May 31, 2023

Coulomb, Inc.
501 Locust Ave.
Floor 1, Ste 2
Charlottesville, VA 22902

Dear Ethan Bush,

Enclosed is the EMC Wireless test report for compliance testing of the Lumin Smart Panel, LSP-12 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.

Michelle Tawmging
Documentation Department
Eurofins Electrical and Electronic Testing NA, Inc.

Reference: (\Coulomb, Inc.\WIR125040-FCC247 Rev. 2)

A2LA ACCREDITED TESTING CERT #0591.01

Electromagnetic Compatibility Criteria Test Report

for the

Lumin Smart Panel, LSP-12

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

Report: WIR125040-FCC247 Rev. 2

May 31, 2023

Prepared For:

Coulomb, Inc.
501 Locust Ave.
Floor 1, Ste 2
Charlottesville, VA 22902

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

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Donald Salguero
Wireless Lab

Engineering Statement: The measurements shown in this report were made in accordance with the procedures indicated. 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.

Michael Griffiths
Manager, Wireless Lab

Report Status Sheet

Revision	Report Date	Reason for Revision
Ø	March 31, 2023	Initial Issue.
1	April 17, 2023	Updated customer address; Updated EUT name; Updated Table 7; Updated Figure 1.
2	May 31, 2023	Updated applicant name; Updated EUT name; Added Supported Channel List; Updated Equipment Overview and Test Configuration; Removed MPE section.

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Executive Summary

A. Purpose of Test

An EMC evaluation was performed to determine compliance of the Lumin Smart Panel, LSP-12, 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 Lumin Smart Panel, LSP-12. Coulomb, Inc. should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the Lumin Smart Panel, LSP-12, 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 Coulomb, Inc., purchase order number 230123-E1. 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)	Spurious Emissions in Non-restricted Bands	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 Coulomb, Inc. to perform testing on the Smart Panel, LSP-12, under Coulomb, Inc.'s purchase order number 230123-E1.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the Lumin Smart Panel, LSP-12.

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

Model(s) Tested:	Lumin Smart Panel, LSP-12	
Model(s) Covered:	Lumin Smart Panel, LSP-12	
EUT Specifications:	Primary Power: 120/240 VDC	
	FCC ID: 2AY52-LSP12WE	
	Type of Modulations:	CCK, OFDM
	Equipment Code:	DTS
	Max RF Output Power:	19.03dBm; 80mW
	EUT Frequency Ranges:	2412-2462 MHz; 2422-2452 MHz
Analysis:	The results obtained relate only to the item(s) tested.	
Environmental Test Conditions:	Temperature: 15-35° C	
	Relative Humidity: 30-60%	
	Barometric Pressure: 860-1060 mbar	
Evaluated by:	Donald Salguero	
Report Date(s):	May 31, 2023	

Table 2. EUT Summary Table

20 MHz BW Channels			40MHz BW Channels		
Channel #	**Frequency (MHz)**	**Tested Channels**	**Channel #**	**Frequency (MHz)**	**Tested Channels**
1	2412	x			
2	2417				
3	2422		3	2422	x
4	2427		4	2427	
5	2432		5	2432	
6	2437	x	6	2437	x
7	2442		7	2442	
8	2447		8	2447	
9	2452		9	2452	x
10	2457				
11	2462	x			

Table 3. Supported Channel List

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 4. References

C. Test Site

All testing was performed at Eurofins Electrical and Electronic Testing NA, Inc., 914 W. Patapsco 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. Eurofins Electrical and Electronic Testing NA, Inc. has been accredited by the American Association for Laboratory Accreditation (A2LA) (Certificate #: 0591.01) in accordance with ISO/IEC 17025:2017.

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 5. Uncertainty Calculations Summary

E. Equipment Overview and Test Configuration

Name of EUT/Model:	Lumin Smart Panel, LSP-12
Description of EUT and Intended Use:	Sample Lumin Smart Panel, LSP-12 — residential electrical load management device — with support equipment (primarily a breaker panel) to simplify setup to connection with a 120/240 VAC power source and provide representative conditions. Breakers and wiring are included to simulate completed installation; load simulation current draw is not relevant to EMC testing. Test mode drivers have been configured for the wireless radio to support EMC testing operation modes. Note that the wireless transceiver is a third-party module with agency certifications granted to the original manufacturer, FN-Link: FCC ID: 2AATL-8223A-SR IC: 24844-8223ASR
Selected Operation Mode(s):	Online Operation Mode: The device operates with a continuous network connection. The provided EUT setup shall be powered and connected to the local network via Ethernet while simultaneously broadcasting test mode data across 2.4 GHz Wi-Fi bands. Lumin will provide an operating manual for directly controlling the Wi-Fi radio.
Rational for the selection of the Operation Mode(s):	The device operates with a continuous network connection when installed. The device supports Ethernet and 2.4 GHz Wi-Fi, typically with data transfer only occurring over one or the other protocol (Bluetooth and 5 GHz Wi-Fi radios in the transceiver module are disabled in the factory-installed and -managed software, and cannot be enabled by the end user). However, it is possible for momentary transition states in which both Ethernet and Wi-Fi transmitters are active, so this is selected as the peak emission operation mode. The physical EUT assembly provides a representative radiofrequency environment with respect to dead metal and 60 Hz AC power conductors.
Susceptibility Criteria:	
Monitoring Method(s):	System operation for the EUT is verified by navigating to http://lumin-8812ac243d8f.local/ in a Web Browser once the EUT is connected to the local network via Ethernet. Refresh the site to check for continued operation. If the site reloads successfully, the device is operating properly. If the site fails to reload, the device has lost power, been improperly configured, or malfunctioned.
Emissions Class Declaration:	Class B
Configurations:	See the block diagram of the EUT assembly (LS-100693). Remove the outer product cover by unlatching the pair of clasps, pulling the bottom of the cover out, and lifting up. Remove the external antenna from the exposed interface compartment. Install an Ethernet cable between a router and the RJ45 port in the product labelled "Ethernet, " utilizing the 3/4" knockout in the bottom of the enclosure to route the cable. Replace the product outer cover by hooking over the top and latching. Mount the EUT vertically (the Lumin logo on the smart panel oriented upright). Install the included external antenna on the RP-SMA jack of the product. Orient the installed antenna to point up.
Rated Power Input	
Input Voltage Range:	120/240
AC or DC:	AC
Voltage Frequency:	60
Number of Phases:	1
Current:	0.5
Uses an external AC/DC Adapter:	False
The EUT can be battery powered:	False
Power Input Under Test	
Input Voltage:	
Frequency:	

Physical Description	
EUT Arrangement:	Floor Standing
System with Multiple Chassis?	False
Size (HxWxD) inches:	48x31x6
Weight (lbs.):	85
Highest Internal Frequency (MHz):	2500
Other Info	
EUT Software (Internal to EUT):	QCMBR
Support Software (used by support PC to exercise EUT):	QCA Radio Control Toolkit
Firmware:	1.0
Transmitter Parameters	
Description of your unit:	DSSS
Modulation Type:	Adaptive
Number of Channels:	11 (20MHz BW) channels; 7 (40MHz BW) channels
Frequency Range (MHz):	2412-2462MHz; 2422-2452MHz
Antenna Type:	External dipole
Antenna Gain (dB):	2
PMN:	Lumin Smart
HVIN:	8223A-SR
FVIN:	1.0
HMN:	
Data Rates:	300 Mbps
Expected Power Level:	16 dBm
Number of Antenna:	1
Number of Intentional Transmitters:	1
Number of Certified Intentional Transmitter Modules:	1
FCC ID:	2AY52-LSP12WE
IC ID:	27016-LSP12WE

Table 6. Equipment Details

Name/Description	Model Number	Part Number	Serial Number	Rev. #
UFB 6AWG 2C 7STR CU BLK WHT, 10AWG SOLID CU BARE, GRY JACKET	N.A.	21469203	N.A.	N.A.
UFB 10AWG 2C SOLID CU BLK WHT, 10AWG SOLID CU BARE, GRY JACKET	N.A.	13056717	N.A.	N.A.
NM B, 6/3 STRANDED CU BLK WHT RED, 12/1 SOLID CU BARE, BLK JACKET	N.A.	63950045	N.A.	N.A.
LOAD CENTER, 2 PHASE, 6 SPACES, 12 CIRCUITS, 125A	N.A.	BR612L125RP	N.A.	N.A.
5 TERMINAL GALVANIZED GROUND BAR KIT	N.A.	GBK5CS	N.A.	N.A.
CIRCUIT BREAKER, 15A, 1 POLE, STANDARD TRIP	N.A.	BR115	N.A.	N.A.
CIRCUIT BREAKER, 20A, 2 POLE, STANDARD TRIP	N.A.	BR220	N.A.	N.A.
CIRCUIT BREAKER, 40A, 1 POLE, STANDARD TRIP	N.A.	BR140	N.A.	N.A.
CIRCUIT BREAKER, 70A, 2 POLE, STANDARD TRIP	N.A.	BR270	N.A.	N.A.
3/8 IN CLAMP ON TYPE SERVICE ENTRANCE CONNECTOR CONDUIT FITTINGS	N.A.	49650	N.A.	N.A.
3/4 IN CLAMP ON TYPE SERVICE ENTRANCE CONNECTOR CONDUIT FITTINGS	N.A.	49660	N.A.	N.A.
BLACK INSULATED MULTI CABLE CONNECTOR DUAL ENTRY 2 PORTS 4 14	N.A.	97102	N.A.	N.A.
LSP 12 OR.1.7 TOP LEVEL	N.A.	LS-100687	N.A.	N.A.
LSP 12 OR.2.0 BRACKET	N.A.	LS-100417	N.A.	N.A.
LSP 12 OR.2.0 SPACER	N.A.	LS-100419	N.A.	N.A.
200A CT ASSEMBLY A	N.A.	LS-100007	N.A.	N.A.
200A CT ASSEMBLY B	N.A.	LS-100009	N.A.	N.A.
STAINLESS 1/4" 20 LOCKNUT	N.A.	96278A511	N.A.	N.A.
FLAT WASHER FOR 1/4" SCREW	N.A.	90107A029	N.A.	N.A.
1/4" WOOD SCREW HEX HEAD 2" LONG	N.A.	91478A550	N.A.	N.A.

Table 7. EUT List

Port Name on EUT	Cable Desc. or reason for none	3 Meters or Longer	Length as tested (m)	Max Length (m)	Shielded?	Termination Box ID & Port Name
RP-SMA JACK	NONE: DIRECT CXN FOR EXTERNAL ANTENNA	No			No	
ETHERNET	CAT 5+ ETHERNET	No		30	Yes	NETWORK ROUTER
USB	NONE: NOT USED IN END APPLICATIONS	No			No	
RS-485	NONE: NOT USED IN END APPLICATION	No			No	

Table 8. Ports and Cabling

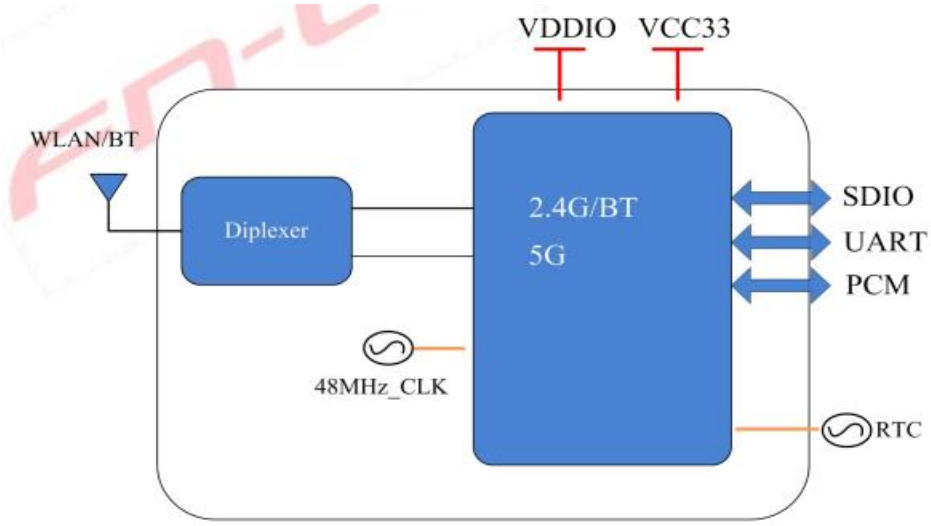

Figure 1. Block Diagram

F. 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.

G. Disposition of EUT

The test sample including all support equipment submitted to the Electro-Magnetic Compatibility Lab for testing was returned to Coulomb, 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.

Test Results: The EUT as tested is compliant the criteria of §15.203. EUT uses unique connector.
Antenna Gain: 2dBi
Antenna Type: Whip Dipole

Test Engineer: Donald Salguero

Test Date: March 21, 2023

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 requirements of this section. No anomalies noted.

Test Engineer: Donald Salguero

Test Date: March 21, 2023

Conducted Emissions Datasheet			
METrak Number	125040	**Test Specification**	FCC Part 15, Subpart B, Section 15.107; ICES-003, Section 3.2.1
Customer	Lumin	**Equipment Class**	B
EUT Name	Lumin Smart Panel	**Engineer**	Donald Salguero
Model/Part Number	LSP-12	**Test Date(s)**	3/21/2023
Serial Number	N/A	**Temperature**	19.7°C
Mode of Operation	Active Connection	**Relative Humidity**	31%
Notes:			
Start Frequency	150 kHz	**Stop Frequency**	30 MHz
Line Under Test	Line 1		

Frequency	Quasi-Peak Measurement	Correction Factor	Corrected Measurement	Quasi-Peak Limit	Margin	Result
MHz	dBµV	dB	dBµV	dBµV	dB	Pass/Fail
0.15	49.32	10.5	59.82	66	-6.18	PASS
5.044	43.1	10.05	53.15	60	-6.85	PASS
5.064	43.14	10.05	53.19	60	-6.81	PASS
5.098	43.1	10.05	53.15	60	-6.85	PASS
5.119	43.09	10.05	53.14	60	-6.86	PASS
5.144	43.05	10.05	53.1	60	-6.9	PASS

Frequency	Average Measurement	Correction Factor	Corrected Measurement	Average Limit	Margin	Result
MHz	dBµV	dB	dBµV	dBµV	dB	Pass/Fail
4.956	35.31	10.05	45.36	46	-0.643	PASS
5.14	35.31	10.05	45.36	50	-4.636	PASS
5.16	35.33	10.05	45.38	50	-4.62	PASS
5.181	35.24	10.05	45.29	50	-4.705	PASS
5.206	35.26	10.05	45.31	50	-4.69	PASS
5.227	35.24	10.05	45.29	50	-4.708	PASS

Table 10. CEV Data (240V60Hz, L1)

Conducted Emissions Datasheet			
METrak Number	125040	Test Specification	FCC Part 15, Subpart B, Section 15.107; ICES-003, Section 3.2.1
Customer	Lumin	Equipment Class	B
EUT Name	Lumin Smart Panel	Engineer	Donald Salguero
Model/Part Number	LSP-12	Test Date(s)	3/21/2023
Serial Number	N/A	Temperature	19.7°C
Mode of Operation	Active Connection	Relative Humidity	31%
Notes:			
Start Frequency	150 kHz	Stop Frequency	30 MHz
Line Under Test	Line 2		

Frequency	Quasi-Peak Measurement	Correction Factor	Corrected Measurement	Quasi-Peak Limit	Margin	Result
MHz	dBµV	dB	dBµV	dBµV	dB	Pass/Fail
5.169	29.42	10.1	39.52	60	-20.479	PASS
5.215	29.74	10.1	39.84	60	-20.158	PASS
5.236	30.01	10.1	40.11	60	-19.89	PASS
5.286	30.26	10.11	40.37	60	-19.631	PASS
5.331	29.64	10.11	39.75	60	-20.252	PASS
5.498	28.94	10.11	39.05	60	-20.955	PASS

Frequency	Average Measurement	Correction Factor	Corrected Measurement	Average Limit	Margin	Result
MHz	dBµV	dB	dBµV	dBµV	dB	Pass/Fail
5.194	21.18	10.1	31.28	50	-18.717	PASS
5.219	21.67	10.1	31.78	50	-18.222	PASS
5.244	21.8	10.1	31.9	50	-18.097	PASS
5.286	21.69	10.11	31.79	50	-18.205	PASS
5.323	21.29	10.11	31.4	50	-18.605	PASS
5.348	21	10.11	31.11	50	-18.891	PASS

Table 11. CEV Data (240V60Hz, L2)

Conducted Emissions Datasheet						
METrak Number	125040		**Test Specification**	FCC Part 15, Subpart B, Section 15.107; ICES-003, Section 3.2.1		
Customer	Lumin		**Equipment Class**	B		
EUT Name	Lumin Smart Panel		**Engineer**	Donald Salguero		
Model/Part Number	LSP-12		**Test Date(s)**	3/21/2023		
Serial Number	N/A		**Temperature**	19.7°C		
Mode of Operation	Active Connection		**Relative Humidity**	31%		
Notes:						
Start Frequency	150 kHz		**Stop Frequency**	30 MHz		
Line Under Test	Neutral					

Frequency	Quasi-Peak Measurement	Correction Factor	Corrected Measurement	Quasi-Peak Limit	Margin	Result
MHz	dBµV	dB	dBµV	dBµV	dB	Pass/Fail
5.227	38.75	10.08	48.84	60	-11.164	PASS
5.277	38.78	10.08	48.87	60	-11.135	PASS
5.311	38.46	10.08	48.54	60	-11.457	PASS
7.718	39.8	10.12	49.92	60	-10.081	PASS
7.76	40.2	10.12	50.32	60	-9.68	PASS
7.83	39.85	10.12	49.97	60	-10.027	PASS

Frequency	Average Measurement	Correction Factor	Corrected Measurement	Average Limit	Margin	Result
MHz	dBµV	dB	dBµV	dBµV	dB	Pass/Fail
5.277	33.2	10.08	43.28	50	-6.716	PASS
7.73	33.47	10.12	43.59	50	-6.408	PASS
7.755	34.28	10.12	44.4	50	-5.598	PASS
7.785	34.71	10.12	44.83	50	-5.172	PASS
7.805	34.76	10.12	44.88	50	-5.116	PASS
7.83	34.26	10.12	44.38	50	-5.617	PASS

Table 12. CEV Data (240V60Hz, N)

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 was compliant with requirements of this section. No anomalies noted.

Test Engineer: Donald Salguero

Test Date: March 24, 2023

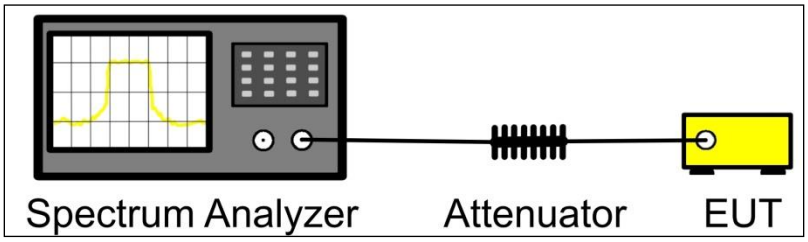

Figure 2. Block Diagram, Occupied Bandwidth Test Setup

Mode	Frequency (MHz)	Measured -6dB Bandwidth (MHz)	Measured 99% Bandwidth (MHz)
802.11b	2412	7.689	13.3151
	2437	7.24	13.3556
	2462	8.179	13.2958
802.11g	2412	14.609	16.536
	2437	15.466	16.5962
	2462	15.233	16.4504
802.11n 20	2412	14.119	17.5741
	2437	15.585	17.6388
	2462	13.889	17.552
802.11n 40	2422	35.182	35.8993
	2437	35.293	36.0628
	2452	35.215	36.0442

Table 13. OBW, Test Results

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: Donald Salguero

Test Date: March 21, 2023

Mode	On Time (ms)	Period (ms)	DC (%)	1/T (Hz)	VBW (Hz)
802.11b	--	--	100%	--	≥ 10
802.11g	2.05	2.225	92.13%	449	≥ 500
802.11n 20	1.91	2.026	94.27%	494	≥ 500
802.11n 40	0.915	1.055	86.73%	948	≥ 1000

Table 14. DC Test Results

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 and cable loss factors were programmed into the spectrum analyzer.

Test Results: The EUT was compliant with requirements of this section. No anomalies noted.

Test Engineer: Donald Salguero

Test Date: March 21, 2023

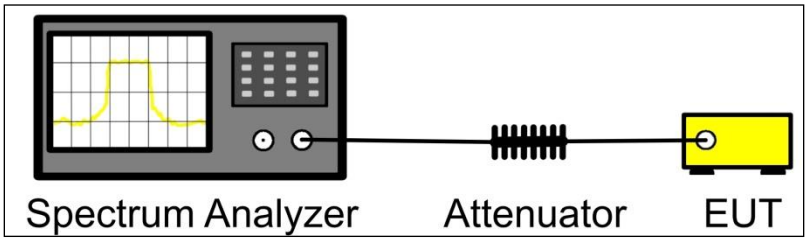

Figure 3. Power Output Test Setup

Mode	Frequency (MHz)	Measured Conducted Power (dBm)	DCCF (dB)	Limit (dBm)	Margin (dB)	Antenna Gain (dBi)	EIRP (dBm)	Limit EIRP (dBm)	Margin (dB)
802.11b	2412	18.78	0	30	-11.22	2	20.78	36	-15.22
	2437	19.03	0	30	-10.97	2	21.03	36	-14.97
	2462	18.25	0	30	-11.75	2	20.25	36	-15.75
802.11g	2412	17.04	0.36	30	-12.6	2	19.4	36	-16.6
	2437	17.28	0.36	30	-12.36	2	19.64	36	-16.36
	2462	15.93	0.36	30	-13.71	2	18.29	36	-17.71
802.11n 20	2412	15.79	0.26	30	-13.95	2	18.05	36	-17.95
	2437	16.88	0.26	30	-12.86	2	19.14	36	-16.86
	2462	14.85	0.26	30	-14.89	2	17.11	36	-18.89
802.11n 40	2422	13.87	0.62	30	-15.51	2	16.49	36	-19.51
	2437	15.95	0.62	30	-13.43	2	18.57	36	-17.43
	2452	12.86	0.62	30	-16.52	2	15.48	36	-20.52

Table 15. Output Power, Test Results

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 16. 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 17.

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 17. 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. Radiated Emissions were investigated up to 25 GHz

Test Results: The EUT was compliant with requirements of this section. No anomalies noted.

On the measurements performed for the 30MHz to 1GHz frequency span, there are emissions that appear to be over the 15.209 limit line. However, they do not fall on a restricted band; therefore, they are subject to the 100kHz 20/30 dBc limit per 15.247 (d).

Test Engineer: Donald Salguero

Test Date: March 24, 2023

Mode	Channel Frequency (MHz)	Measured Frequency (MHz)	Corrected Amplitude (dBuV/m)	Limit (dBuV/m)	Margin (dB)
802.11b	2412	2390	49.01	54	-4.99
			58.85	74	-15.15
	2462	2483.5	48.55	54	-5.45
			59.69	74	-14.31
802.11g	2412	2390	53.96	54	-0.04
			68.05	74	-5.95
	2462	2483.5	53.44	54	-0.56
			65.15	74	-8.85
802.11n 20MHz	2412	2390	52.12	54	-1.88
			64.46	74	-9.54
	2462	2483.5	51.65	54	-2.35
			64.07	74	-9.93
802.11n 40MHz	2422	2390	53.21	54	-0.79
			65.42	74	-8.58
	2452	2483.5	53.26	54	-0.74
			64.28	74	-9.72

Table 18. Conducted in lieu of Radiated Emissions, Test Results at Band Edges

Mode	Channel Frequency (MHz)	Measured Frequency (MHz)	Corrected Amplitude (dBuV/m)	30dBc Limit (dBuV/m)	Margin (dB)
802.11b	2412	452	53.77	81.73	-27.96
	2437	476.2	56.00	83.75	-27.75
	2462	502.1	53.34	81.15	-27.81
802.11g	2412	452	44.55	81.01	-36.46
	2437	474.6	44.33	77.54	-33.21
	2462	502.1	40.58	75.51	-34.93
802.11n 20MHz	2412	448.7	41.59	75.85	-34.26
	2437	477.8	42.82	77.57	-34.75
	2462	500.4	39.02	74.36	-35.34
802.11n 40MHz	2422	461.6	38.57	74.04	-35.47
	2437	476.2	42.88	73.53	-30.65
	2452	490.8	37.65	70.42	-32.77

Table 19. Conducted in lieu of Radiated Emissions, Test Results

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(d) Spurious Emissions in Non-restricted Bands

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 was compliant with requirements of this section. No anomalies noted.

Test Engineer: Donald Salguero

Test Date: March 21, 2023

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 PKPSD, as described in ANSI C63.10-2013, section 11.10.2. Attenuator and cable loss factors were programmed into the spectrum analyzer.

Test Results: The EUT was compliant with requirements of this section. No anomalies noted.

Test Engineer: Donald Salguero

Test Date: March 21, 2023

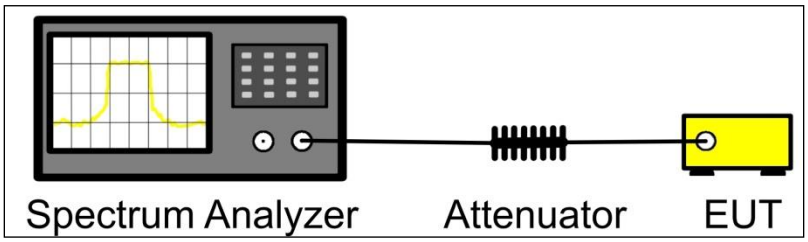

Figure 4. Block Diagram, Power Spectral Density Test Setup

Mode	Frequency (MHz)	Measured Conducted PSD (dBm)	Limit (dBm)	Margin (dB)
802.11b	2412	0.42	8	-7.58
	2437	-2.22	8	-10.22
	2462	-3.06	8	-11.06
802.11g	2412	-3.97	8	-11.97
	2437	-4.24	8	-12.24
	2462	-5.11	8	-13.11
802.11n 20	2412	-2.91	8	-10.91
	2437	-3.96	8	-11.96
	2462	-6.1	8	-14.1
802.11n 40	2422	-7.78	8	-15.78
	2437	-8.7	8	-16.7
	2452	-9.72	8	-17.72

Table 20. PSD, Test Results

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 Number	Description	Manufacturer	Model Number	Serial Number	Calibration Date	Calibration Due Date
1T4751	Antenna - Bilog	Sunol Sciences	JB6	A101910	6/1/2022	12/1/2023
1T4576	Antenna, Active Horn	Com-Power	AHA-118	711065	7/8/2022	1/31/2024
1T8743	Preamplifier	A.H. Systems, Inc.	PAM-0118P	419	Func Verify	Func Verify
1T4300	SEMI-ANECHOIC CHAMBER (NSA)	EMC TEST SYSTEMS	NONE	NONE	8/19/2021	8/31/2023
1T4300B	Semi-Anechoic 3m Chamber sVSWR	EMC TEST SYSTEMS	NONE	NONE	9/30/2021	9/30/2023
1T4681	Spectrum Analyzer (PSA)	Agilent Technologies	E4448A	MY46180897	10/15/2021	4/15/2023
1T4744	Antenna, Horn	ETS-Lindgren	3116	126519	12/16/2022	6/16/2024
1T4752	Pre-Amplifier	Miteq	JS44-18004000-35-8P	1594792	Func Verify	Func Verify
1T9990	Thermometer/Hygrometer	Fisher Scientific	06-662-4, 11725843	210843372	10/1/2021	10/1/2023

Table 21. Equipment List

Conducted Emissions Equipment List						
Asset Number	**Description**	**Manufacturer**	**Model Number**	**Serial Number**	**Calibration Date**	**Calibration Due Date**
1T4795	LISN	Com-Power	LI-150A	201065	10/17/2022	4/30/2024
1T8910	LISN	Com-Power	LI-150C	201223	11/21/2022	5/31/2024
1T4796	LISN	Com-Power	LI-150A	201072	10/17/2022	4/30/2024
1T7450	Transient Limiter	Com-Power	LIT-153A	22010020	Not Required	Not Required
1T9572	EMI Receiver	Gauss Instruments	TDEMI X40	1902001	10/13/2021	10/31/2023
1T4405	EMC Test Room 2	MET Laboratories	N/A	N/A	Not Required	Not Required

Table 22. CEV Equipment List

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

End of Report

