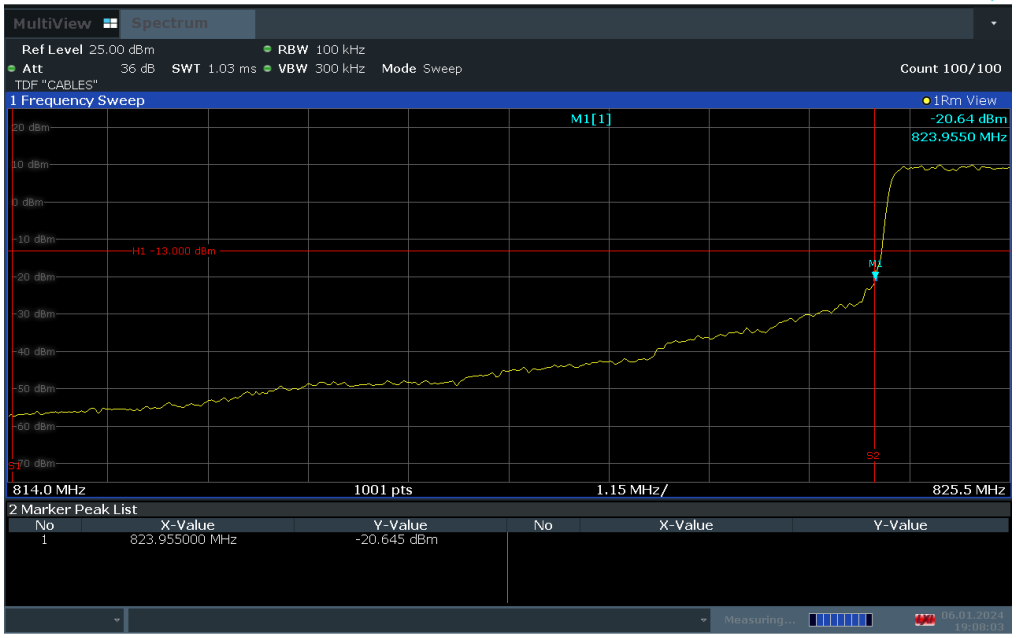
19:06:24 06.01.2024

Plot 7-78. Lower BE Plot (LTE Band 26 – 1.4MHz QPSK – Full RB Configuration)

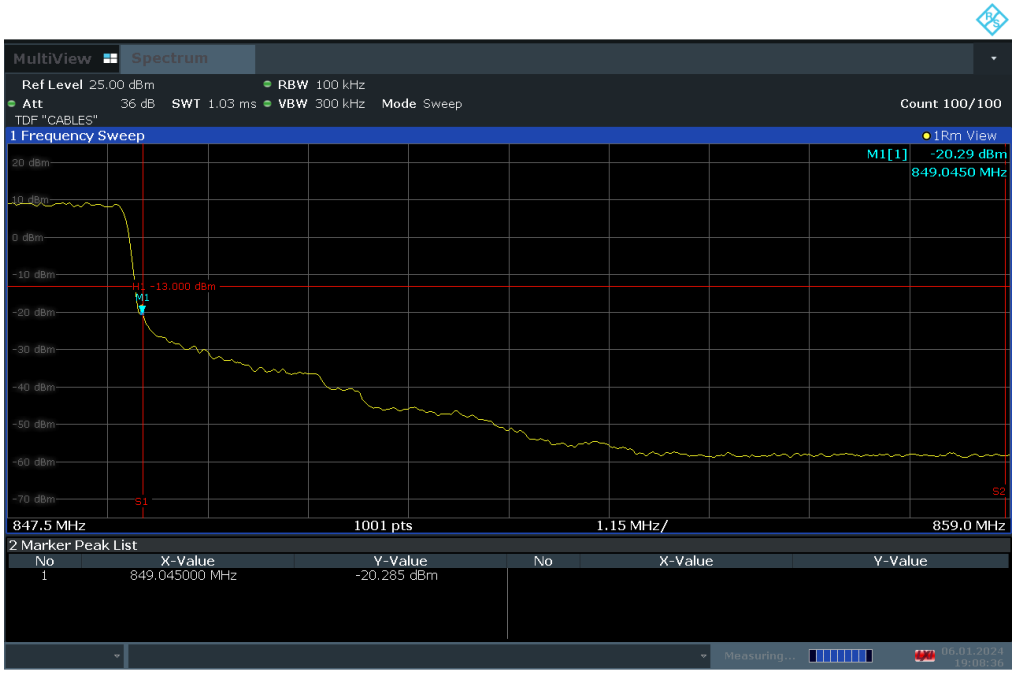


19:07:28 06.01.2024

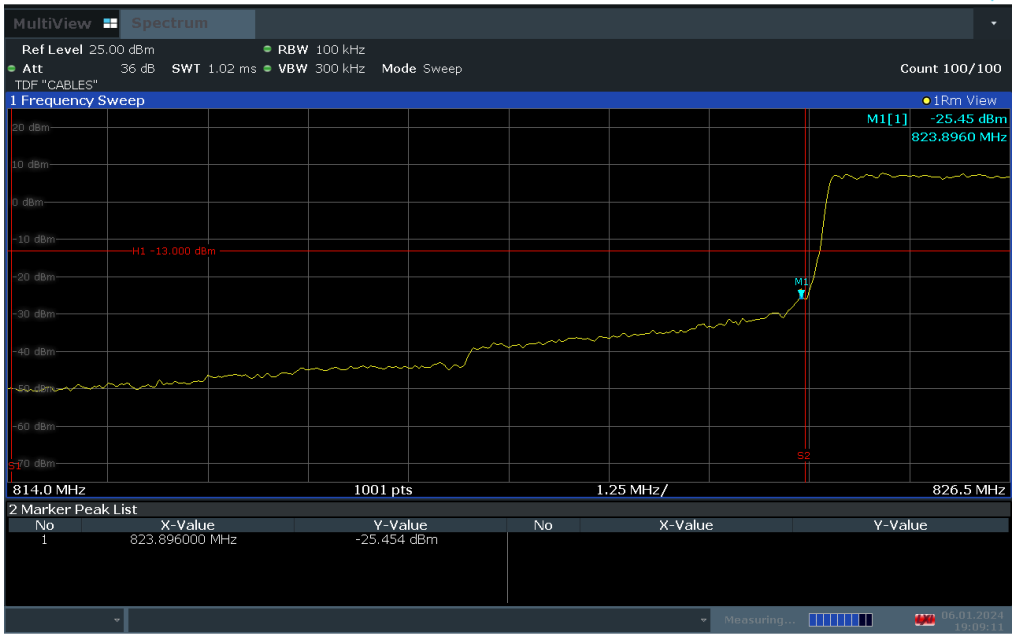
Plot 7-79. Upper BE Plot (LTE Band 26 – 1.4MHz QPSK – Full RB Configuration)



Plot 7-80. Lower BE Plot (LTE Band 26 - 3MHz QPSK – Full RB Configuration)

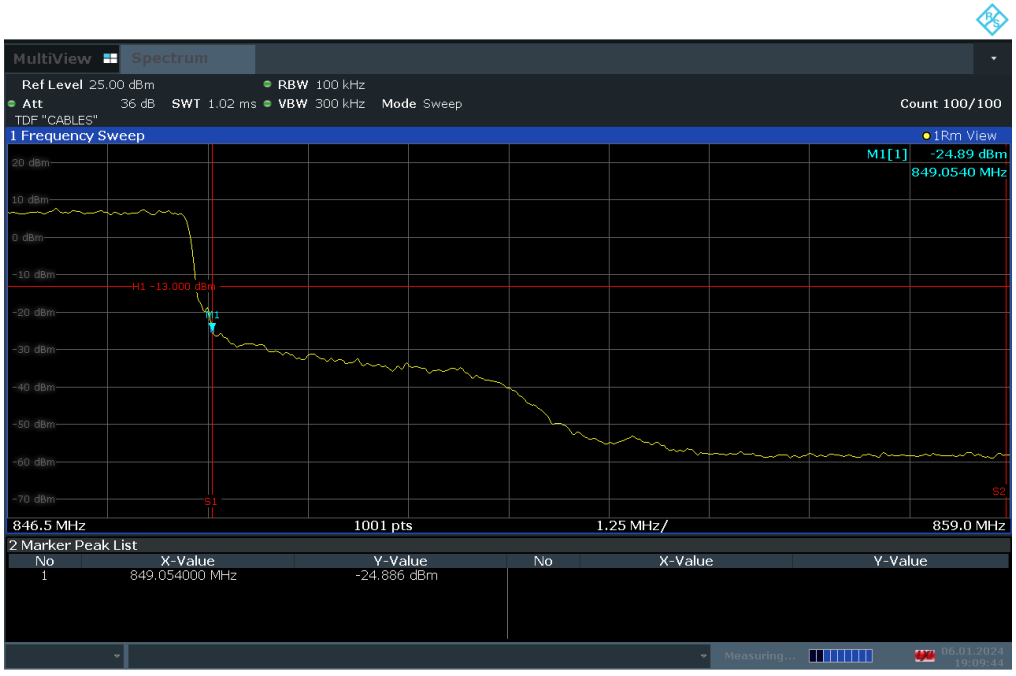


Plot 7-81. Upper BE Plot (LTE Band 26 - 3MHz QPSK – Full RB Configuration)



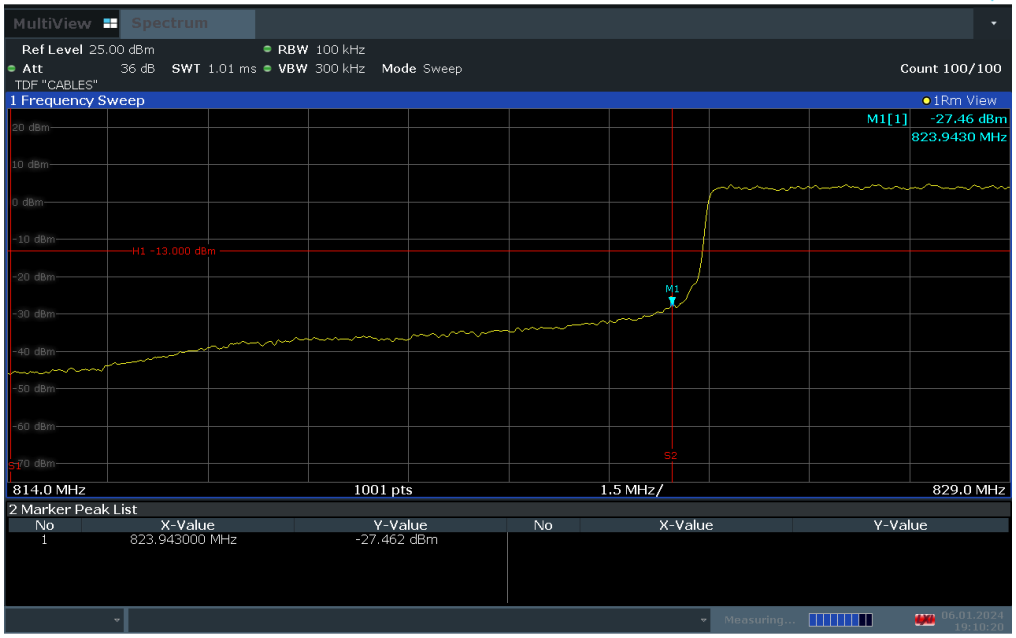
19:09:12 06.01.2024

Plot 7-82. Lower BE Plot (LTE Band 26 - 5MHz QPSK – Full RB Configuration)



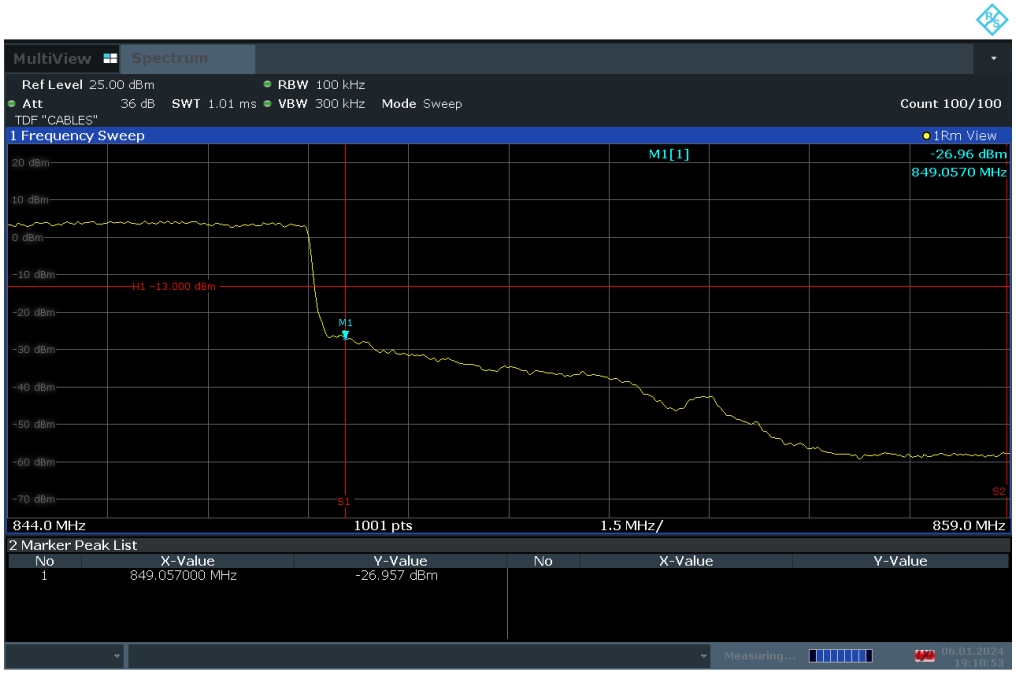
19:09:45 06.01.2024

Plot 7-83. Upper BE Plot (LTE Band 26 - 5MHz QPSK – Full RB Configuration)



19:10:21 06.01.2024

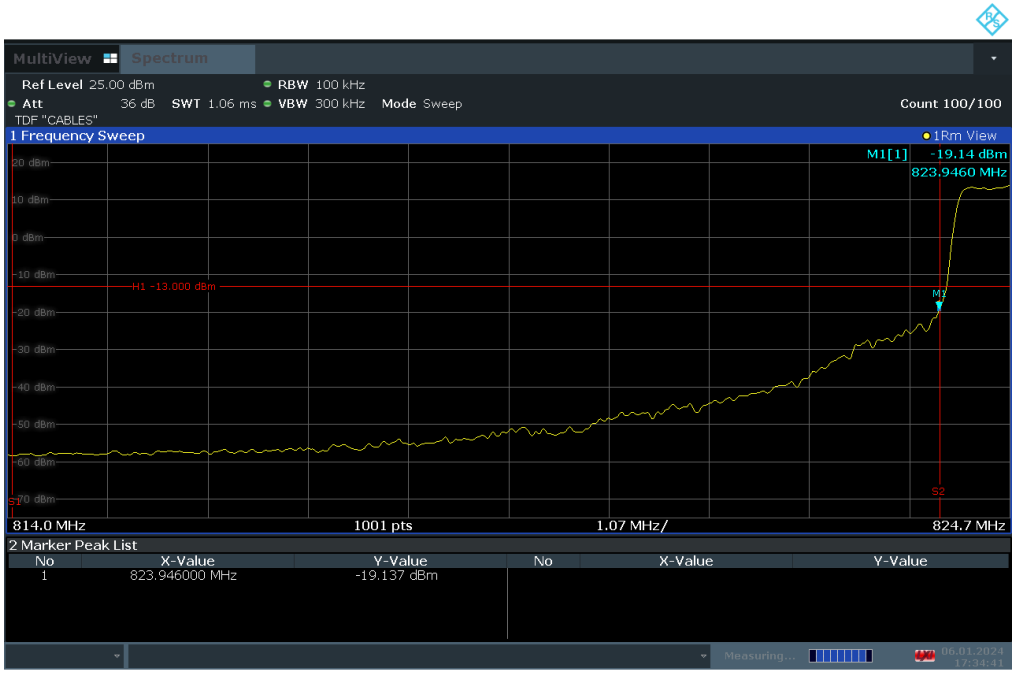
Plot 7-84. Lower BE Plot (LTE Band 26 - 10MHz QPSK – Full RB Configuration)



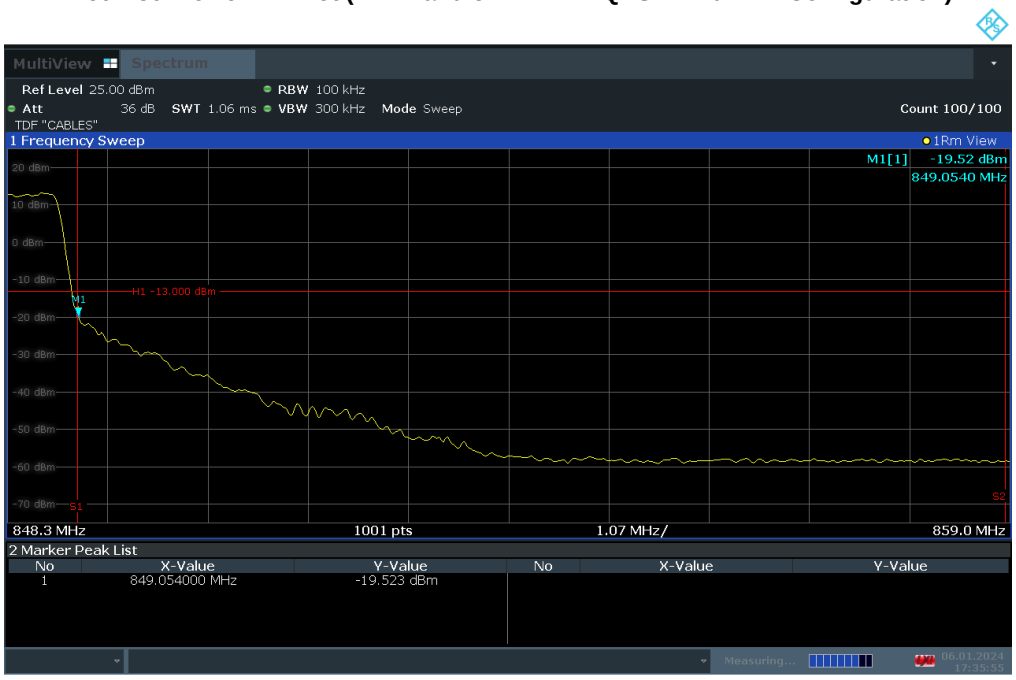
19:10:54 06.01.2024

Plot 7-85. Upper BE Plot (LTE Band 26 - 10MHz QPSK – Full RB Configuration)

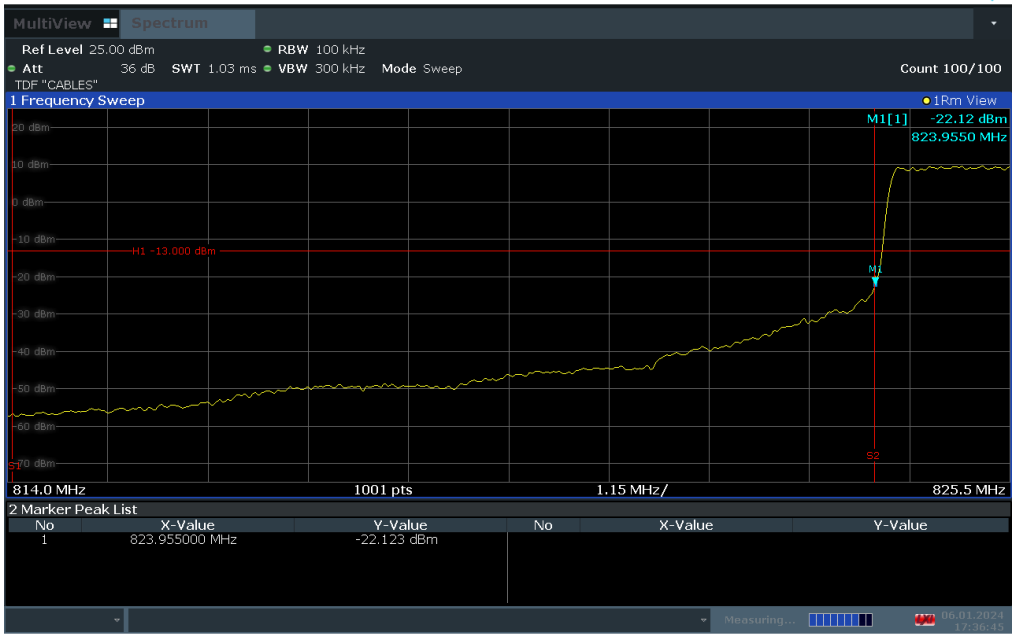
LTE Band 5



Plot 7-86. Lower BE Plot (LTE Band 5 – 1.4MHz QPSK – Full RB Configuration)

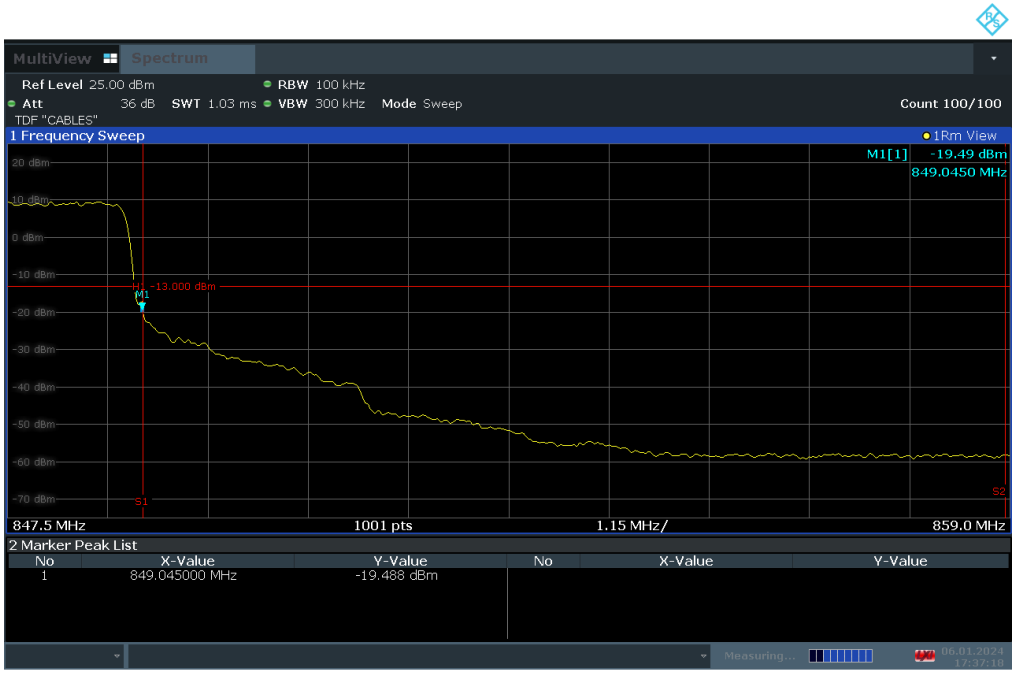


Plot 7-87. Upper BE Plot (LTE Band 5 – 1.4MHz QPSK – Full RB Configuration)



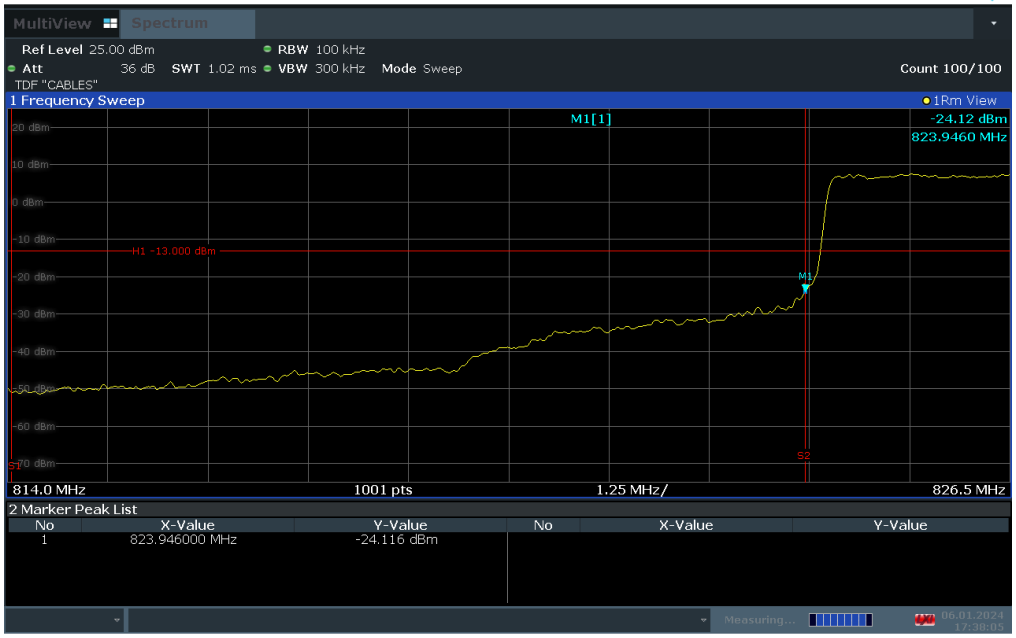
17:36:46 06.01.2024

Plot 7-88. Lower BE Plot (LTE Band 5 - 3MHz QPSK – Full RB Configuration)



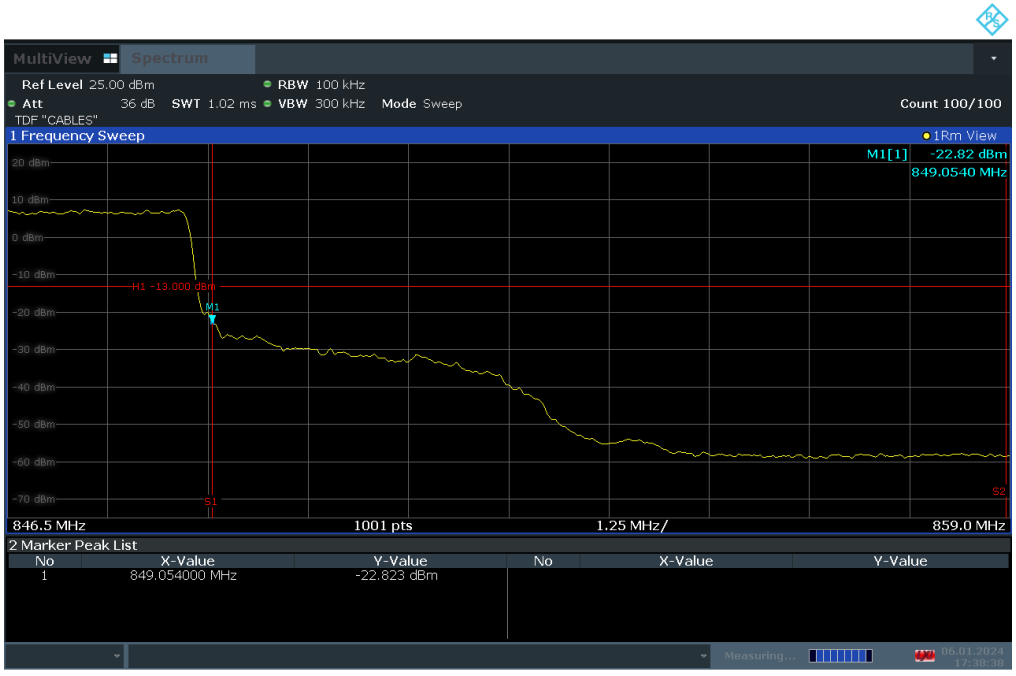
17:37:19 06.01.2024

Plot 7-89. Upper BE Plot (LTE Band 5 - 3MHz QPSK – Full RB Configuration)



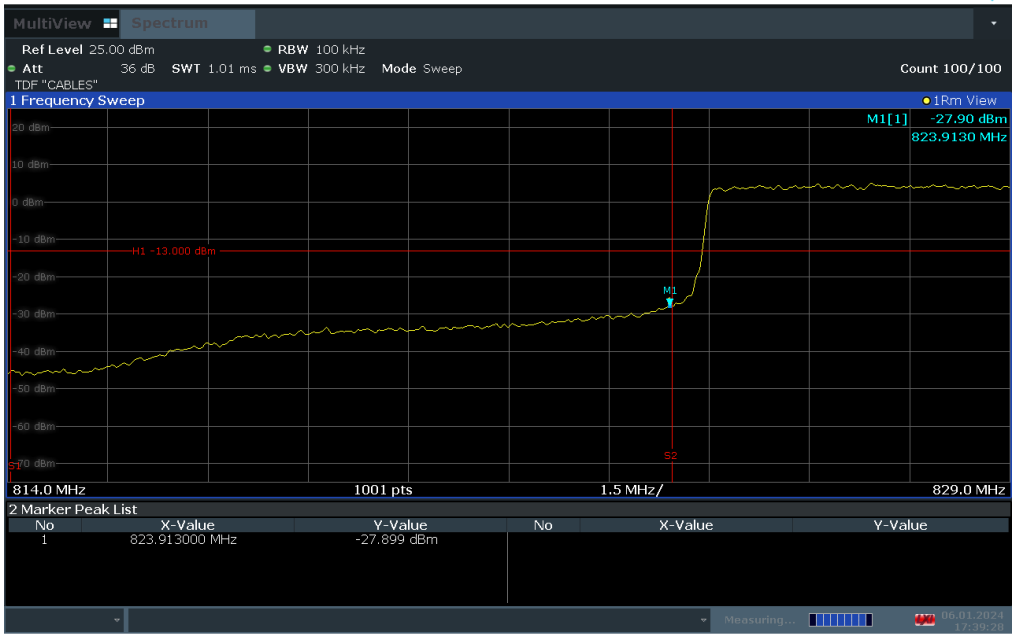
17:38:06 06.01.2024

Plot 7-90. Lower BE Plot (LTE Band 5 - 5MHz QPSK – Full RB Configuration)



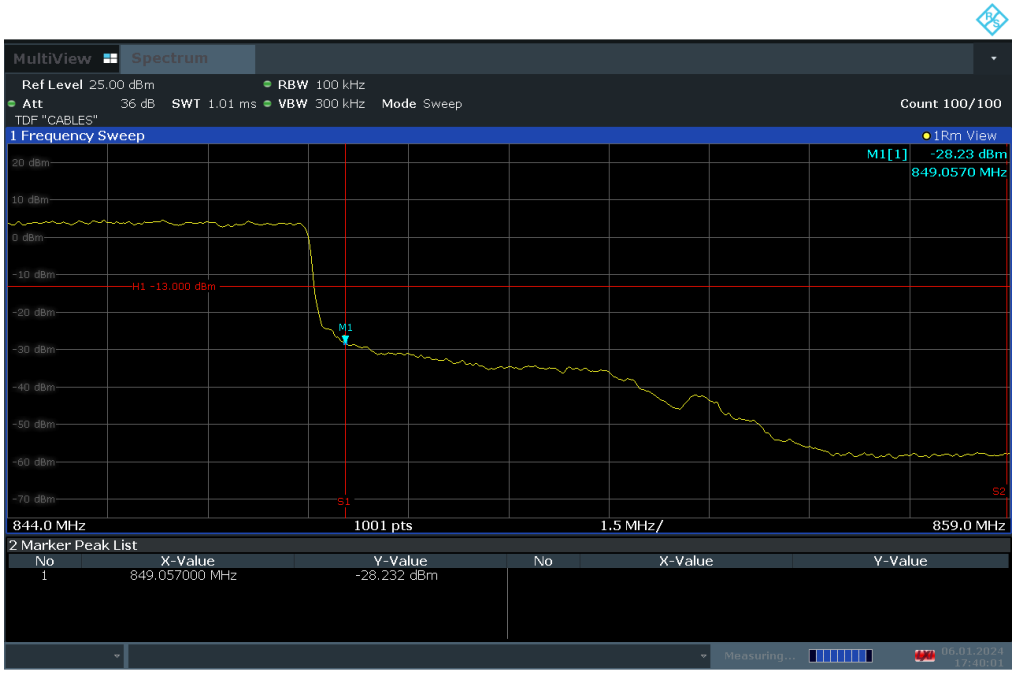
17:38:38 06.01.2024

Plot 7-91. Upper BE Plot (LTE Band 5 - 5MHz QPSK – Full RB Configuration)



17:39:29 06.01.2024

Plot 7-92. Lower BE Plot (LTE Band 5 - 10MHz QPSK – Full RB Configuration)

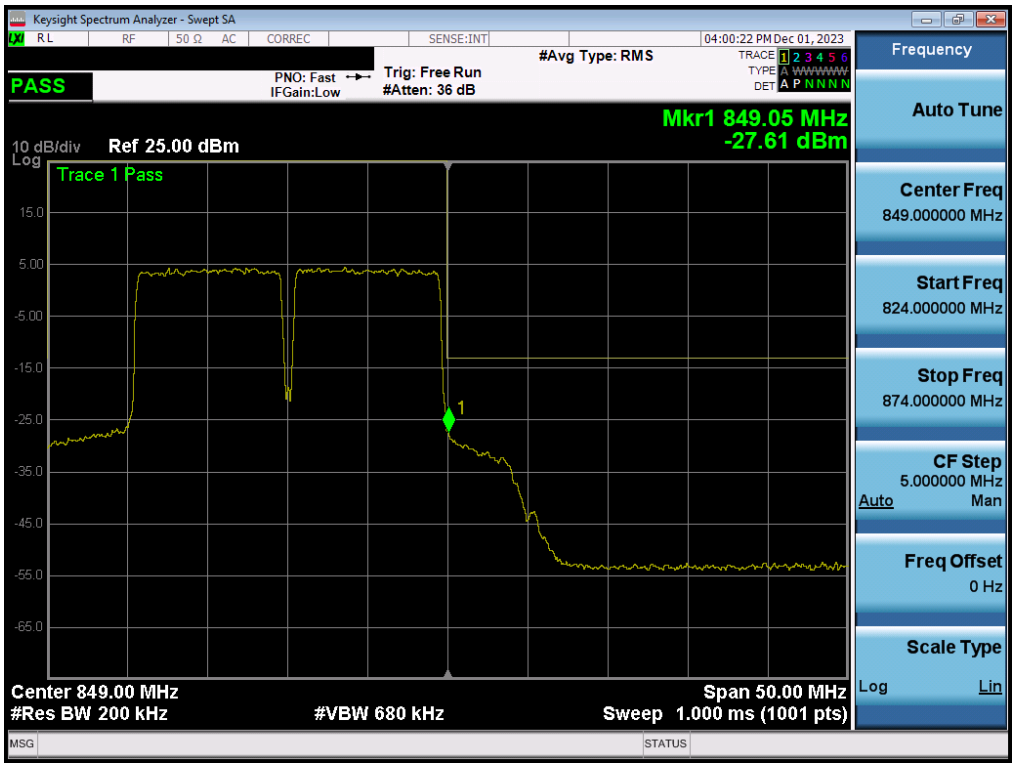


17:40:02 06.01.2024

Plot 7-93. Upper BE Plot (LTE Band 5 - 10MHz QPSK – Full RB Configuration)

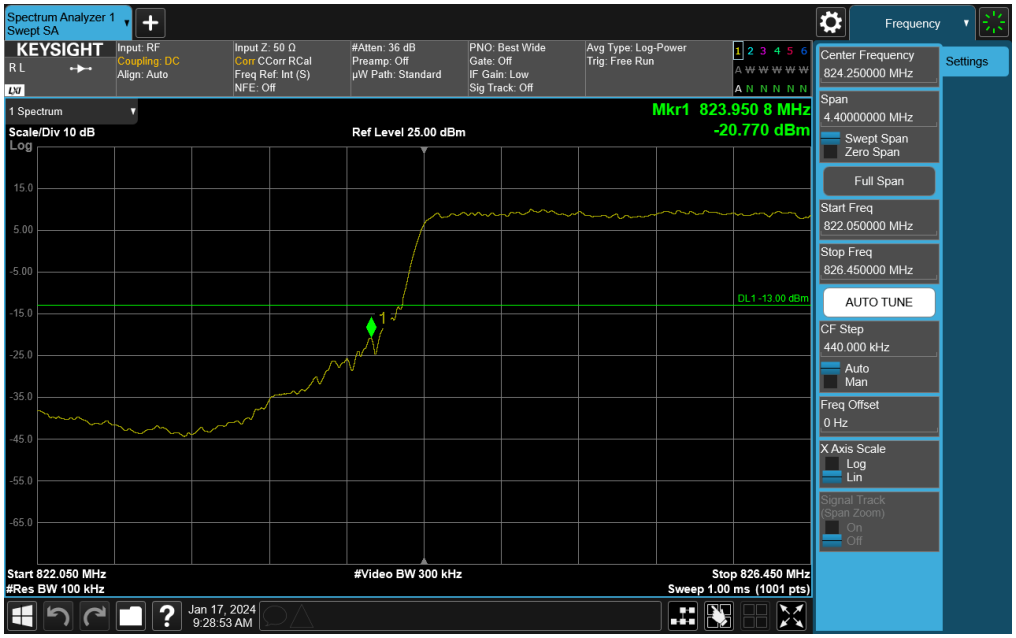
ULCA - LTE Band 5

Plot 7-94. Lower BE Plot (ULCA – LTE Band 5 – (10 + 10)MHz QPSK – Full RB Configuration)

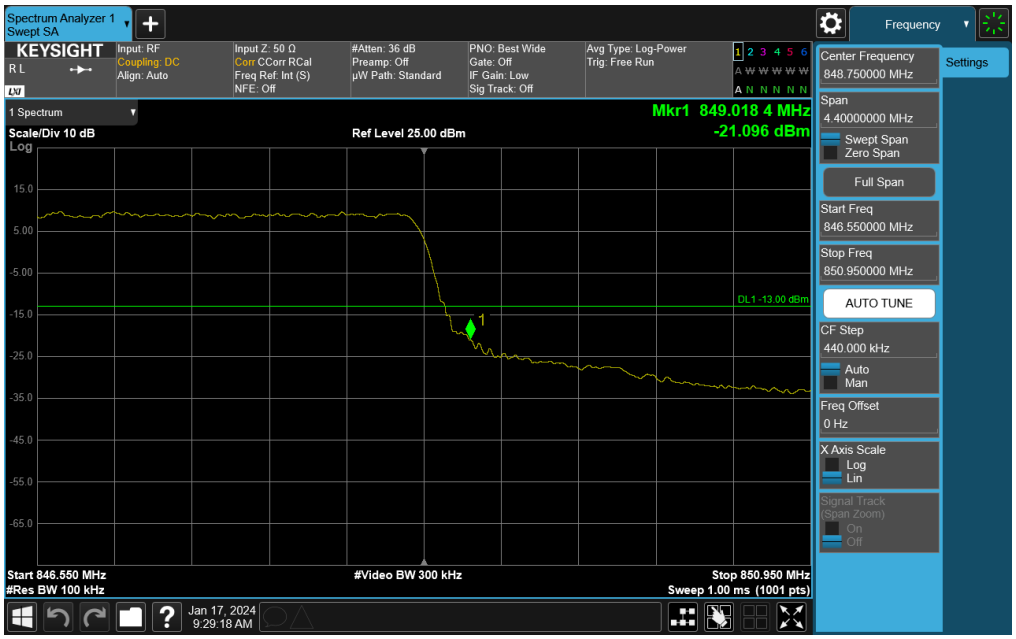


Plot 7-95. Upper BE Plot (ULCA – LTE Band 5 - (10 + 10)MHz QPSK – Full RB Configuration)

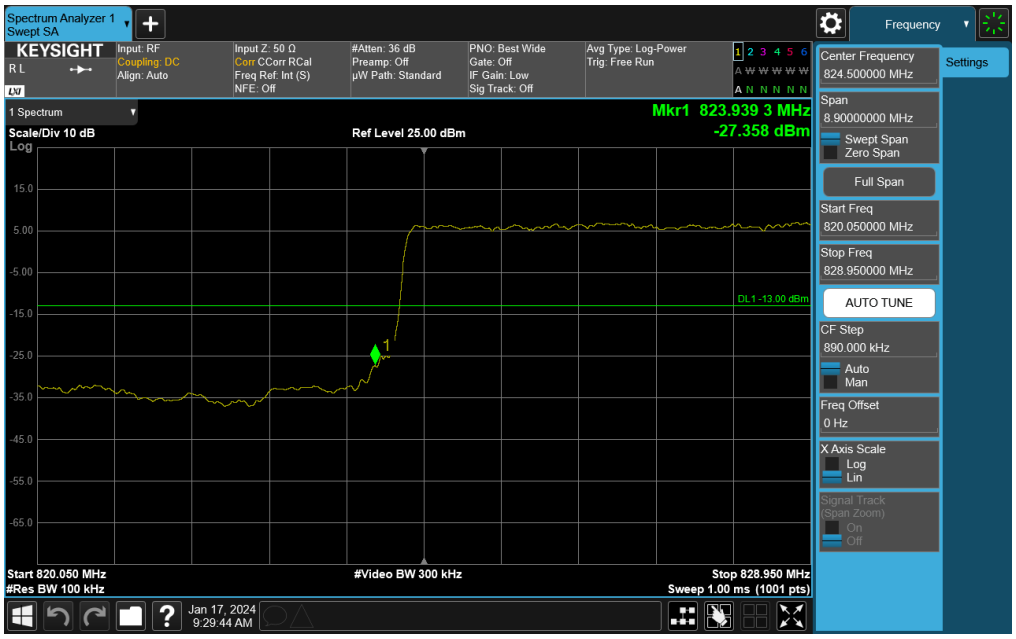
NR Band n26



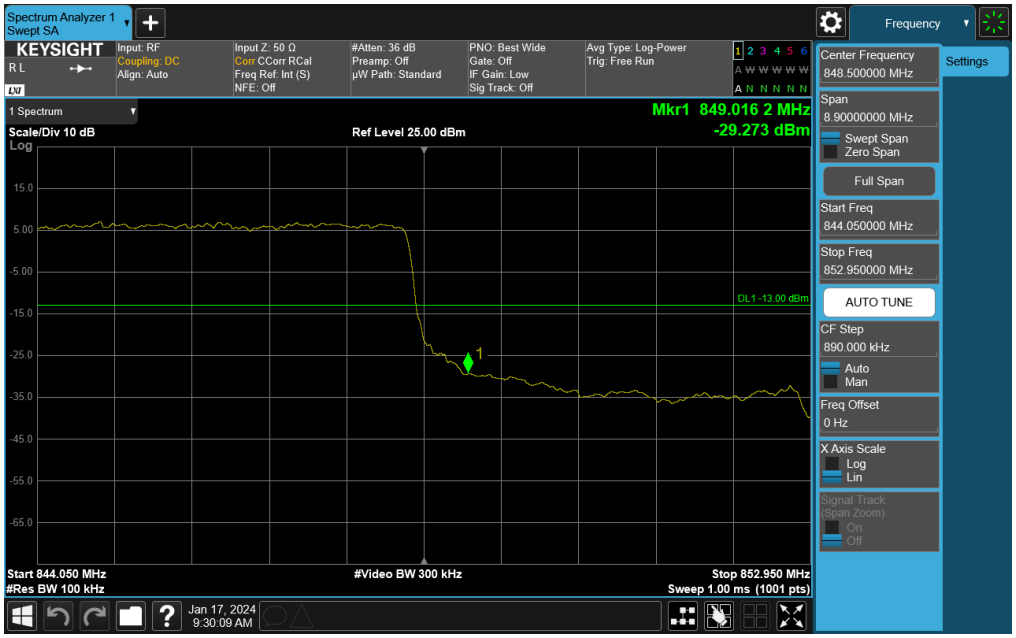
Plot 7-96. Lower BE Plot (NR Band n26 DFT-s-OFDM QPSK – 5.0MHz - Full RB)



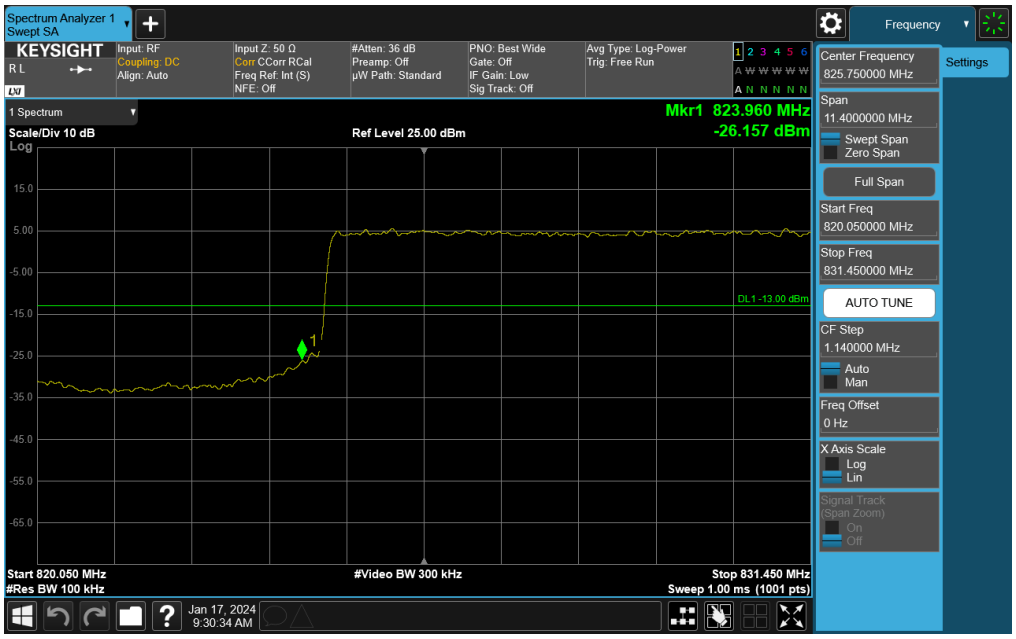
Plot 7-97. Upper BE Plot (NR Band n26 DFT-s-OFDM QPSK – 5.0MHz - Full RB)



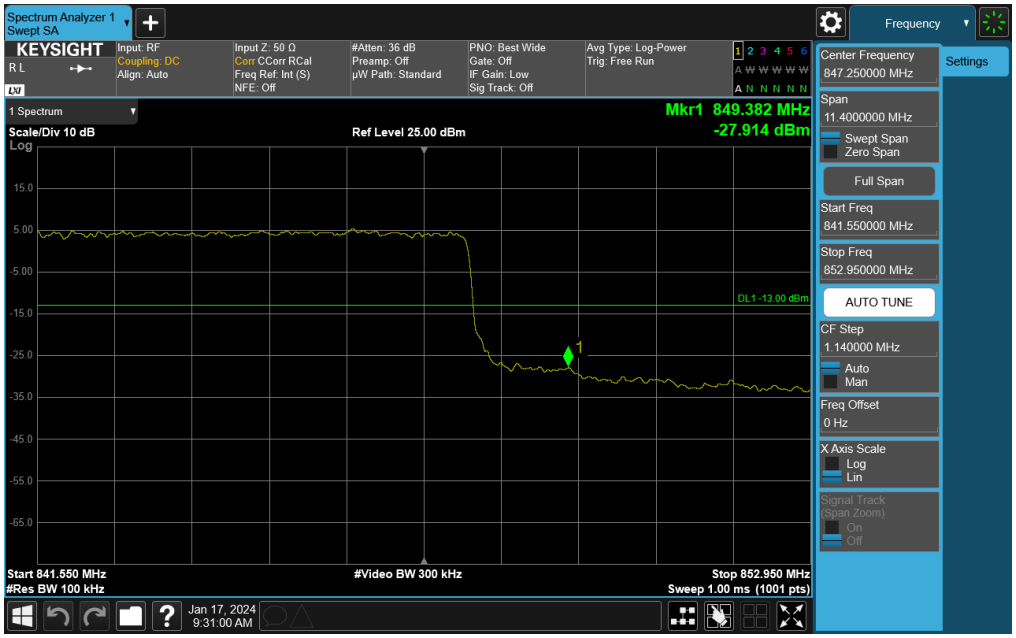
Plot 7-98. Lower BE Plot (NR Band n26 DFT-s-OFDM QPSK – 10.0MHz - Full RB)



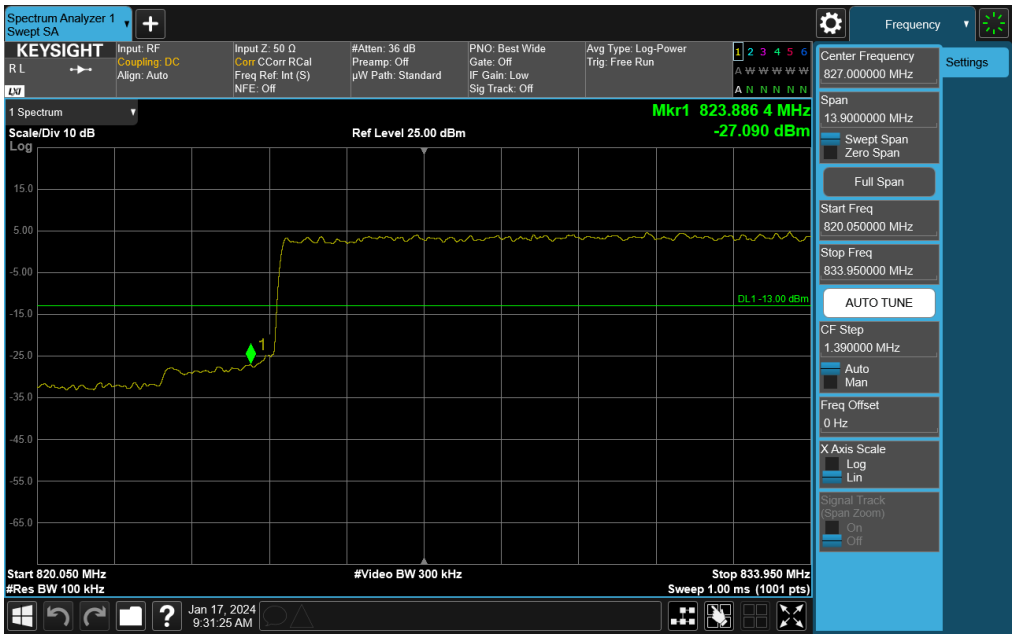
Plot 7-99. Upper BE Plot (NR Band n26 DFT-s-OFDM QPSK – 10.0MHz - Full RB)



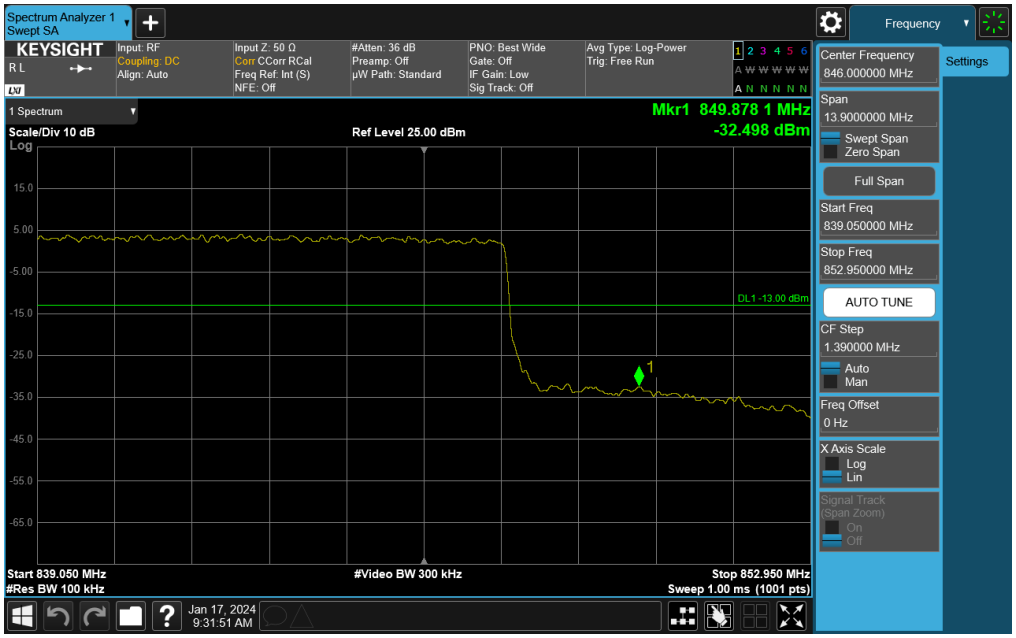
Plot 7-100. Lower BE Plot (NR Band n26 DFT-s-OFDM QPSK – 15.0MHz - Full RB)



Plot 7-101. Upper BE Plot (NR Band n26 DFT-s-OFDM QPSK – 15.0MHz - Full RB)



Plot 7-102. Lower BE Plot (NR Band n26 DFT-s-OFDM QPSK – 20.0MHz - Full RB)



Plot 7-103. Upper BE Plot (NR Band n26 DFT-s-OFDM QPSK – 20.0MHz - Full RB)