



CERTIFICATION TEST REPORT

Report Number. : 11526444-E1V3

Applicant : SONOS, INC.
614 CHAPALA STREET
SANTA BARBARA, CA, 93101, U.S.A.

Model : S13

FCC ID : SBVRM012

IC : 5373A-RM012

EUT Description : 802.11 a/b/g/n (HT20) Client Device

Test Standard(s) : FCC 47 CFR PART 15 SUBPART C
INDUSTRY CANADA RSS - 247 ISSUE 2
INDUSTRY CANADA RSS-GEN ISSUE 4

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Prepared by:

UL Verification Services Inc.
47173 Benicia Street
Fremont, CA 94538, U.S.A.
TEL: (510) 771-1000
FAX: (510) 661-0888



NVLAP LAB CODE 200065-0

Revision History

Rev.	Issue Date	Revisions	Revised By
V1	06/30/17	Initial Issue	D. Corona
V2	07/18/17	Updated Section 5.2 & 9.1 (KDB 414788)	D. Corona
V3	07/31/17	Updated Section 9.1 & remove below 30MHz data.	D. Corona

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: SONOS, INC.

EUT DESCRIPTION: 802.11 a/b/g/n (HT20) Client Device

MODEL: S13

SERIAL NUMBER: 170378-28-CA-10-05-CC-2, 170378-28-CA-10-05-CC-0, 170378-28-CA-00-07-80-E

DATE TESTED: MARCH 27 – JUNE 01, 2017

APPLICABLE STANDARDS	
STANDARD	TEST RESULTS
CFR 47 Part 15 Subpart C	Pass
Industry Canada RSS-247 Issue 2	Pass
Industry Canada RSS-GEN ISSUE 4	Pass

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Verification Services Inc. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government.

Approved & Released For
UL Verification Services Inc. By:

Tested By:



DAN CORONIA
CONSUMER TECHNOLOGY DIVISION
WISE PROJECT LEAD
UL VERIFICATION SERVICES INC



GLENN ESCANO
CONSUMER TECHNOLOGY DIVISION
WISE LAB ENGINEER
UL VERIFICATION SERVICES INC

2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC CFR 47 Part 2, FCC CFR 47 Part 15, KDB 558074 D01 v04, KDB 662911 D01 Multiple Transmitter Output v02r01 and ANSI C63.10-2013, RSS-GEN Issue 4, and RSS-247 Issue 2.

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 and 47266 Benicia Street, Fremont, California, USA. Line conducted emissions are measured only at the 47173 address. The following table identifies which facilities were utilized for radiated emission measurements documented in this report. Specific facilities are also identified in the test results sections.

47173 Benicia Street	47266 Benicia Street
☒ Chamber A(IC: 2324B-1)	☐ Chamber D(IC: 22541-1)
☐ Chamber B(IC: 2324B-2)	☐ Chamber E(IC: 22541-2)
☐ Chamber C(IC: 2324B-3)	☐ Chamber F(IC: 22541-3)
	☐ Chamber G(IC: 22541-4)
	☐ Chamber H(IC: 22541-5)

The above test sites and facilities are covered under FCC Test Firm Registration # 208313. UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0. Chambers A through C are covered under Industry Canada company address code 2324B with site numbers 2324B -1 through 2324B-3, respectively. Chambers D through H are covered under Industry Canada company address code 22541 with site numbers 22541 -1 through 22541-5, respectively.

4. CALIBRATION AND UNCERTAINTY

4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

4.2. SAMPLE CALCULATION

Where relevant, the following sample calculation is provided:

$$\begin{aligned} \text{Field Strength (dBuV/m)} &= \text{Measured Voltage (dBuV)} + \text{Antenna Factor (dB/m)} + \\ &\text{Cable Loss (dB)} - \text{Preamp Gain (dB)} \\ 36.5 \text{ dBuV} + 18.7 \text{ dB/m} + 0.6 \text{ dB} - 26.9 \text{ dB} &= 28.9 \text{ dBuV/m} \end{aligned}$$

4.3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

Parameter	Uncertainty
Worst Case Conducted Disturbance, 9KHz to 0.15 MHz	3.84 dB
Worst Case Conducted Disturbance, 0.15 to 30 MHz	3.65 dB
Worst Case Radiated Disturbance, 9KHz to 30 MHz	3.15 dB
Worst Case Radiated Disturbance, 30 to 1000 MHz	5.36 dB
Worst Case Radiated Disturbance, 1000 to 18000 MHz	4.32 dB
Worst Case Radiated Disturbance, 18000 to 26000 MHz	4.45 dB
Worst Case Radiated Disturbance, 26000 to 40000 MHz	5.24 dB

Uncertainty figures are valid to a confidence level of 95%.

5. EQUIPMENT UNDER TEST

5.1. DESCRIPTION OF EUT

The EUT is 802.11 a/b/g/n (HT20) Client Device. Product model S13 is a high-performance all-in-one wireless smart speaker and part of Sonos' home sound system. S13 adds integrated voice control functionality with far field microphones. Moreover, the device will support multiple voice platforms and music services, allowing customers to effortlessly control their music on Sonos.

5.2. MAXIMUM OUTPUT POWER

The transmitter has a maximum conducted output power as follows:

Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
2412 - 2462	802.11b 3TX	24.49	281.19
2412 - 2462	802.11g 3TX	23.20	208.93
2412 - 2462	802.11n HT20 3TX	23.40	218.78

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes an integrated antenna, with a maximum gain as follows:

Frequency (GHz)	Peak Antenna Gain (dBi)		
	Chain 0	Chain 1	Chain 2
2.4	2.69	2.02	1.33

5.4. SOFTWARE AND FIRMWARE

The test utility software used during testing was Atheros Radio Test 2 (ART2-GUI).

5.5. WORST-CASE CONFIGURATION AND MODE

Radiated bandage, harmonics, and spurious emissions from 1 GHz to 18GHz were performed. The EUT was set to transmit at the Low/Middle/High channels with designed (target) output powers.

Radiated emission below 1GHz, above 18GHz, and power line conducted emission were performed with the EUT was set to transmit at the channel with highest output power as worst-case scenario.

The EUT can only be setup in desktop orientation; therefore, all radiated testing was performed with the EUT in desktop orientation.

Worst-case data rates as provided by the client were:

802.11b mode: 11 Mbps

802.11g mode: 24 Mbps

802.11n HT20mode: MCS9

5.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	Manufacturer	Model	Serial Number	FCC ID
Laptop AC/DC adapter	Lenovo	92P1160	11S92P1160Z1ZBGH798B12	NA
Laptop	Lenovo	7659	L3-AL664 08/03	NA

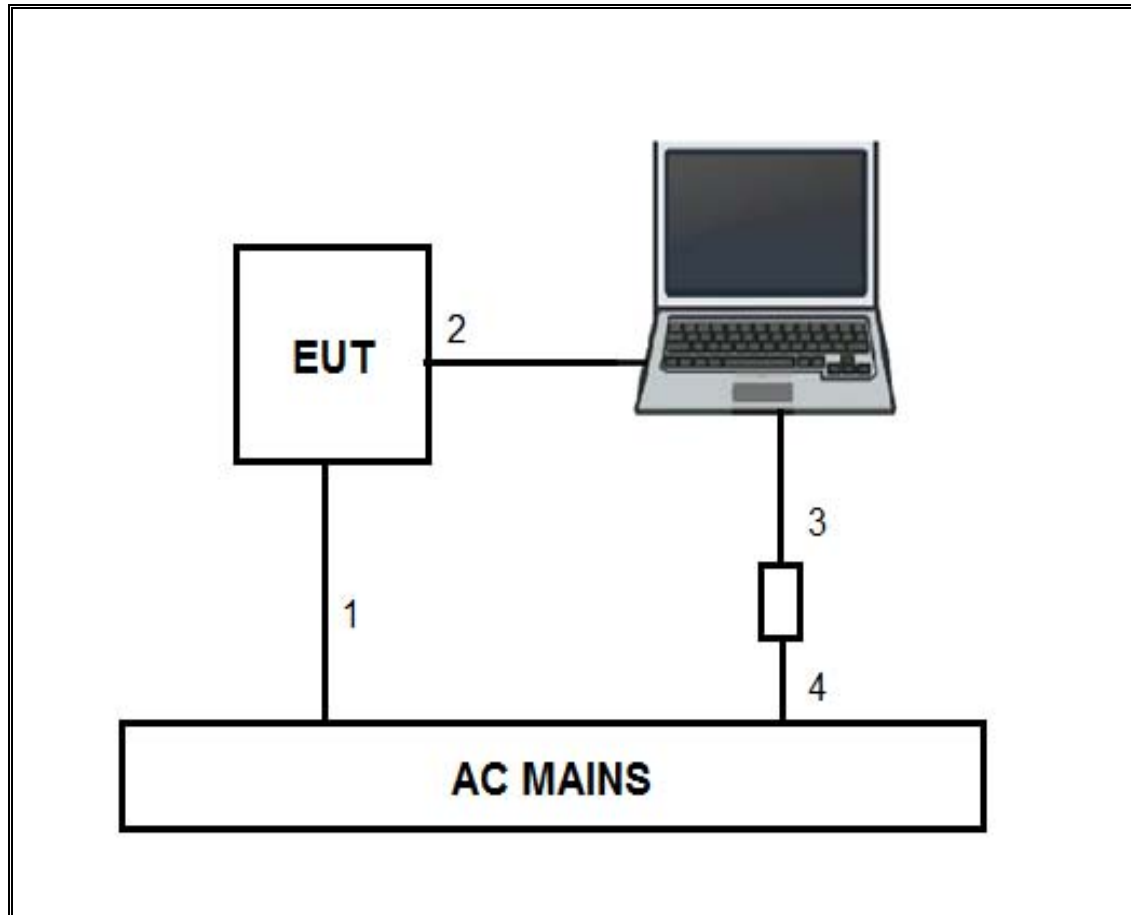
I/O CABLES

I/O Cable List						
Cable No	Port	# of identical ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	AC Power	1	AC	Unshielded	2	AC Mains to EUT
2	Ethernet	1	RJ45	Unshielded	10	EUT to Laptop
3	DC Power	1	DC	Shielded	1.2	AC/DC Adapter to Laptop
4	AC Power	1	AC	Unshielded	1	AC Mains to AC/DC Adapter

TEST SETUP

The EUT is a stand-alone unit, and the radio is exercised by Atheros Radio Test 2 (ART2-GUI) software via Ethernet.

SETUP DIAGRAM



6. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

Test Equipment List					
Description	Manufacturer	Model	T No.	Cal Date	Cal Due
Amplifier, 1 - 18GHz	Miteq	AFS42	1165	08/01/16	08/01/17
Amplifier, 10KHz to 1GHz, 32dB	Sonoma	310	300	11/10/16	11/10/17
Amplifier, 1GHz to 26.5GHz, 23.5dB	Agilent	8449B	404	07/05/16	07/05/17
Antenna, Broadband Hybrid 30MHz to 2000MHz	Sunol Science	JB1	130	03/09/17	03/09/18
Antenna, Horn 1-18GHz	ETS-Lindgren	3117	346	02/22/17	02/22/18
Antenna, Horn 18 - 26.5GHz	Seavey Division	MWH-1826/B	449	05/26/17	05/26/18
EMI Test Receiver 9KHz-7GHz	R&S	ESCI7	1436	09/23/16	09/23/17
LISN for Conducted Emissions	Fischer	50/250-25-2	1310	06/08/16	06/08/17
Loop Antenna, 10KHz-30MHz	EMCO	6502	35	3/24/17*	3/24/18*
PSA Spectrum Analyzer 40GHz	Agilent	E4446A	146	07/13/16	07/13/17
Spectrum Analyzer, PXA, 3Hz to 44GHz	Keysight	N9030A	1466	04/11/17	04/11/18
Power Cable, Line Conducted Emissions	UL	PG1	N/A	07/28/16	07/28/17
Power Meter, P-series single channel	Keysight	N1911A	1262	07/08/16	07/08/17
Power Sensor, P-series, 50MHz to 18GHz, Wideband	Agilent	N1911A	750	10/17/16	10/17/17

Test Software List			
Description	Manufacturer	Model	Version
Radiated Software	UL	UL EMC	Ver 9.5, Apr 26, 2016
Conducted Software	UL	UL EMC	Ver 9.5, May 26, 2015
Antenna Port Software	UL	UL RF	Ver 6.0, Jan 19, 2017

The following test and measurement equipment was utilized for the tests documented in this report:

NOTE: *testing is completed before equipment calibration expiration date.

7. MEASUREMENT METHODS

On Time and Duty Cycle: KDB 558074 D01 v04, Section 6.

6 dB BW: KDB 558074 D01 v04, Section 8.1.

99% BW: ANSI C63.10-2013, Section 6.9.3.

Output Power: KDB 558074 D01 v04, Section 9.2.3.2.

Power Spectral Density: KDB 558074 D01 v04, Section 10.3.

Out-of-band emissions in non-restricted bands: KDB 558074 D01 v04, Section 11.1 (b).

Out-of-band emissions in restricted bands: KDB 558074 D01 v04, Section 12.1.

Band-edge: KDB 558074 D01 v04, Section 12.1.

AC Power Line Conducted Emissions: ANSI C63.10-2013, Section 6.2.

8. ANTENNA PORT TEST RESULTS

ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

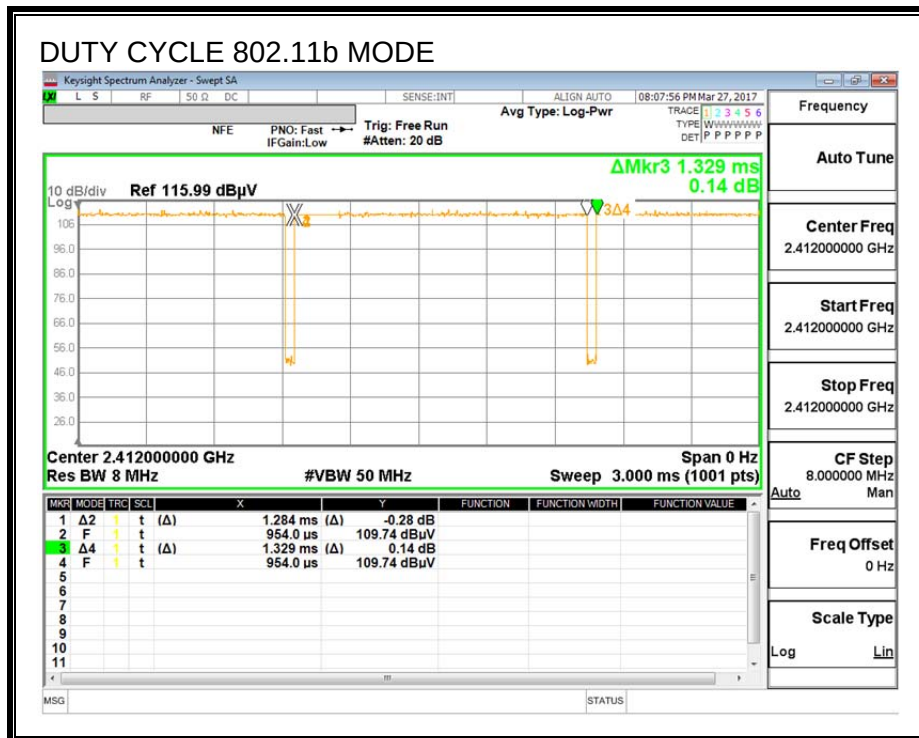
PROCEDURE

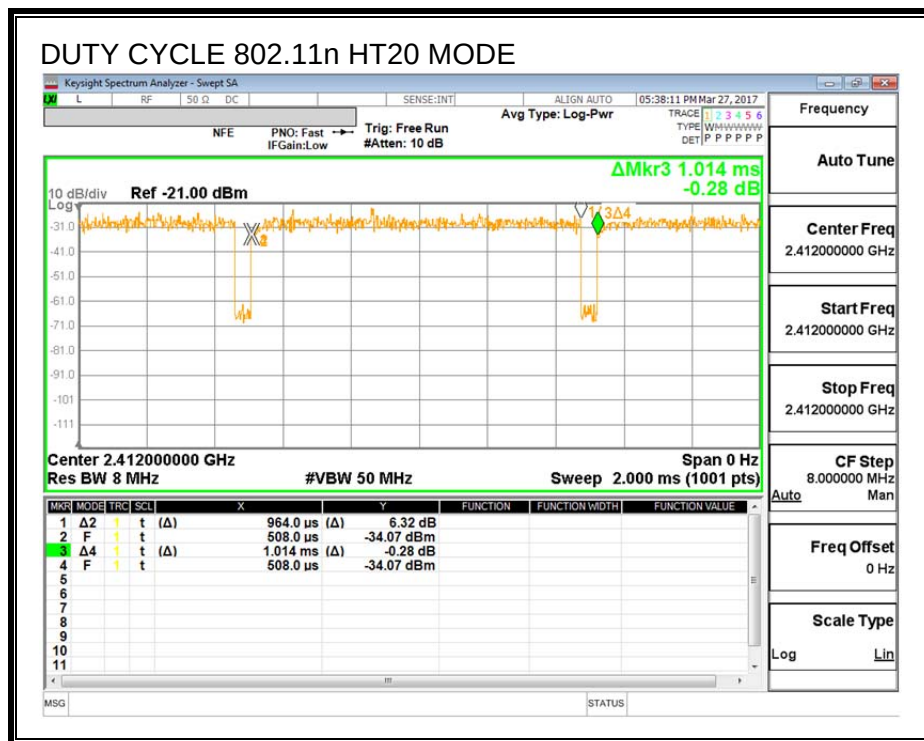
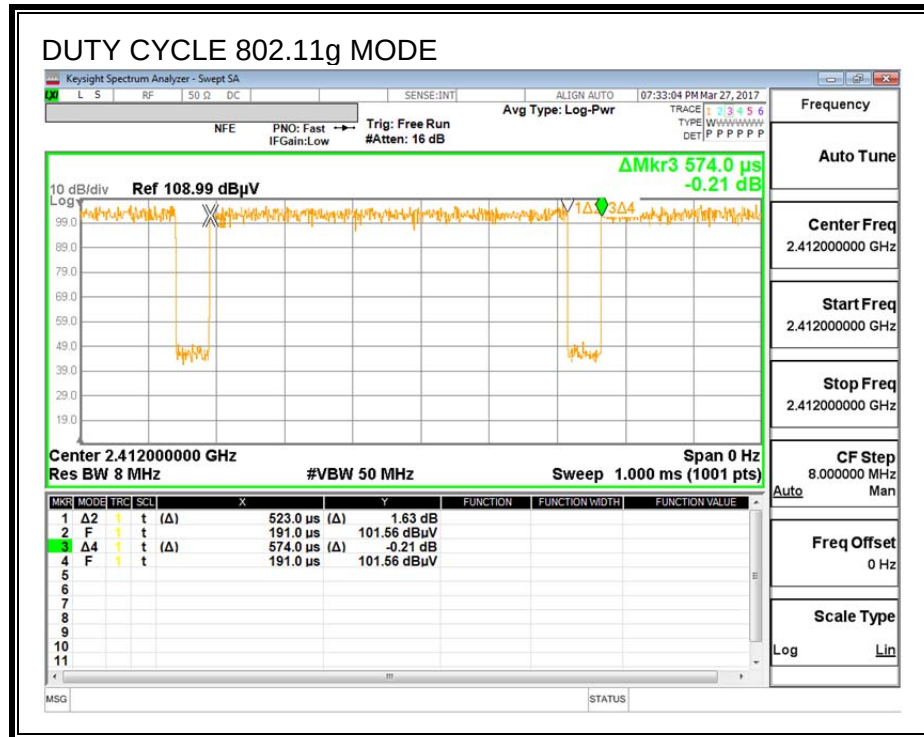
KDB 558074 Zero-Span Spectrum Analyzer Method.

ON TIME AND DUTY CYCLE RESULTS

Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/B Minimum VBW (kHz)
11b 3TX CDD	1.284	1.329	0.966	96.613	0.149	0.778
11g 3TX CDD	0.523	0.574	0.911	91.114	0.404	1.912
11n HT20 3TX CDD	0.964	1.014	0.95	95.069	0.219	1.037

DUTY CYCLE PLOTS





8.1. 11b 3TX CDD MIMO MODE IN THE 2.4GHz BAND

8.1.1. 6 dB BANDWIDTH

LIMITS

FCC §15.247 (a) (2)

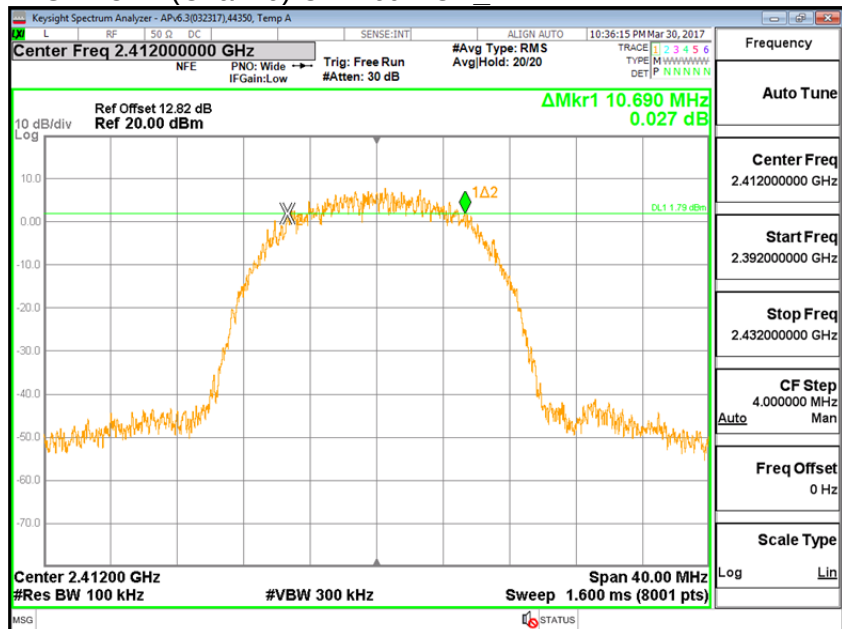
IC RSS-247 (5.2) (a)

The minimum 6 dB bandwidth shall be at least 500 kHz.

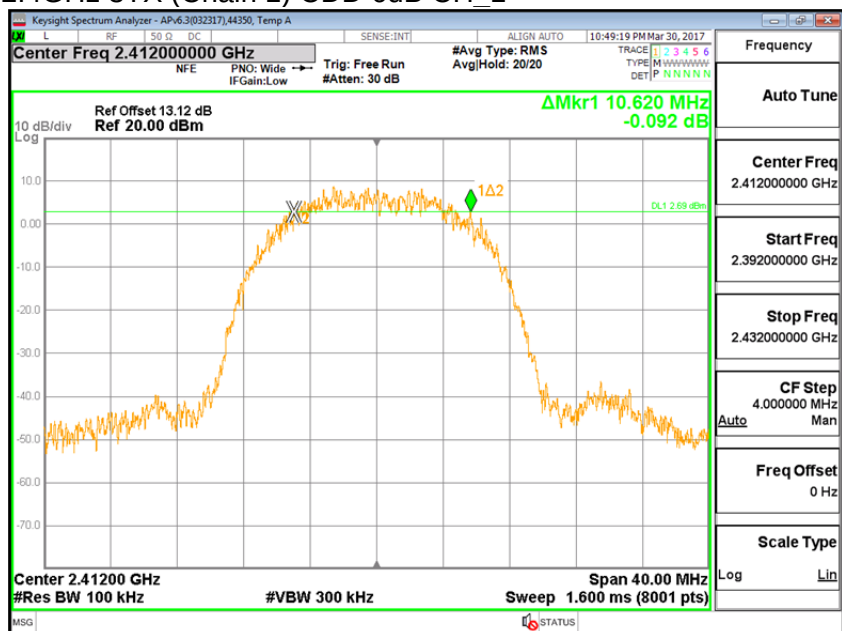
RESULTS

Channel	Frequency	6 dB BW Chain 0 (MHz)	6 dB BW Chain 1 (MHz)	6 dB BW Chain 2 (MHz)	Minimum Limit (MHz)
Low_1	2412	10.690	10.620	9.705	0.5
Middle_6	2437	9.935	9.595	11.080	0.5
High_11	2462	10.965	9.735	10.325	0.5

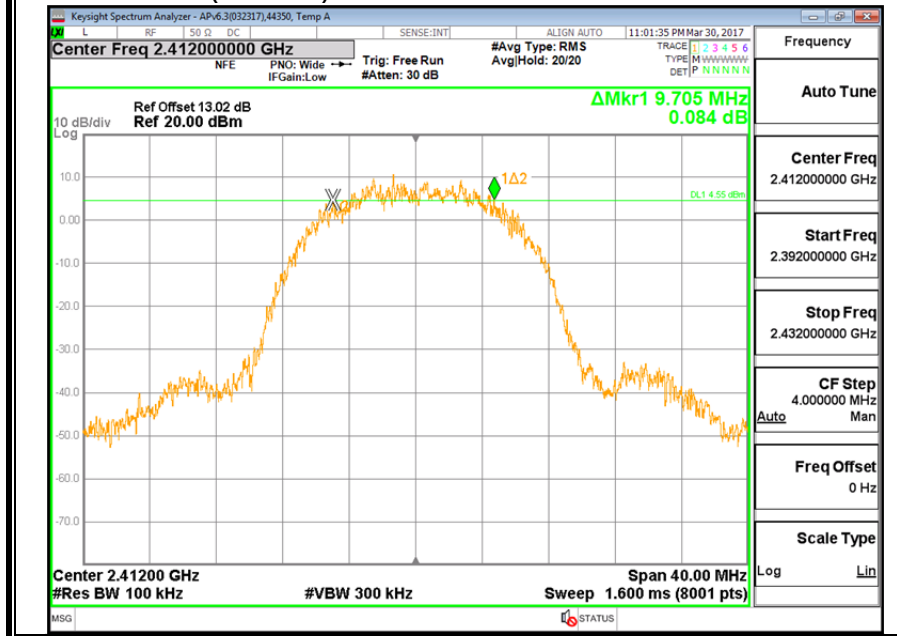
2.4GHz 3TX (Chain 0) CDD 6dB CH_1



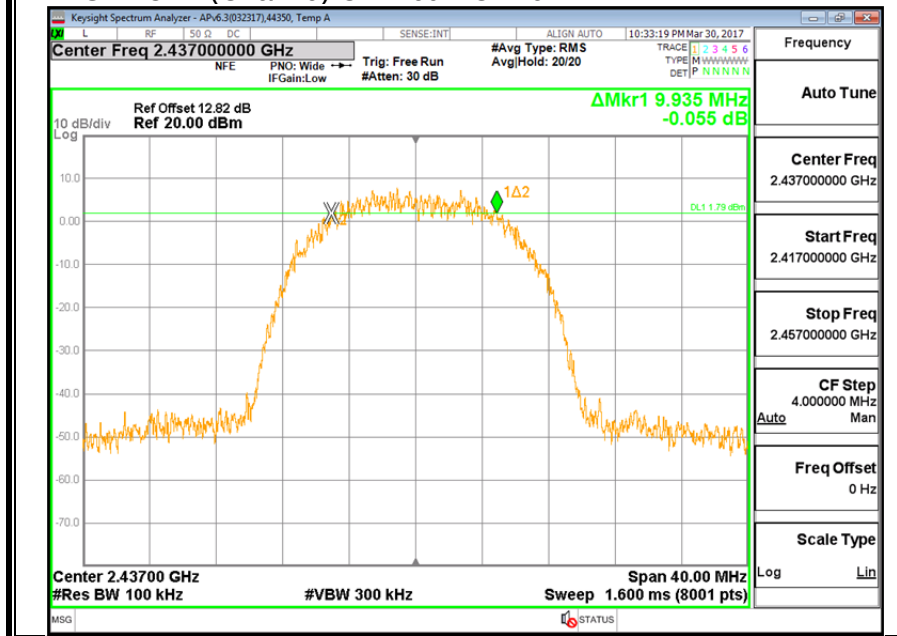
2.4GHz 3TX (Chain 1) CDD 6dB CH_1



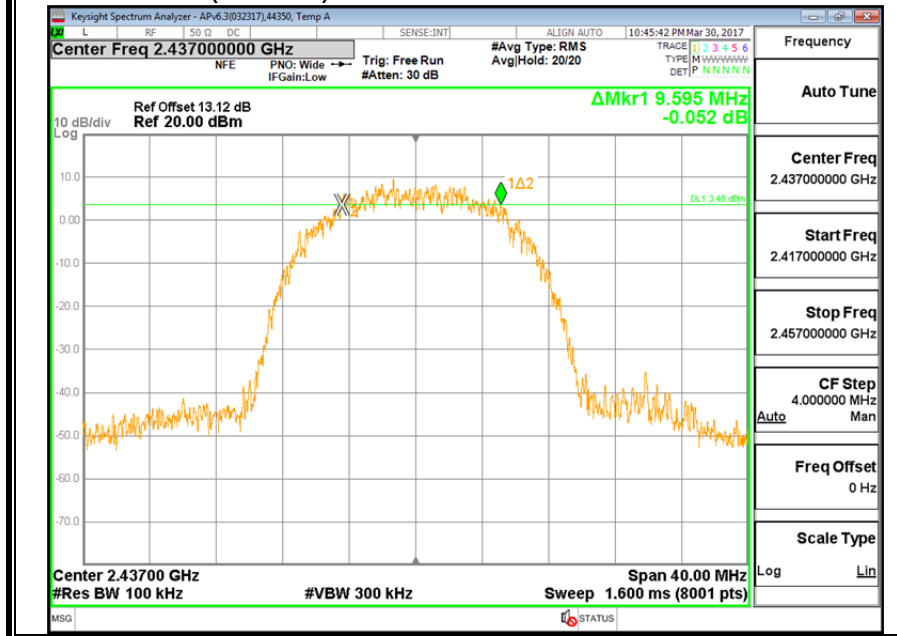
2.4GHz 3TX (Chain 2) CDD 6dB CH 1



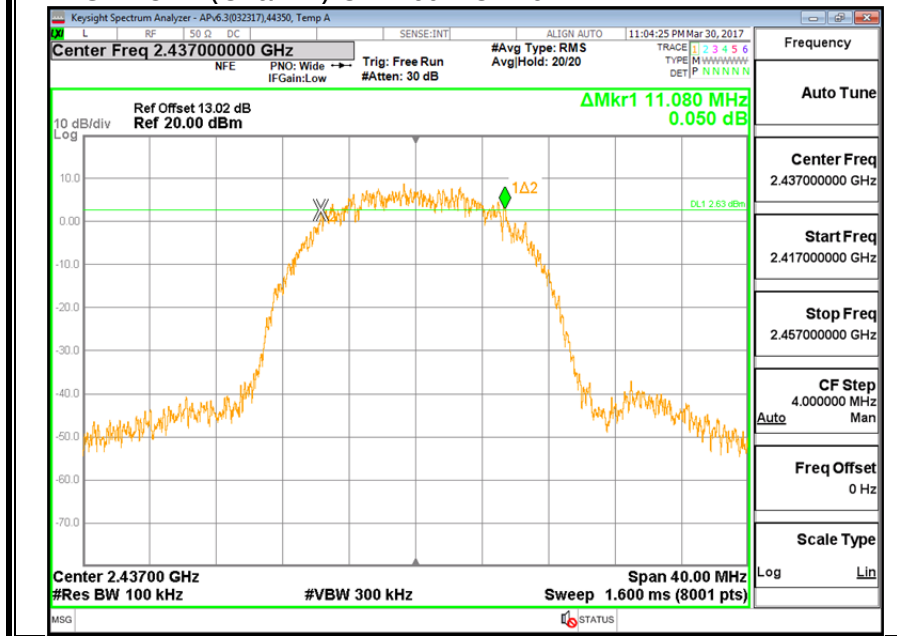
2.4GHz 3TX (Chain 0) CDD 6dB CH 6



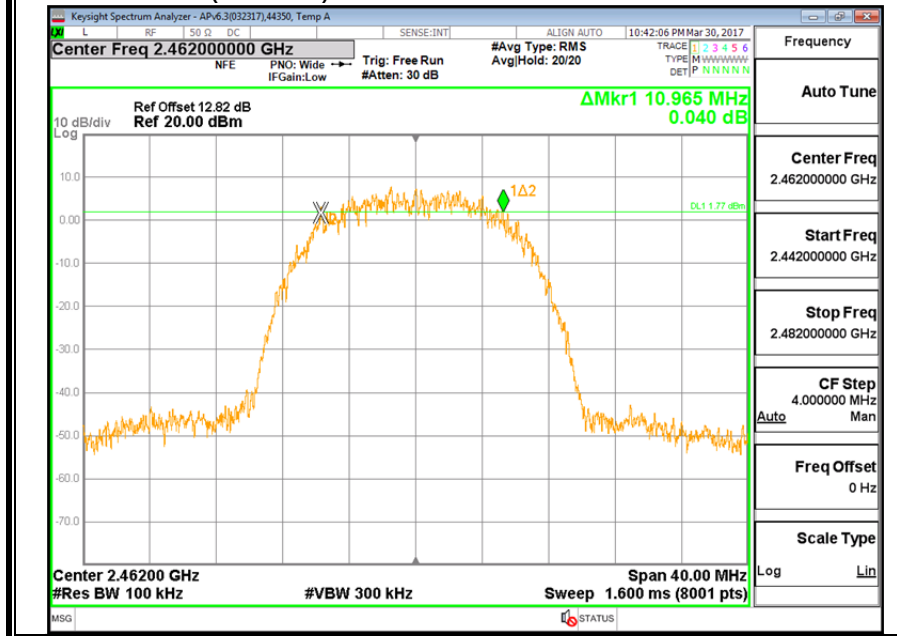
2.4GHz 3TX (Chain 1) CDD 6dB CH 6



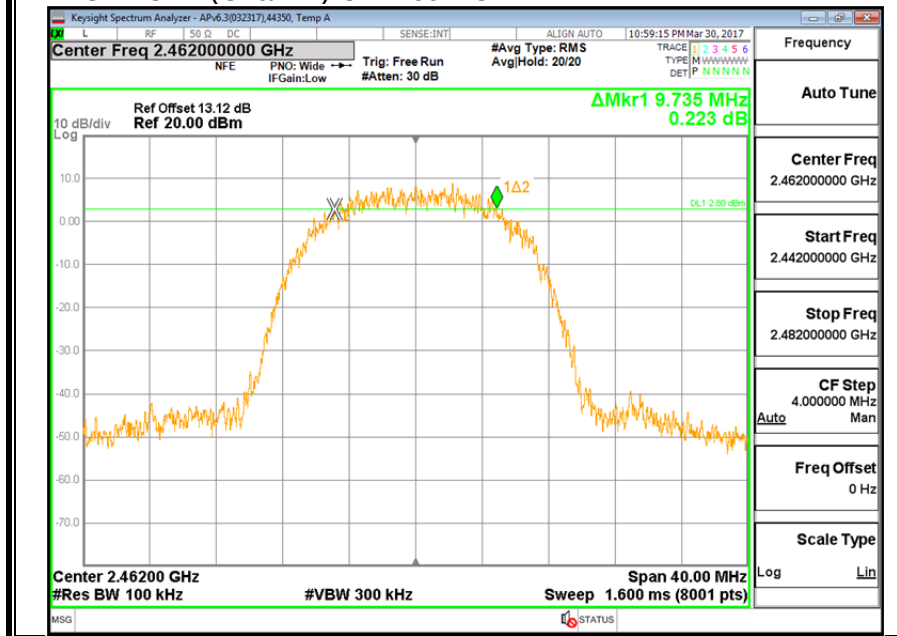
2.4GHz 3TX (Chain 2) CDD 6dB CH 6

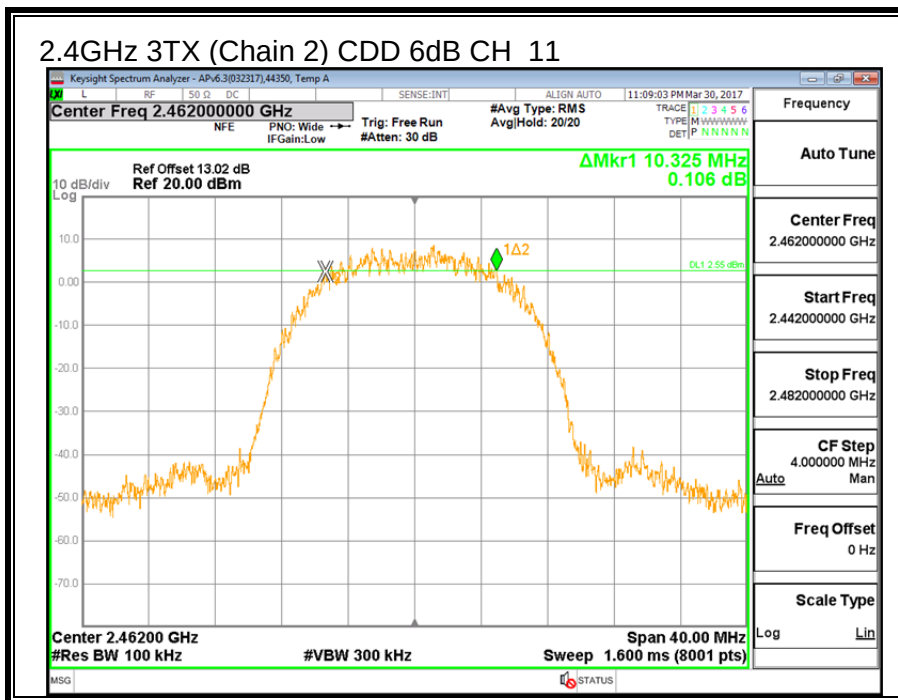


2.4GHz 3TX (Chain 0) CDD 6dB CH 11



2.4GHz 3TX (Chain 1) CDD 6dB CH 11





8.1.2. 99% BANDWIDTH

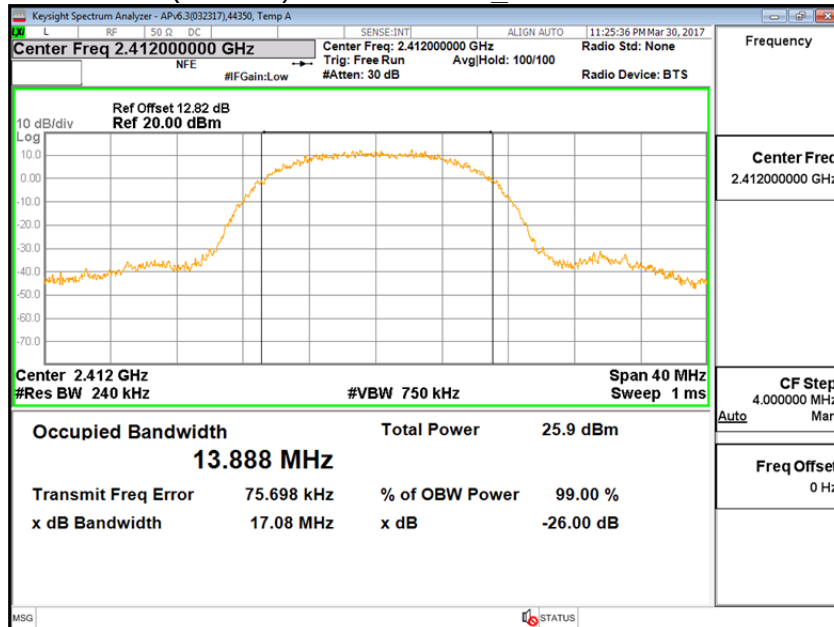
LIMITS

None; for reporting purposes only.

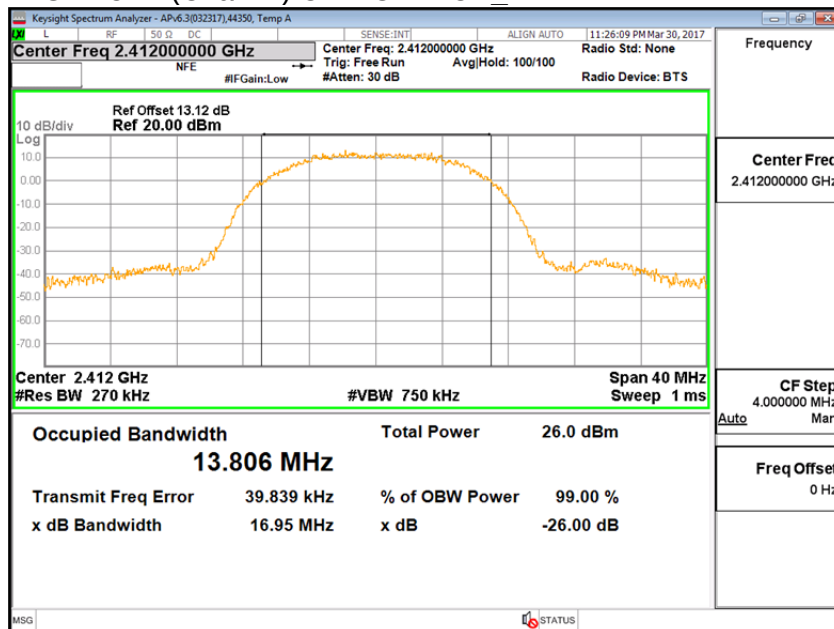
RESULTS

Channel	Frequency (MHz)	99% Bandwidth Chain 0 (MHz)	99% Bandwidth Chain 1 (MHz)	99% Bandwidth Chain 2 (MHz)
Low_1	2412	13.888	13.806	13.890
Middle_6	2437	13.750	13.780	13.763
High_11	2462	13.751	13.780	13.724

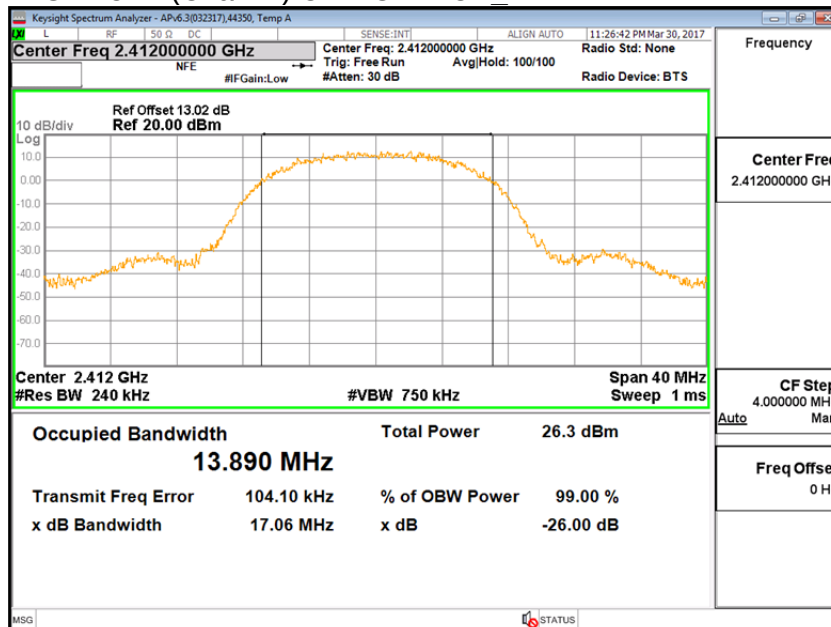
2.4GHz 3TX (Chain 0) CDD OBW CH_1



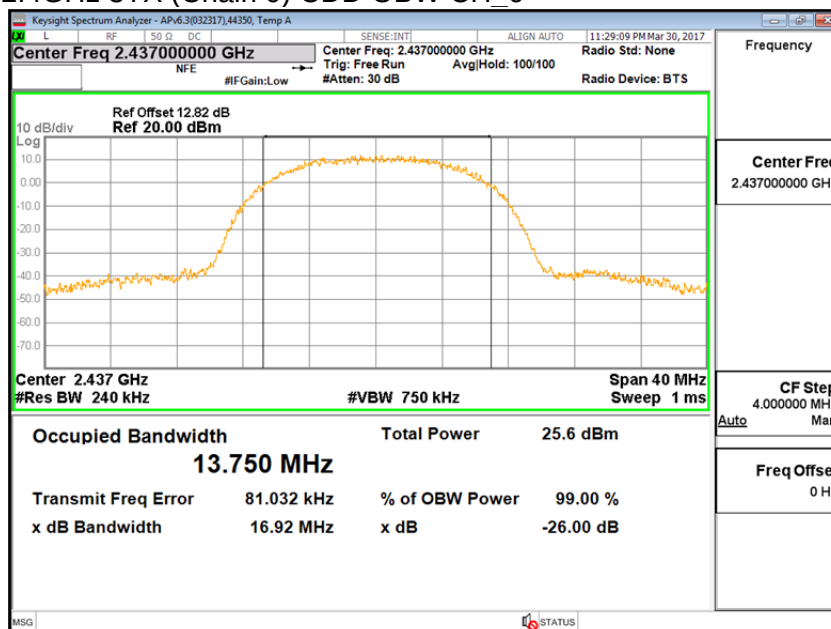
2.4GHz 3TX (Chain 1) CDD OBW CH_1



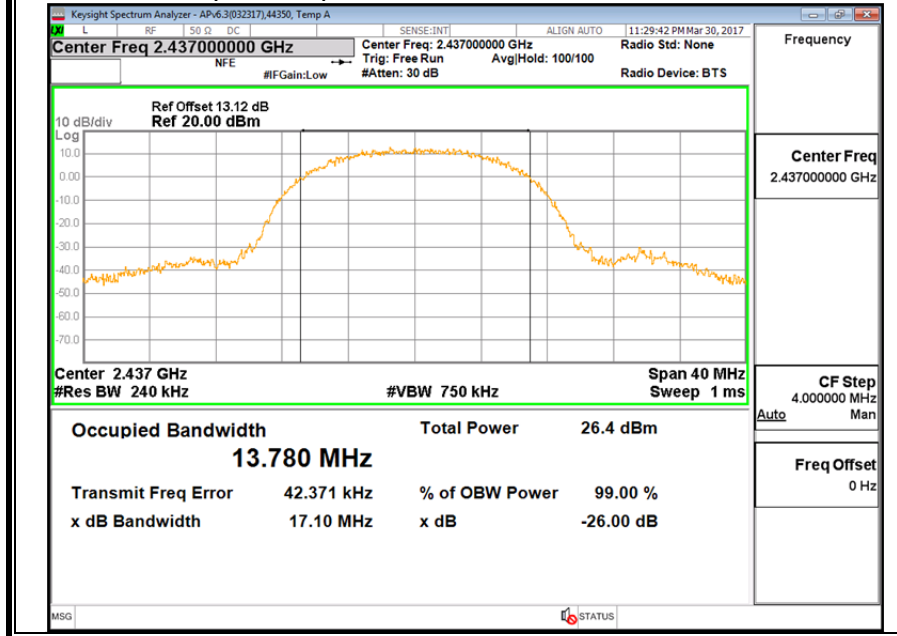
2.4GHz 3TX (Chain 2) CDD OBW CH_1



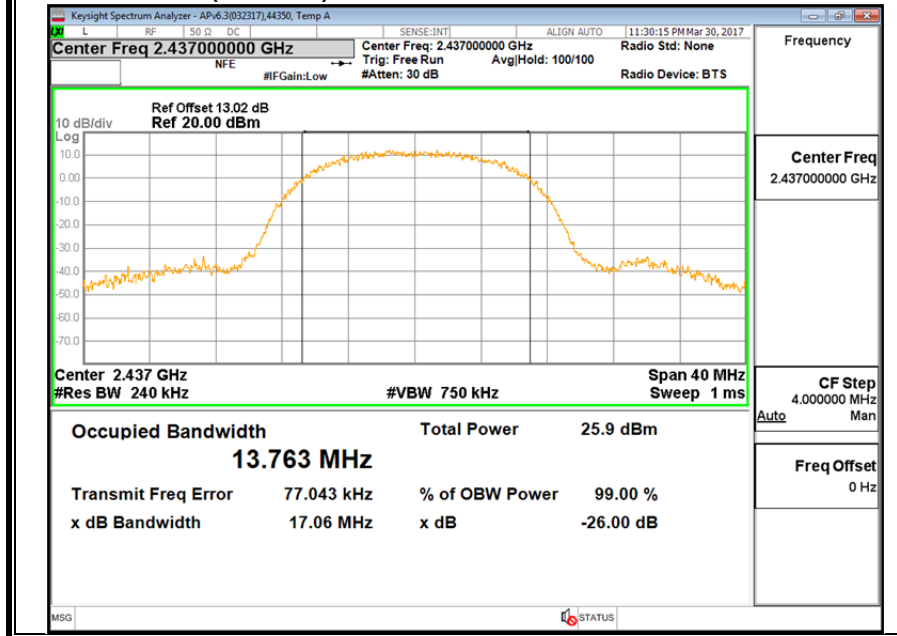
2.4GHz 3TX (Chain 0) CDD OBW CH_6



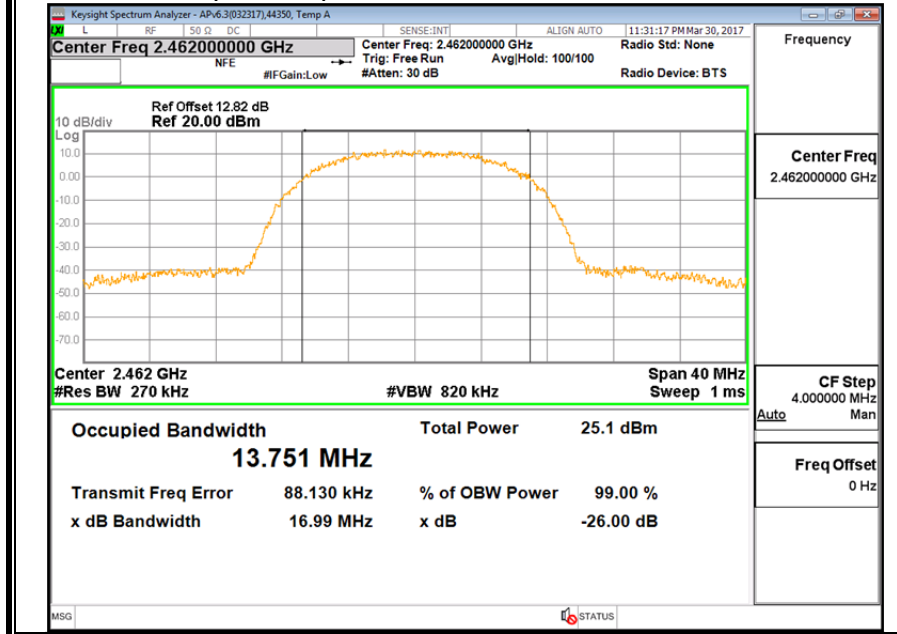
2.4GHz 3TX (Chain 1) CDD OBW CH 6



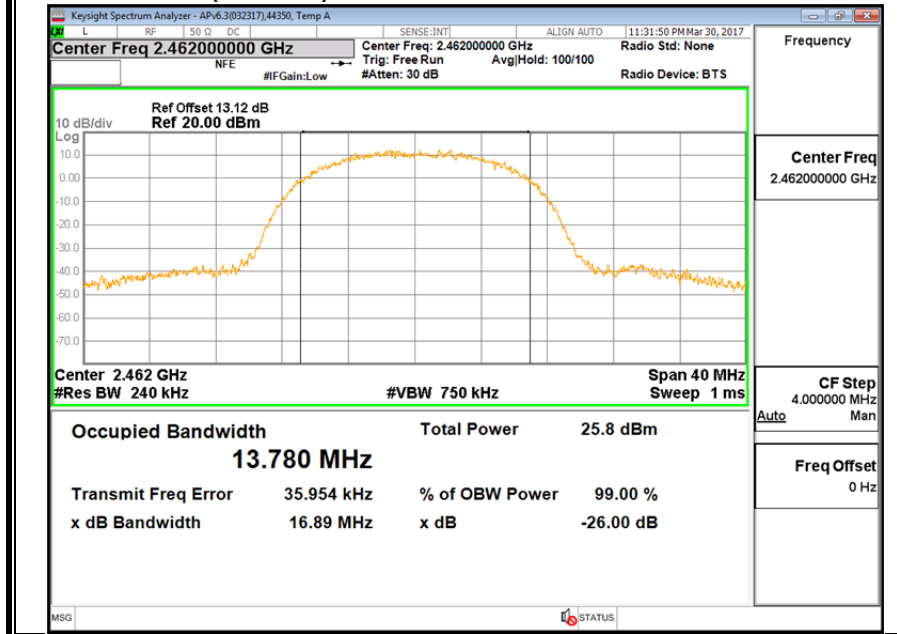
2.4GHz 3TX (Chain 2) CDD OBW CH 6

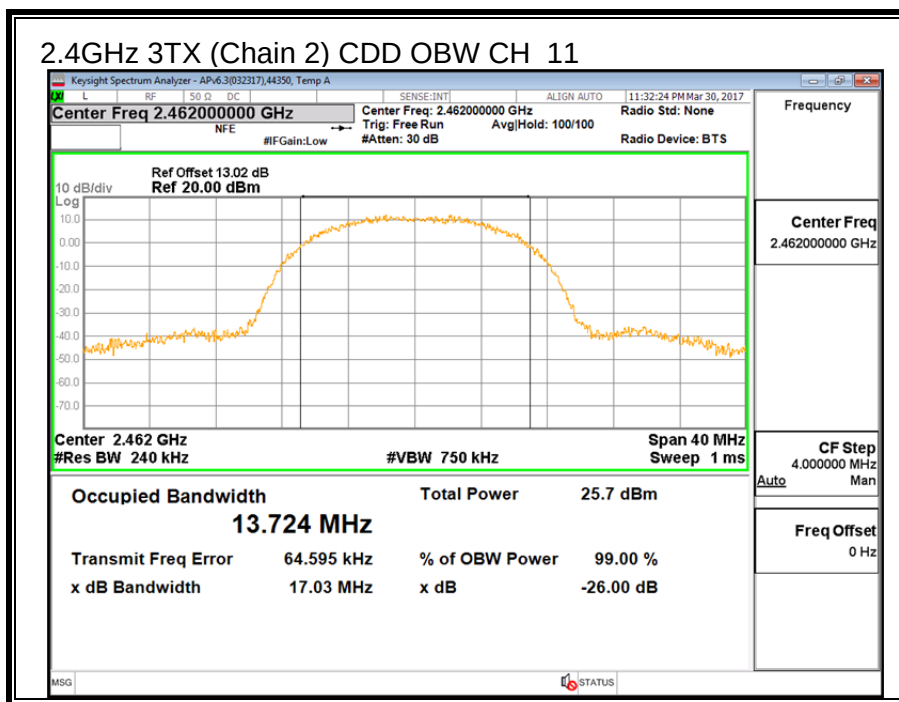


2.4GHz 3TX (Chain 0) CDD OBW CH 11



2.4GHz 3TX (Chain 1) CDD OBW CH 11





8.1.3. OUTPUT POWER

ID:	44350	Date:	3/30/17
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LIMITS

FCC §15.247

IC RSS-247 (5.4) (d)

For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 1 Watt, based on the use of antennas with directional gains that do not exceed 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

DIRECTIONAL ANTENNA GAIN

The TX chains are uncorrelated and the antenna gain is unequal among the chains. The directional gain is:

Chain 0 Antenna Gain (dBi)	Chain 1 Antenna Gain (dBi)	Chain 2 Antenna Gain (dBi)	Uncorrelated Chains Directional Gain (dBi)
2.69	2.02	1.33	2.05

RESULTS

Limits

Channel	Frequency (MHz)	Directional Gain (dBi)	FCC Power Limit (dBm)	IC Power Limit (dBm)	IC EIRP Limit (dBm)	Max Power (dBm)
Low	2412	2.05	30.00	30	36	30.00
Mid	2437	2.05	30.00	30	36	30.00
High	2462	2.05	30.00	30	36	30.00

Results

Channel	Frequency (MHz)	Chain 0 Meas Power (dBm)	Chain 1 Meas Power (dBm)	Chain 2 Meas Power (dBm)	Total Corr'd Power (dBm)	Power Limit (dBm)	Margin (dB)
Low	2412	19.74	19.65	19.78	24.49	30.00	-5.51
Mid	2437	18.82	19.39	19.38	23.98	30.00	-6.02
High	2462	18.76	18.89	19.12	23.70	30.00	-6.30

8.1.4. POWER SPECTRAL DENSITY

LIMITS

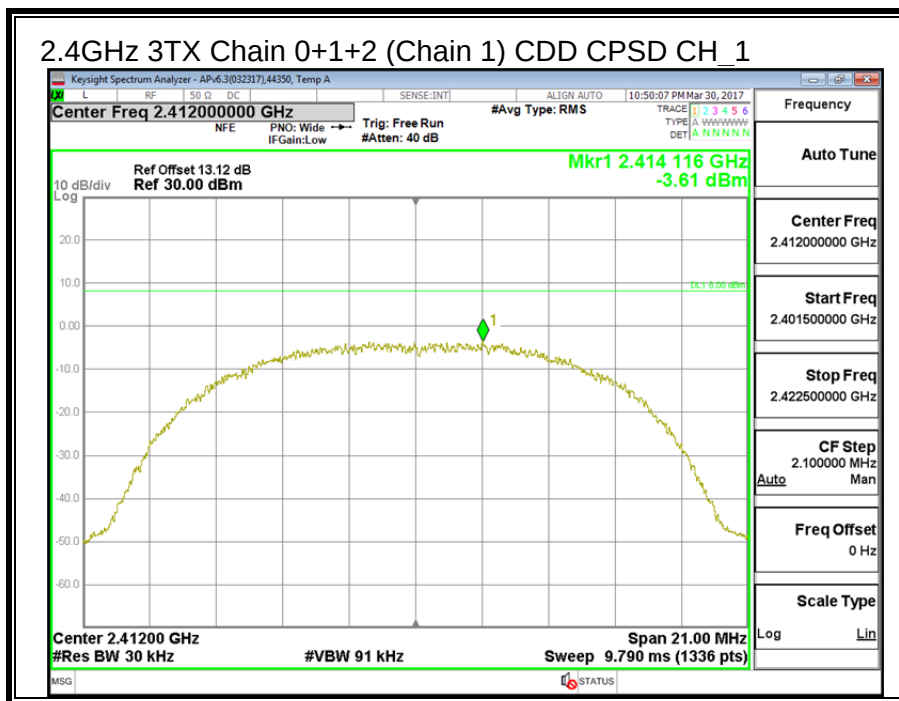
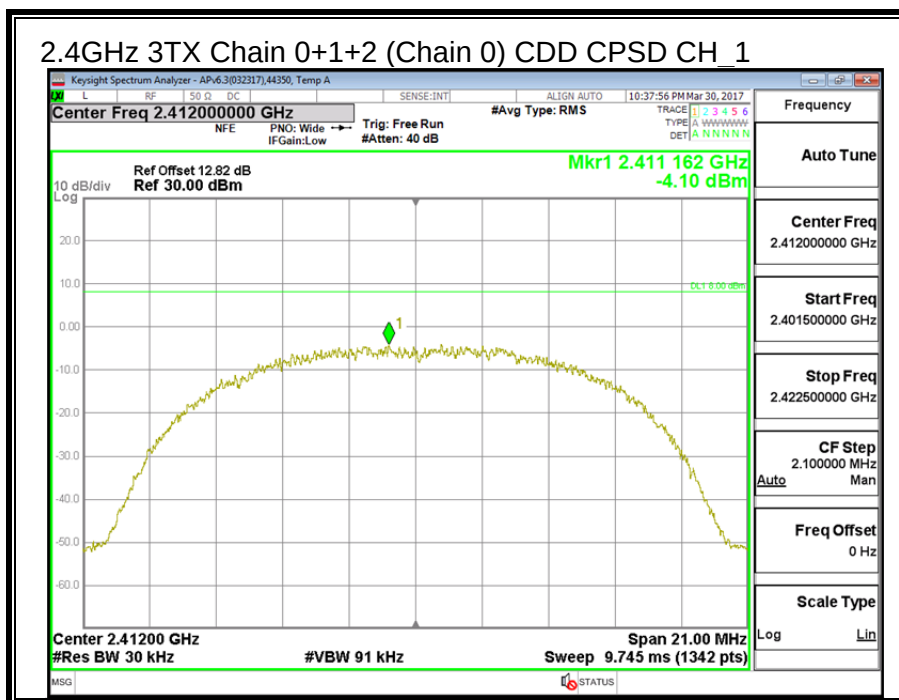
FCC §15.247

IC RSS-247 (5.2) (b)

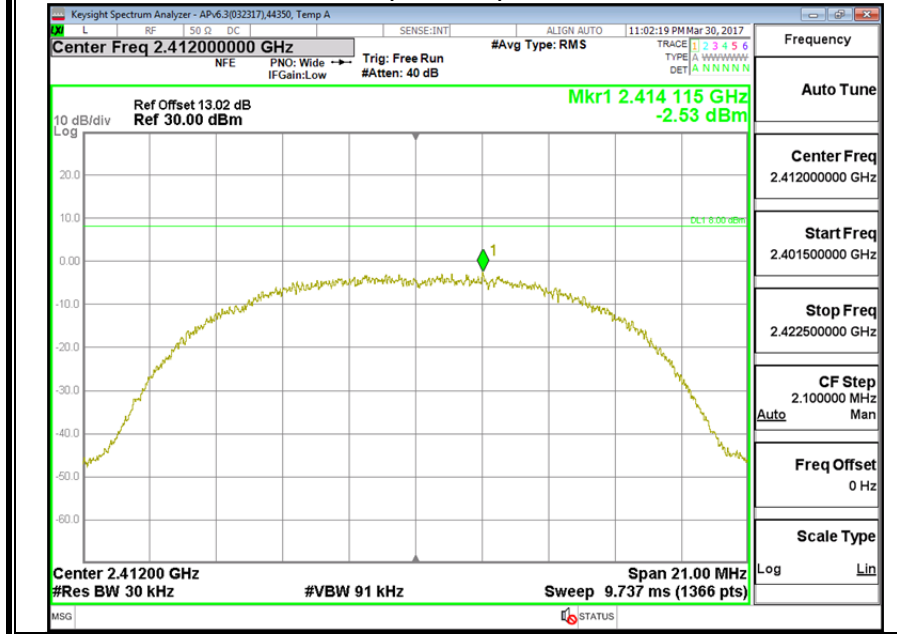
For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 KHz band during any time interval of continuous transmissions.

RESULTS

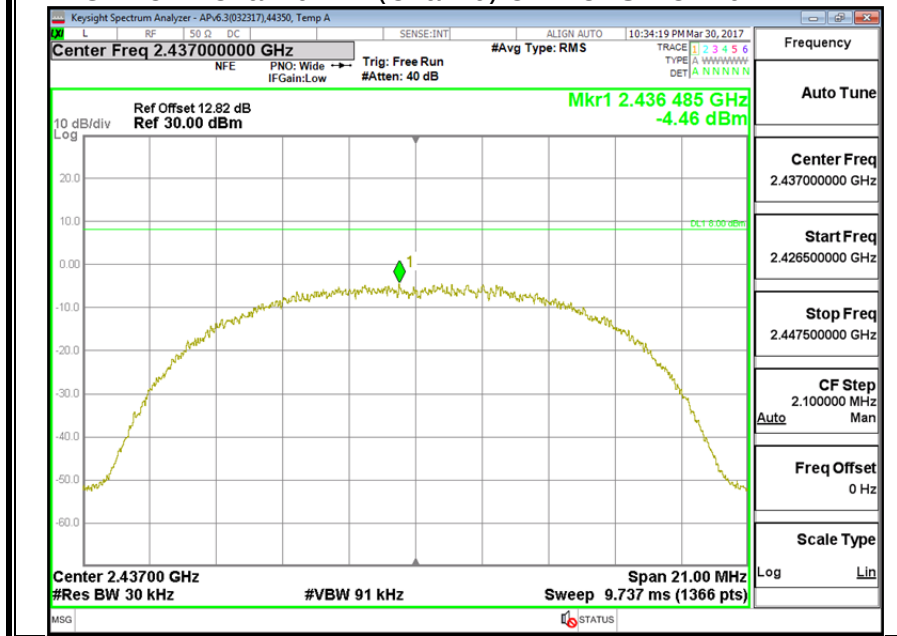
Duty Cycle CF (dB)	0.15	Included in Calculations of Corr'd PSD					
PSD Results							
Channel	Frequency	Chain 0 Meas	Chain 1 Meas	Chain 2 Meas	Total Corr'd PSD	Limit	Margin
	(MHz)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)	(dB)
Low	2412	-4.10	-3.61	-2.53	1.56	8.0	-6.4
Mid	2437	-4.46	-3.55	-3.68	1.04	8.0	-7.0
High	2462	-4.13	-3.74	-3.93	0.99	8.0	-7.0



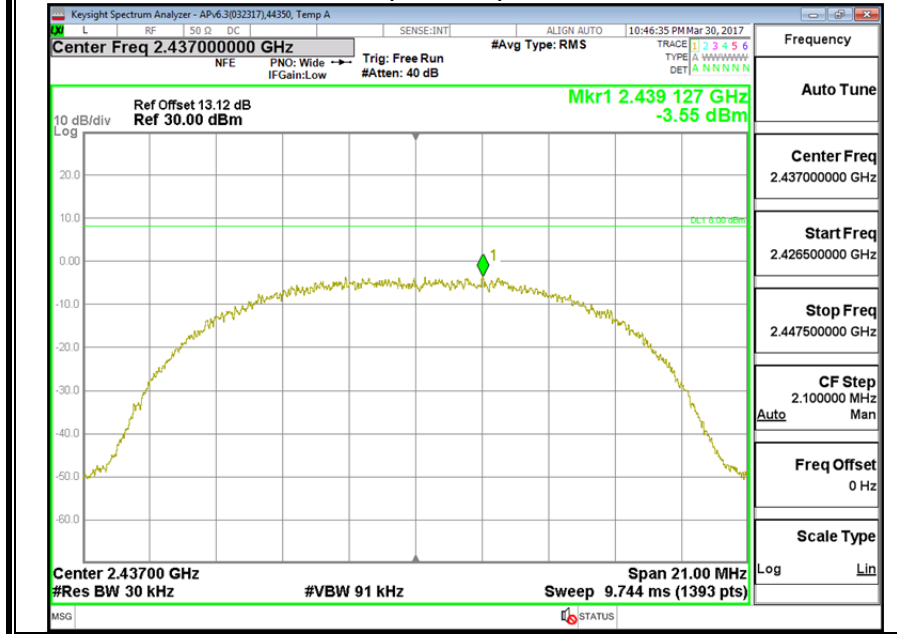
2.4GHz 3TX Chain 0+1+2 (Chain 2) CDD CPSP CH 1



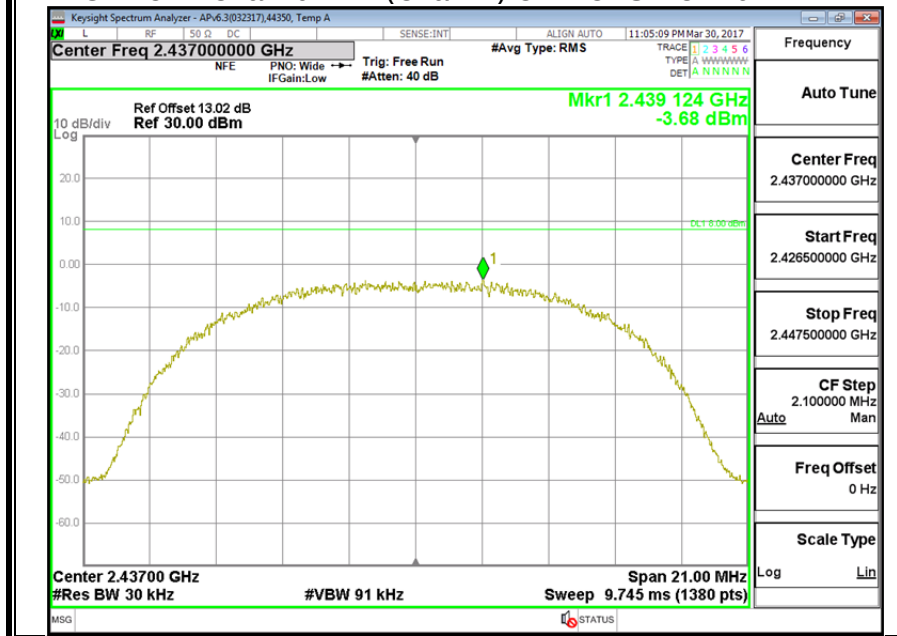
2.4GHz 3TX Chain 0+1+2(Chain 0) CDD CPSP CH 6



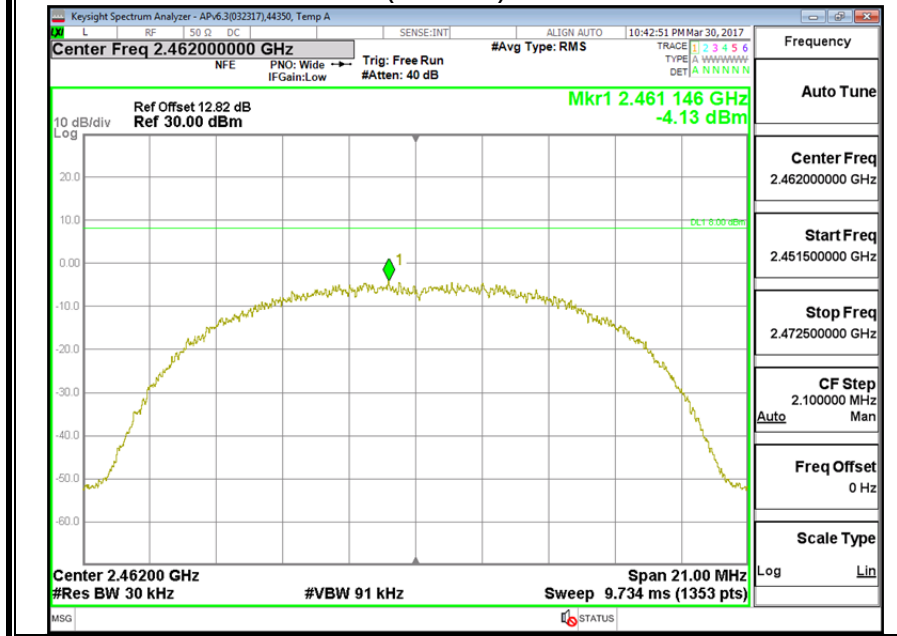
2.4GHz 3TX Chain 0+1+2 (Chain 1) CDD CPSP CH 6



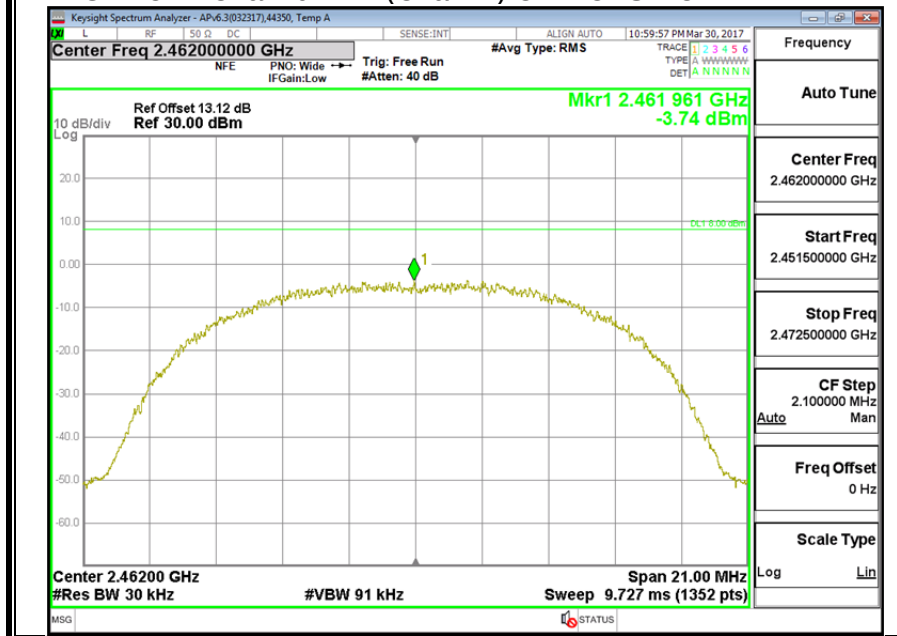
2.4GHz 3TX Chain 0+1+2 (Chain 2) CDD CPSP CH 6

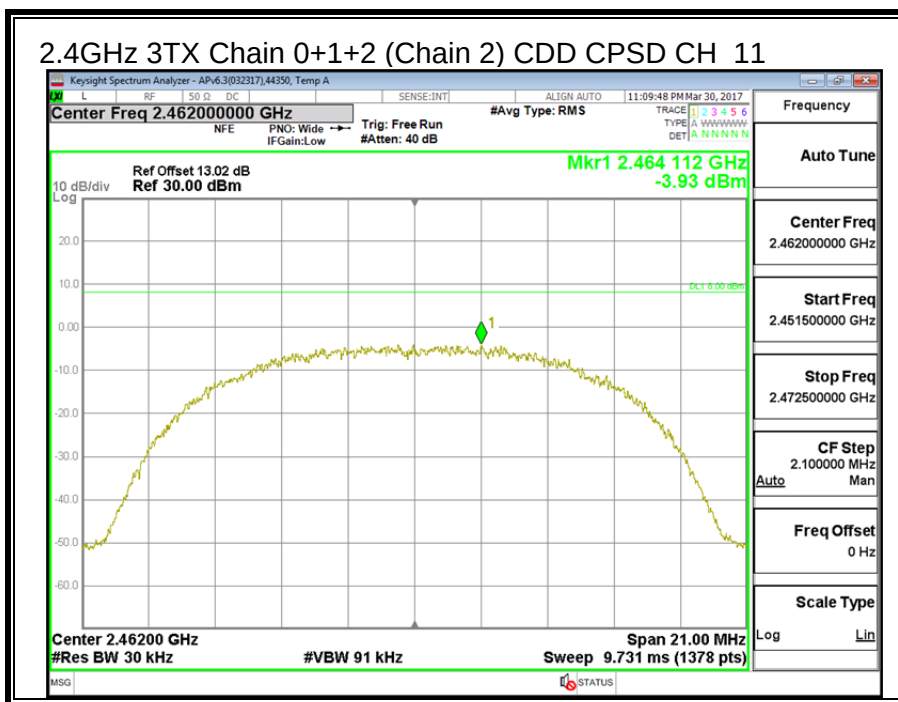


2.4GHz 3TX Chain 0+1+2 (Chain 0) CDD CPSP CH 11

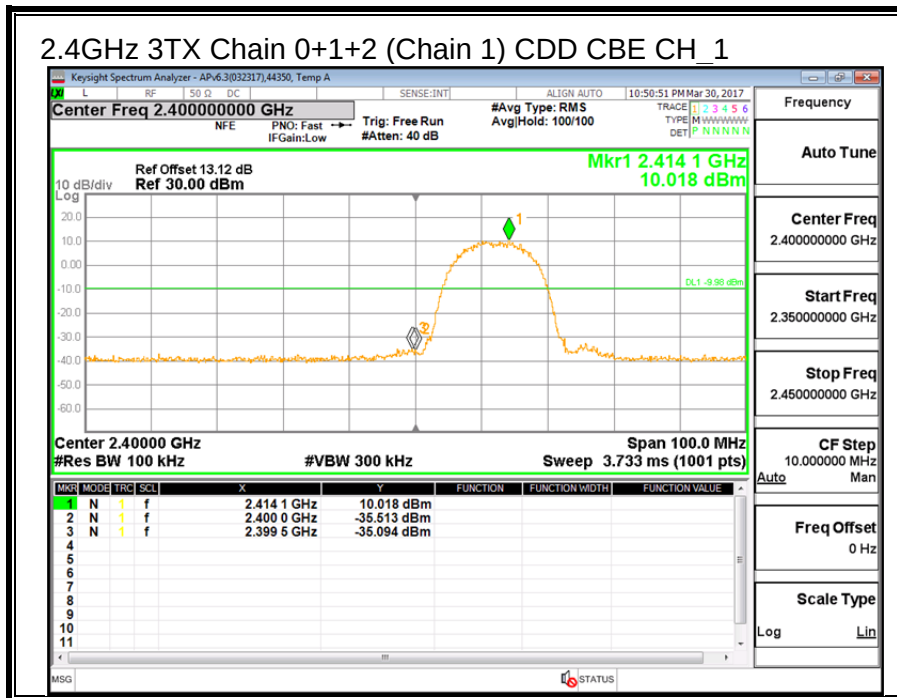
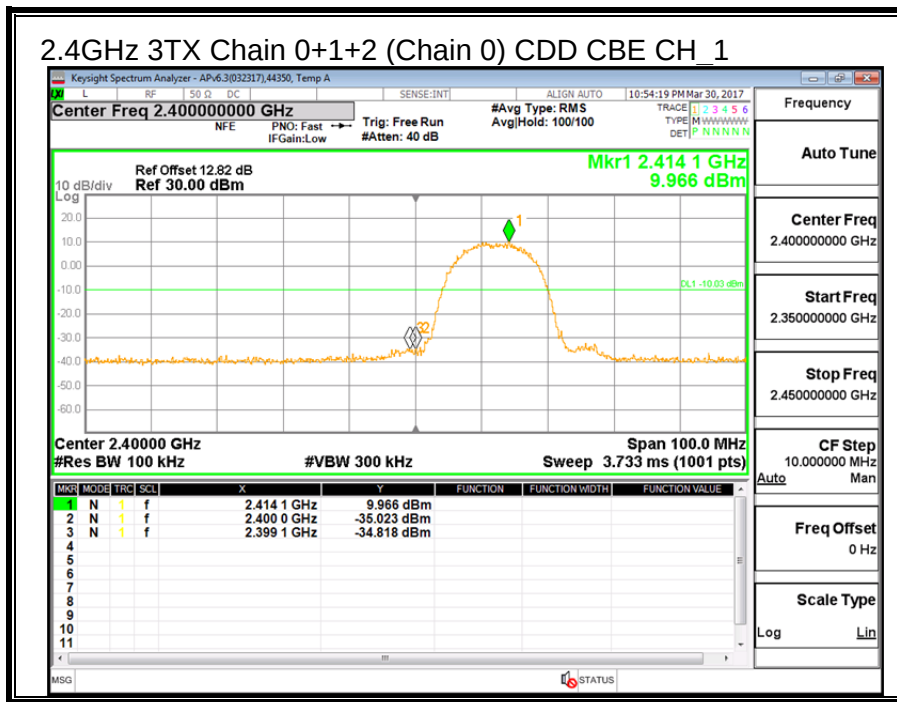


2.4GHz 3TX Chain 0+1+2 (Chain 1) CDD CPSP CH 11

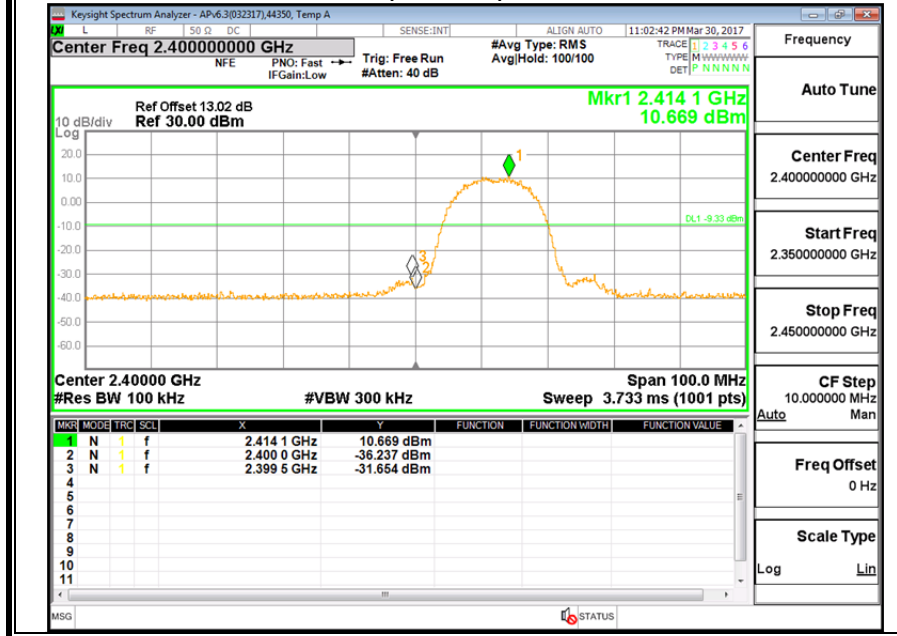




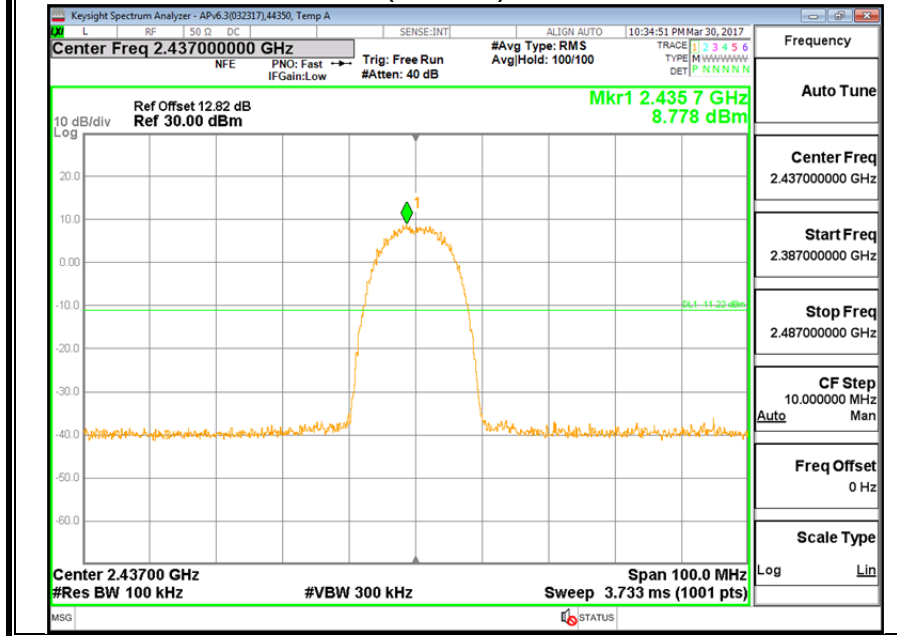
8.1.5. CONDUCTED BANDEDGE AND SPURIOUS EMISSIONS



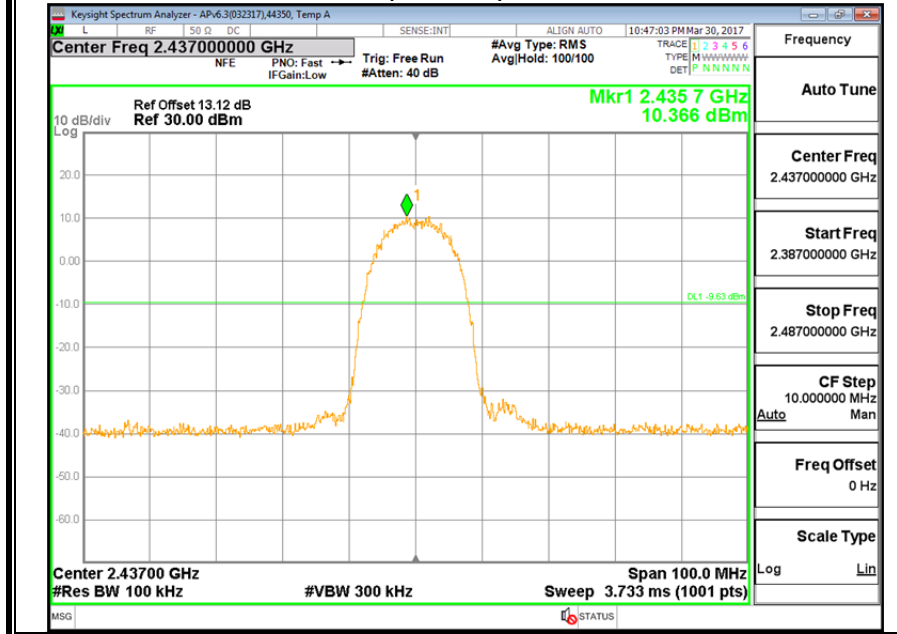
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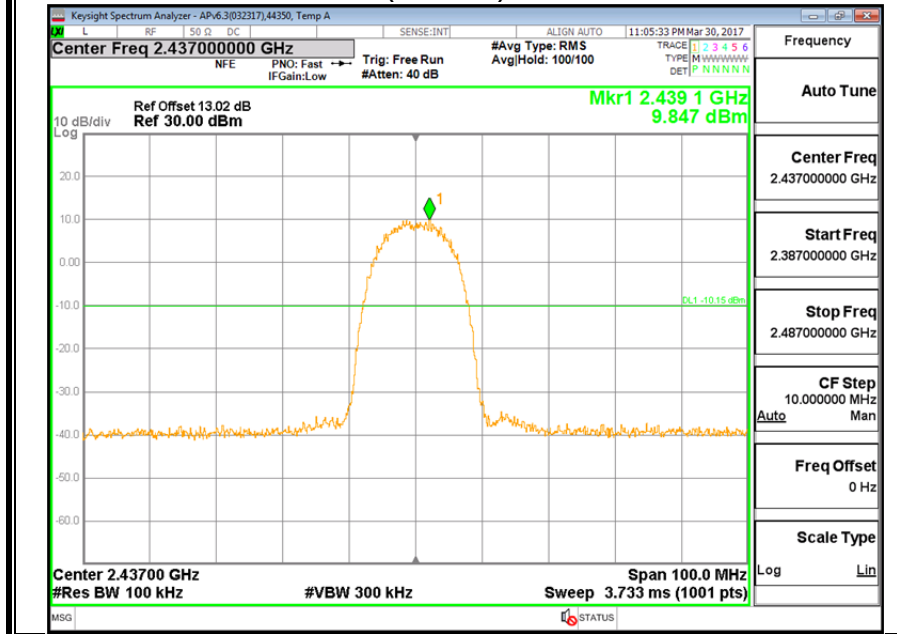
2.4GHz 3TX Chain 0+1+2 (Chain 0) CDD CBE CH 6



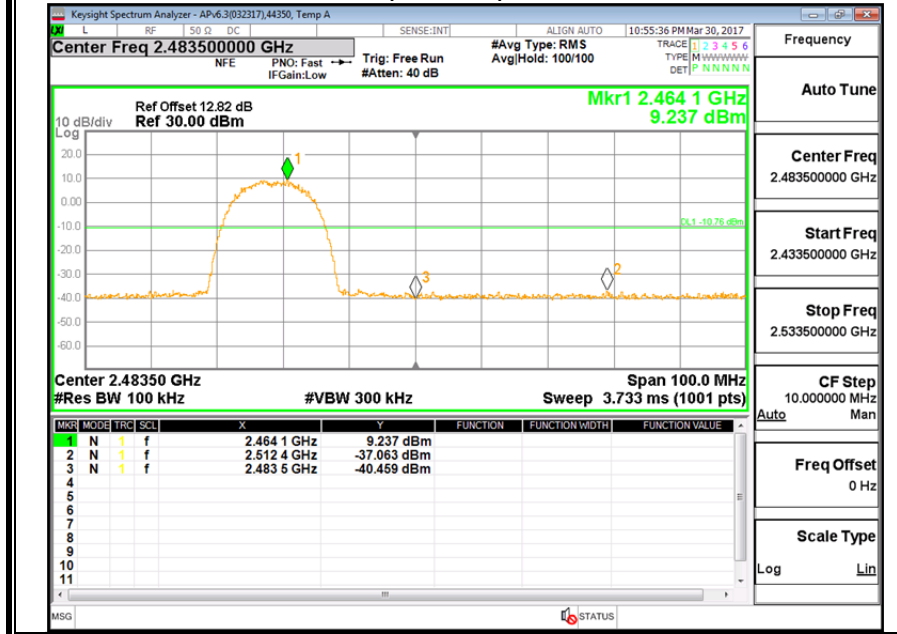
2.4GHz 3TX Chain 0+1+2 (Chain 1) CDD CBE CH 6



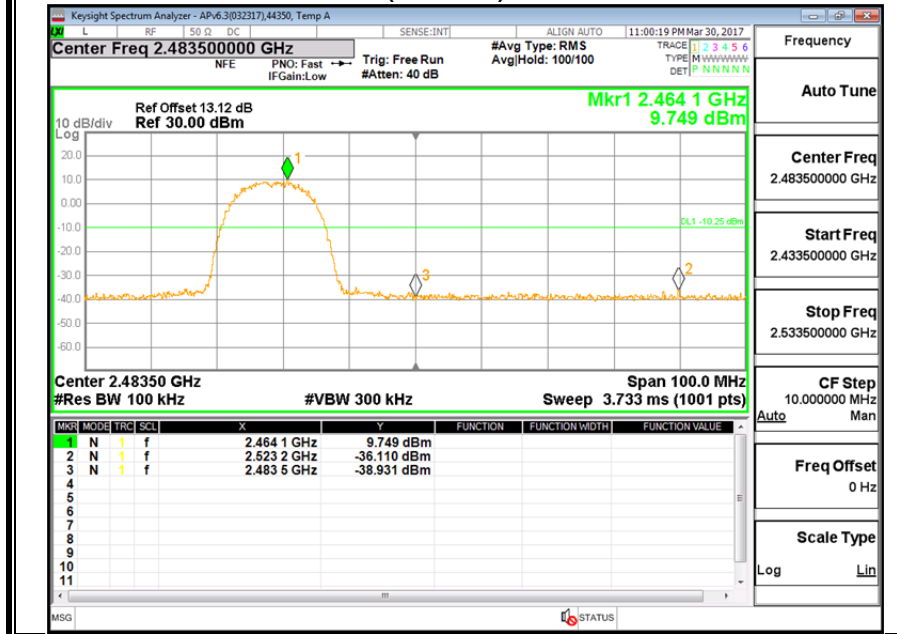
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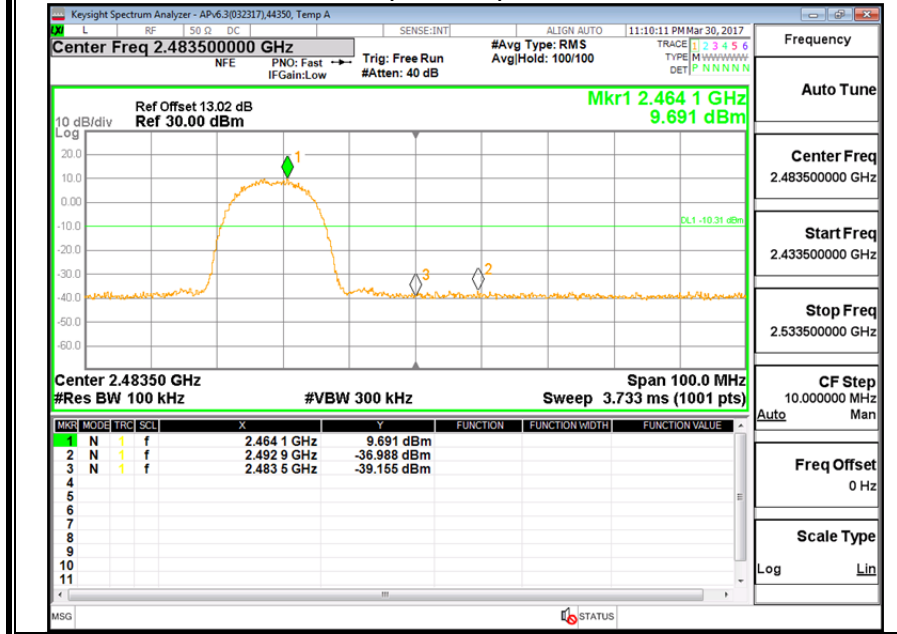
2.4GHz 3TX Chain 0+1+2 (Chain 0) CDD CBE CH 11



2.4GHz 3TX Chain 0+1+2 (Chain 1) CDD CBE CH 11



2.4GHz 3TX Chain 0+1+2 (Chain 2) CDD CBE CH 11



2.4GHz 3TX Chain 0+1+2 (Chain 0) CDD CSPUR CH 1

