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C2PC Test Report

Prepared for: Analog Devices LLC

Address: 2200 Avenue 2000

Cork Airport Business Park

Product: ETERNA2

Test Report No: R20210610-20-E1A

Approved by:

Nic S. Johnson, NCE

Technical Manager

iNARTE Certified EMC Engineer #EMC-003337-NE

DATE: August 15, 2022

Total Pages: 32

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REVISION PAGE

Rev. No.	Date	Description	
DRAFT	15 December 2021	Original – NJohnson	
		Prepared by FLane	
Α	1 March 2022	Updated Name of EUT, Address, and Client name – FLane	

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1.0 SUMMARY OF TEST RESULTS

The worst-case measurements were reported in this report. Summary of test results presented in this report correspond to the following section:

FCC Part 15.247

The EUT has been tested according to the following specifications:

- (1) US Code of Federal Regulations, Title 47, Part 15
- (2) ISED RSS-Gen, Issue 5
- (3) ISED RSS-247, Issue 2

APPLIED STANDARDS AND REGULATIONS						
Standard Section	Test Type	Result				
FCC Part 15.35 RSS Gen, Issue 5, Section 6.10	Duty Cycle	Pass				
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Peak output power	Pass				
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Bandwidth	Pass				
FCC Part 15.209 RSS-Gen Issue 4, Section 7.1	Receiver Radiated Emissions	Pass				
FCC Part 15.209 (restricted bands), 15.247 (unrestricted) RSS-247 Issue 2 Section 5.5, RSS-Gen Issue 4, Section 8.9	Transmitter Radiated Emissions	Pass				
FCC Part 15.209, 15.247(d) RSS-247 Issue 2 Section 5.5	Band Edge Measurement	Pass				

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2.0 **EUT DESCRIPTION**

2.1 **EQUIPMENT UNDER TEST**

Summary and Operating Condition:

EUT	ETERNA2 in Emerson ET310 host	
EUT Received	3 November 2021	
EUT Tested	9 November 2021- 24 November 2021	
Serial No.	00902 (NCEE Assigned Serial Number)	
Operating Band	Operating Band 2400 – 2483.5 MHz	
Device Type	802.15.4 DSSS	
Power Supply / Voltage	Powered through USB connector to test PC	

NOTE: For more detailed features description, please refer to the manufacturer's specifications or user's manual.

2.2 **DESCRIPTION OF TEST MODES**

The operating range of the EUT is dependent on the device type found in section 2.1:

For Bluetooth Transmissions:

Channel	Frequency
Low	2405 MHz
Mid	2440 MHz
High	2475 MHz

These are the only representative channels tested in the frequency range according to FCC Part 15.31 and RSS-Gen Table A1. See the operational description for a list of all channel frequency and designations.

2.3 **DESCRIPTION OF SUPPORT UNITS**

None

3.0 LABORATORY AND GENERAL TEST DESCRIPTION

3.1 LABORATORY DESCRIPTION

All testing was performed at the following Facility:

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A2LA Certificate Number: 1953.01
FCC Accredited Test Site Designation No: US1060
Industry Canada Test Site Registration No: 4294A-1
NCC CAB Identification No: US0177

Environmental conditions varied slightly throughout the tests:

Relative humidity of 35 \pm 4% Temperature of 22 \pm 3° Celsius



3.2 TEST PERSONNEL

No.	PERSONNEL	TITLE	ROLE	
1	Nic Johnson	Technical Manager	Review/editing	
2	Fox Lane	Test Engineer	Testing and report	

Notes:

All personnel are permanent staff members of NCEE Labs. No testing or review was sub-contracted or performed by sub-contracted personnel.

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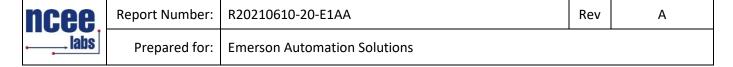
3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer (26.5GHz)	N9038A	MY56400083	May 5, 2020	May 5, 2022
Keysight EXA Signal Analyzer	N9010A	MY56070862	July 20, 2021	July 20, 2023
SunAR RF Motion	JB1	A091418	July 27, 2021	July 27, 2022
EMCO Horn Antenna	3115	6415	March 16, 2020	March 16, 2022
Rohde & Schwarz Preamplifier*	TS-PR18	3545700803	April 14, 2020	April 14, 2022
Trilithic High Pass Filter*	6HC330	23042	April 14, 2020	April 14, 2022
TDK Emissions Lab Software	V11.25	700307	NA	NA
RF Cable (preamplifier to antenna)*	MFR-57500	01-07-002	April 14, 2020	April 14, 2022
RF Cable (antenna to 10m chamber bulkhead)*	FSCM 64639	01E3872	April 14, 2020	April 14, 2022
RF Cable (10m chamber bulkhead to control room bulkhead)*	FSCM 64639	01E3874	April 14, 2020	April 14, 2022
RF Cable (control room bulkhead to test receiver)*	FSCM 64639	01F1206	April 14, 2020	April 14, 2022
N connector bulkhead (10m chamber)*	PE9128	NCEEBH1	April 14, 2020	April 14, 2022
N connector bulkhead (control room)*	PE9128	NCEEBH2	April 14, 2020	April 14, 2022

^{*}Internal Characterization

Notes:

All equipment is owned by NCEE Labs and stored permanently at NCEE Labs facilities.



3.4 GENERAL TEST PROCEDURE AND SETUP FOR RADIO MEASUREMNTS

Measurement type presented in this report (Please see the checked box below):

Conducted ⊠

The conducted measurements were performed by connecting the output of the transmitter directly into a spectrum analyzer using an impedance matched cable and connector soldered to the EUT in place of the antenna. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.



Figure 1 - Bandwidth Measurements Test Setup

Radiated

All the radiated measurements were taken at a distance of 3m from the EUT. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

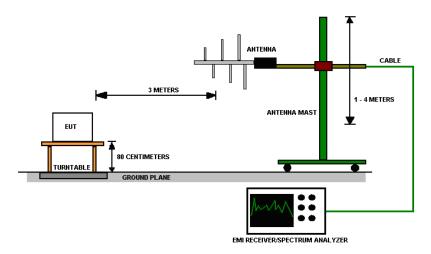


Figure 2 - Radiated Emissions Test Setup

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4.0 **RESULTS**

	Radio Measurements							
Channel	Mode	Occupied Bandwidth (MHz)	6dB Bandwidth (MHz)	Peak Output Power (dBm)	Peak Output Power (mW)	Result		
Low	BT	2.3737	1.59	6.92	4.92	PASS		
Mid	BT	2.5342	1.58	7.36	5.45	PASS		
High	BT	2.4411	1.57	7.00	5.02	PASS		

Occupied Bandwidth = N/A; 6 dB Bandwidth Limit = 500 kHz; Peak Output Power Limit = 30 dBm;

Unrestricted Band-Edge							
CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level (dBuV)	Relative Fundamental (dBuV)	Delta (dB)	Min Delta (dB)	Result
Low	BT	2400.00	22.377	63.107	40.948	20.00	Pass
High	BT	2483.50	7.781	62.623	54.842	20.00	Pass
			Peak Restricted I	Band-Edge			
CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBuV/m @ 3m)	Measurement Type	Limit (dBuV/m @ 3m)*	Margin	Result
Low	BT	2390.00	59.981	Peak	73.98	13.999	Pass
High	BT	2483.50	57.565	Peak	73.98	16.415	Pass
*Limit shown	is the peak l	imit taken from FCC Par	rt 15.209				
			Average Restricted	d Band-Edge			
CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBuV/m @ 3m)	Measurement Type	Limit (dBuV/m @ 3m)*	Margin	Result
Low	BT	2390.00	41.928	Average	53.98	12.052	Pass
High	BT	2483.50	47.840	Average	53.98	6.140	Pass
	*I imit shown is the average limit taken from FCC Part 15 209						

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4.1 DUTY CYCLE

Test Method:

Duty cycle found to be >98%. No duty cycle correction factor was used

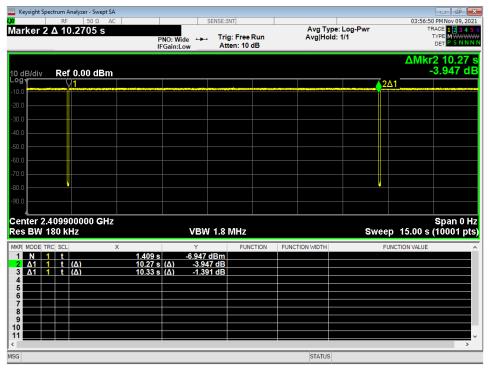


Figure 3 - Duty Cycle, 99.4%

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4.2 RADIATED EMISSIONS

Test Method: ANSI C63.10-2013, Section 6.5, 6.6

Limits for radiated emissions measurements:

Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

FREQUENCIES (MHz)	FIELD STRENGTH (µV/m)	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

NOTE:

- 1. The lower limit shall apply at the transition frequencies.
- 2. Emission level (dBuV/m) = 20 * log * Emission level (μ V/m).
- 3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.
- 4. The EUT was tested for spurious emissions while running off of battery power and external USB power. The worse-case emissions were produced while running off of USB power, so results from this mode are presented.

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Test procedures:

- a. The EUT was placed on the top of a rotating table above the ground plane in a 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation. The table was 0.8m high for measurements from 30MHz-1Ghz and 1.5m for measurements from 1GHz and higher.
- b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.
- d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.
- e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.
- f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.
- g. The EUT was maximized in all 3 orthogonal positions. The results are presented for the axis that had the highest emissions.

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Test setup:

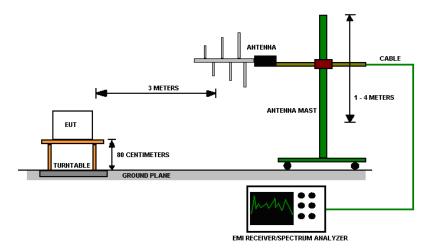


Figure 4 - Radiated Emissions Test Setup

NOTE:

- 1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Peak detection (PK) and Quasi-peak detection (QP) at frequencies below 1GHz.
- 2. The resolution bandwidth 1 MHz for all measurements and at frequencies above 1GHz, A peak detector was used for all measurements above 1GHz. Measurements were made with an EMI Receiver.

Deviations from test standard:

No deviation.

EUT operating conditions

Details can be found in section 2.1 of this report.

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Test results:

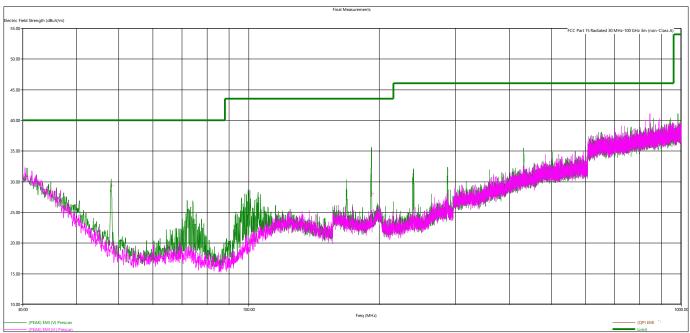


Figure 5 - Radiated Emissions Plot, Receive

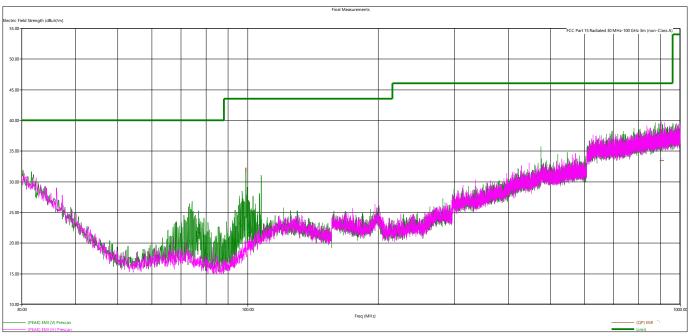


Figure 6 - Radiated Emissions Plot, BT

REMARKS:

- 1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
- 2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
- 3. The other emission levels were very low against the limit.
- 4. Margin value = Limit value Emission level



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Quasi-Peak Measurements, BT								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dBµV/m	dBµV/m	dB	cm.	deg.			
905.616720	33.40	46.02	12.62	143.00	213.00	Н	Low	BT
98.930160	31.94	43.52	11.58	107.00	0.00	V	Low	BT
47.991120	29.33	40.00	10.67	105.00	11.00	V	NA	Receive
191.906400	28.01	43.52	15.51	177.00	181.00	V	NA	Receive

^{*}Unit was maximized on 3 orthogonal angles and worst-case emissions were reported, all other emissions were found to be at least 10dB below limit line

Peak Measurements, BT								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dBµV/m	dBµV/m	dB	cm.	deg.			
2404.556000	101.81	NA	NA	539.00	306.00	Н	Low	BT
2404.464000	99.76	NA	NA	138.00	152.00	V	Low	BT
2440.618000	100.80	NA	NA	522.00	306.00	Н	Mid	ВТ
2474.502000	98.59	NA	NA	255.00	216.00	V	High	BT
7213.332000	57.50	73.98	16.48	163.00	108.00	Н	Low	BT
4800.060000	57.27	73.98	16.71	126.00	155.00	V	Low	BT
4950.848000	58.39	73.98	15.59	115.00	82.00	Н	High	BT
4796.148000	58.19	73.98	15.79	319.00	54.00	V	High	ВТ
7426.364000	61.88	73.98	12.10	130.00	108.00	V	High	ВТ
4793.390000	56.78	73.98	17.20	255.00	85.00	Н	Mid	ВТ
7318.430000	59.09	73.98	14.89	266.00	108.00	V	Mid	BT

Average Measurements, BT								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dBµV/m	dBµV/m	dB	cm.	deg.			
2404.556000	96.30	NA	NA	539.00	306.00	Н	Low	BT
2404.464000	93.46	NA	NA	138.00	152.00	V	Low	BT
2440.618000	93.99	NA	NA	522.00	306.00	Н	Mid	BT
2474.502000	92.55	NA	NA	255.00	216.00	V	High	BT
7213.332000	48.02	53.98	5.96	163.00	108.00	Н	Low	BT
4800.060000	30.06	53.98	23.92	126.00	155.00	V	Low	BT
4950.848000	51.16	53.98	2.82	115.00	82.00	Н	High	BT
4796.148000	29.75	53.98	24.23	319.00	54.00	V	High	BT
7426.364000	53.88	53.98	0.10	130.00	108.00	V	High	BT
4793.390000	29.59	53.98	24.39	255.00	85.00	Н	Mid	BT
7318.430000	50.34	53.98	3.64	266.00	108.00	V	Mid	ВТ

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4.3 BAND EDGES

Test Method: All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

Limits of band-edge measurements:

For FCC Part 15.247 Device:

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.205(c))

Test procedures:

The highest emissions level beyond the band-edge was measured and recorded. All band edge measurements were evaluated to the general limits in Part 15.209. More details can be found in section 3.4 of this report.

Deviations from test standard:

No deviation.

Test setup:

Test setup details can be found in section 3.4 of this report.

EUT operating conditions:

Details can be found in section 2.1 of this report.

Test results:

Pass

Comments:

- 1. All the band edge plots can be found in the Appendix C.
- 2. If the device falls under FCC Part 15.247 (Details can be found in summary of test results), compliance is shown in the unrestricted band edges by showing minimum delta of 20 dB between peak and the band edge.
- 3. The restricted band edge compliance is shown by comparing to the general limit defined in Part 15.209. The limit shown in the graph accounts for the antenna gain of the device.

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OUTPUT POWER 4.4

Test Method: All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

Limits of power measurements:

For FCC Part 15.247 Device:

The maximum allowed peak output power is 30 dBm.

Test procedures:

Details can be found in section 3.4 of this report.

Deviations from test standard:

No deviation.

Test setup:

Details can be found in section 3.4 of this report.

EUT operating conditions:

Details can be found in section 2.1 of this report.

Test results:

Pass

Comments:

- 1. All the output power plots can be found in the Appendix C.
- 2. All the measurements were found to be compliant.
- 3. The measurements are listed in the tables in section 4.0.

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4.5 BANDWIDTH

Test Method: All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

Limits of bandwidth measurements:

For FCC Part 15.247 Device:

The 99% occupied bandwidth is for informational purpose only. The 6dB bandwidth of the signal must be greater than 500 kHz.

Test procedures:

Details can be found in section 3.4 of this report.

Deviations from test standard:

No deviation.

Test setup:

Test setup details can be found in section 3.4 of this report.

EUT operating conditions:

Details can be found in section 2.1 of this report.

Test results:

Pass

Comments:

- 1. All the bandwidth plots can be found in the Appendix C.
- 2. All the measurements were found to be compliant.
- 3. The measurements are listed in the tables in section 4.0.

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APPENDIX A: SAMPLE CALCULATION

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

$$FS = RA + AF - (-CF + AG) + AV$$

where FS = Field Strength

RA = Receiver Amplitude

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Amplifier Gain

AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dB μ V is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dB μ V/m.

$$FS = 55 + 12 - (-1.1 + 20) + 0 = 48.1 \text{ dB}\mu\text{V/m}$$

The 48.1 dB_μV/m value can be mathematically converted to its corresponding level in μV/m.

Level in $\mu V/m = Common Antilogarithm [(48.1 dB<math>\mu V/m)/20$]= 254.1 $\mu V/m$

AV is calculated by the taking the $20*log(T_{on}/100)$ where T_{on} is the maximum transmission time in any 100ms window.

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EIRP Calculations

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

EIRP (Watts) = [Field Strength (V/m) x antenna distance (m)]² / 30

Power (watts) = 10^{Power} (dBm)/10] / 1000

Voltage $(dB\mu V)$ = Power (dBm) + 107 (for 50 Ω measurement systems)

Field Strength $(V/m) = 10^{field Strength} (dB\mu V/m) / 20] / 10^6$

Gain = 1 (numeric gain for isotropic radiator)

Conversion from 3m field strength to EIRP (d=3):

 $EIRP = [FS(V/m) \times d^2]/30 = FS[0.3]$ for d = 3

 $EIRP(dBm) = FS(dB\mu V/m) - 10(log 10^9) + 10log[0.3] = FS(dB\mu V/m) - 95.23$

10log(10^9) is the conversion from micro to milli

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APPENDIX B - MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

Test	Frequency Range	Uncertainty Value (dB)		
Radiated Emissions, 3m	30MHz - 1GHz	3.82		
Radiated Emissions, 3m	1GHz - 18GHz	4.44		
Emissions limits, conducted	30MHz – 18GHz	±3.30 dB		

Expanded uncertainty values are calculated to a confidence level of 95%.

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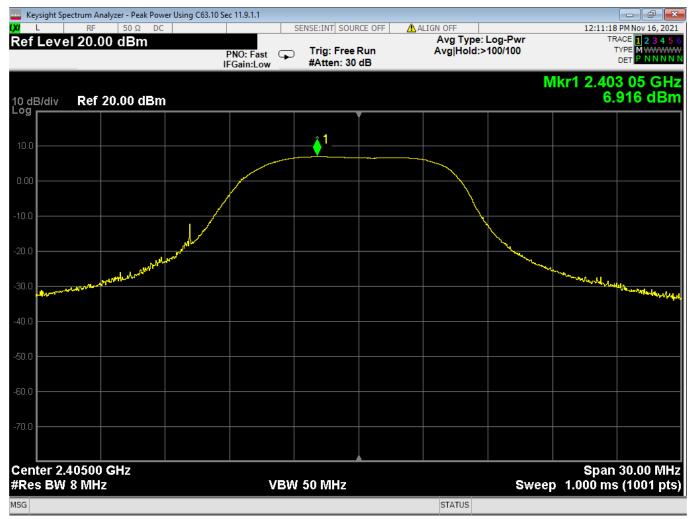
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APPENDIX C - GRAPHS AND TABLES



01 Power, Low, BT

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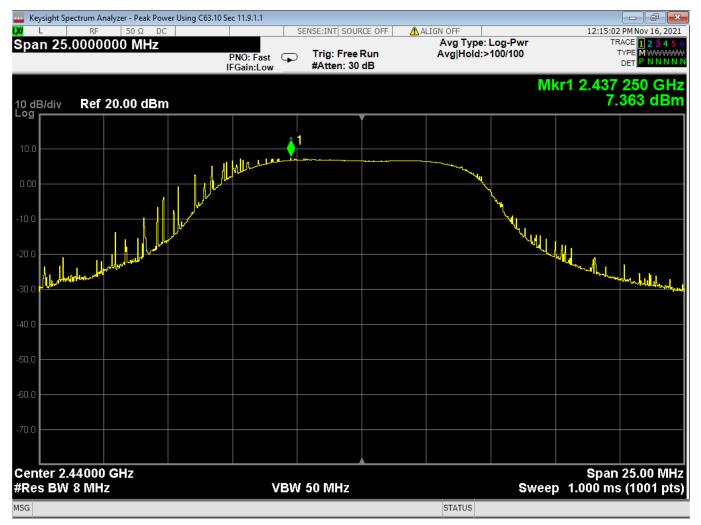
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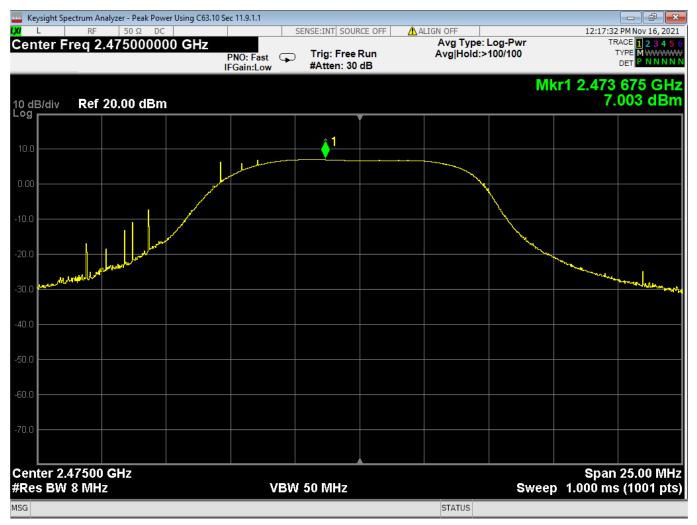
02 Power, Mid, BT

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03 Power, High, BT

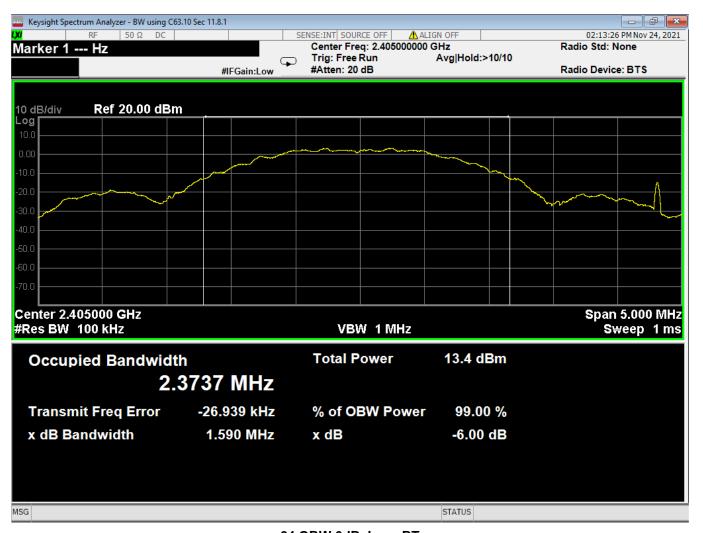
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04 OBW 6dB, Low, BT

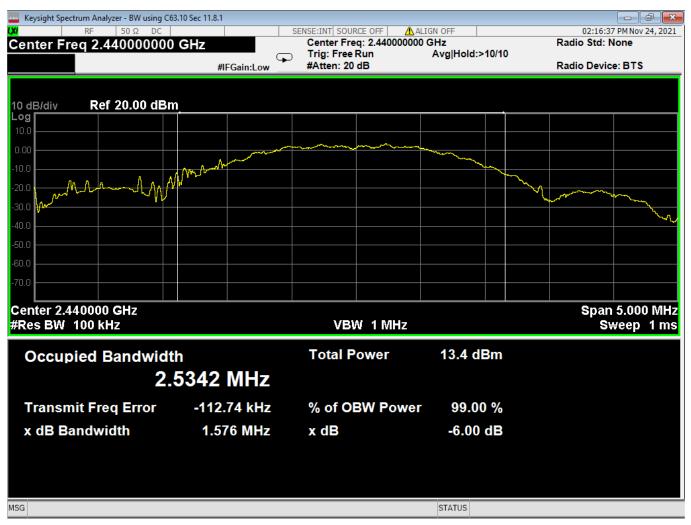
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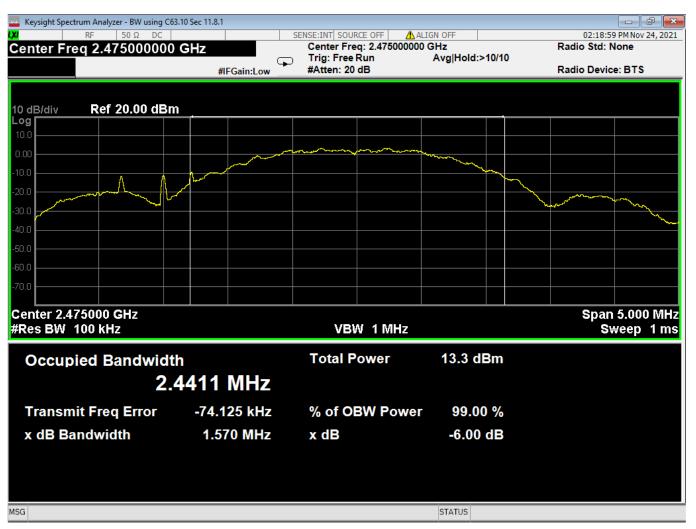
05 OBW 6dB, Mid, BT

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06 OBW 6dB, High, BT

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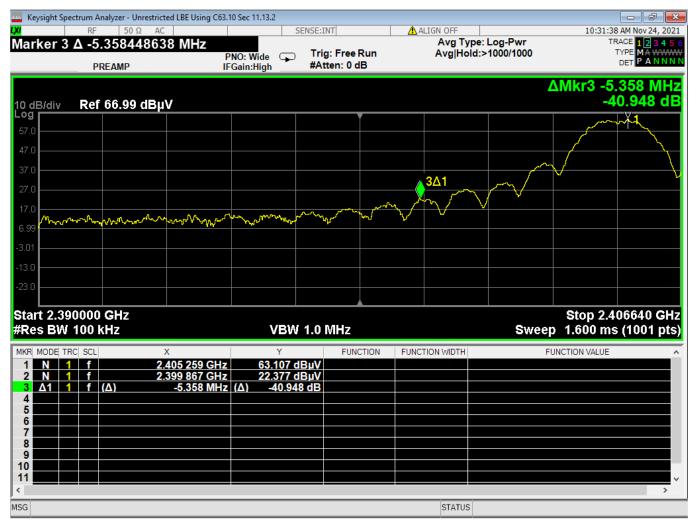


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07 Unrestricted Bandedge, Low, BT

Relative measurement, no corrections added

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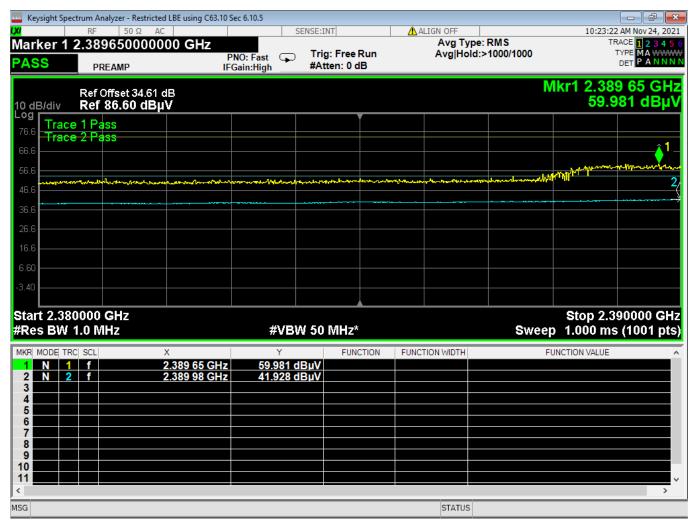
08 Unrestricted Bandedge, High, BT

Relative measurement, no corrections added

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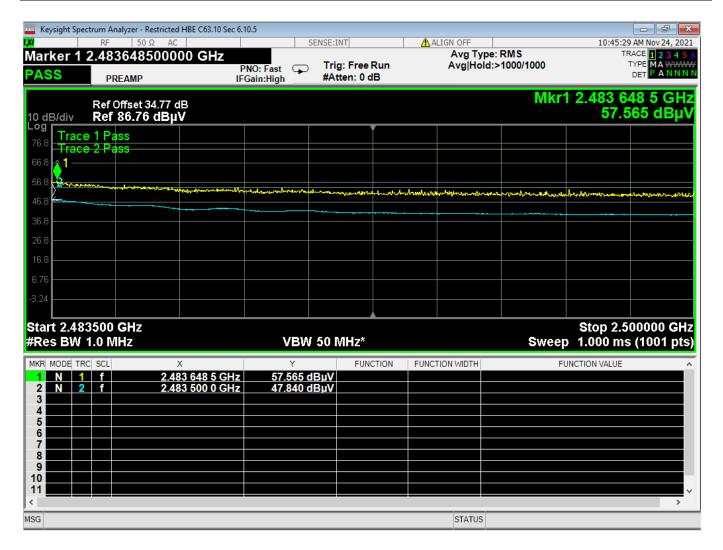


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