FCC Test Report

Report No.: AGC00213211102FE03

FCC ID	:	2AJOT-TWS-731
APPLICATION PURPOSE	:	Original Equipment
PRODUCT DESIGNATION	:	Nokia Clarity Earbuds+
BRAND NAME	:	Nokia
MODEL NAME	:	TWS-731
APPLICANT	:	HMD Global Oy
DATE OF ISSUE	:	Dec. 01, 2021
STANDARD(S)	:	FCC Part 15.247
REPORT VERSION	:	V1.1

Attestation of Global Compliance (Shenzhen) Co., Ltd

REPORT REVISE RECORD

Report Version	Revise Time	Issued Date	Valid Version	Notes
V1.0	/	Nov. 12, 2021	Invalid	Initial Release
V1.1	1st	Dec. 01, 2021	Valid	Revise report

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1. VERIFICATION OF CONFORMITY

Applicant	HMD Global Oy
Address	Bertel Jungin aukio 9, Espoo 02600 Finland
Manufacturer	HMD Global Oy
Address	Bertel Jungin aukio 9, Espoo 02600 Finland
Factory	Sky Wing Technology Co., Ltd.
Address	Building 2, No. 11, Renmin Road, Huaide Zone, Humen Town, Dongguan, Guangdong Province, China
Product Designation	Nokia Clarity Earbuds+
Brand Name	Nokia
Test Model	TWS-731
Date of test	Nov. 09, 2021 to Nov. 12, 2021
Deviation	No any deviation from the test method
Condition of Test Sample	Normal
Test Result	Pass
Report Template	AGCRT-US-BR/RF

We hereby certify that:

The above equipment was tested by Attestation of Global Compliance (Shenzhen) Co., Ltd. The test data, data evaluation, test procedures, and equipment configurations shown in this report were made in accordance with the procedures given in ANSI C63.10 (2013) and the energy emitted by the sample EUT tested as described in this report is in compliance with radiated emission limits of FCC PART 15.247.

Prepared By	John Zeng (Project Engineer)	Dec. 01, 2021
Reviewed By	Calvin Liu (Reviewer)	Dec. 01, 2021
Approved By	Max Zhang (Authorized Officer)	Dec. 01, 2021

2. GENERAL INFORMATION

2.1. PRODUCT DESCRIPTION

The EUT is designed as “Nokia Clarity Earbuds+”. It is designed by way of utilizing the GFSK, Pi/4 DQPSK and 8DPSK technology to achieve the system operation.

A major technical description of EUT is described as following

Operation Frequency	2.402GHz to 2.480GHz
RF Output Power	3.783dBm (Max)
Bluetooth Version	V5.2
Modulation	BR☒GFSK, EDR☒π /4-DQPSK, ☒8DPSK BLE☐GFSK 1Mbps ☐GFSK 2Mbps
Number of channels	79 Channels
Hardware Version	T18F_AB1562F_V1.0_20210416
Software Version	V1.5.1
Antenna Designation	FPC Antenna (Comply with requirements of the FCC part 15.203)
Antenna Gain	-2.58dBi
Power Supply	DC 3.7V by battery
Note: The EUT comprises left and right channel headsets, both are the same, the right headset had been tested and recorded in this report as the worst case.	

2.2. TABLE OF CARRIER FREQUENCYS

Frequency Band	Channel Number	Frequency
2402~2480MHz	0	2402 MHz
	1	2403 MHz
	:	:
	38	2440 MHz
	39	2441 MHz
	40	2442 MHz
	:	:
	77	2479 MHz
	78	2480 MHz

2.3. RECEIVER INPUT BANDWIDTH

The input bandwidth of the receiver is 1.3MHz, in every connection one Bluetooth device is the master and the other one is slave. The master determines the hopping sequence. The slave follows this sequence. Both devices shift between RX and TX time slot according to the clock of the master. Additionally, the type of connection (e.g. single of multi slot packet) is set up at the beginning of the connection. The master adapts its hopping frequency and its TX/RX timing according to the packet type of the connection. Also, the slave of the connection will use these settings. Repeating of a packet has no influence on the hopping sequence. The hopping sequence generated by the master of the connection will be followed in any case. That means, a repeated packet will not be send on the same frequency, it is send on the next frequency of the hopping sequence.

2.4. EXAMPLE OF A HOPPING SEQUENCY IN DATA MODE

Example of a hopping sequence in data mode:
40, 21, 44, 23, 04, 15, 66, 56, 19, 78, 07, 28, 69, 55,
36, 45, 05, 13, 43, 74, 57, 35, 67, 76, 02, 34, 54, 63,
42, 11, 30, 06, 64, 25, 75, 48, 17, 33, 58, 01, 29, 14,
51, 72, 03, 31, 50, 61, 77, 18, 10, 47, 12, 68, 08, 49,
20, 00, 73, 09, 16, 60, 71, 41, 24, 53, 38, 26, 46, 37,
65, 32, 70, 52, 27, 59, 22, 62, 39

2.5. EQUALLY AVERAGE USE OF FREQUENCIES AND BEHAVIOUR

The generation of the hopping sequence in connection mode depends essentially on two input values:

1. LAP/UAP of the master of the connection.
2. Internal master clock.

The LAP (lower address part) are the 24 LSB's of the 48 BD_ADDRESS. The BD_ADDRESS is an unambiguous number of every Bluetooth unit. The UAP (upper address part) are the 24MSB's of the 48BD_ADDRESS

The internal clock of a Bluetooth unit is derived from a free running clock which is never adjusted and is never turned off. For behavior action with other units only offset is used. It has no relation to the time of the day. Its resolution is at least half the RX/TX slot length of 312.5us. The clock has a cycle of about one day(23h30).

In most case it is implemented as 28 bits counter. For the deriving of the hopping sequence the entire. LAP (24 bits),4LSB's(4bits) (Input 1) and the 27MSB's of the clock (Input 2) are used. With this input values different mathematical procedures (permutations, additions, XOR-operations) are performed to generate the Sequence. This will be done at the beginning of every new transmission.

Regarding short transmissions the Bluetooth system has the following behavior:

The first connection between the two devices is established, a hopping sequence was generated. For Transmitting the wanted data the complete hopping sequence was not used. The connection ended.

The second connection will be established. A new hopping sequence is generated. Due to the fact the Bluetooth clock has a different value, because the period between the two transmission is longer (and it Cannot be shorter) than the minimum resolution of the clock(312.5us). The hopping sequence will always differ from the first one.

2.6. RELATED SUBMITTAL(S) / GRANT (S)

This submittal(s) (test report) is intended for **FCC ID: 2AJOT-TWS-731** filing to comply with the FCC PART 15.247 requirements.

2.7. TEST METHODOLOGY

Both conducted and radiated testing was performed according to the procedures in ANSI C63.10 (2013). Radiated testing was performed at an antenna to EUT distance 3 meters.

2.8. SPECIAL ACCESSORIES

Refer to section 5.2.

2.9. EQUIPMENT MODIFICATIONS

Not available for this EUT intended for grant.

2.10. ANTENNA REQUIREMENT

This intentional radiator is designed with a permanently attached antenna of an antenna to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

For more information of the antenna, please refer to the APPENDIX B: PHOTOGRAPHS OF EUT.

3. MEASUREMENT UNCERTAINTY

The reported uncertainty of measurement y ±U, where expended uncertainty U is based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95%.

Item	Measurement Uncertainty
Uncertainty of Conducted Emission for AC Port	U_c = ±3.1 dB
Uncertainty of Radiated Emission below 1GHz	U_c = ±4.0 dB
Uncertainty of Radiated Emission above 1GHz	U_c = ±4.8 dB
Uncertainty of total RF power, conducted	U_c = ±0.8 dB
Uncertainty of RF power density, conducted	U_c = ±2.6 dB
Uncertainty of spurious emissions, conducted	U_c = ±2 %
Uncertainty of Occupied Channel Bandwidth	U_c = ±2 %

4. DESCRIPTION OF TEST MODES

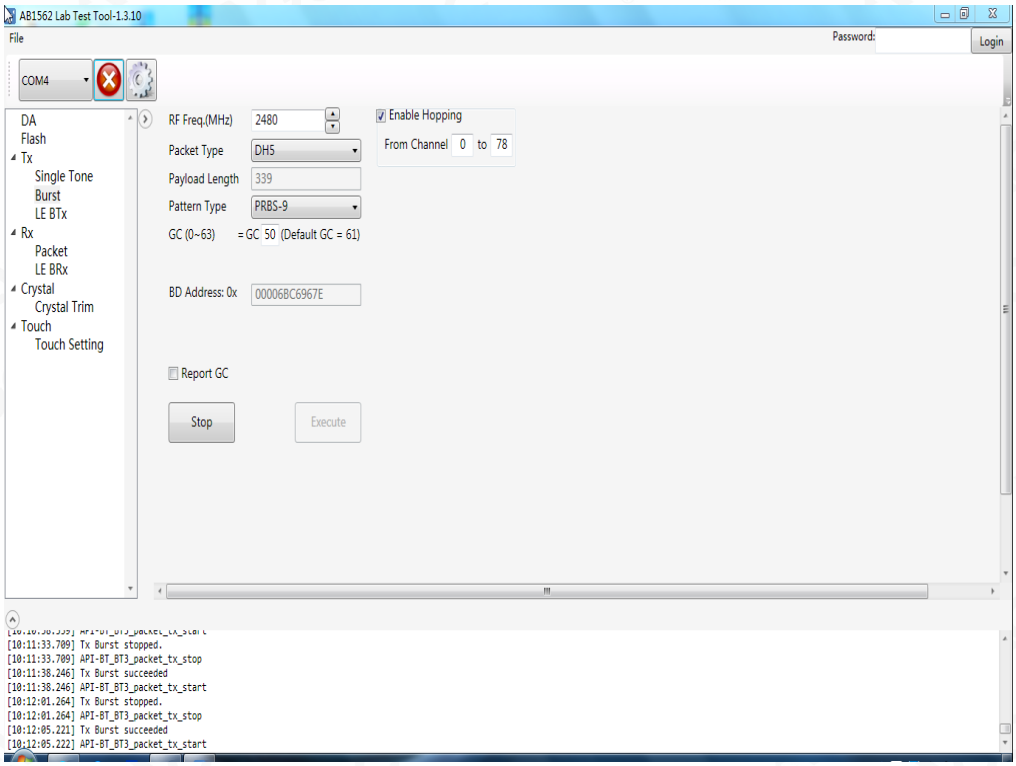
NO.	TEST MODE DESCRIPTION
1	Low channel GFSK
2	Middle channel GFSK
3	High channel GFSK
4	Low channel π/4-DQPSK
5	Middle channel π/4-DQPSK
6	High channel π/4-DQPSK
7	Low channel 8DPSK
8	Middle channel 8DPSK
9	High channel 8DPSK
10	Hopping mode GFSK
11	Hopping mode π/4-DQPSK
12	Hopping mode 8DPSK

Note: 1. Only the result of the worst case was recorded in the report, if no other cases.

2. For Radiated Emission, 3axis were chosen for testing for each applicable mode.

3. For Conducted Test method, a temporary antenna connector is provided by the manufacture.

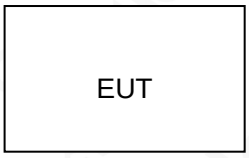
Software Setting



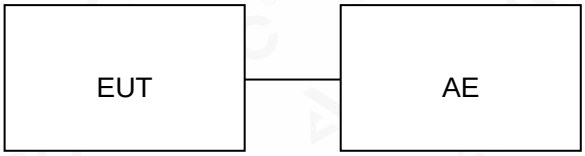
5. SYSTEM TEST CONFIGURATION

5.1. CONFIGURATION OF EUT SYSTEM

Radiated Emission Configure:



Conducted Emission Configure:



5.2. EQUIPMENT USED IN TESTED SYSTEM

Item	Equipment	Model No.	ID or Specification	Remark
1	Nokia Clarity Earbuds+	TWS-731	2AJOT-TWS-731	EUT
2	Control Box	USB-TTL	N/A	AE

5.3. SUMMARY OF TEST RESULTS

FCC RULES	DESCRIPTION OF TEST	RESULT
15.247 (b)(1)	Peak Output Power	Compliant
15.247 (a)(1)	20 dB Bandwidth	Compliant
15.247 (d)	Conducted Spurious Emission	Compliant
15.209	Radiated Emission	Compliant
15.247 (a)(1)(iii)	Number of Hopping Frequency	Compliant
15.247 (a)(1)(iii)	Time of Occupancy	Compliant
15.247 (a)(1)	Frequency Separation	Compliant
15.207	Conducted Emission	Not applicable

Note: The BT function cannot transmit when charging.

6. TEST FACILITY

Test Site	Attestation of Global Compliance (Shenzhen) Co., Ltd
Location	1-2/F, Building 19, Junfeng Industrial Park, Chongqing Road, Heping Community, Fuhai Street, Bao'an District, Shenzhen, Guangdong, China
Designation Number	CN1259
FCC Test Firm Registration Number	975832
A2LA Cert. No.	5054.02
Description	Attestation of Global Compliance (Shenzhen) Co., Ltd is accredited by A2LA

TEST EQUIPMENT OF RADIATED EMISSION TEST

Equipment	Manufacturer	Model	S/N	Cal. Date	Cal. Due
TEST RECEIVER	R&S	ESCI	10096	Apr. 14, 2021	Apr. 13, 2022
EXA Signal Analyzer	Aglient	N9010A	MY53470504	Dec. 07, 2020	Dec. 06, 2021
2.4GHz Filter	EM Electronics	2400-2500MHz	N/A	Mar. 23, 2020	Mar. 22, 2022
Attenuator	ZHINAN	E-002	N/A	Sep. 03, 2020	Sep. 02, 2022
Horn Antenna	SCHWARZBECK	BBHA9170	768	Oct. 31, 2021	Oct. 30, 2023
Active loop antenna (9K-30MHz)	ZHINAN	ZN30900C	18051	May 22, 2020	May 21, 2022
Double-Ridged Waveguide Horn	ETS	3117	00034609	Apr. 23, 2021	Apr. 22, 2023
Preamplifier Assembly	ETS LINDGREN	3117PA	00225134	Sep. 03, 2020	Sep. 02, 2022
WIDEBAND REQUENCY ANTENNA	SCHWARZBECK	VULB9168	VULB9168-494	Jan. 08, 2021	Jan. 07, 2023
Test Software	Tonscend	JS32-RE(Ver.2.5)	N/A	N/A	N/A

7. PEAK OUTPUT POWER

7.1. MEASUREMENT PROCEDURE

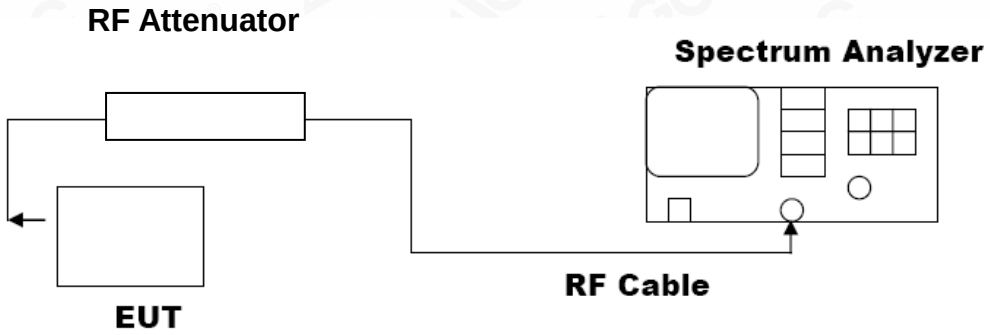
For peak power test:

1. Connect EUT RF output port to the Spectrum Analyzer through an RF attenuator
2. Span: Approximately five times the 20 dB bandwidth, centered on a hopping channel.
3. RBW > 20 dB bandwidth of the emission being measured.
4. VBW ⩾RBW.
5. Sweep: Auto.
6. Detector function: Peak.
7. Trace: Max hold.

Allow trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission. The indicated level is the peak output power, after any corrections for external attenuators and cables.

7.2. TEST SET-UP (BLOCK DIAGRAM OF CONFIGURATION)

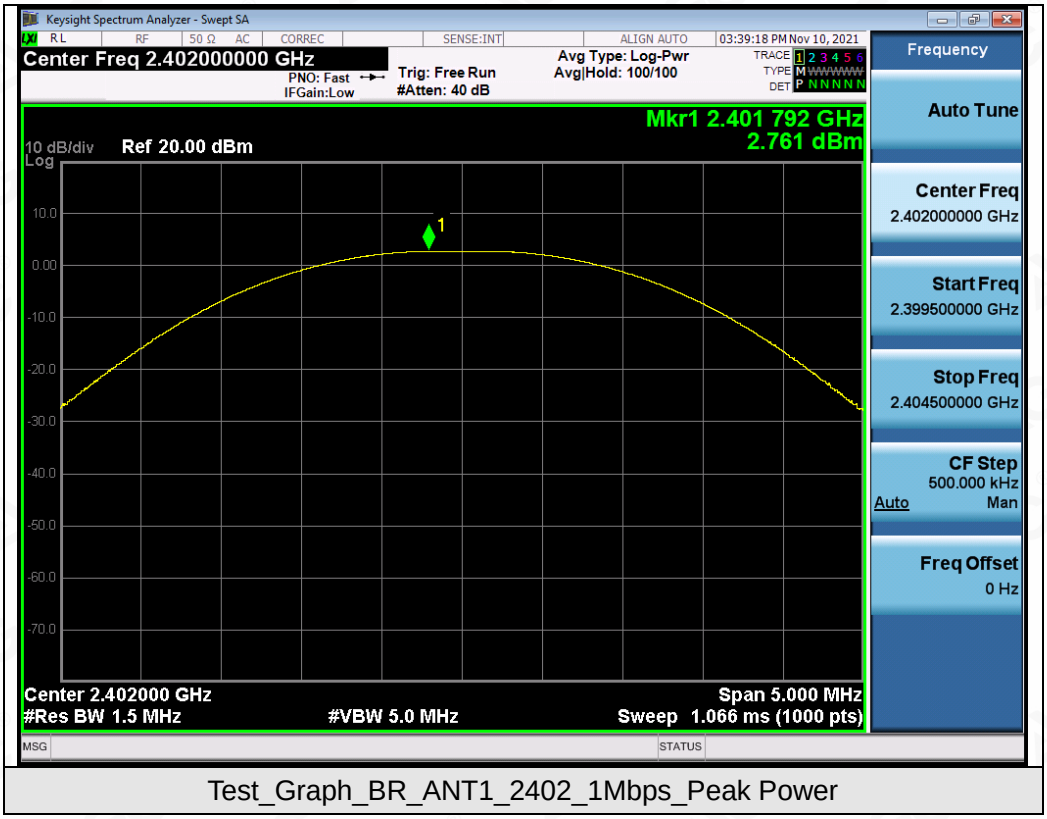
PEAK POWER TEST SETUP



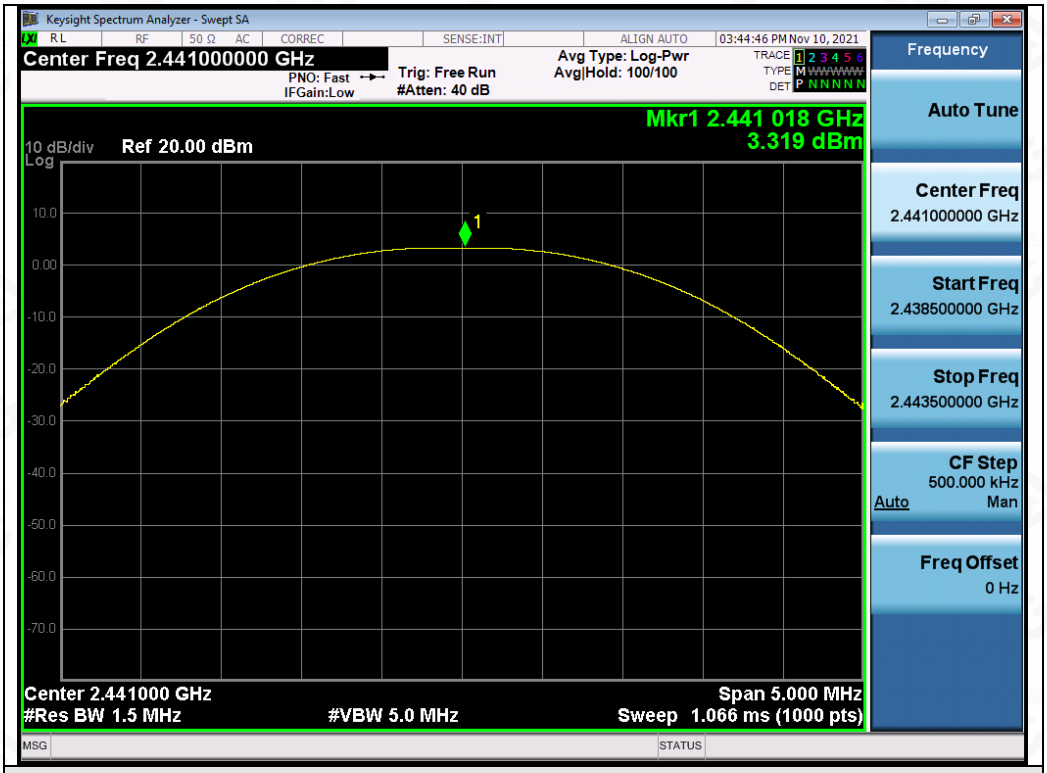
7.3. LIMITS AND MEASUREMENT RESULT

Test Data of Conducted Output Power				
Test Mode	Test Channel (MHz)	Peak Power (dBm)	Limits (dBm)	Pass or Fail
GFSK	2402	2.761	≤21	Pass
	2441	3.319	≤21	Pass
	2480	3.694	≤21	Pass
π /4-DQPSK	2402	2.742	≤21	Pass
	2441	3.346	≤21	Pass
	2480	3.720	≤21	Pass
8DPSK	2402	2.785	≤21	Pass
	2441	3.394	≤21	Pass
	2480	3.783	≤21	Pass

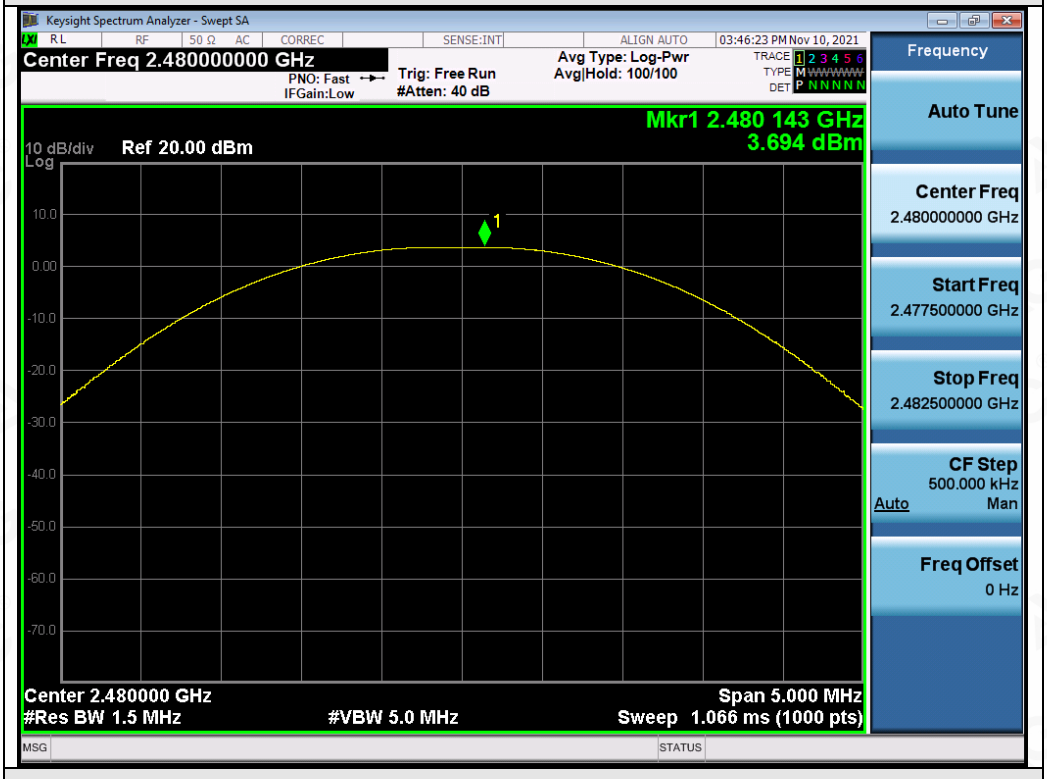
Test Graphs of Conducted Output Power



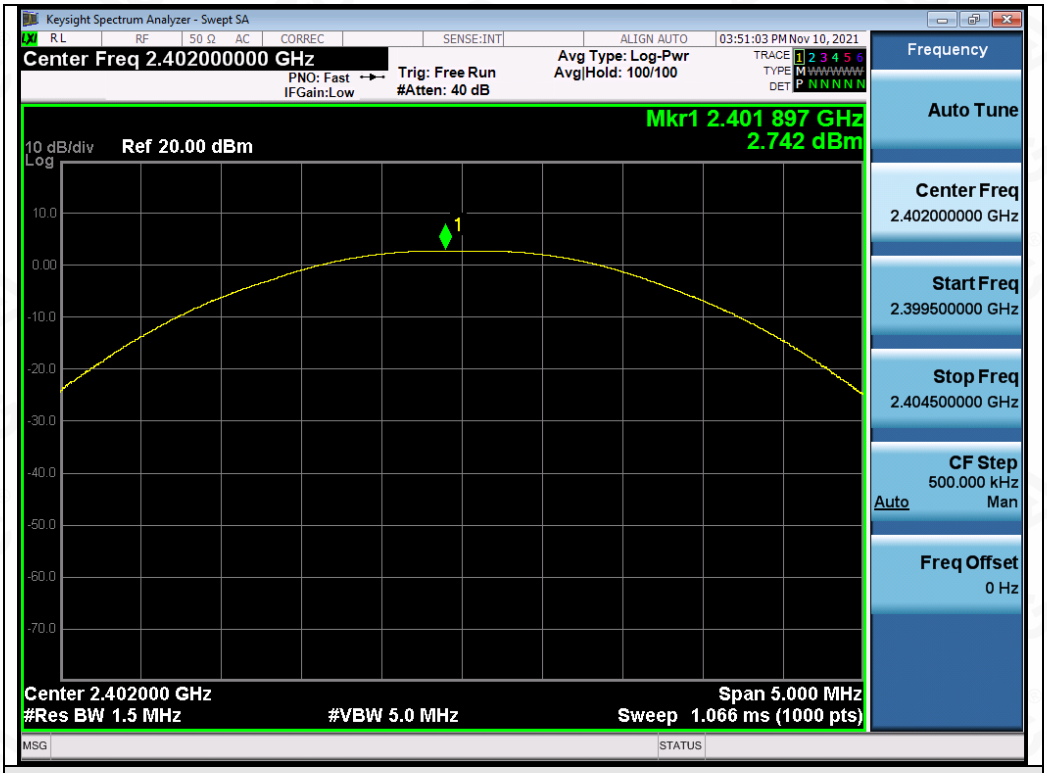
Test_Graph_BR_ANT1_2402_1Mbps_Peak Power



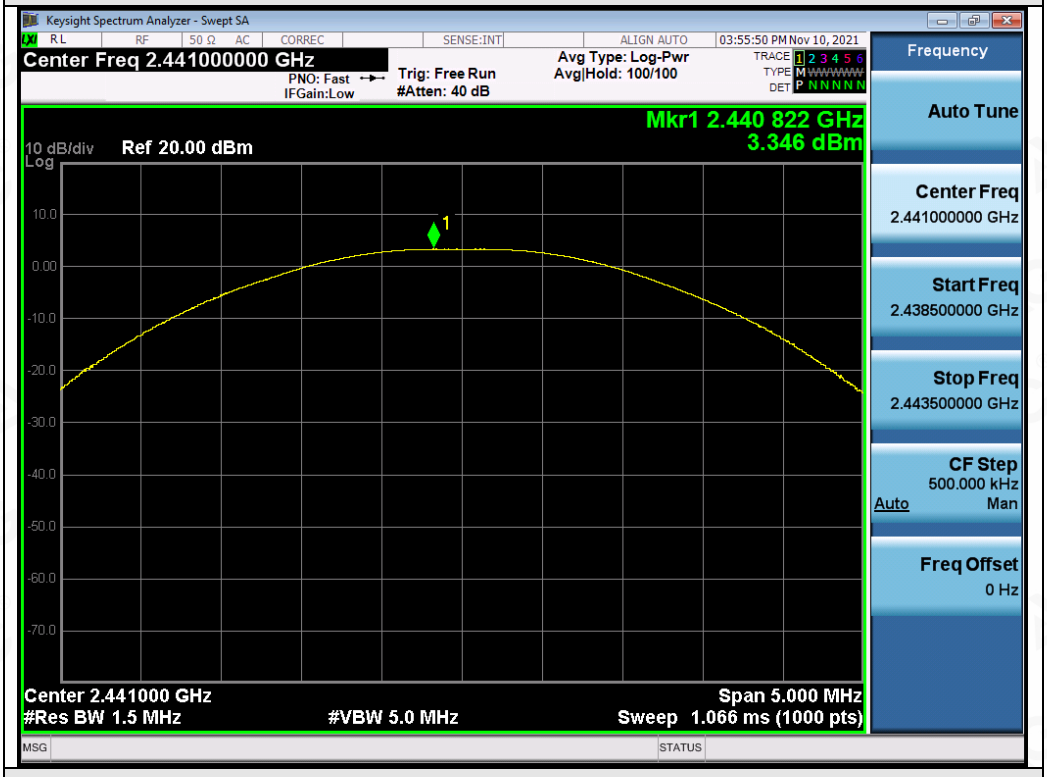
Test_Graph_BR_ANT1_2441_1Mbps_Peak Power



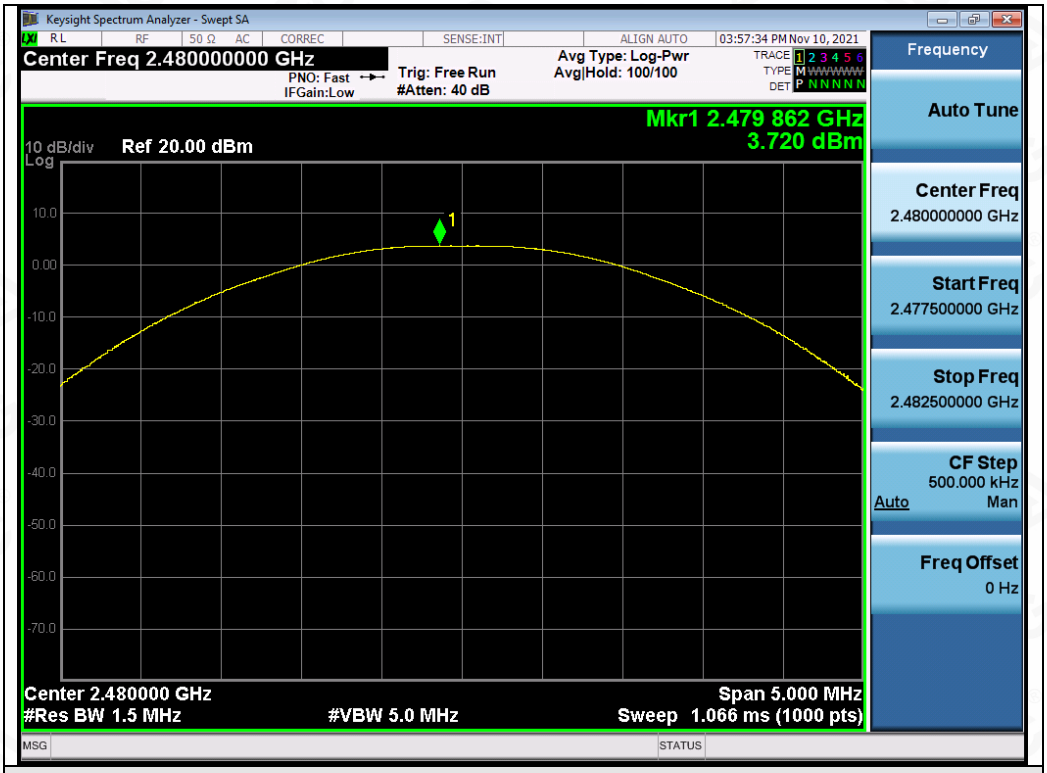
Test_Graph_BR_ANT1_2480_1Mbps_Peak Power



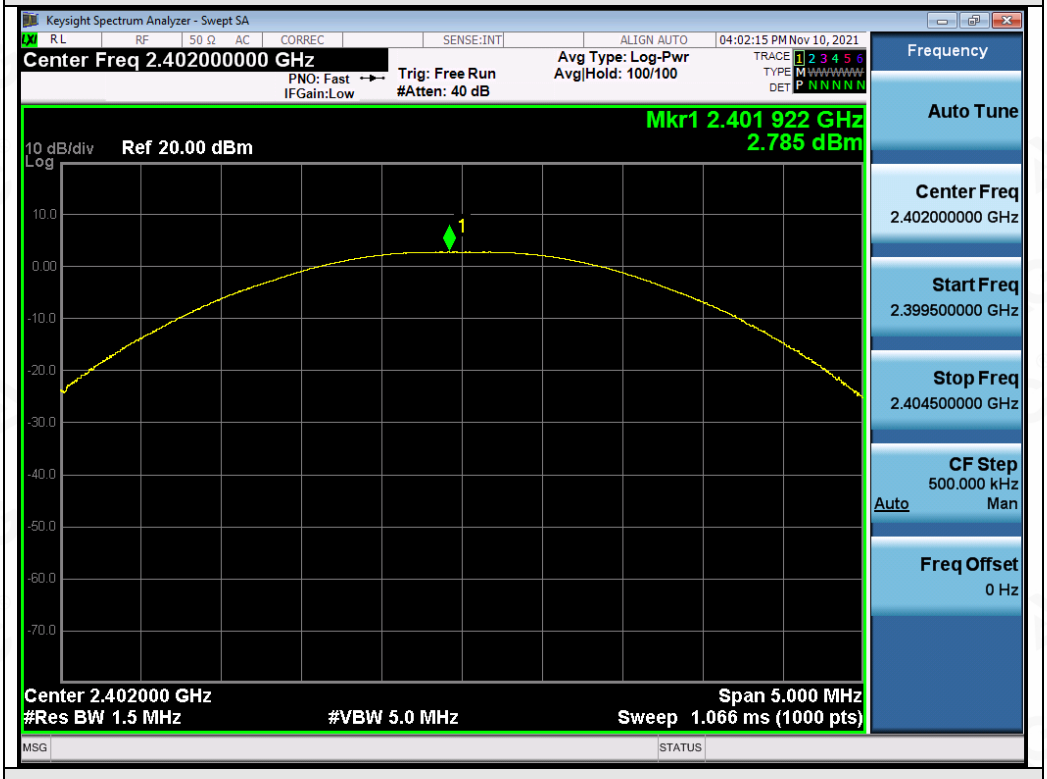
Test_Graph_EDR_ANT1_2402_2Mbps_Peak Power



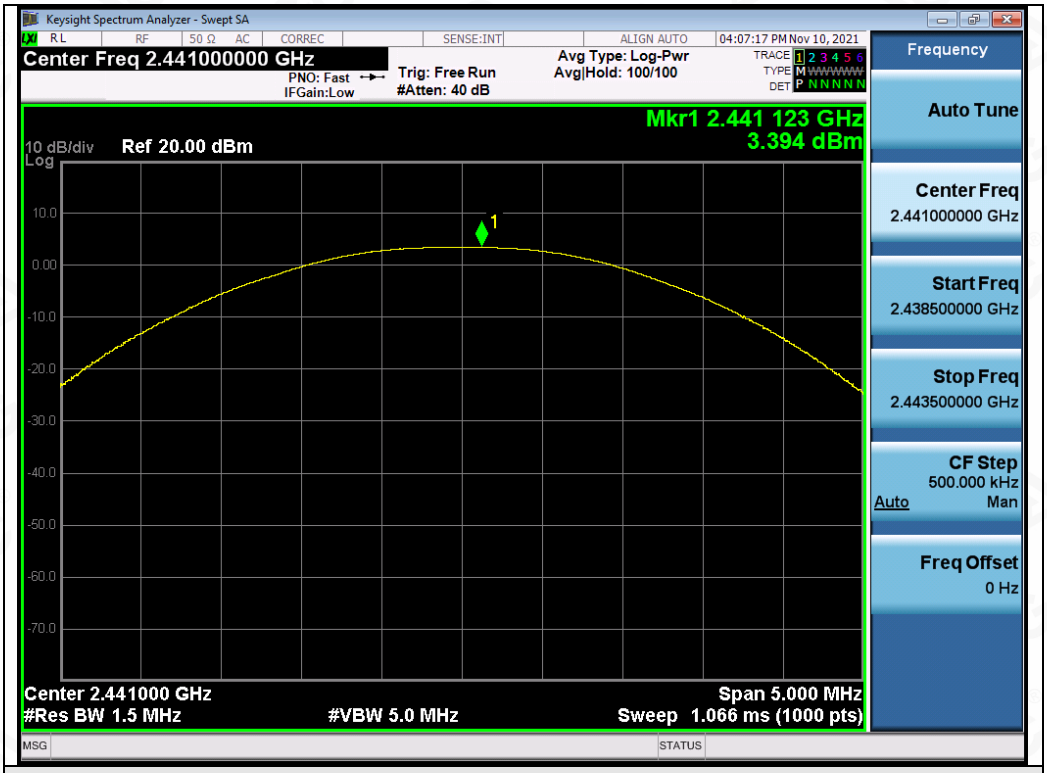
Test_Graph_EDR_ANT1_2441_2Mbps_Peak Power



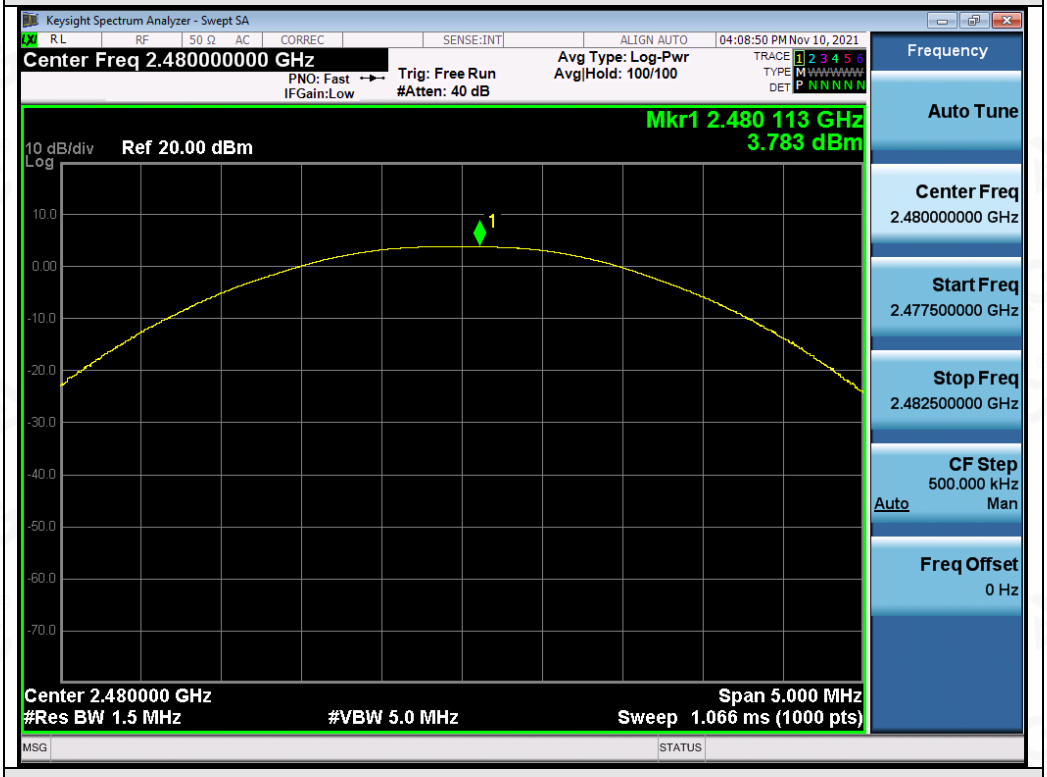
Test_Graph_EDR_ANT1_2480_2Mbps_Peak Power



Test_Graph_EDR_ANT1_2402_3Mbps_Peak Power



Test_Graph_EDR_ANT1_2441_3Mbps_Peak Power



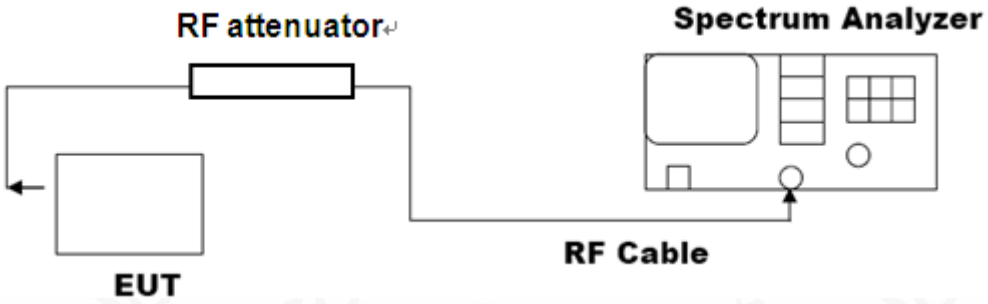
Test_Graph_EDR_ANT1_2480_3Mbps_Peak Power

8. 20DB BANDWIDTH

8.1. MEASUREMENT PROCEDURE

1. Connect EUT RF output port to the Spectrum Analyzer through an RF attenuator
2, Set the EUT Work on the top, the middle and the bottom operation frequency individually.
3. Set Span = approximately 2 to 5 times the 20 dB bandwidth, centered on a hoping channel
   The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW and video bandwidth (VBW) shall be approximately three times RBW; Sweep = auto; Detector function = peak
4. Set SPA Trace 1 Max hold, then View.

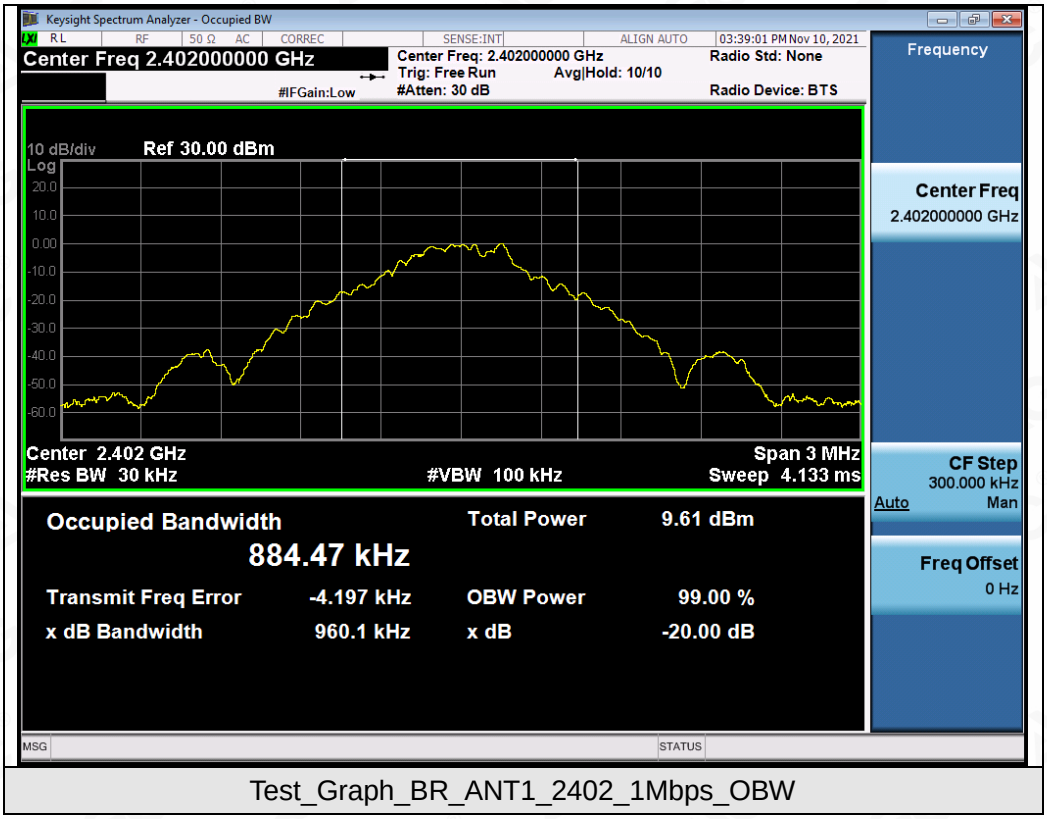
8.2. TEST SET-UP (BLOCK DIAGRAM OF CONFIGURATION)



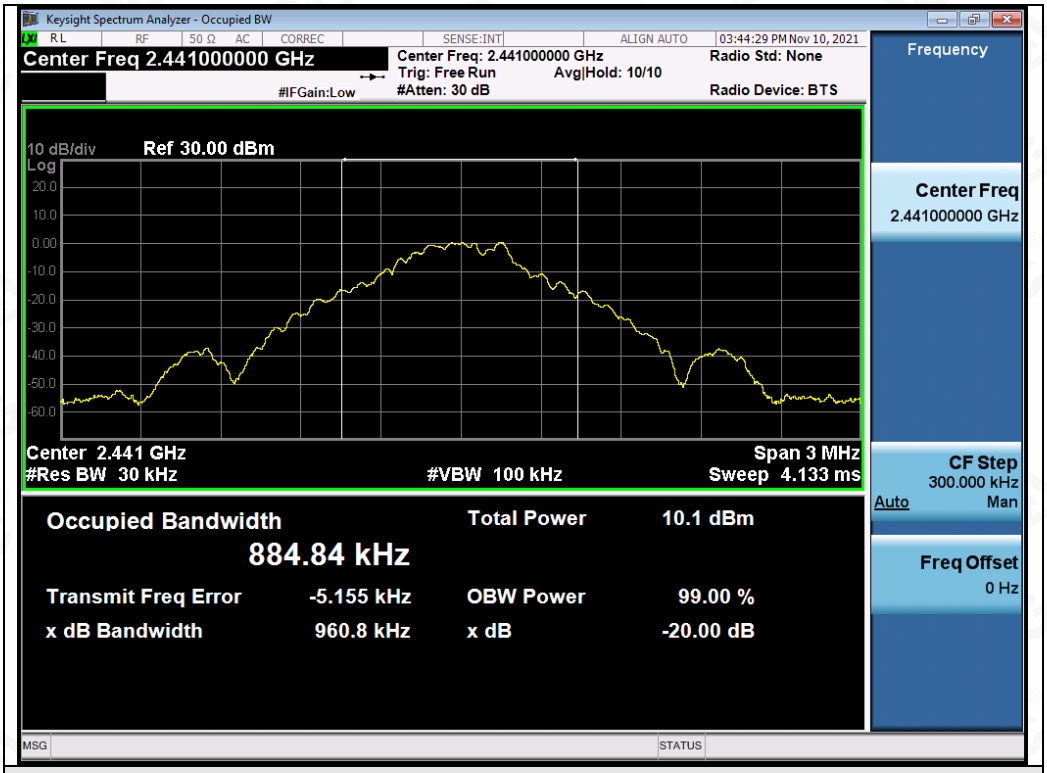
8.3. LIMITS AND MEASUREMENT RESULTS

Test Data of Occupied Bandwidth and -20dB Bandwidth					
Test Mode	Test Channel (MHz)	99% Occupied Bandwidth (MHz)	-20dB Bandwidth (MHz)	Limits	Pass or Fail
GFSK	2402	0.884	0.960	N/A	Pass
	2441	0.885	0.961	N/A	Pass
	2480	0.884	0.959	N/A	Pass
π /4-DQPSK	2402	1.149	1.229	N/A	Pass
	2441	1.149	1.229	N/A	Pass
	2480	1.149	1.229	N/A	Pass
8DPSK	2402	1.153	1.267	N/A	Pass
	2441	1.152	1.268	N/A	Pass
	2480	1.153	1.267	N/A	Pass

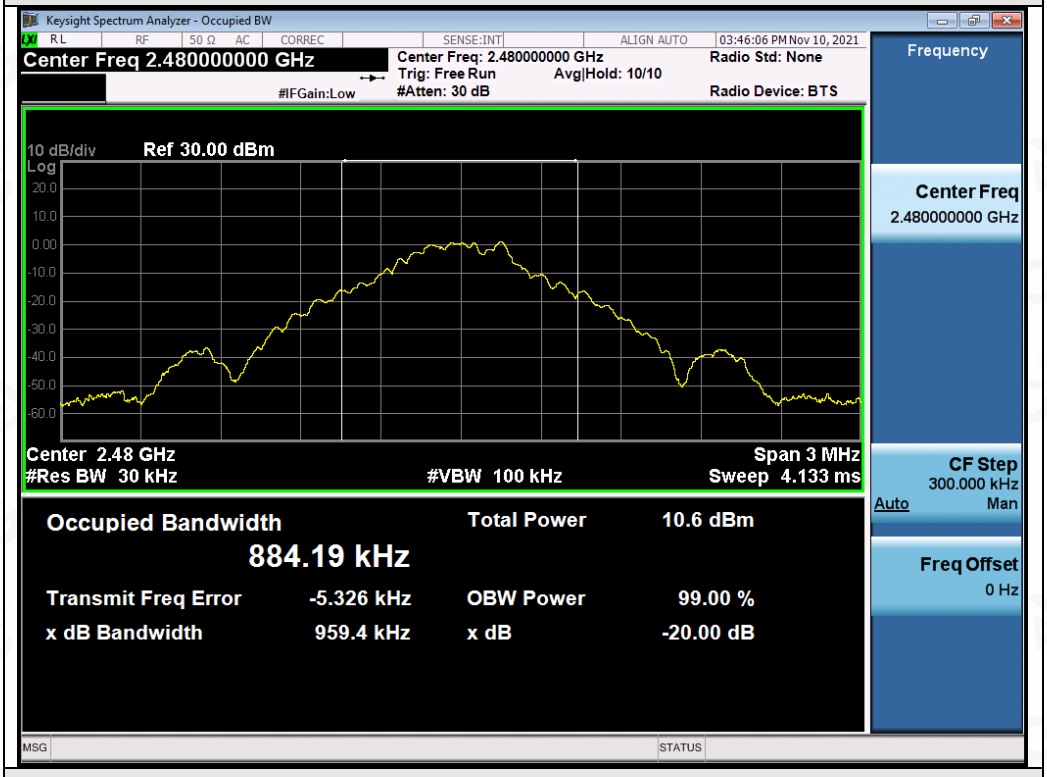
Test Graphs of Occupied Bandwidth and -20 Bandwidth



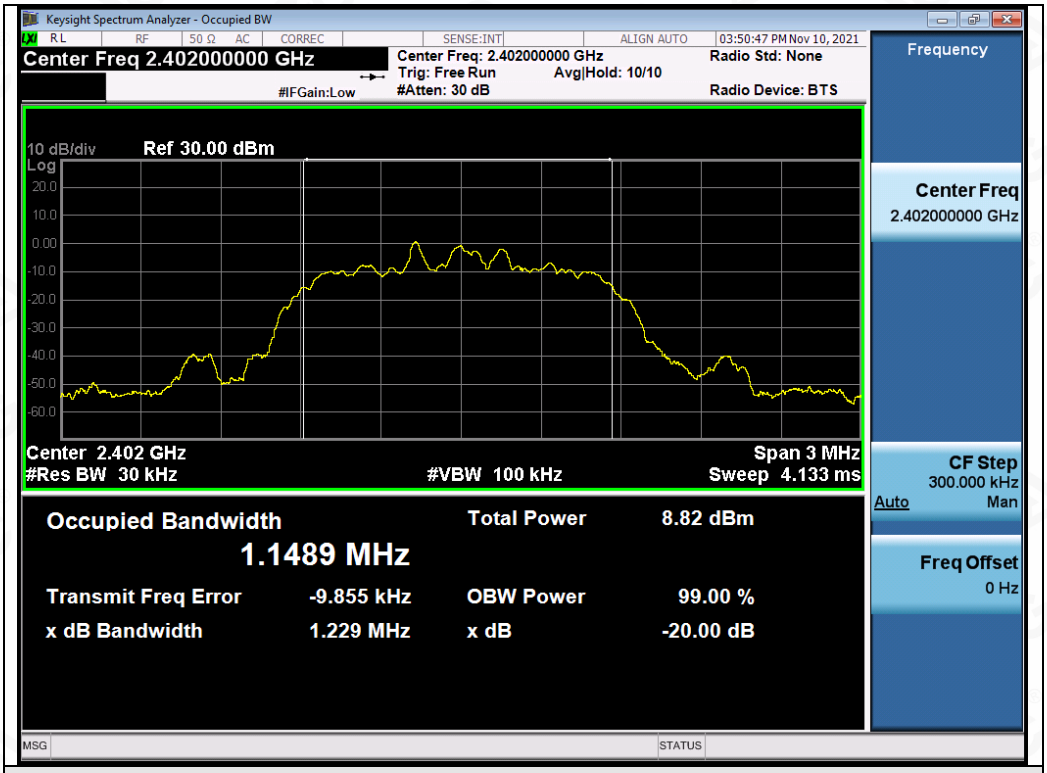
Test_Graph_BR_ANT1_2402_1Mbps_OBW



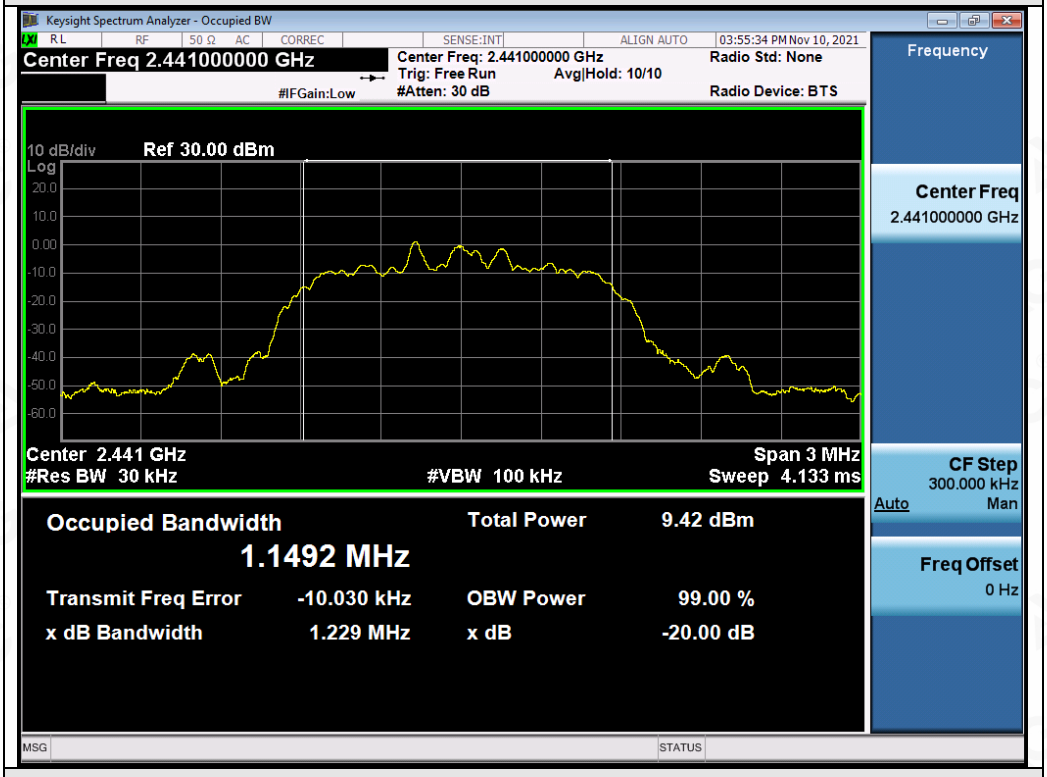
Test_Graph_BR_ANT1_2441_1Mbps_OBW



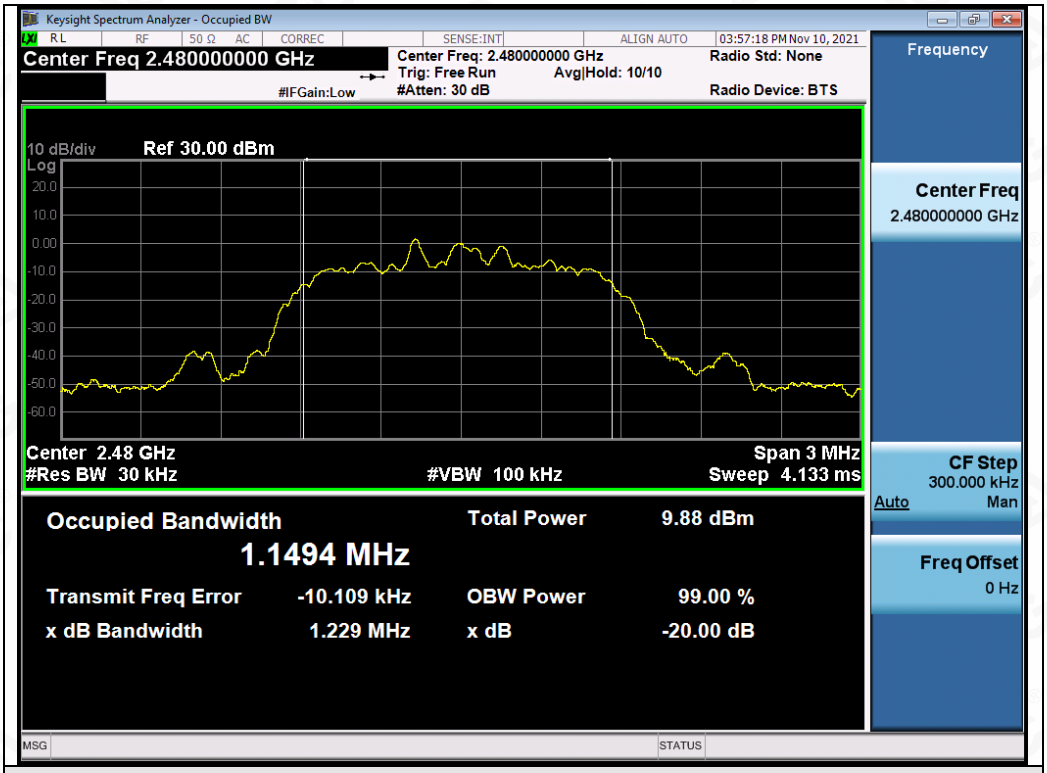
Test_Graph_BR_ANT1_2480_1Mbps_OBW



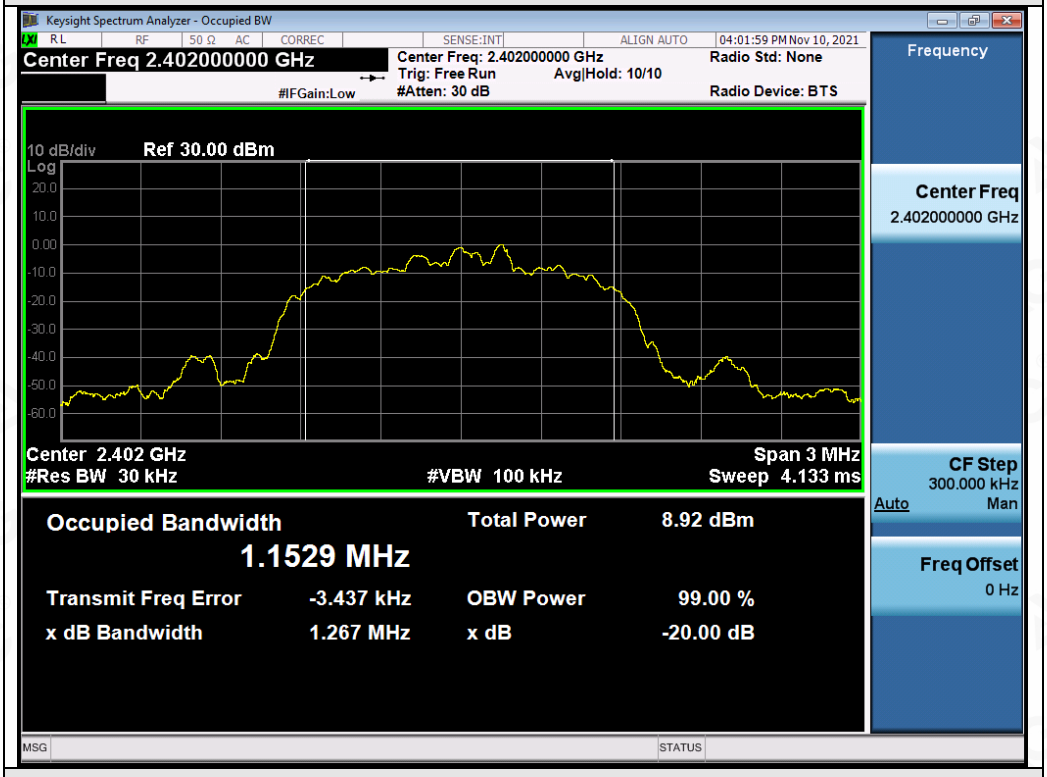
Test_Graph_EDR_ANT1_2402_2Mbps_OBW



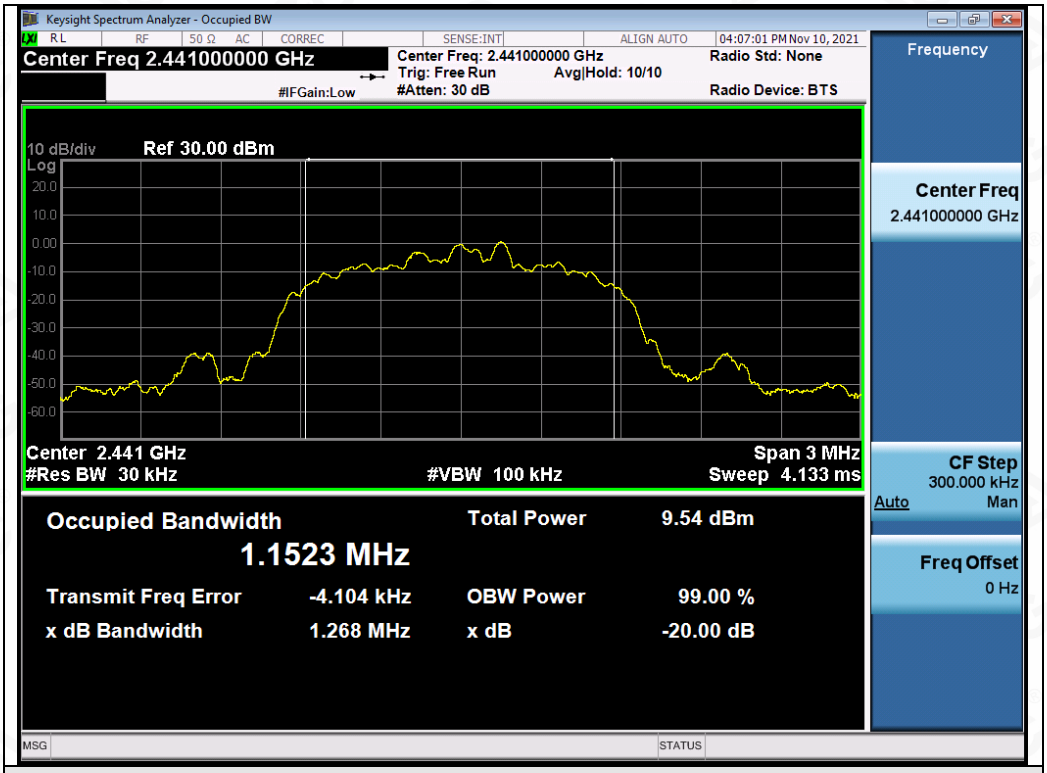
Test_Graph_EDR_ANT1_2441_2Mbps_OBW



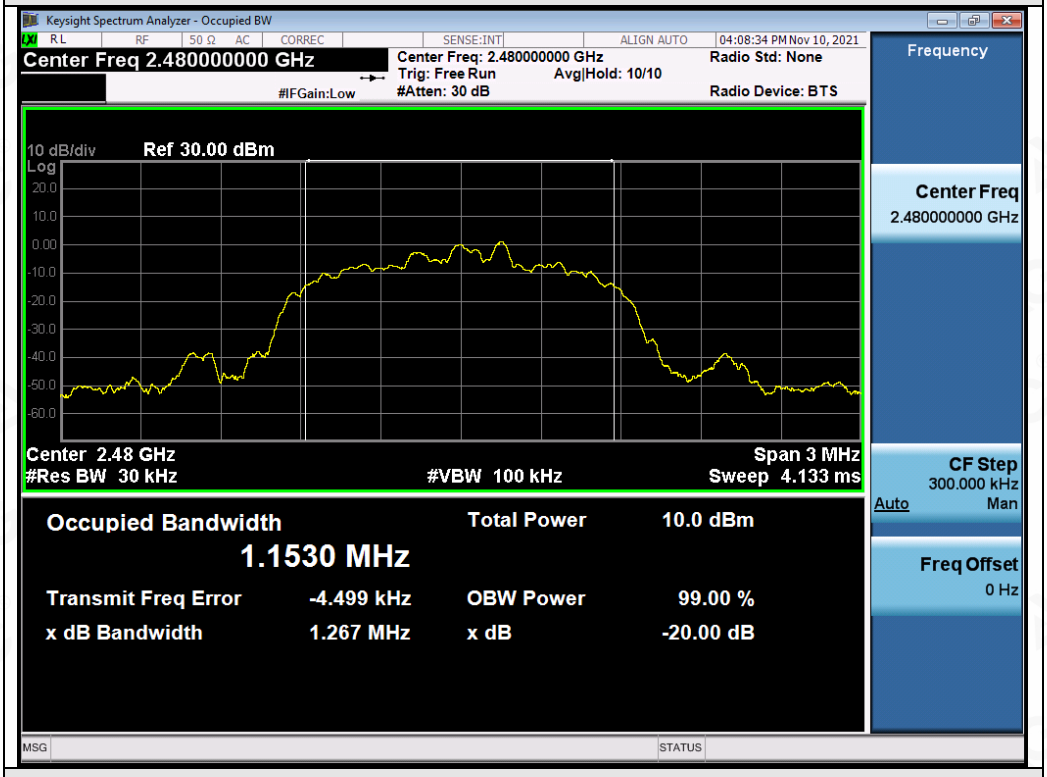
Test_Graph_EDR_ANT1_2480_2Mbps_OBW



Test_Graph_EDR_ANT1_2402_3Mbps_OBW



Test_Graph_EDR_ANT1_2441_3Mbps_OBW



Test_Graph_EDR_ANT1_2480_3Mbps_OBW

9. CONDUCTED SPURIOUS EMISSION

9.1. MEASUREMENT PROCEDURE

1. Connect EUT RF output port to the Spectrum Analyzer through an RF attenuator
2. Set the EUT Work on the top, the Middle and the bottom operation frequency individually.
3. Set the Span = wide enough to capture the peak level of the in-band emission and all spurious emissions from the lowest frequency generated in the EUT up through the 10th harmonic.
   RBW = 100 kHz; VBW= 300 kHz; Sweep = auto; Detector function = peak.
4. Set SPA Trace 1 Max hold, then View.

9.2. TEST SET-UP (BLOCK DIAGRAM OF CONFIGURATION)

The same as described in section 8.2

9.3. MEASUREMENT EQUIPMENT USED

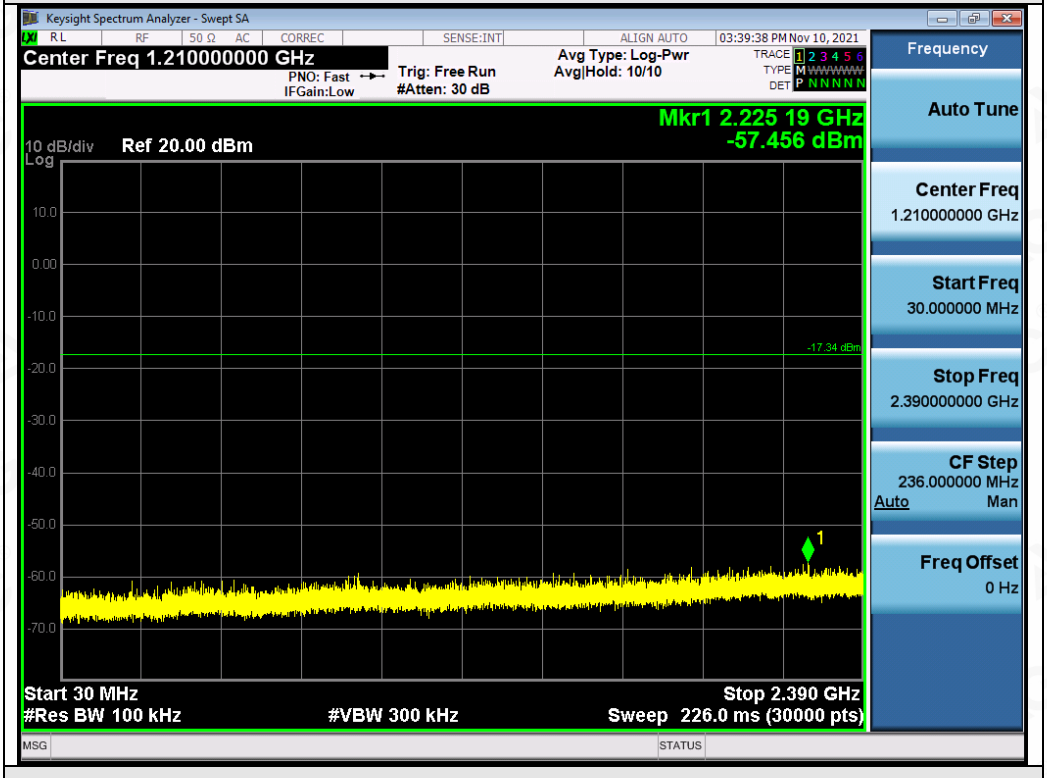
The same as described in section 6

9.4. LIMITS AND MEASUREMENT RESULT

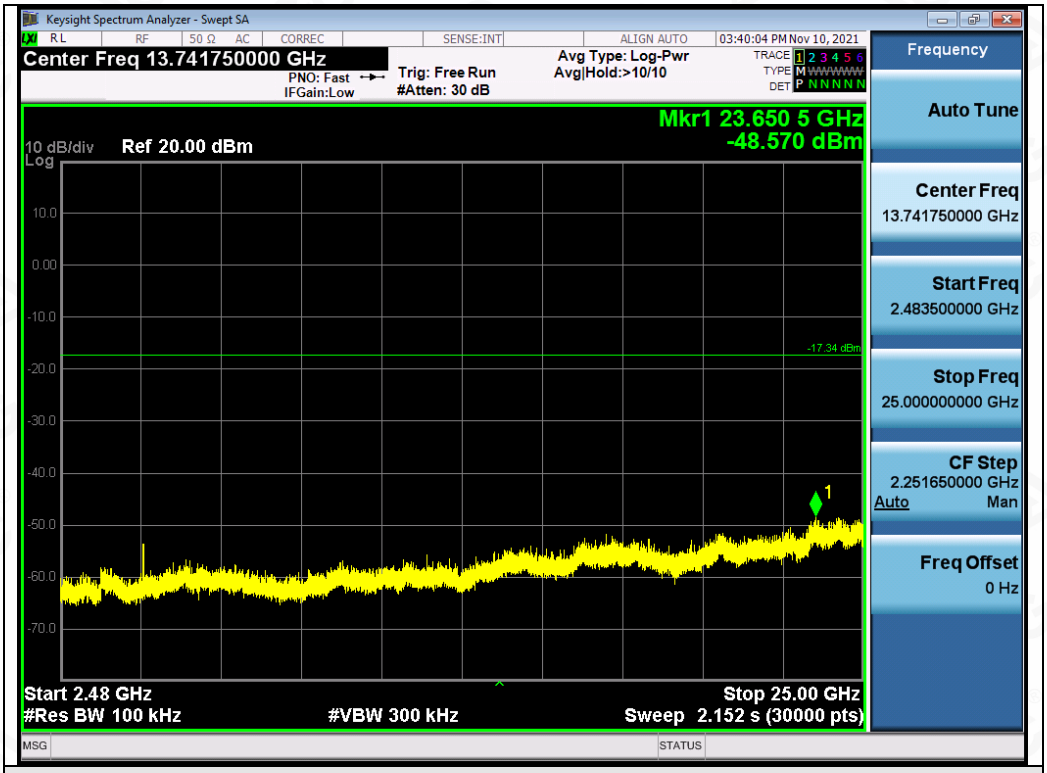
LIMITS AND MEASUREMENT RESULT		
Applicable Limits	**Measurement Result**	
	Test Data	**Criteria**
In any 100 kHz Bandwidth Outside the frequency band in which the spread spectrum intentional radiator is operating, the radio frequency power that is produce by the intentional radiator shall be at least 20 dB below that in 100KHz bandwidth within the band that contains the highest level of the desired power. In addition, radiation emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in§15.209(a))	At least -20dBc than the limit Specified on the BOTTOM Channel	PASS
	At least -20dBc than the limit Specified on the TOP Channel	PASS

Test Graphs of Spurious Emissions in Non-Restricted Frequency Bands

Test_Graph_BR_ANT1_2402_1Mbps_Reference Level

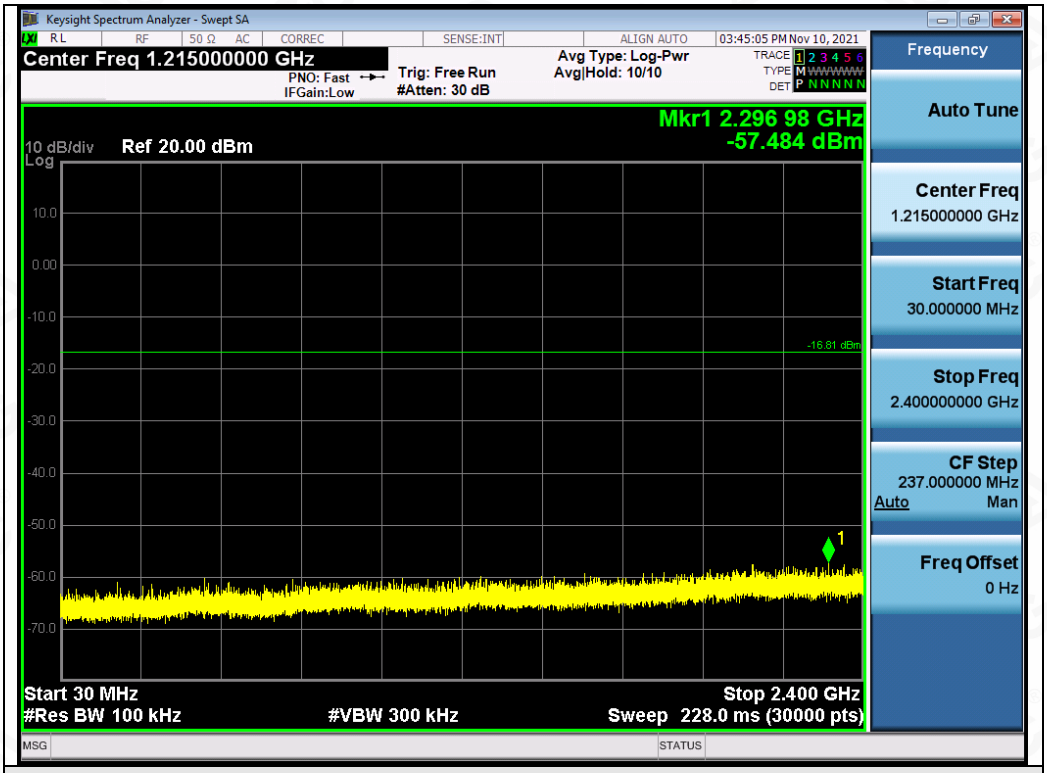


Test_Graph_BR_ANT1_2402_1Mbps_Lower Band Emissions

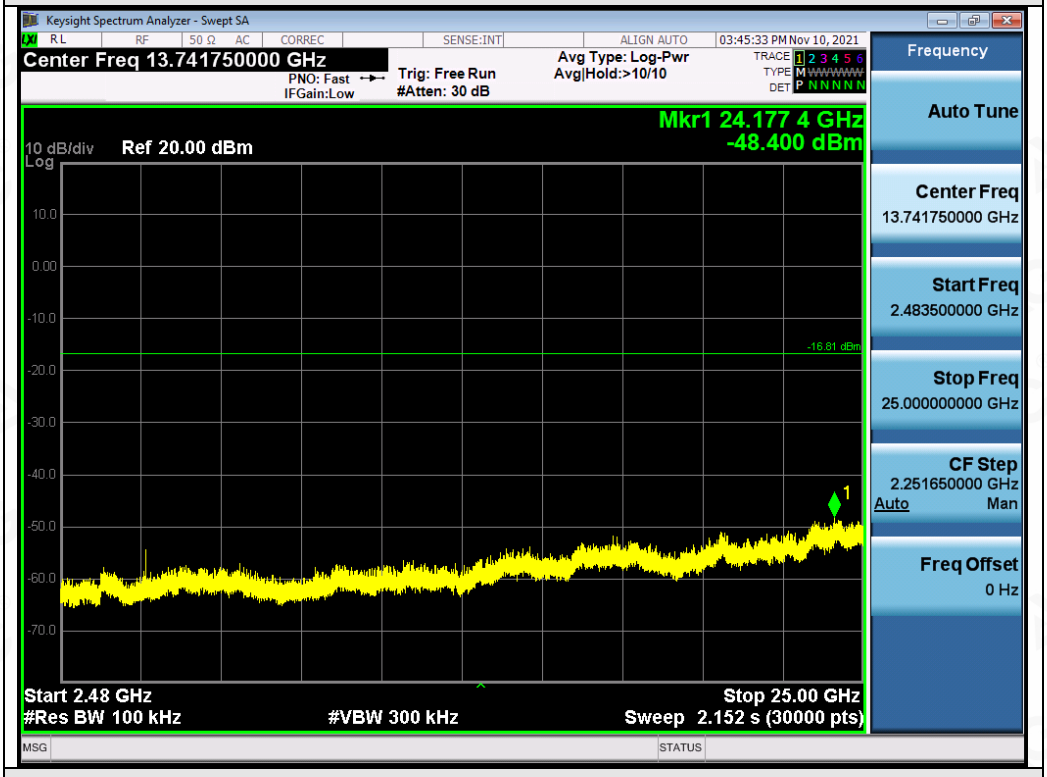


Test_Graph_BR_ANT1_2402_1Mbps_Higher Band Emissions

Test_Graph_BR_ANT1_2441_1Mbps_Reference Level

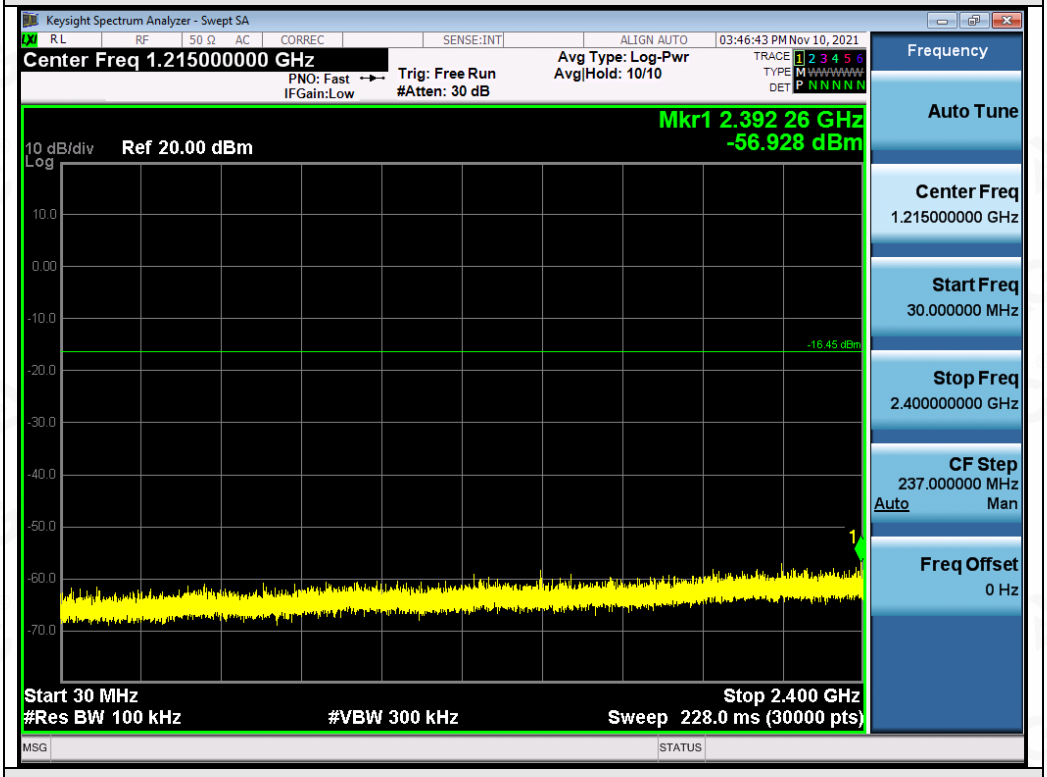


Test_Graph_BR_ANT1_2441_1Mbps_Lower Band Emissions

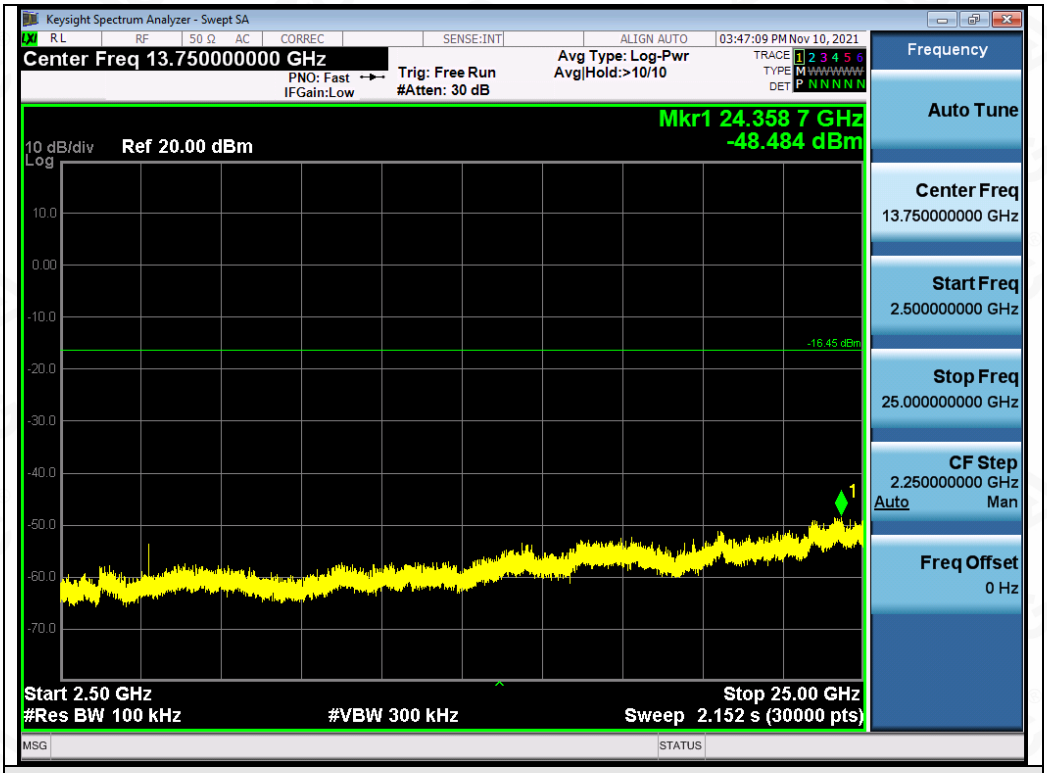


Test_Graph_BR_ANT1_2441_1Mbps_Higher Band Emissions

Test_Graph_BR_ANT1_2480_1Mbps_Reference Level

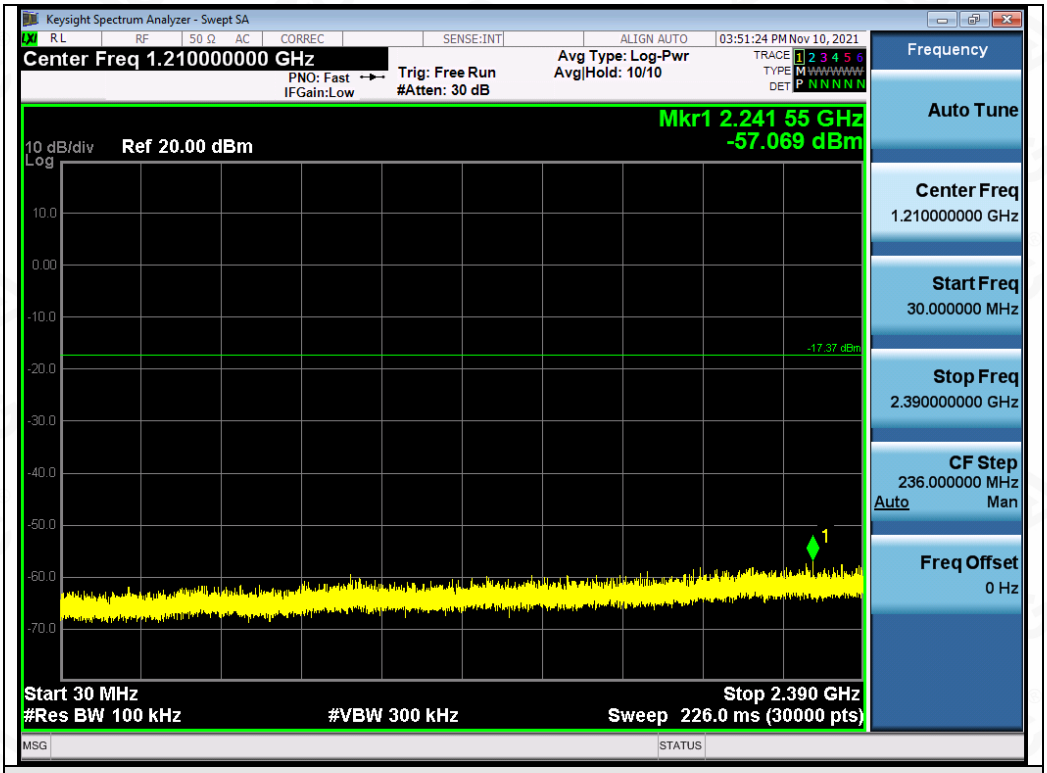


Test_Graph_BR_ANT1_2480_1Mbps_Lower Band Emissions



Test_Graph_BR_ANT1_2480_1Mbps_Higher Band Emissions

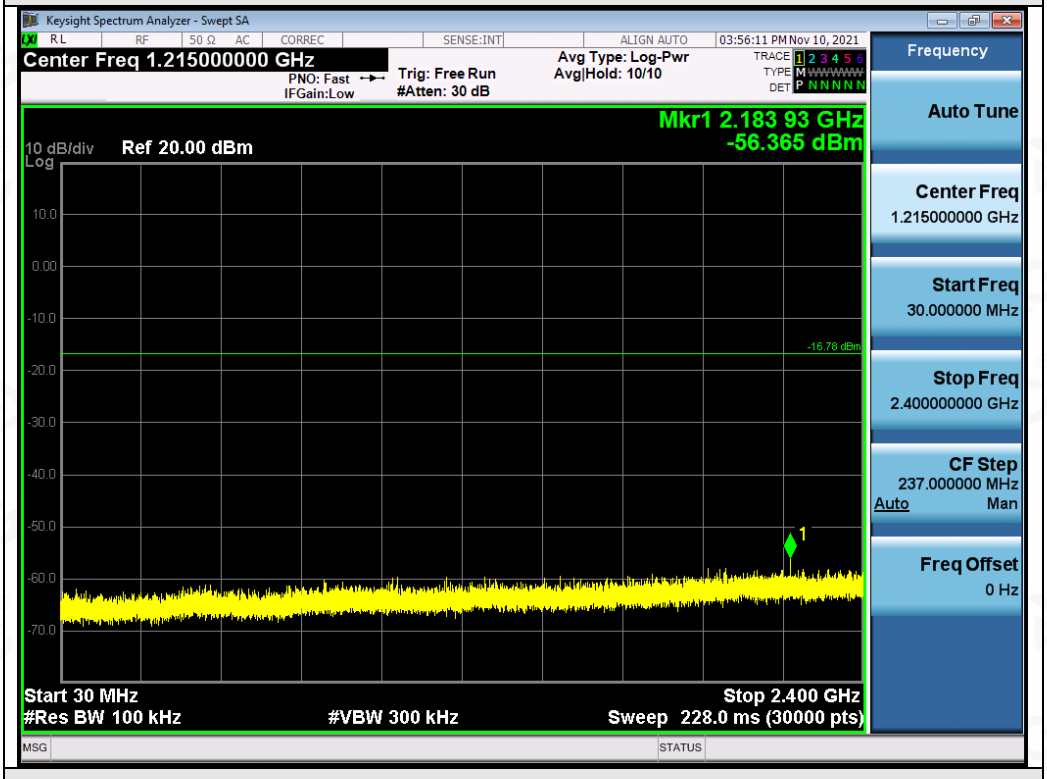
Test_Graph_EDR_ANT1_2402_2Mbps_Reference Level



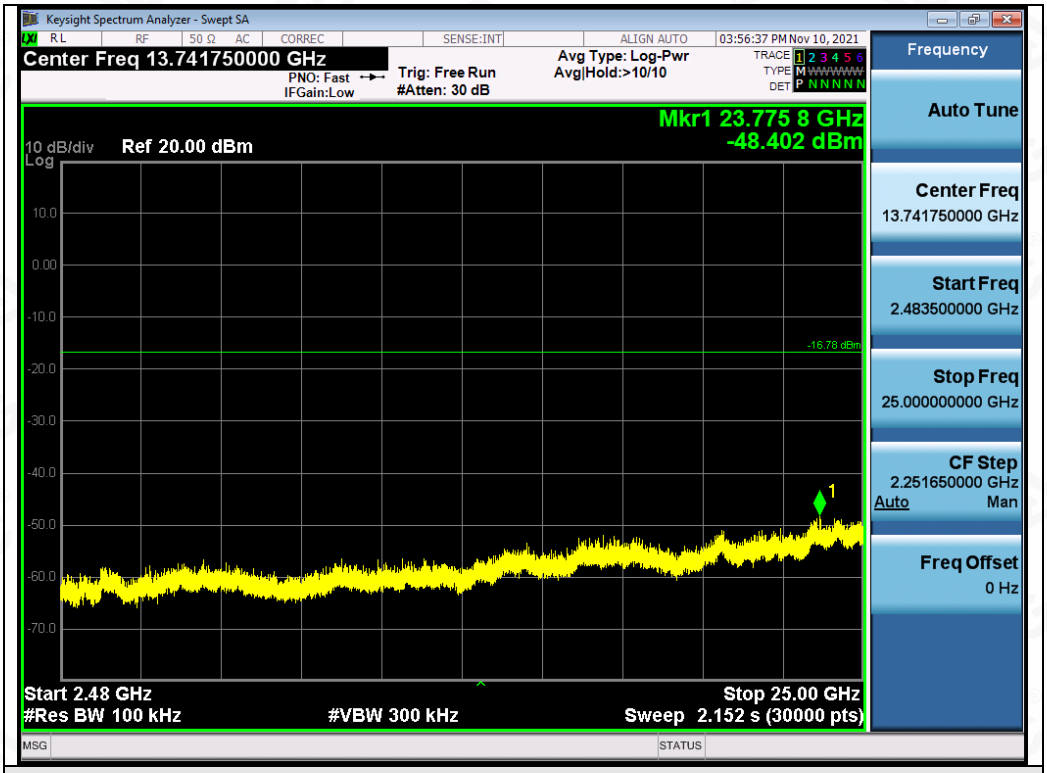
Test_Graph_EDR_ANT1_2402_2Mbps_Lower Band Emissions

Test_Graph_EDR_ANT1_2402_2Mbps_Higher Band Emissions

Test_Graph_EDR_ANT1_2441_2Mbps_Reference Level

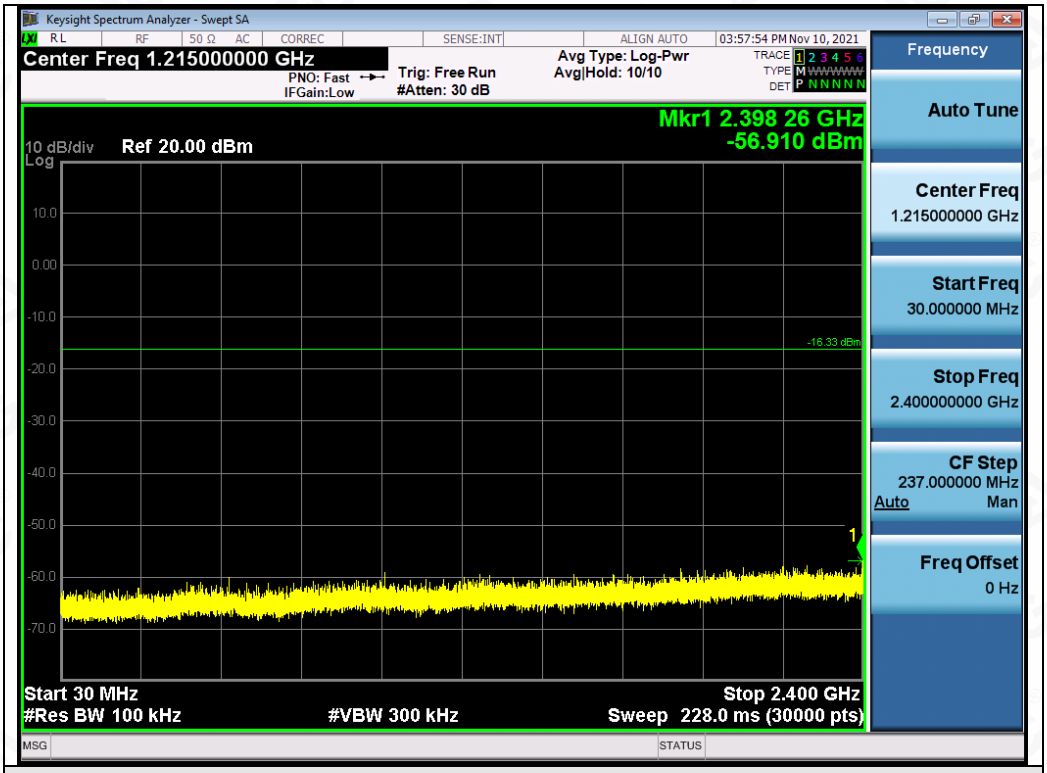


Test_Graph_EDR_ANT1_2441_2Mbps_Lower Band Emissions



Test_Graph_EDR_ANT1_2441_2Mbps_Higher Band Emissions

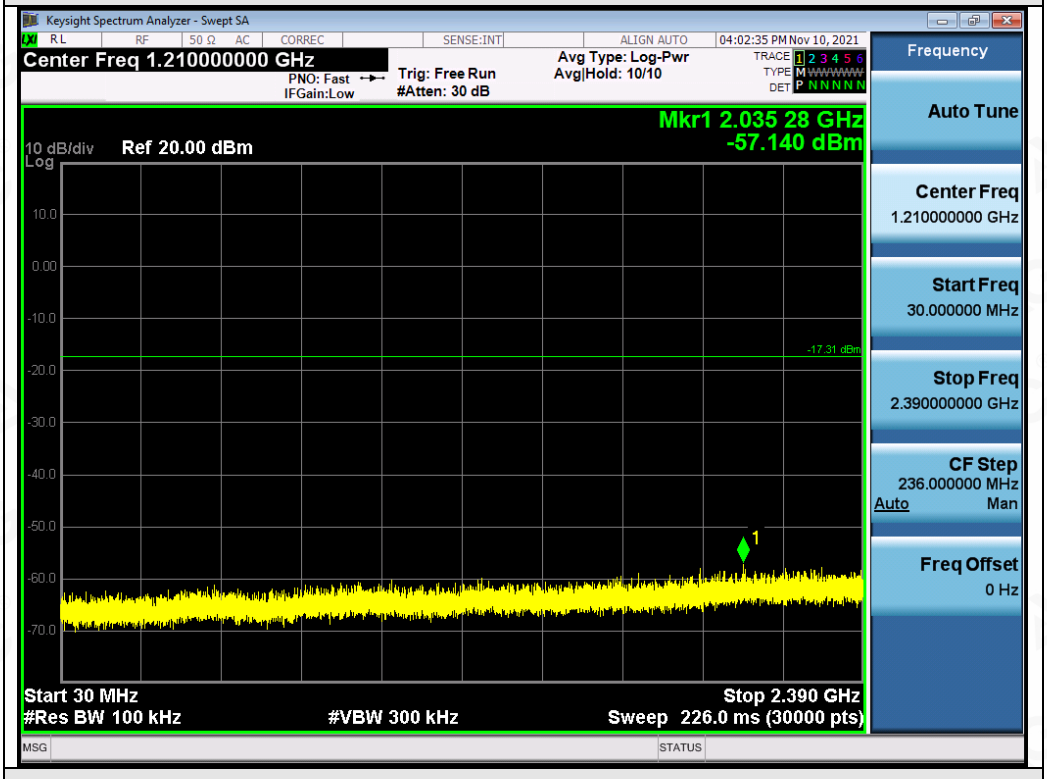
Test_Graph_EDR_ANT1_2480_2Mbps_Reference Level



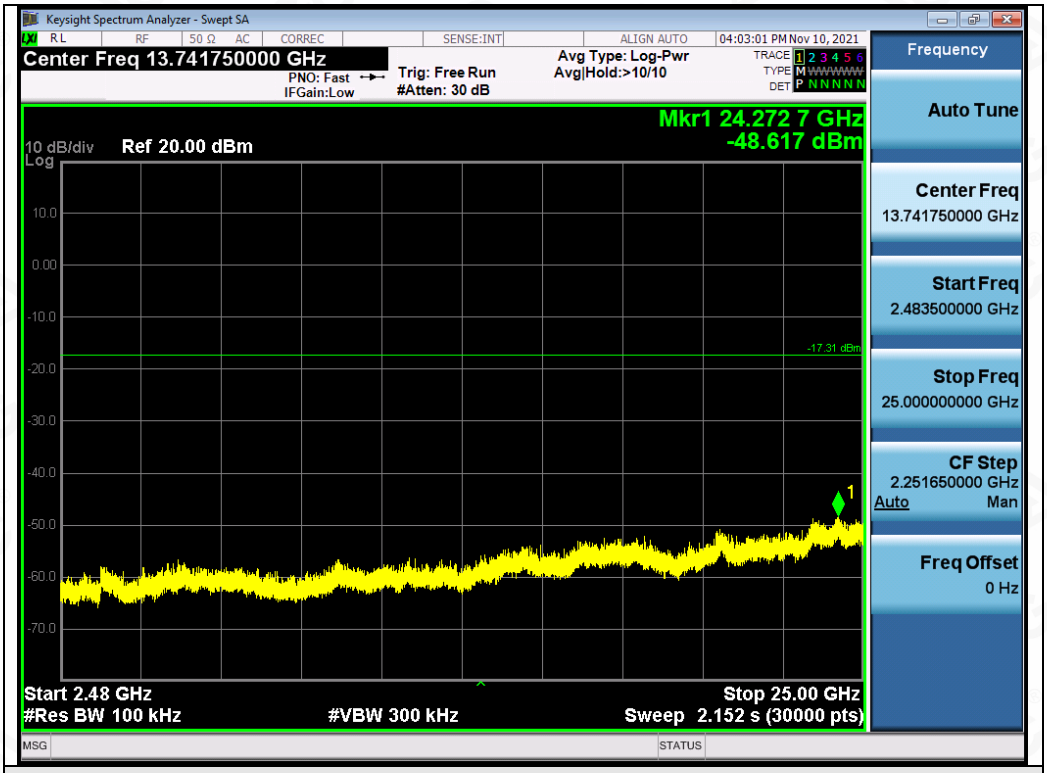
Test_Graph_EDR_ANT1_2480_2Mbps_Lower Band Emissions

Test_Graph_EDR_ANT1_2480_2Mbps_Higher Band Emissions

Test_Graph_EDR_ANT1_2402_3Mbps_Reference Level



Test_Graph_EDR_ANT1_2402_3Mbps_Lower Band Emissions



Test_Graph_EDR_ANT1_2402_3Mbps_Higher Band Emissions

Test_Graph_EDR_ANT1_2441_3Mbps_Reference Level