HEADQUARTERS: 914 WEST PATAPSCO AVENUE • BALTIMORE, MARYLAND 21230 • PHONE (410) 354-3300 • FAX (410) 354-3313

07/06/2021

Lutron Electronics Co., Inc.
7200 Suter Road
Coopersburg, PA 18036

Dear Keith Kennedy,

Enclosed is the EMC Wireless test report for compliance testing of the Lutron Electronics Co., Inc., x96 as tested to the requirements of Title 47 of the CFR, Ch. 1 (10-1-06 ed.), Part 15 Subpart C for Intentional Radiators.

Thank you for using the services of Eurofins Electrical and Electronic Testing NA, Inc. If you have any questions regarding these results or if Eurofins Electrical and Electronic Testing NA, Inc. can be of further service to you, please feel free to contact me.

Sincerely yours,
EUROFINS ELECTRICAL AND ELECTRONIC TESTING NA, INC.

Joel Huna
Documentation Department

Reference: (\Lutron Electronics Co., Inc.\WIR112138B-FCC247 Rev. 2)

ACCREDITED
TESTING CERT #0591.01

Electromagnetic Compatibility Criteria
Test Report

for the

Lutron Electronics Co., Inc.
x96

Tested under
the FCC Certification Rules
contained in
15.247 Subpart C for Intentional Radiators

Report: WIR112138B-FCC247 Rev. 2

07/06/2021

Prepared For:

Lutron Electronics Co., Inc.
7200 Suter Road
Coopersburg, PA 18036

Prepared By:
Eurofins Electrical and Electronic Testing NA, Inc.
914 West Patapso Avenue, Baltimore, MD 21230

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Deepak Giri, Project Engineer
Electromagnetic Compatibility Lab

Engineering Statement: The measurements shown in this report were made in accordance with the procedures indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of the FCC Rules Part 15.247 under normal use and maintenance.

Steve Pitta,
Director, Electromagnetic Compatibility Lab

Report Status Sheet

Revision	Report Date	Reason for Revision
∅	06/01/2021	Initial Issue.
1	06/17/2021	Customer Comments.
2	07/06/2021	TCB Review.

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Executive Summary

A. Purpose of Test

An EMC evaluation was performed to determine compliance of the Lutron Electronics Co., Inc. x96, with the requirements of Part 15, §15.247. All references are to the most current version of Title 47 of the Code of Federal Regulations in effect. In accordance with §2.1033, the following data is presented in support of the Certification of the x96. Lutron Electronics Co., Inc. should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the x96, has been **permanently** discontinued.

B. Executive Summary

The following tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with Part 15, §15.247, in accordance with Lutron Electronics Co., Inc., purchase order number 5239116. All tests were conducted using measurement procedure ANSI C63.10-2013.

FCC Reference 47 CFR Part 15.247:2005	Description	Compliance
Title 47 of the CFR, Part 15 §15.203	Antenna Requirement	Compliant
Title 47 of the CFR, Part 15 §15.207(a)	Conducted Emission Limits	Compliant
Title 47 of the CFR, Part 15 §15.247(a)(2)	6dB Occupied Bandwidth	Compliant
Title 47 of the CFR, Part 15 §15.247(b)	Peak Power Output	Compliant
Title 47 of the CFR, Part 15 §15.247(c)	20 dBc Emissions	Compliant
Title 47 of the CFR, Part 15 §15.247(d); §15.209; §15.205	Radiated Spurious Emissions Requirements	Compliant
Title 47 of the CFR, Part 15; §15.247(e)	Peak Power Spectral Density	Compliant
Title 47 of the CFR, Part 15 §15.247(i)	Maximum Permissible Exposure (MPE)	Compliant

Table 1. Executive Summary of EMC Part 15.247 ComplianceTesting

Equipment Configuration

A. Overview

Eurofins Electrical and Electronic Testing NA, Inc. was contracted by Lutron Electronics Co., Inc. to perform testing on the x96, under Lutron Electronics Co., Inc.'s purchase order number 5239116.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the Lutron Electronics Co., Inc., x96.

The results obtained relate only to the item(s) tested.

Model(s) Tested:	x96	
Model(s) Covered:	x96	
EUT Specifications:	Primary Power: 120 – 277 VAC	
	FCC ID: JPZ0133	
	Type of Modulations:	OQPSK
	Equipment Code:	DTS
	Peak RF Output Power:	19.11dBm
	EUT Frequency Ranges:	2405 – 2480 MHz
Analysis:	The results obtained relate only to the item(s) tested.	
Environmental Test Conditions:	Temperature: 15-35º C	
	Relative Humidity: 30-60%	
	Barometric Pressure: 860-1060 mbar	
Evaluated by:	Deepak Giri	
Report Date(s):	06/17/2021	

Table 2. EUT Summary Table

B. References

CFR 47, Part 15, Subpart C	Federal Communication Commission, Code of Federal Regulations, Title 47, Part 15: General Rules and Regulations, Allocation, Assignment, and Use of Radio Frequencies
ANSI C63.4:2014	Methods and Measurements of Radio-Noise Emissions from Low-Voltage Electrical And Electronic Equipment in the Range of 9 kHz to 40 GHz
ISO/IEC 17025:2017	General Requirements for the Competence of Testing and Calibration Laboratories
ANSI C63.10-2013	American National Standard for Testing Unlicensed Wireless Devices
KDB 558074 v05r02	Guidance For Performing Compliance Measurements On Digital Transmission Systems (DTS) Operating Under Section 15.247

Table 3. References

C. Test Site

All testing was performed at Eurofins Electrical and Electronic Testing NA, Inc., 914 West Patapso Avenue, Baltimore, MD 21230. All equipment used in making physical determinations is accurate and bears recent traceability to the National Institute of Standards and Technology.

Radiated Emissions measurements were performed in a 3 meter semi-anechoic chamber (equivalent to an Open Area Test Site). In accordance with §2.948(a)(3), a complete site description is contained at Eurofins Electrical and Electronic Testing NA, Inc.

D. Measurement Uncertainty

Test Method	Typical Expanded Uncertainty	K	Confidence Level
Radiated Emissions, (30 MHz – 1 GHz)	±3.20	2	95%
Radiated Emissions, (1 GHz – 6 GHz)	±2.52	2	95%
Conducted Emission Voltage	±2.03	2	95%
RF Frequencies	±4.52 Hz	2	95%
RF Power Conducted Emissions	±2.32 dB	2	95%
RF Power Conducted Spurious Emissions	±2.25 dB	2	95%
RF Power Radiated Emissions	±3.01 dB	2	95%

Table 4. Uncertainty Calculations Summary

E. Description of Test Sample

The Lutron Electronics Co., Inc. x96, Equipment Under Test (EUT), is a load controller with integrated wireless communication and low voltage output. The EUT contains an RF transceiver and an antenna that cannot be changed by the user. The purpose of wireless communication is to receive commands and transmit status back to the control system. The x96 runs on 120V or 277V AC inputs and outputs 21VDC and RS485 control signals. The x96 mounts on a wall using a junction box.

Model tested was HW-X96, and this device is identical in construction to HW-X96-X-J1 and CM-X96-J1.

x96 – Block Diagram of Test Configuration

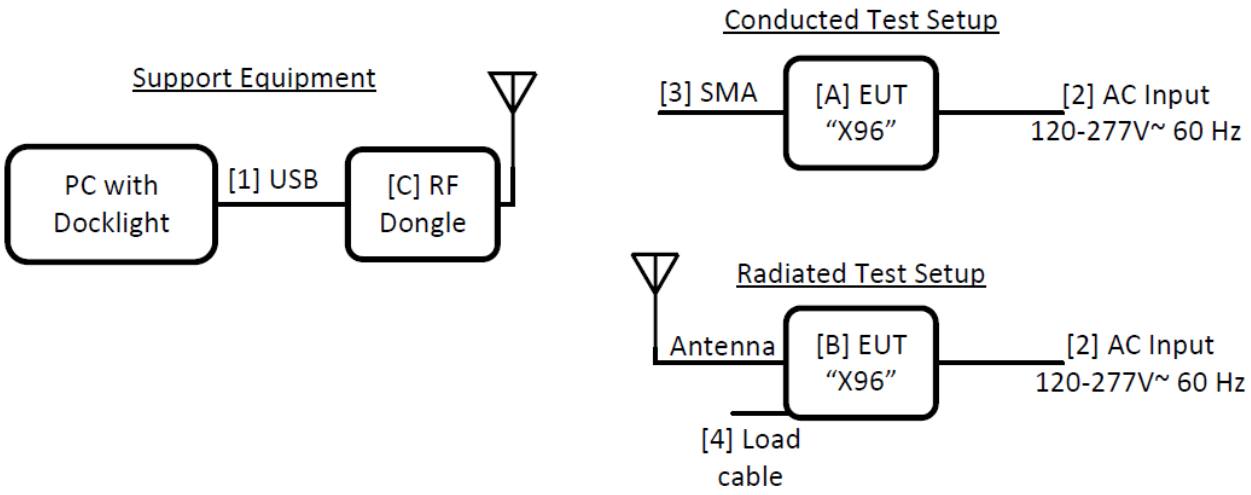

Figure 1: Block Diagram of Test Configuration

F. Equipment Configuration

The EUT was set up as outlined in the Block Diagram of Test Setup. All cards, racks, etc., incorporated as part of the EUT is included in the following list.

Ref. ID	Slot #	Name / Description	Model Number	Part Number	Serial Number	Rev. #
	Conducted sample	LED Controller	HW-X96			
	Radiated sample	LED Controller	HW-X96			

Table 5. Equipment Configuration

G. Support Equipment

Ref. ID	Name/Description	Manufacturer	Model Number	*Customer Supplied Calibration Data
N/A	2.4GHz Dongle	NCD Communications	N/A	N/A

Table 6. Support Equipment

H. Ports and Cabling Information

Ref. ID	Port Name on EUT	Cable Desc. or reason for none	QTY	Length as tested (m)	Max Length (m)	Shielded?	Termination Box ID & Port Name
N/A	Power	18AWG min	1	1	N/A	No	Black-Hot, Silver-Neutral, Green-Ground
N/A	Output	Lutron QS Cable (power and communication)	1	10	15	No	Load

Table 7. Ports and Cabling

I. Mode of Operation

a) While powering a load, the device is in radio stand by mode awaiting commands b) Transmitting

J. Method of Monitoring EUT Operation

Transmissions can be captured on a spectrum analyzer. The device draws power from the AC input at all times.

K. Modifications

a) Modifications to EUT

No modifications were made to the EUT.

b) Modifications to Test Standard

No modifications were made to the test standard.

L. Disposition of EUT

The test sample including all support equipment submitted to the Electro-Magnetic Compatibility Lab for testing was returned to Lutron Electronics Co., Inc. upon completion of testing.

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.203 Antenna Requirement

Test Requirement: **§ 15.203:** An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

The structure and application of the EUT were analyzed to determine compliance with Section 15.203 of the Rules. Section 15.203 states that the subject device must meet at least one of the following criteria:

a.) Antenna must be permanently attached to the unit.

b.) Antenna must use a unique type of connector to attach to the EUT.

c.) Unit must be professionally installed. Installer shall be responsible for verifying that the correct antenna is employed with the unit.

Results: The EUT as tested is compliant the criteria of §15.203. As per 15.203, antenna is permanently attached which satisfies the requirement.

Test Engineer(s): Deepak Giri

Test Date(s): 04/28/2021

Gain	Type	Model	Manufacturer
0 dBi	PIFA on the PCB	N/A	N/A

Table 8. Antenna List

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.207(a) Conducted Emissions Limits

Test Requirement(s): **§ 15.207 (a):** For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30MHz, shall not exceed the limits in the following table, as measured using a 50 μH/50 Ω line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency range (MHz)	§ 15.207(a), Conducted Limit (dBμV)	
	Quasi-Peak	Average
* 0.15- 0.5	66 - 56	56 - 46
0.5 - 5	56	46
5 - 30	60	50

Table 9. Conducted Limits for Intentional Radiators from FCC Part 15 § 15.207(a)

Test Procedure: The EUT was placed on a 0.8 m-high wooden table inside a screen room. The EUT was situated such that the back of the EUT was 0.4 m from one wall of the vertical ground plane, and the remaining sides of the EUT were no closer than 0.8 m from any other conductive surface. The EUT was powered from a 50 Ω/50 μH Line Impedance Stabilization Network (LISN). The EMC receiver scanned the frequency range from 150 kHz to 30 MHz. Conducted Emissions measurements were made in accordance with *ANSI C63.10-2013*. The measurements were performed over the frequency range of 0.15 MHz to 30 MHz using a 50 Ω/50 μH LISN as the input transducer to an EMC/field intensity meter.

Test Results: The EUT was compliant with this requirement.

Test Engineer(s): Deepak Giri

Test Date(s): 04/16/2021

15.207(a) Conducted Emissions Test Results

Line Under Test:		Phase												
Frequency (MHz)	Uncorrected Meter Reading (dBuV) QP	Cable Loss (dB)	External Attenuation (dB)	Corrected Measurement (dBuV) QP	Limit (dBuV) QP	Pass/Fail QP	Margin (dB) QP	Uncorrected Meter Reading (dBuV) Avg.	Cable Loss (dB)	External Attenuation (dB)	Corrected Measurement (dBuV) AVG	Limit (dBuV) AVG	Pass/Fail AVG	Margin (dB) AVG
0.1501	47.68	0	10	57.68	65.99	PASS	-8.31	42.13	0	10	52.13	55.99	PASS	-3.86
0.2015	38.96	0	10	48.96	63.55	PASS	-14.59	33.49	0	10	43.49	53.55	PASS	-10.06
0.301	38.3	0	10	48.3	60.22	PASS	-11.92	30.46	0	10	40.46	50.22	PASS	-9.76
0.59	28.25	0	10	38.25	56	PASS	-17.75	19.91	0	10	29.91	46	PASS	-16.09
2.53	27.83	0	10	37.83	56	PASS	-18.17	18.93	0	10	28.93	46	PASS	-17.07
15.25	20.42	0.02	10	30.44	60	PASS	-29.56	13.14	0.02	10	23.16	50	PASS	-26.84

Table 10. Conducted Emissions, 15.207(a), 120 VAC, Phase Line, Test Results

Note 1: * - At this frequency, the measured electric-field strength exhibits a margin of compliance that is less than 3 dB below the specification limit. We recommend that every emission measured, have at least a 3 dB margin to allow for deviations in the emission characteristics that may occur during the production process.

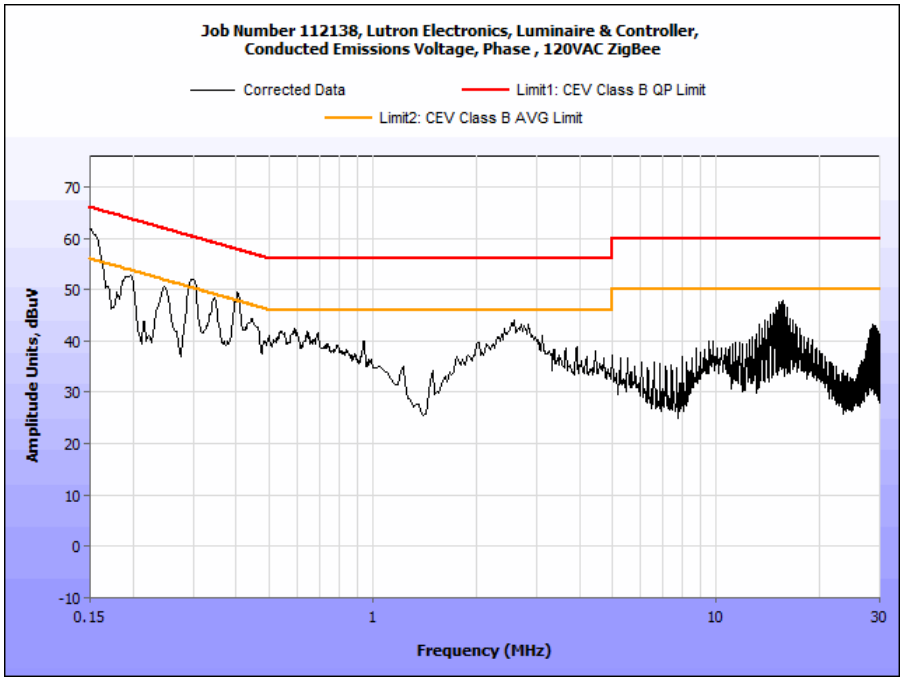

Figure 2. Conducted Emissions, 15.207(a), 120 VAC, Phase Line

15.207(a) Conducted Emissions Test Results

Line Under Test:		Neutral												
Frequency (MHz)	Uncorrected Meter Reading (dBuV) QP	Cable Loss (dB)	External Attenuation (dB)	Corrected Measurement (dBuV) QP	Limit (dBuV) QP	Pass/Fail QP	Margin (dB) QP	Uncorrected Meter Reading (dBuV) Avg.	Cable Loss (dB)	External Attenuation (dB)	Corrected Measurement (dBuV) AVG	Limit (dBuV) AVG	Pass/Fail AVG	Margin (dB) AVG
0.1515	50.69	0	10	60.69	65.92	PASS	-5.23	42.74	0	10	52.74	55.92	PASS	-3.18
0.2018	43.37	0	10	53.37	63.54	PASS	-10.17	35.51	0	10	45.51	53.54	PASS	-8.03
0.303	42.05	0	10	52.05	60.16	PASS	-8.11	31.93	0	10	41.93	50.16	PASS	-8.23
0.6062	26.04	0	10	36.04	56	PASS	-19.96	15.67	0	10	25.67	46	PASS	-20.33
2.553	25.49	0	10	35.49	56	PASS	-20.51	19.59	0	10	29.59	46	PASS	-16.41
15.4	20.37	0.02	10	30.39	60	PASS	-29.61	12.59	0.02	10	22.61	50	PASS	-27.39

Table 11. Conducted Emissions, 15.207(a), 120 VAC, Neutral Line, Test Results

Note 1: * - At this frequency, the measured electric-field strength exhibits a margin of compliance that is less than 3 dB below the specification limit. We recommend that every emission measured, have at least a 3 dB margin to allow for deviations in the emission characteristics that may occur during the production process.

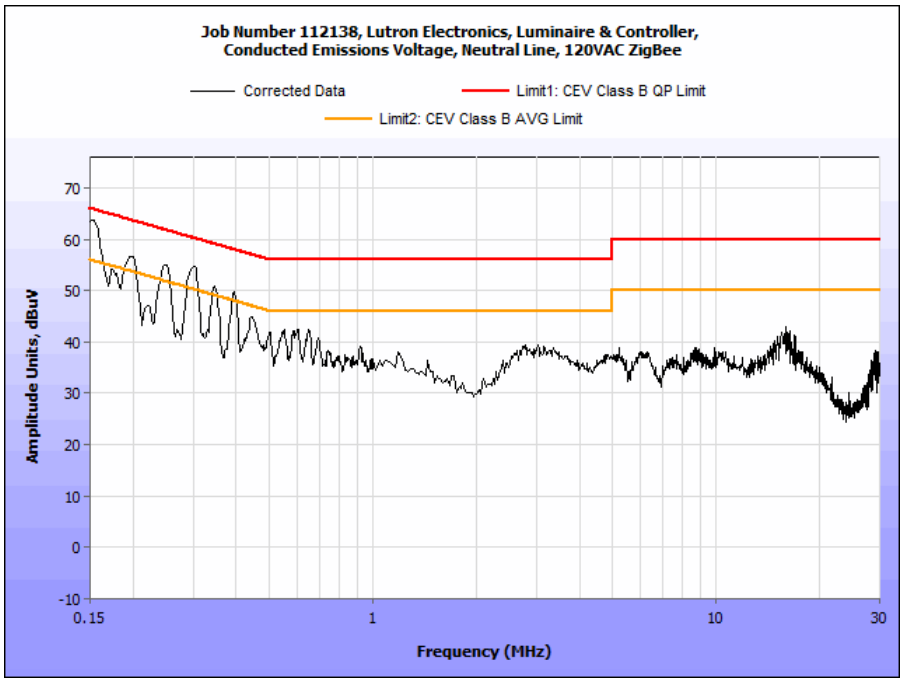

Figure 3. Conducted Emissions, 15.207(a), 120 VAC, Neutral Line

Line Under Test:		Phase												
Frequency (MHz)	Uncorrected Meter Reading (dBuV) QP	Cable Loss (dB)	External Attenuation (dB)	Corrected Measurement (dBuV) QP	Limit (dBuV) QP	Pass/Fail QP	Margin (dB) QP	Uncorrected Meter Reading (dBuV) Avg.	Cable Loss (dB)	External Attenuation (dB)	Corrected Measurement (dBuV) AVG	Limit (dBuV) AVG	Pass/Fail AVG	Margin (dB) AVG
0.15	41.76	0	10	51.76	66	PASS	-14.24	28.69	0	10	38.69	56	PASS	-17.31
0.2005	44.47	0	10	54.47	63.59	PASS	-9.12	31.27	0	10	41.27	53.59	PASS	-12.32
0.3945	38.1	0	10	48.1	57.97	PASS	-9.87	28.4	0	10	38.4	47.97	PASS	-9.57
0.658	27.59	0	10	37.59	56	PASS	-18.41	15.57	0	10	25.57	46	PASS	-20.43
2.755	25.49	0	10	35.49	56	PASS	-20.51	12.81	0	10	22.81	46	PASS	-23.19
15.45	23.94	0.02	10	33.96	60	PASS	-26.04	11.49	0.02	10	21.51	50	PASS	-28.49

Table 12. Conducted Emissions, 15.207(a), 277 VAC, Phase, Test Results

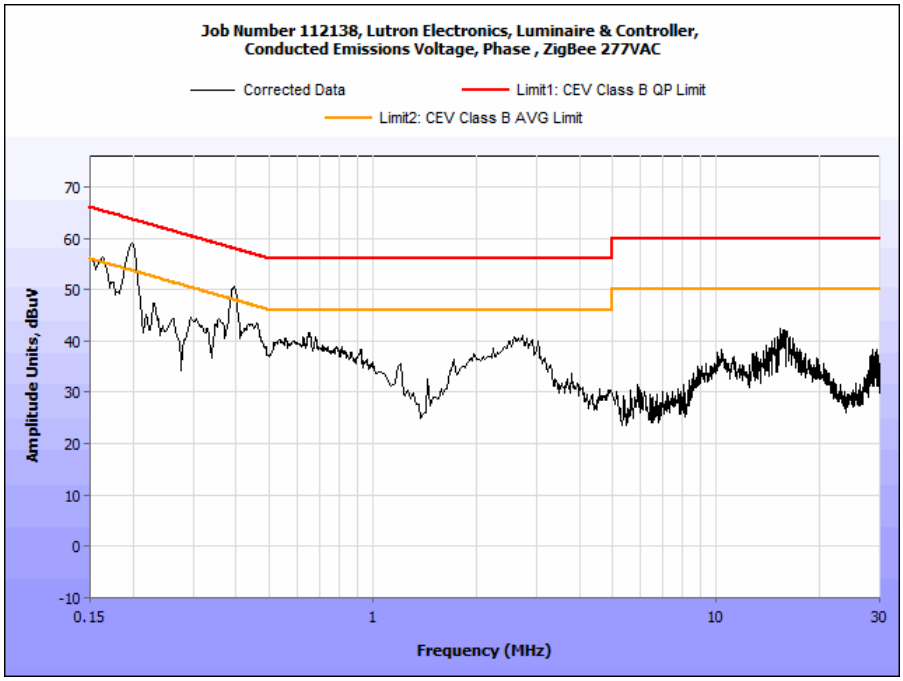

Figure 4. Conducted Emissions, 15.207(a), 277 VAC, Neutral Plot

Line Under Test:		Neutral												
Frequency (MHz)	Uncorrected Meter Reading (dBuV) QP	Cable Loss (dB)	External Attenuation (dB)	Corrected Measurement (dBuV) QP	Limit (dBuV) QP	Pass/Fail QP	Margin (dB) QP	Uncorrected Meter Reading (dBuV) Avg.	Cable Loss (dB)	External Attenuation (dB)	Corrected Measurement (dBuV) AVG	Limit (dBuV) AVG	Pass/Fail AVG	Margin (dB) AVG
0.1624	41.42	0	10	51.42	65.34	PASS	-13.92	28.2	0	10	38.2	55.34	PASS	-17.14
0.2042	39.14	0	10	49.14	63.44	PASS	-14.3	32.37	0	10	42.37	53.44	PASS	-11.07
0.372	39.86	0	10	49.86	58.46	PASS	-8.6	31.93	0	10	41.93	48.46	PASS	-6.53
0.9425	26.51	0	10	36.51	56	PASS	-19.49	22.7	0	10	32.7	46	PASS	-13.3
8.605	22.85	0	10	32.85	60	PASS	-27.15	18.76	0	10	28.76	50	PASS	-21.24
15.42	22.41	0.02	10	32.43	60	PASS	-27.57	16.04	0.02	10	26.06	50	PASS	-23.94

Table 13. Conducted Emissions, 15.207(a), 277 VAC, Neutral, Test Results

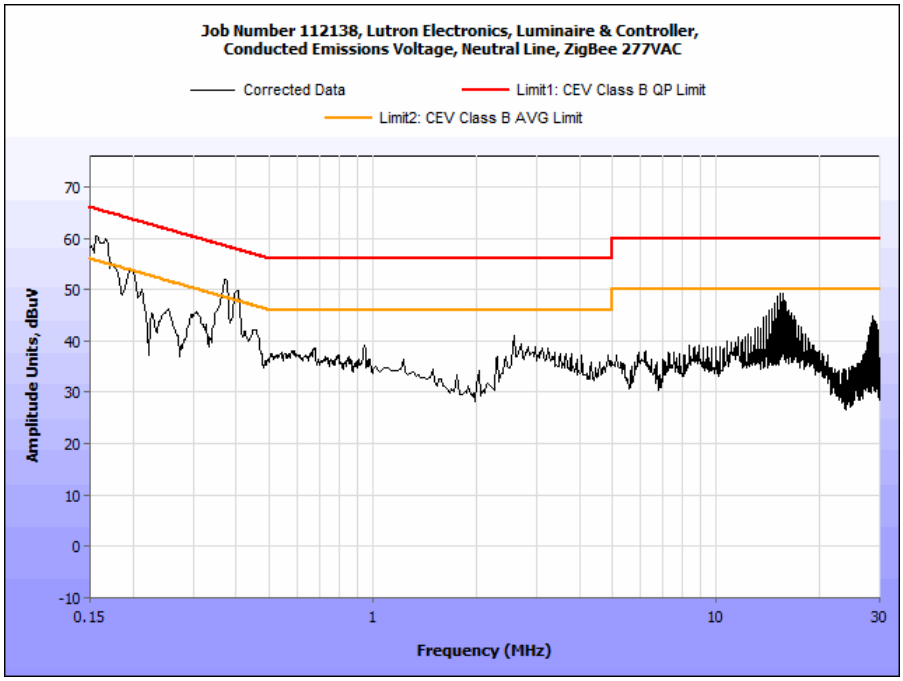

Figure 5. Conducted Emissions, 15.207(a), 277 VAC, Neutral Plot

15.207(a) Conducted Emissions Test Setup Photo

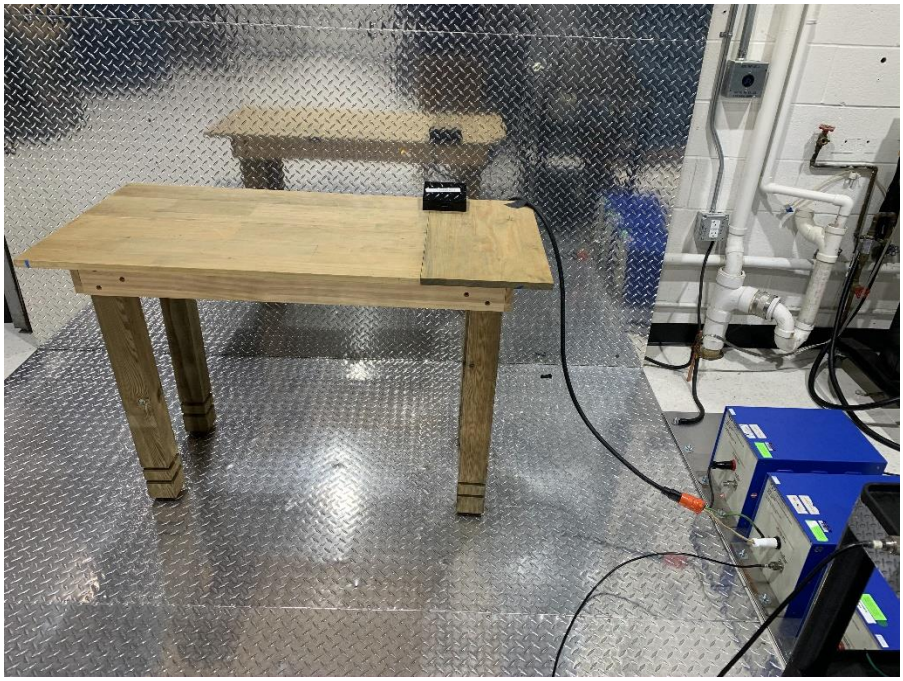

Figure 6. Conducted Emissions, 15.207(a), Test Setup

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(a)(2) 6 dB Bandwidth

Test Requirements: **§ 15.247(a)(2):** Operation under the provisions of this section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

For systems using digital modulation techniques, the EUT may operate in the 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz bands. The minimum 6dB bandwidth shall be at least 500 kHz.

Test Procedure: The EUT was connected to a spectrum analyzer through a cable and an attenuator. Measurements were taken with the EUT set to transmit continuously on its low, mid, and high channels for all its bandwidths. The 6dB bandwidth was measured according to measurement method 11.8.2 Option 2 of ANSI C63.10-2013.

Test Results The EUT as tested is compliant with § 15.247 (a)(2).

The 6 dB Bandwidth was determined from the plots on the following pages.

Test Engineer(s): Deepak Giri

Test Date(s): 04/26/2021

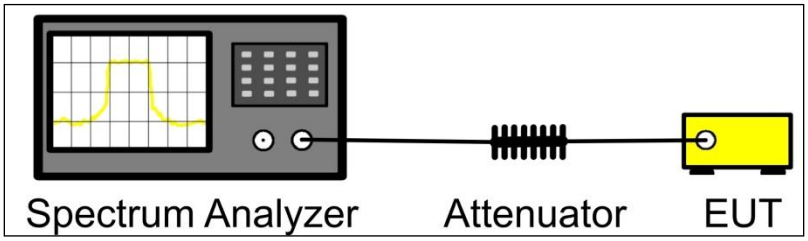

Figure 7. Block Diagram, Occupied Bandwidth Test Setup

Occupied Bandwidth Test Results

Occupied Bandwidth		
Carrier Channel	**Frequency (MHz)**	**Measured 6 dB Bandwidth (MHz)**
Low	2405	1.665
Mid	2440	1.700
High	2480	1.674

Table 14. 6 dB Occupied Bandwidth, Test Results

6 dB Occupied Bandwidth Test Results

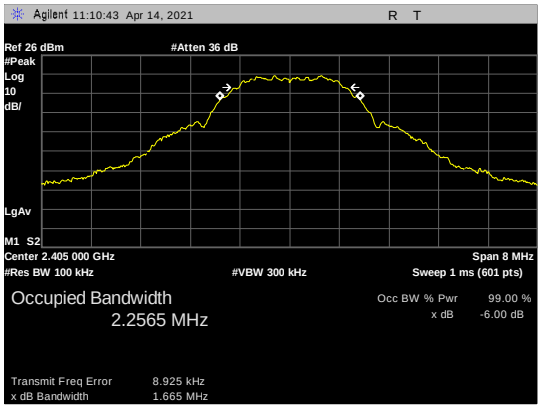

Figure 8: 6 dB Occupied Bandwidth, ZigBee low channel DTS bandwidth

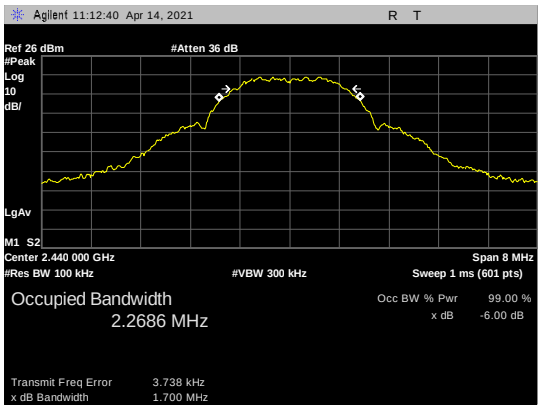

Figure 9: 6 dB Occupied Bandwidth, ZigBee mid channel DTS bandwidth

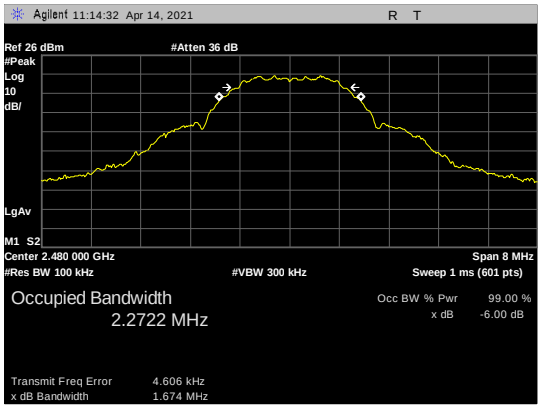

Figure 10: 6 dB Occupied Bandwidth, ZigBee high channel DTS bandwidth

Electromagnetic Compatibility Criteria for Intentional Radiators

Duty Cycle

Test Procedure: The EUT was connected to a spectrum analyzer and was ran at the maximum achievable duty cycle for all modes. The duty cycle was measured in accordance with section 11.6 of ANSI C63.10-2013.

Test Engineer(s): Deepak Giri

Test Date(s): 04/26/2021

Frequency (MHz)	Mode	Bandwidth (MHz)	ON Time (ms)	OFF Time (ms)	Period (ms)	Duty Cycle (%)	Correction Factor (dB)
2405	IEEE 15.4	8	100	0	100	100	0
2440		8	100	0	100	100	0
2480		8	100	0	100	100	0

Table 15. Duty Cycle Measurements

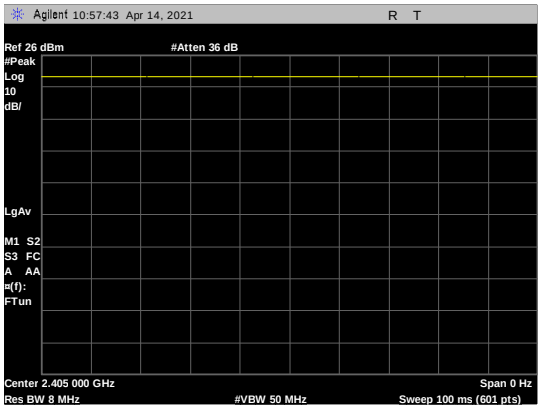

Figure 11: ZigBee low channel duty cycle

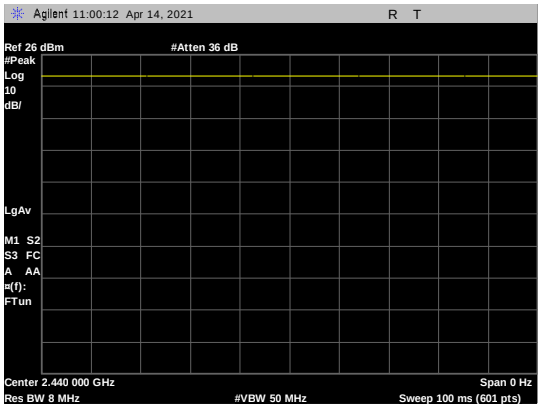

Figure 12: ZigBee mid channel duty cycle

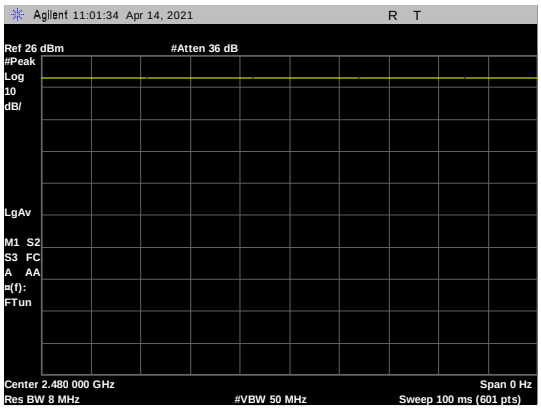

Figure 13: ZigBee high channel duty cycle

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(b) Conducted Power Output

Test Requirements: **§15.247(b):** The maximum peak output power of the intentional radiator shall not exceed the following:

§15.247(b)(3): For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

§15.247(c)(4): The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Test Procedure: The EUT was connected to a spectrum analyzer through a cable and an attenuator. Measurements were taken with the EUT set to transmit continuously on its low, mid, and high channels for all its bandwidths at maximum power. Power was measured according to measurement method AVGSA-2, as described in ANSI C63.10-2013, section 11.9.2.2.4. Attenuator, cable loss, and duty factor were programmed into the spectrum analyzer.

Test Results: The EUT as tested is compliant with the Peak Power Output limits of **§15.247(b)**.

Test Engineer(s): Deepak Giri

Test Date(s): 04/26/2021

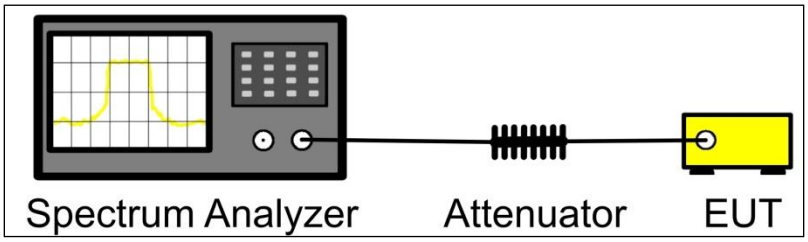

Figure 14. Power Output Test Setup

Maximum Conducted Power Output Test Results

Frequency (Mhz)	Peak conducted power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	Conducted output power Limit (dBm)	EIRP Limit (dBm)
2405	19.13	0	19.13	30	36
2440	19.03	0	19.03	30	36
2480	19.11	0	19.11	30	36

Table 16. Maximum Conducted Power Output, Test Results

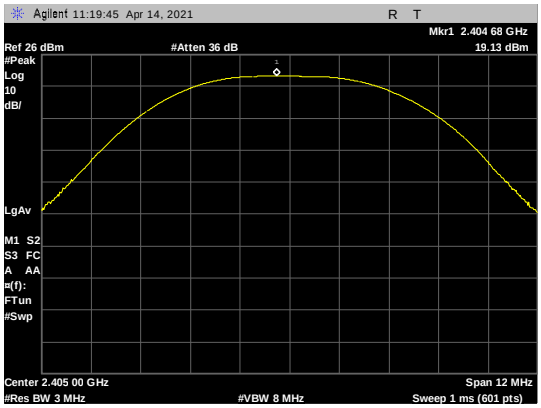

Figure 15: Peak Conducted Output Power, ZigBee low channel

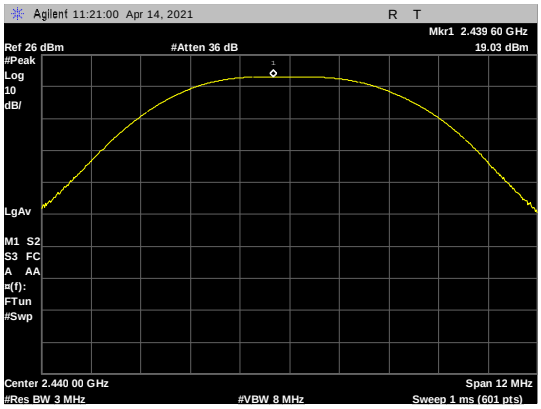

Figure 16: Peak Conducted Output Power, ZigBee mid channel

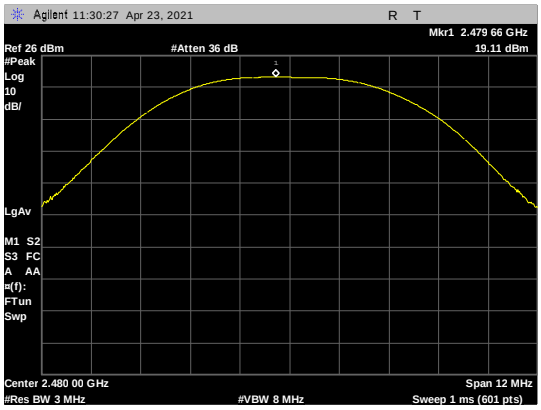

Figure 17: Peak Conducted Output Power, ZigBee high channel

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.209 Radiated Spurious Emissions Requirements and Band Edge

Test Requirements: **§15.247(d); §15.205:** Emissions outside the frequency band.

§15.205(a): Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090–0.110----------	16.42–16.423	399.9–410	4.5–5.15
[1] 0.495–0.505----------	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905----------	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128----------	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775----------	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775----------	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218----------	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825----------	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225----------	123–138	2200–2300	14.47–14.5
8.291–8.294----------	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366----------	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675----------	156.7–156.9	2655–2900	22.01–23.12
8.41425–8.41475----------	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293----------	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025----------	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725----------	322–335.4	3600–4400	([2])
13.36-13.41			

Table 17. Restricted Bands of Operation

[1] Until February 1, 1999, this restricted band shall be 0.490 – 0.510 MHz.
[2] Above 38.6

Test Requirement(s): **§ 15.209 (a):** Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in Table 18.

Frequency (MHz)	§ 15.209(a),Radiated Emission Limits (dBµV) @ 3m
30 - 88	40.00
88 - 216	43.50
216 - 960	46.00
Above 960	54.00

Table 18. Radiated Emissions Limits Calculated from FCC Part 15, § 15.209 (a)

Test Procedures: The transmitter was turned on. Measurements were performed of the low, mid and high Channels. The EUT was rotated orthogonally through all three axes. Plots shown are corrected for both antenna correction factor and distance and compared to a 3 m limit line. Only noise floor was measured above 18 GHz.

Test Results: The EUT as tested is compliant with the Radiated Spurious Emission limits of **§ 15.247(d) and § 15.209**. Protocol limited duty cycle (30%) correction were applied to obtain the final Average measurement on emissions associated with fundamental. Radiated cabinet emissions were measured using 50Ohm terminator at EUT antenna terminal. Emissions were measured from 30Mhz-25Ghz. Pre-amplifier was used in18-25Ghz measurement.

Emission close to the limit line were re-evaluated using appropriate detector and test method.

Plots presented are cumulative results of 3 orthogonal EUT positions.

Test Engineer(s): Deepak Giri

Test Date(s): 04/28/2021

Radiated Spurious Emissions, Test Results

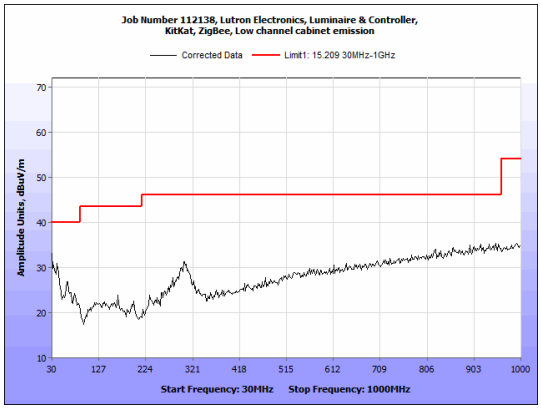

Figure 18: Radiated Spurious Emissions, ZigBee Low Channel 30Mhz-1Ghz Radiated cabinet emission.

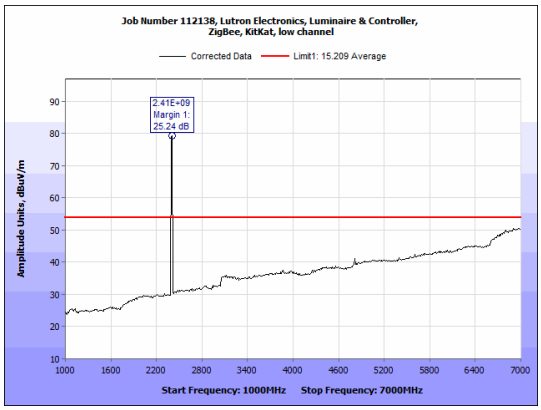

Figure 19: Radiated Spurious Emissions, ZigBee Low Channel 1Ghz-7Ghz Average.

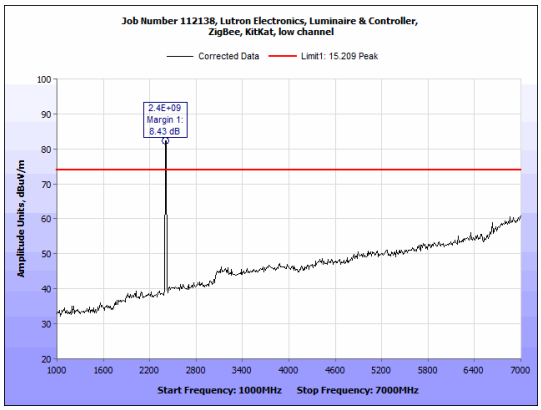

Figure 20: Radiated Spurious Emissions, ZigBee Low Channel 1Ghz-7Ghz Peak.

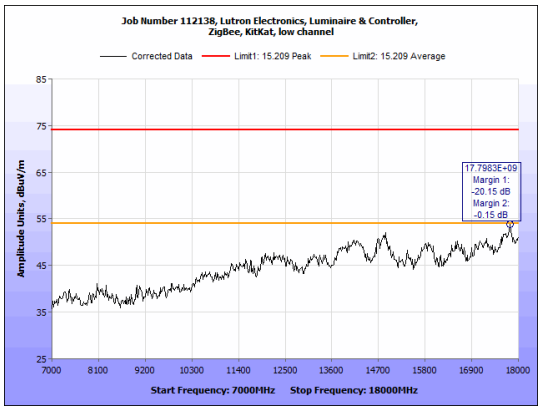

Figure 21: Radiated Spurious Emissions, ZigBee Low Channel 7Ghz-18Ghz PK and AVG.

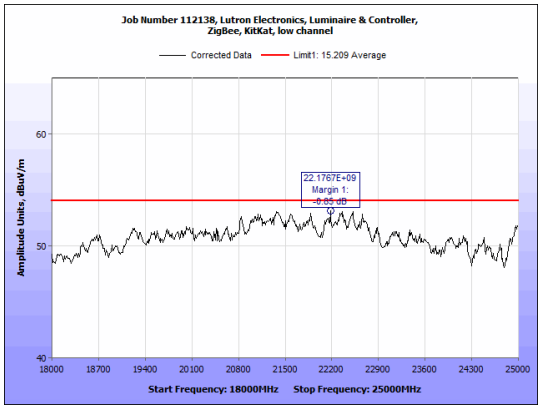

Figure 22: Radiated Spurious Emissions, ZigBee Low Channel 18Ghz-25Ghz Average.

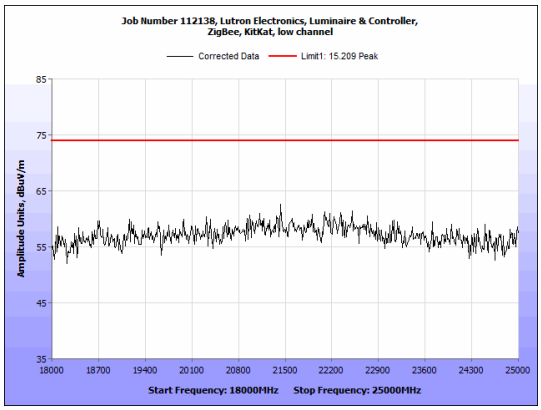

Figure 23: Radiated Spurious Emissions, ZigBee Low Channel 18Ghz-25Ghz Peak.

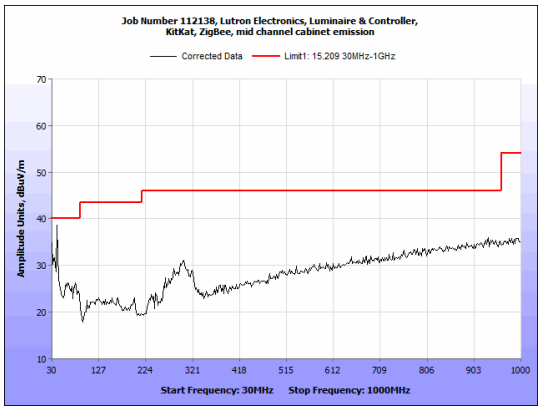

Figure 24: Radiated Spurious Emissions, ZigBee Mid Channel 30Mhz-1Ghz Radiated cabinet emission.

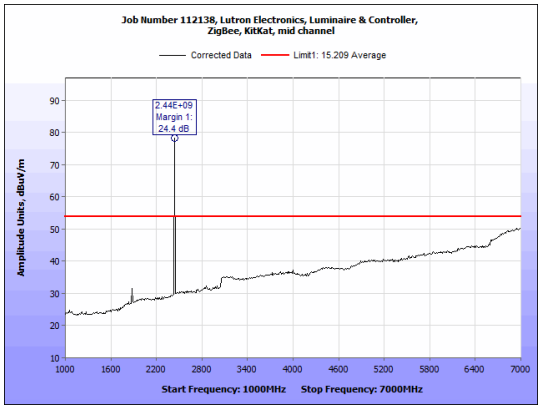

Figure 25: Radiated Spurious Emissions, ZigBee Mid Channel 1Ghz-7Ghz Average.

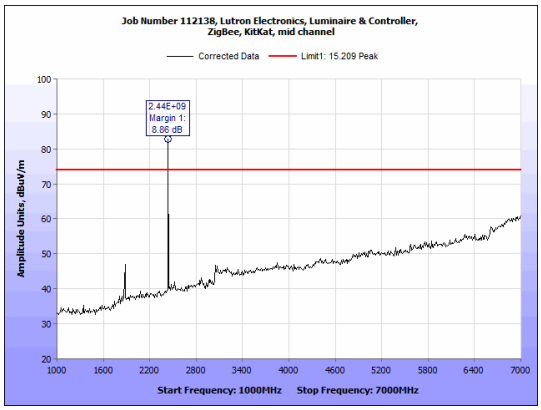

Figure 26: Radiated Spurious Emissions, ZigBee Mid Channel 1Ghz-7Ghz Peak.

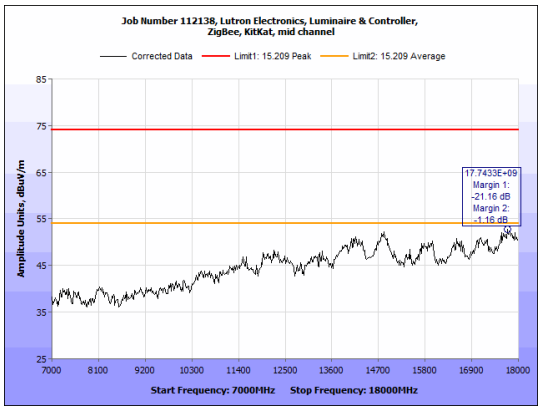

Figure 27: Radiated Spurious Emissions, ZigBee Mid Channel 7Ghz-18Ghz PK and AVG.

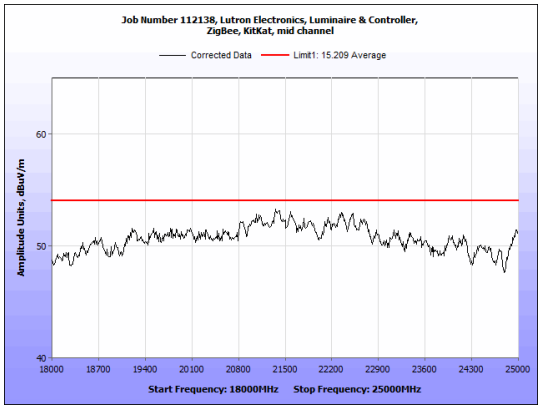

Figure 28: Radiated Spurious Emissions, ZigBee Mid Channel 18Ghz-25Ghz Average.

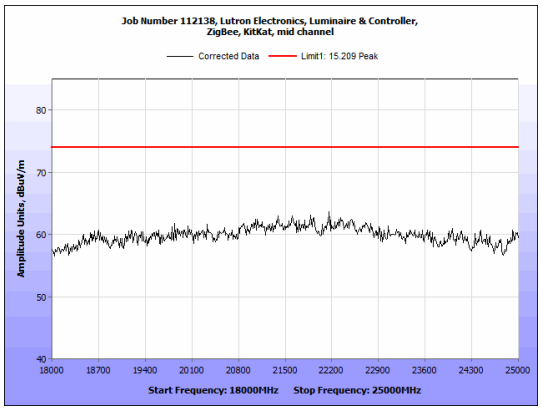

Figure 29: Radiated Spurious Emissions, ZigBee Mid Channel 18Ghz-25Ghz Peak.

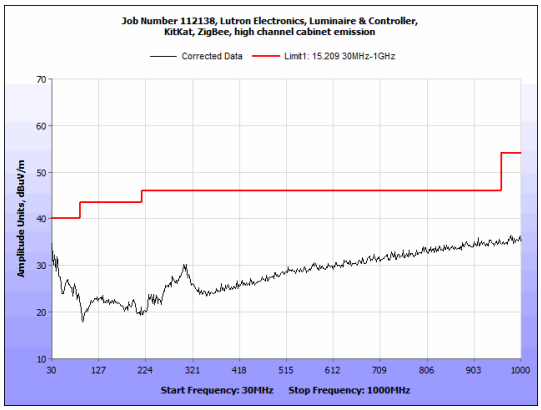

Figure 30: Radiated Spurious Emissions, ZigBee HighChannel 30Mhz-1Ghz

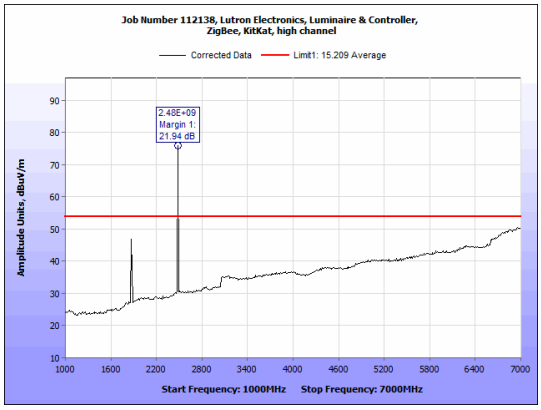

Figure 31: Radiated Spurious Emissions, ZigBee High Channel 1Ghz-7Ghz Average.

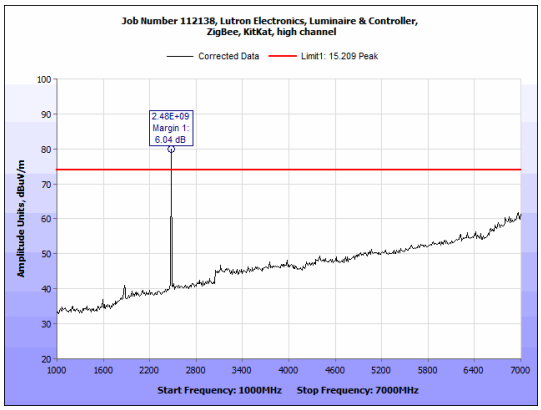

Figure 32: Radiated Spurious Emissions, ZigBee High Channel 1Ghz-7Ghz Peak.

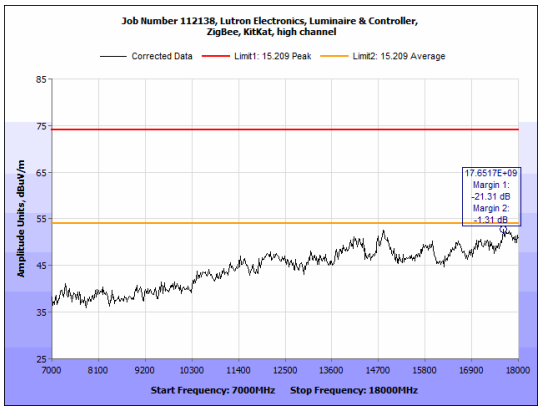

Figure 33: Radiated Spurious Emissions, ZigBee High Channel 7Ghz-18Ghz PK and AVG.

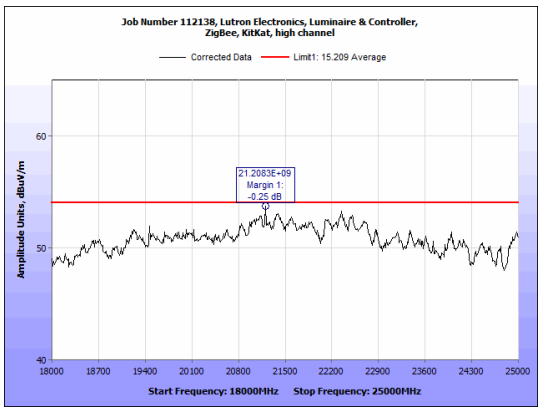

Figure 34: Radiated Spurious Emissions, ZigBee High Channel 18Ghz-25Ghz Average.

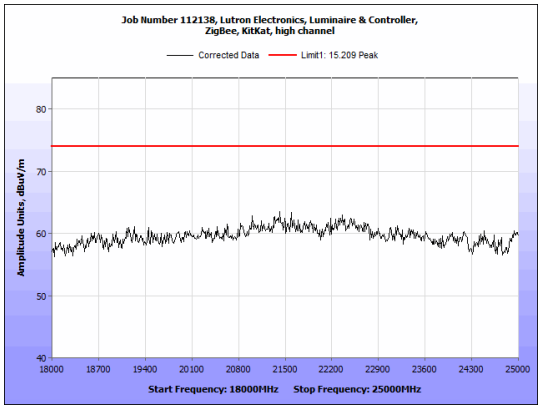

Figure 35: Radiated Spurious Emissions, ZigBee High Channel 18Ghz-25Ghz Peak.

Radiated Band Edge Measurements

Test Procedures: The transmitter was turned on. Measurements were performed of the low and high Channels. The EUT was rotated orthogonally through all three axes. Plots shown are corrected for both antenna correction factor and distance and compared to a 3 m limit line. Protocol limited duty cycle (30%) correction were applied to obtain the final Average measurement on emissions associated with fundamental. Restricted band emissions were measured using conducted test method defined in 11.12.2, 11.12.2.2, 11.12.2.4 and 11.12.2.5.3. Restricted band edges were measured without in-band notch filter. Out of band restricted emissions were measured using In-band notch filter.

Frequency(Ghz)	Channel	Measurement Type	EIRP (dBm)	Field Strength(dBuV/m)	DCCF(dB)	Limit(dBuV/m)	Margin	Bands
2.39	Low Center: 2405 MHz	AVG	-53.67	41.56	10.45	54	-22.89	restricted band
2.4835	High Center: 2480 MHz	AVG	-36.1	59.13	10.45	54	-5.32	restricted band
4.8	Low Center: 2405 MHz	AVG	-44.24	50.99	10.45	54	-13.46	restricted band
4.88	Mid Center: 2440 MHz	AVG	-43.44	51.79	10.45	54	-12.66	restricted band
4.96	High Center: 2480 MHz	AVG	-43.53	51.7	10.45	54	-12.75	restricted band

Table 19. Radiated Band Measurements

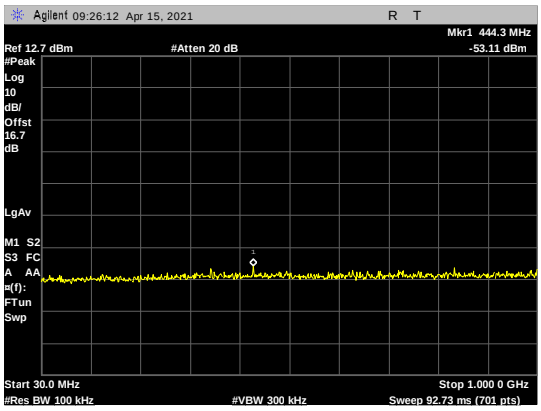

Figure 36: Restricted Band Emissions, ZigBee 30Mhz-1Ghz low channel peak

Note: Plot on this page was measured in a conducted setup.

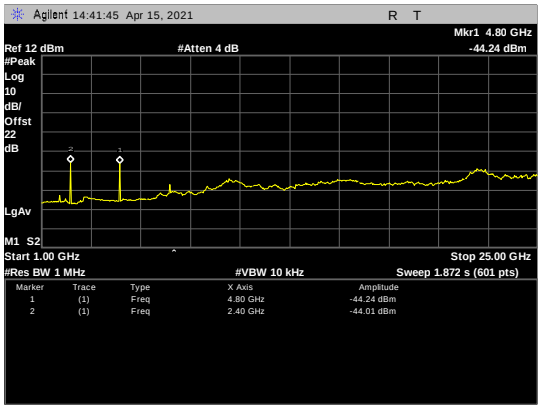

Figure 37: Restricted Band Emissions, ZigBee 1Ghz-25Ghz low channel average

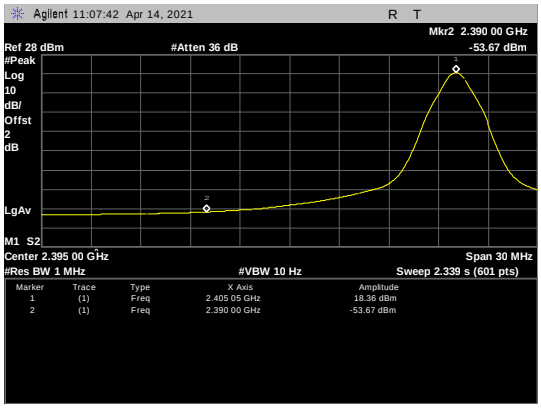

Figure 38: Restricted Band Edge, ZigBee low channel average

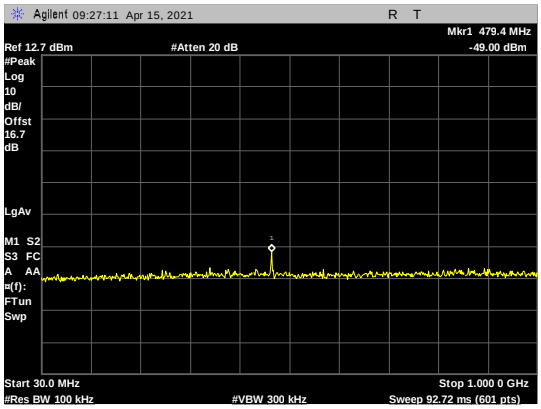

Figure 39: Restricted Band Emissions, ZigBee 30Mhz-1Ghz mid channel peak

Note: Plots on this page were measured in a conducted setup.

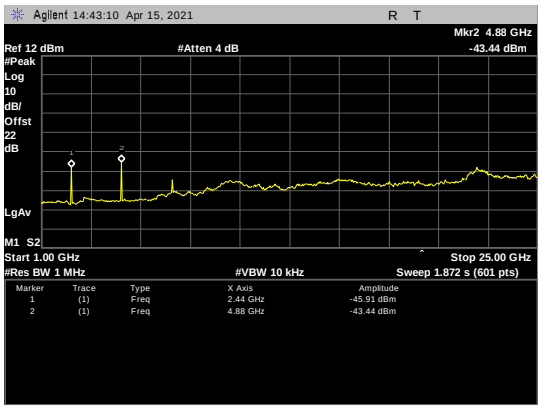

Figure 40: Restricted Band Emissions, ZigBee 1Ghz-25Ghz mid channel average

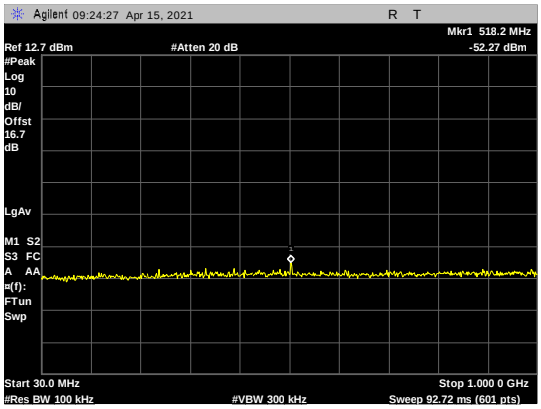

Figure 41: ZigBee 30Mhz-1Ghz high channel restricted band emissions peak

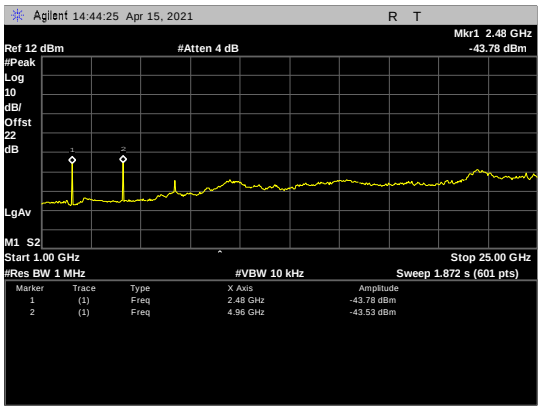

Figure 42: Restricted Band Emissions, ZigBee 1Ghz-25Ghz high channel average

Note: Plot on this page were measured in a conducted setup.

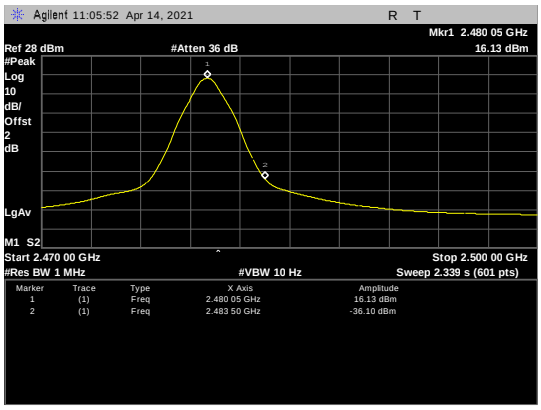

Figure 43: Restricted Band Edge, ZigBee high channel restricted band edge average

Note: Plot on this page was measured in a conducted setup.

Radiated Spurious Emissions Test Setup

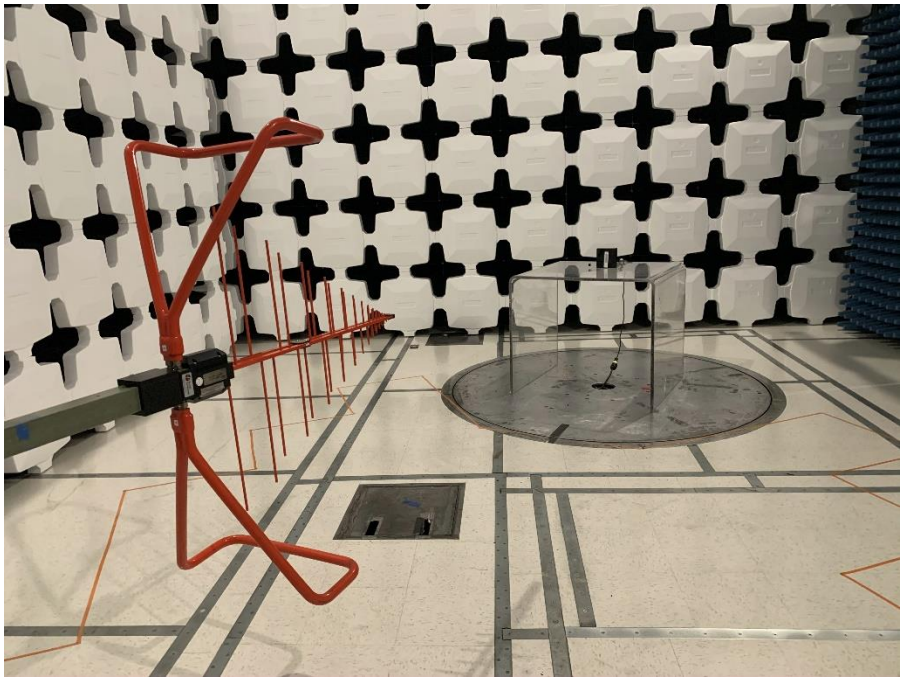

Figure 44: Radiated emission setup 30Mhz-1Ghz

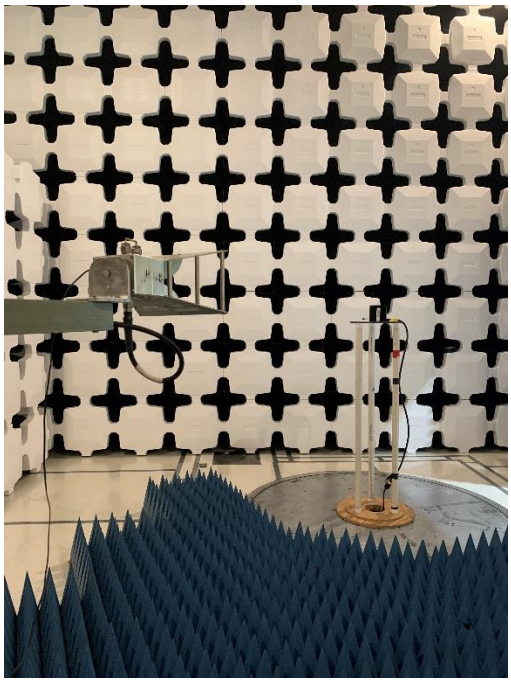

Figure 45: Radiated emission setup 1-18Ghz

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(d) 20 dBc Emissions

Test Requirement: **15.247(d)** 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.

Test Procedure: For intentional radiators with a digital device portion which operates below 10 GHz, the spectrum was investigated as per §15.33(a)(1) and §15.33(a)(4); i.e., the lowest RF signal generated or used in the device up to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

The EUT was connected to a spectrum analyzer through a cable and an attenuator. Measurements were taken with the EUT set to transmit continuously on its low, mid, and high channels for all its bandwidths at maximum power. Conducted spurious emissions were measured according to sections 11.11.2 and 11.11.3 of ANSI C63.10-2013.

Test Results: The EUT as tested is compliant with the Spurious Emission limits of **§15.247(d)**.

Test Engineer(s): Deepak Giri

Test Date(s): 04/26/2021

Spurious Emissions in Non-restricted Bands, Test Results

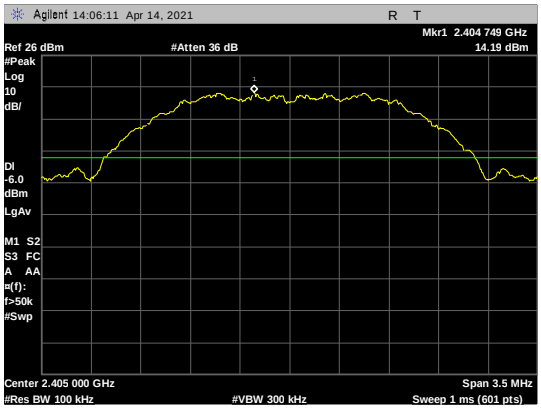

Figure 46: Conducted Spurious Emissions, ZigBee low channel reference level

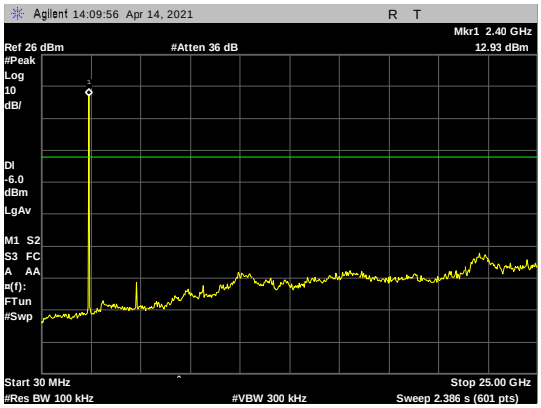

Figure 47: Conducted Spurious Emissions, ZigBee low channel

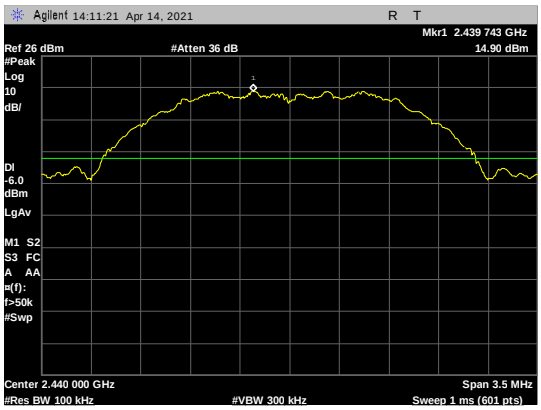

Figure 48: Conducted Spurious Emissions, ZigBee mid channel reference level

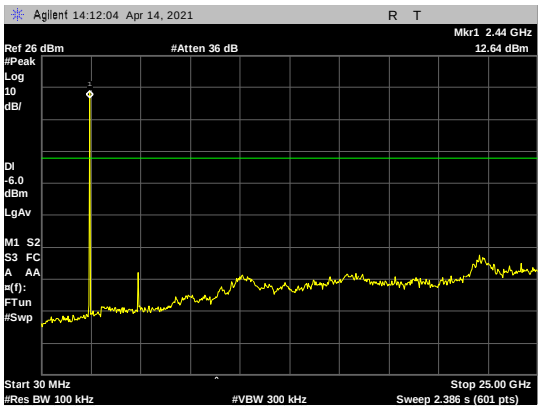

Figure 49: Conducted Spurious Emissions, ZigBee mid channel

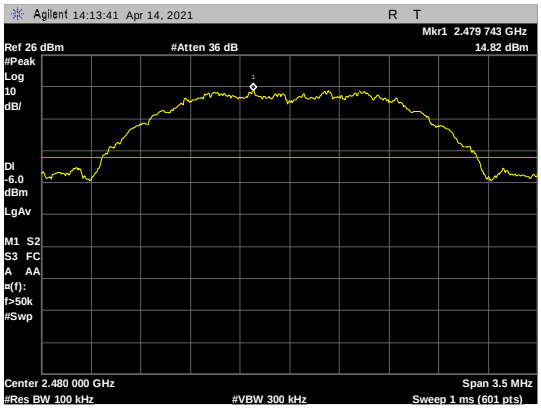

Figure 50: Conducted Spurious Emissions, ZigBee high channel reference level

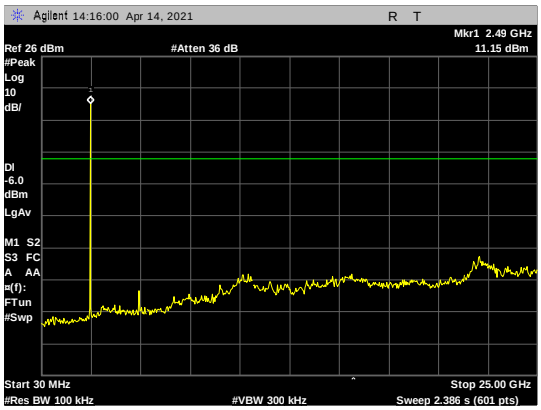

Figure 51: Conducted Spurious Emissions, ZigBee high channel

Table 20. Conducted Bands Measurements

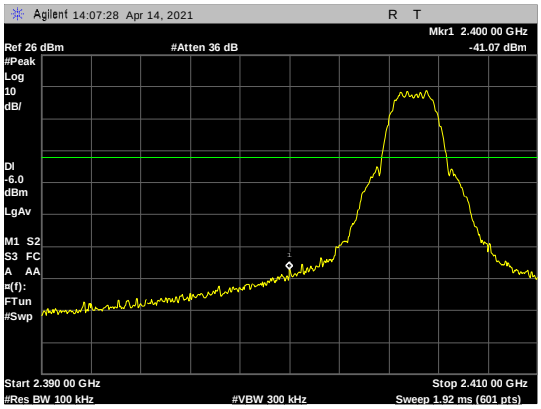

Figure 52: Conducted Emission Band Edge, ZigBee low channel

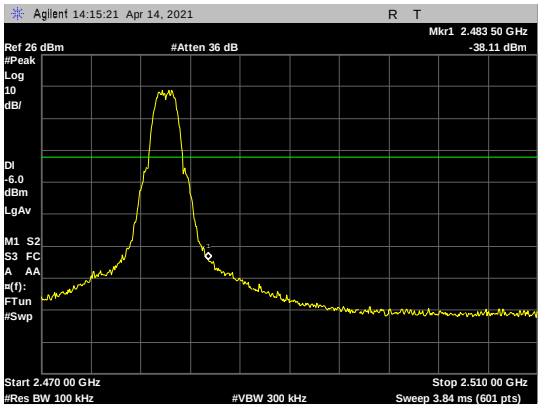

Figure 53: Conducted Emission Band Edge, ZigBee high channel

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(e) Power Spectral Density

Test Requirements: **§15.247(e):** For digitally modulated systems, the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8dBm in any 3 kHz band during any time interval of continuous transmission.

Test Procedure: The EUT was connected to a spectrum analyzer through a cable and an attenuator. Measurements were taken with the EUT set to transmit continuously on its low, mid, and high channels for all its bandwidths at maximum power. Power spectral density was measured according to measurement method AVGPSD-2, as described in ANSI C63.10-2013, section 11.10.5. Attenuator, cable loss, and duty factor were programmed into the spectrum analyzer.

Test Results: The EUT as tested is compliant with the peak power spectral density limits of **§ 15.247 (e)**.

The peak power spectral density was determined from plots on the following page(s).

Test Engineer: Deepak Giri

Test Date: 04/26/2021

Peak Power Spectral Density Test Results

Carrier Channel	Frequency (MHz)	Conducted PSD (dBm)	Antenna Gain (dBi)	Limit (dBm)	Margin (dB)
Low	2405	4.12	0	8	3.88
Mid	2440	3.94	0	8	4.06
High	2480	3.68	0	8	4.32

Table 21. Power Spectral Density, Test Results

Power Spectral Density

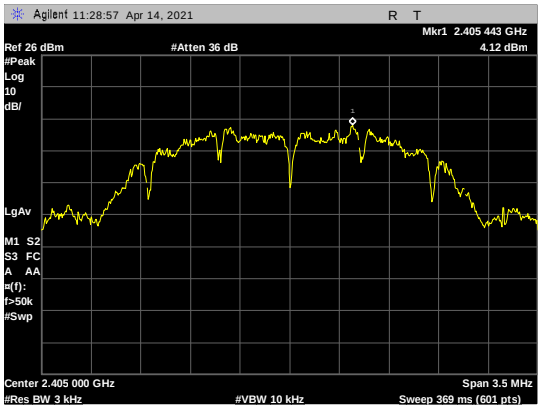

Figure 54: Peak Power Spectral Density, ZigBee low channel

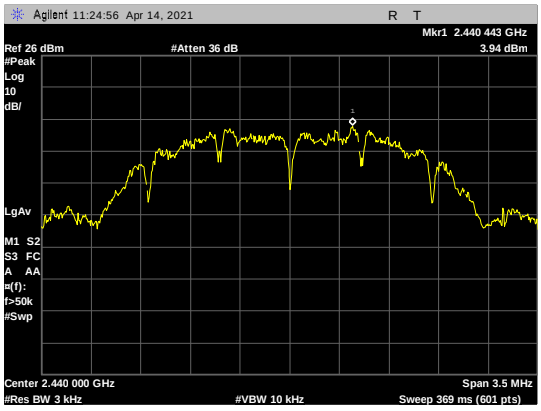

Figure 55: Peak Power Spectral Density, ZigBee mid channel

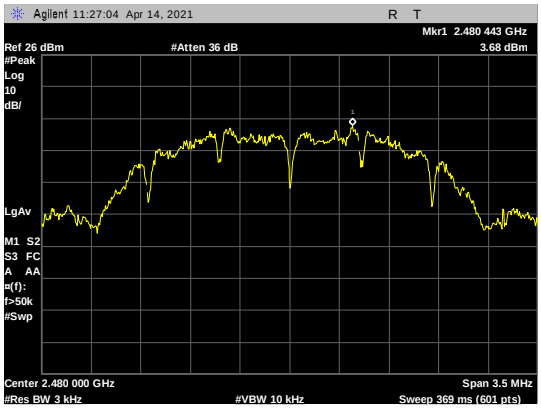

Figure 56: Peak Power Spectral Density, ZigBee high channel

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(i) Maximum Permissible Exposure

RF Exposure Requirements: **§1.1307(b)(1) and §1.1307(b)(2):** Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

RF Radiation Exposure Limit: **§1.1310:** As specified in this section, the Maximum Permissible Exposure (MPE) Limit shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in Sec. 1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of Sec. 2.1093 of this chapter.

Test Results:

FCC									
Frequency (MHz)	**Con. Pwr. (dBm)**	**Con. Pwr. (mW)**	**Ant. Gain (dBi)**	**Ant. Gain numeric**	**Pwr. Density (mW/cm^2)**	**Limit (mW/cm^2)**	**Margin**	**Distance (cm)**	**Result**
2405	19.13	81.470	0	1	0.0162	1	0.9837	20	Pass

The safe distance where Power Density is less than the MPE Limit listed above was found to be 20 cm.

Test Equipment

Calibrated test equipment utilized during testing was maintained in a current state of calibration per the requirements of ISO/IEC 17025:2017.

Asset	Equipment	Manufacturer	Model	Calibration Date	Calibration Due Date
1T4409	EMI Receiver	Rohde & Schwarz	ESIB7	1/21/2021	1/21/2022
1T8744	Spectrum Analyzer (PSA)	Agilent Technologies	E4440A	12/14/2020	12/14/2022
1T4753	Antenna - Bilog	Sunol Sciences	JB6	12/21/2020	6/21/2022
1T4576	Antenna, Active Horn	Com-Power	AHA-118	12/8/2020	6/8/2022
1T4744	Antenna, Horn	ETS-Lindgren	3116	3/4/2021	9/4/2022
1T4752	Pre-Amplifier	Miteq	JS44-18004000-35-8P	Func Verify	Func Verify
1T8743	Preamplifier	A.H. Systems, Inc.	PAM-0118P	Func Verify	Func Verify
1T4794	LISN	Com-Power	LI-150A	11/11/2019	05/11/2021
1T4795	LISN	Com-Power	LI-150A	11/11/2019	05/11/2021
1T4612	Spectrum Analyzer	Agilent Technologies	E4407B	03/04/2020	09/04/2021
1T7479	Transient Limiter	Com-Power	LIT-153A	func verify	func verify

Asset	Equipment	Manufacturer	Model	Calibration Date	Calibration Due Date
1T8834	Conducted Comb Generator	Com-Power	CGC-255E	11/13/2019	05/13/2021
1T9583	Thermo/Hygrometer	Control Company	9337T07	05/09/2019	05/09/2021

Table 22. Test Equipment List

Note: Functionally tested equipment is verified using calibrated instrumentation at the time of testing.

End of Report