

02/18/2021

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

Dear Andrew Vaughn,

Enclosed is the EMC Wireless test report for compliance testing of the Lutron Electronics Co., Inc., Darter Keypad 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 E&E North America. If you have any questions regarding these results or if MET can be of further service to you, please feel free to contact me.

Sincerely yours,
EUROFINS E&E NORTH AMERICA

A handwritten signature in blue ink that reads "Joel Huna".

Joel Huna
Documentation Department

Reference: (\\Lutron Electronics Co., Inc.\\WIR110653B-FCC247 Rev. 3)

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Electromagnetic Compatibility Criteria Test Report

for the

**Lutron Electronics Co., Inc.
Darter Keypad**

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

Report: WIR110653B-FCC247 Rev. 3

02/18/2021

Prepared For:

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

Prepared By:
Eurofins E&E North America
914 West Patapsco Avenue, Baltimore, MD 21230

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15.247 Subpart C for Intentional Radiators



Deepak Giri, Project Engineer
Electromagnetic Compatibility Lab



Joel Huna
Documentation Department

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,
Manager, Electromagnetic Compatibility Lab

Report Status Sheet

Revision	Report Date	Reason for Revision
Ø	01/22/2021	Initial Issue.
1	01/29/2021	Customer Comments.
2	02/05/2021	Updates per TCB Comments
3	02/18/2021	Updated MPE Calculation

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List of Terms and Abbreviations

AC	Alternating Current
ACF	Antenna Correction Factor
Cal	Calibration
<i>d</i>	Measurement Distance
dB	Decibels
dB μ A	Decibels above one microamp
dB μ V	Decibels above one microvolt
dB μ A/m	Decibels above one microamp per meter
dB μ V/m	Decibels above one microvolt per meter
DC	Direct Current
E	Electric Field
DSL	Digital Subscriber Line
ESD	Electrostatic Discharge
EUT	Equipment Under Test
<i>f</i>	Frequency
FCC	Federal Communications Commission
GRP	Ground Reference Plane
H	Magnetic Field
HCP	Horizontal Coupling Plane
Hz	Hertz
IEC	International Electrotechnical Commission
kHz	kilohertz
kPa	kilopascal
kV	kilovolt
LISN	Line Impedance Stabilization Network
MHz	Megahertz
μ H	microhenry
μ	microfarad
μ s	microseconds
NEBS	Network Equipment-Building System
PRF	Pulse Repetition Frequency
RF	Radio Frequency
RMS	Root-Mean-Square
TWT	Traveling Wave Tube
V/m	Volts per meter
VCP	Vertical Coupling Plane

I. Executive Summary

A. Purpose of Test

An EMC evaluation was performed to determine compliance of the Lutron Electronics Co., Inc. Darter Keypad, 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 Darter Keypad. 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 Darter Keypad, 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 5231500. 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(d)	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 Compliance Testing

Eurofins MET Laboratories Inc. (Eurofins E&E North America) is part of the Eurofins Electrical & Electronics (E&E) global compliance network.

II. Equipment Configuration

A. Overview

Eurofins E&E North America was contracted by Lutron Electronics Co., Inc. to perform testing on the Darter Keypad, under Lutron Electronics Co., Inc.'s purchase order number 5231500.

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., Darter Keypad.

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

Model(s) Tested:	Darter Keypad	
Model(s) Covered:	Darter Keypad	
EUT Specifications:	Primary Power: 120 - 277 VAC	
	FCC ID: JPZ0136	
	Type of Modulations:	O-QPSK
	Equipment Code:	DTS
	Peak RF Output Power:	17.72 dBm Conducted
	EUT Frequency Ranges:	2.405 – 2.480 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:	Deepak Giri	
Report Date(s):	02/18/2021	

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

Eurofins MET Laboratories Inc. (Eurofins E&E North America) is part of the Eurofins Electrical & Electronics (E&E) global compliance network.

All testing was performed at Eurofins E&E North America, 914 West 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.

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 MET Laboratories.

D. Measurement Uncertainty

Test Method	Typical Expanded Uncertainty	K	Confidence Level
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%
Conducted Emission Voltage	±2.03 dB	2	95%

Table 4. Uncertainty Calculations Summary

E. Description of Test Sample

The Lutron Electronics Co., Inc. Darter Keypad, Equipment Under Test (EUT), is Wireless remote keypad for installation into a standard WD wallbox and powered at 120-277V. Device does not have a load but provides wireless signals to a Lutron lighting control system.

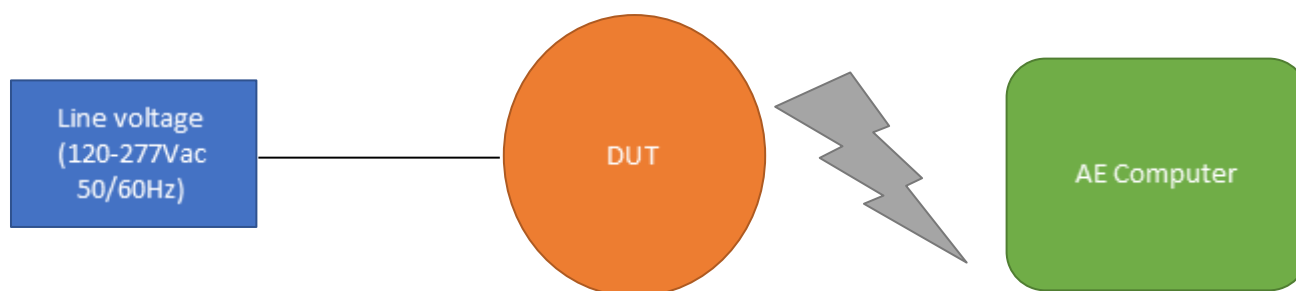


Figure 1. Block Diagram of Test Configuration

F. Equipment Configuration

The EUT was set up as outlined in Figure 1, 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 (White / Light Almond)	Serial Number	Rev. #
Conduct ed		Wireless Keypad	AZ03146	N/A	N/A	
Radiate d		Wireless Keypad	AZ03146	N/A	N/A	

Table 5. Equipment Configuration

G. Support Equipment

Support equipment necessary for the operation and testing of the EUT is included in the following list.

Ref. ID	Name / Description	Manufacturer	Model Number	*Customer Supplied Calibration Data
Computer	2.4G Dongle	NCD Communications		N/A
Test Software	Dart KP_FCC_2.ptp	N/A	N/A	N/A

The 'Customer Supplied Calibration Data' column will be marked as either not applicable, not available, or will contain the calibration date supplied by the customer.

Table 6. Support Equipment

H. Ports and Cabling Information

Ref. ID	Port name on EUT	Cable Description or reason for no cable	Qty	Length as tested (m)	Max Length (m)	Shielded? (Y/N)	Termination Box ID & Port Name
	Power	Romex 18AWG min	1	1	N/A	No	Black-Hot, Silver-Neutral, Green-Ground

Table 7. Ports and Cabling Information

I. Mode of Operation

Stand by mode, awaiting an RF signal Transmitting

J. Method of Monitoring EUT Operation

LED indicator change to a brighter level to indicate the active scene.

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.

III. Electromagnetic Compatibility Criteria for Intentional Radiators

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. Antenna is permanently attached and hence is compliant as per 15.203.

Test Engineer(s): Deepak Giri

Test Date(s): 12/29/2020

Antenna Type	Antenna Gain (dBi)	Manufacturer	Compliant by
Monopole	-1	N/A	Permanently attached

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 μ H/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 (dB μ V)	
	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 μ H 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 μ H LISN as the input transducer to receiver. For the purpose of this testing, the transmitter was turned ON. Scans were performed with the transmitter ON.

Test Results: The EUT was compliant with this requirement. EUT was tested using 120VAC 60Hz power source. EUT was transmitting under IEEE15.4 protocol during test.

Test Engineer(s): Deepak Giri

Test Date(s): 12/15/2020

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
0.1964	34.08	0	10	44.08	63.76	PASS	-19.68	19.36	0	10	29.36	53.76	PASS	-24.4
0.2782	34.3	0	10	44.3	60.87	PASS	-16.57	19.23	0	10	29.23	50.87	PASS	-21.64
0.3285	35.8	0	10	45.8	59.49	PASS	-13.69	20.07	0	10	30.07	49.49	PASS	-19.42
0.403	34.42	0	10	44.42	57.79	PASS	-13.37	18.71	0	10	28.71	47.79	PASS	-19.08
0.824	30.16	0	10	40.16	56	PASS	-15.84	16.09	0	10	26.09	46	PASS	-19.91
1.29	24.2	0	10	34.2	56	PASS	-21.8	10.95	0	10	20.95	46	PASS	-25.05

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

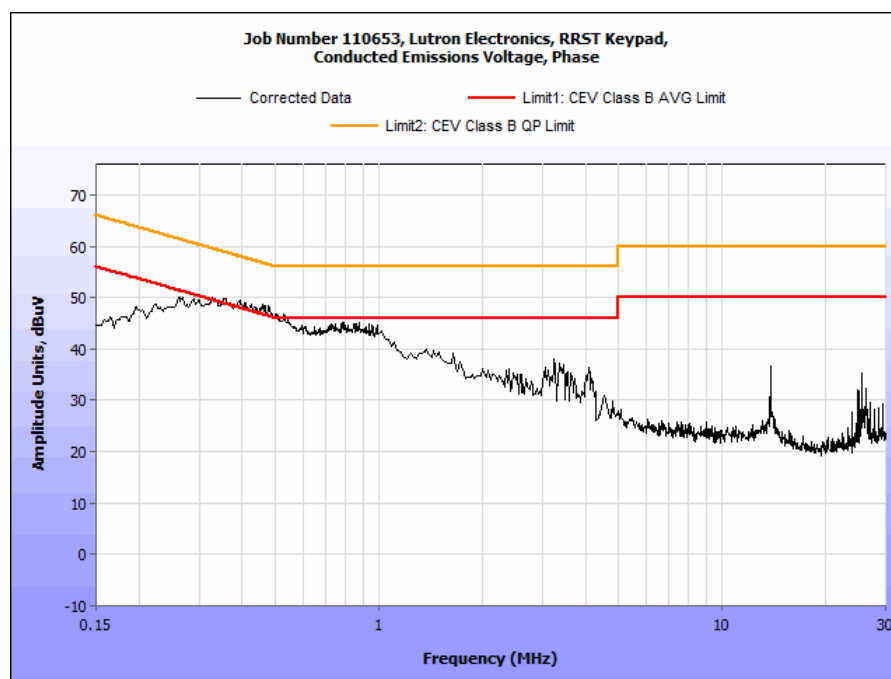


Figure 2. Conducted Emissions, 15.207(a), Phase Line

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
0.199	33.84	0	10	43.84	63.65	PASS	-19.81	20.33	0	10	30.33	53.65	PASS	-23.32
0.262	34.96	0	10	44.96	61.37	PASS	-16.41	20.13	0	10	30.13	51.37	PASS	-21.24
0.35	35.03	0	10	45.03	58.96	PASS	-13.93	20.11	0	10	30.11	48.96	PASS	-18.85
0.412	34.41	0	10	44.41	57.61	PASS	-13.2	19.92	0	10	29.92	47.61	PASS	-17.69
0.788	30.31	0	10	40.31	56	PASS	-15.69	15.95	0	10	25.95	46	PASS	-20.05
1.363	25.11	0	10	35.11	56	PASS	-20.89	12.52	0	10	22.52	46	PASS	-23.48

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

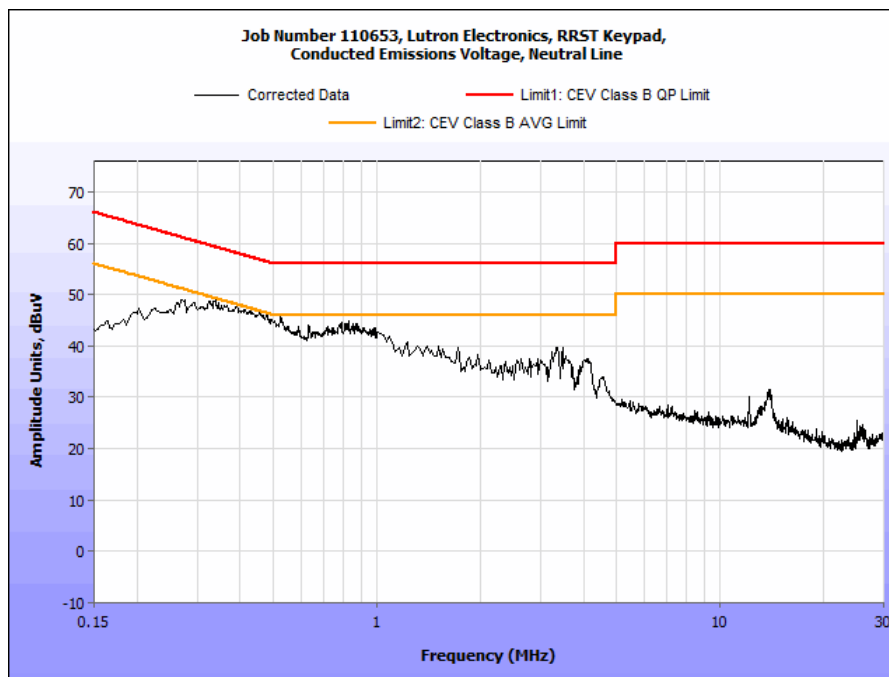


Figure 3. Conducted Emissions, 15.207(a), Neutral Line

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 transmitter was on and transmitting at the highest output power. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using a RBW = 100kHz, VBW = 3*RBW. The 6 dB Bandwidth was measured and recorded following procedure stated in 11.8.1 of ANSI C63.10 2013. The measurements were performed on the low, mid and high channels.

Test Results The EUT was 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): 12/29/2020



Figure 4. Block Diagram, Occupied Bandwidth Test Setup

Occupied Bandwidth Test Results

Frequency (MHz)	Mode	6dB Bandwidth Measured (MHz)	Limit (KHz)
2405	IEEE 15.4	1.680	≥500
2440		1.677	≥500
2480		1.669	≥500

Table 12. 6 dB Occupied Bandwidth, Test Results

6 dB Occupied Bandwidth Test Results

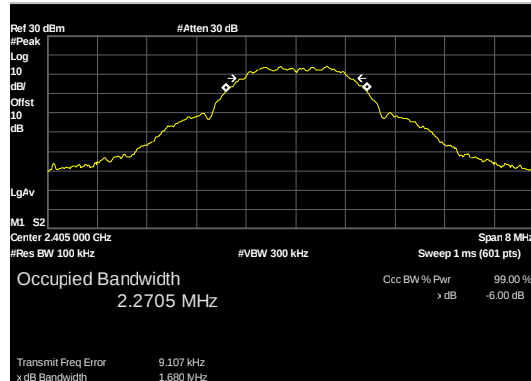


Figure 5: 6db DTS Bandwidth IEEE 15.4 Low Channel

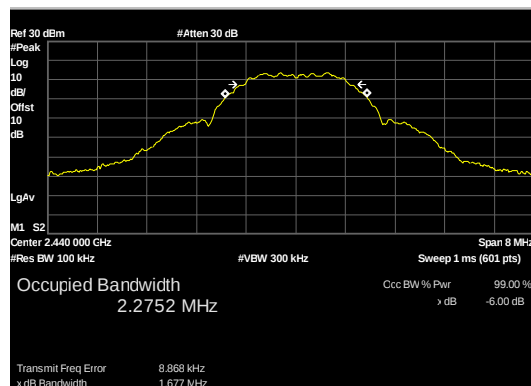


Figure 6: 6db DTS Bandwidth IEEE 15.4 Mid Channel

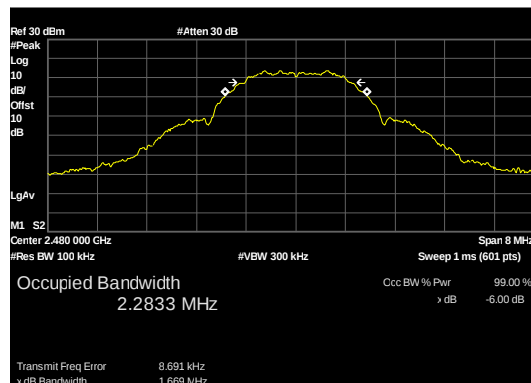


Figure 7: 6db DTS Bandwidth IEEE 15.4 High Channel

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(b) Peak Power Output

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

Digital Transmission Systems (MHz)	Output Limit (Watts)
2400–2483.5	1.000

Table 13. Output Power Requirements from §15.247(b)

§15.247(c): if transmitting antennas of directional gain greater than 6 dBi are used the peak output power from the intentional radiator shall be reduced below the stated values in the 9, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Test Procedure: The EUT was measured at the low, mid and high channels of each band at the maximum power level. Test was performed following the procedure defined in 11.9.1.1 of ANSI C63.10 2013.

Test Results: The EUT was compliant with the Peak Power Output limits of §15.247(b). Test software Dart KP_FCC_2.ptp was used. Power control was at maximum power level pre-set by manufacturer.

Test Engineer(s): Deepak Giri

Test Date(s): 12/29/2020

Frequency (MHz)	Mode	ON Time (ms)	OFF Time (ms)	Period (ms)	Duty Cycle (%)	Correction Factor (dB)
2405	IEEE 15.4	100	0	100	100	0.00
2440		100	0	100	100	0.00
2480		100	0	100	100	0.00

Table 14: Duty Cycle Calculation, IEEE 15.4

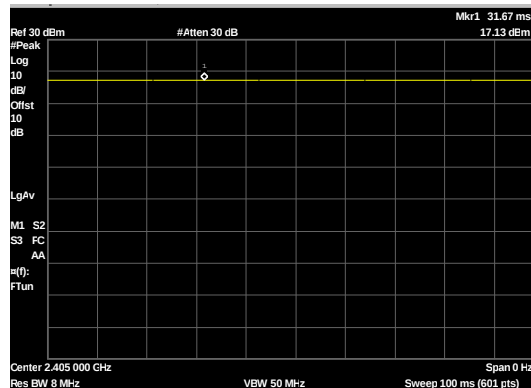


Figure 8: Duty Cycle IEEE 15.4 Low Channel

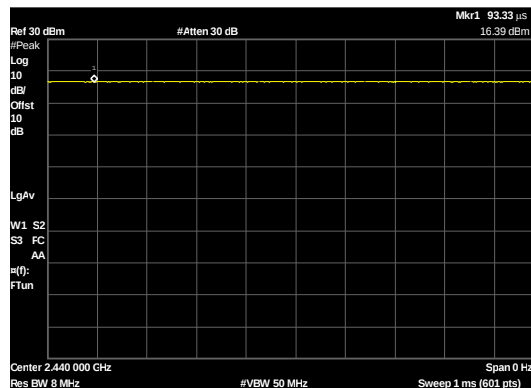


Figure 9: Duty Cycle IEEE 15.4 Mid Channel

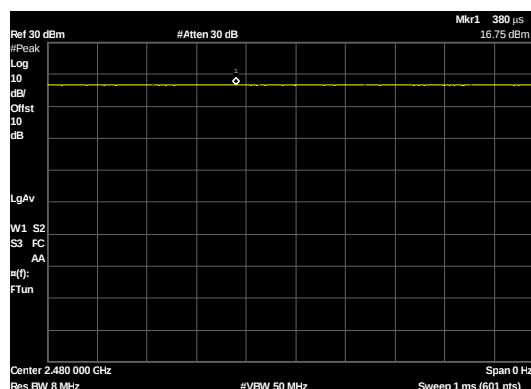


Figure 10: Duty Cycle IEEE 15.4 High Channel

Peak Power Output Test Results

Frequency (MHz)	Mode	Peak Conducted Power measured (dBm)	Conducted Power limit (dBm)	Margin	Antenna Gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)	Margin
2405	IEEE 15.4	17.72	30	-12.28	-1	16.72	36	-19.28
2440		17.26	30	-12.74	-1	16.26	36	-19.74
2480		17.38	30	-12.62	-1	16.38	36	-19.62

Table 15. Peak Power Output, Test Results

Peak Power Output Test Results

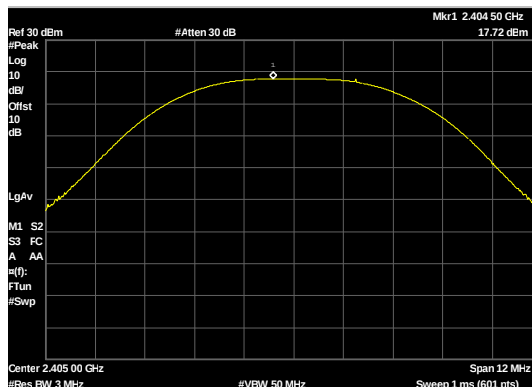


Figure 11: Peak Conducted Output Power IEEE 15.4 Low Channel Maximum Plot

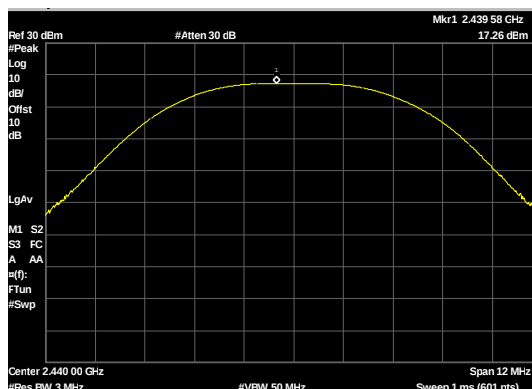


Figure 12: Peak Conducted Output Power IEEE 15.4 Mid Channel Maximum Plot

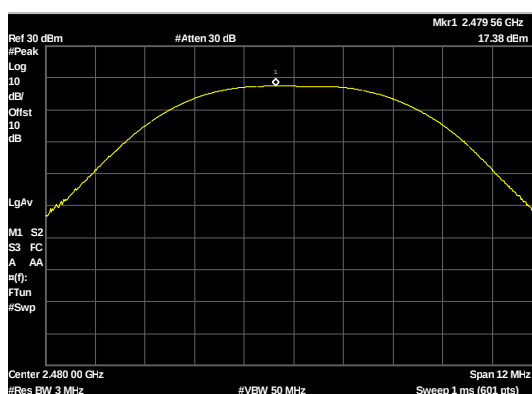


Figure 13: Peak Conducted Output Power IEEE 15.4 High Channel Maximum Plot

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)

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. Measurements were made with both horizontal and vertical polarization of receiving antenna. Plots shown are corrected for both antenna correction factor and distance and compared to a 3 m limit. Procedure defined in 6.3, 6.5 and 6.6 of ANSI C63.10 2013 were used. Only noise floor was measured above 18 GHz.

Test Results: The EUT was compliant with the Radiated Spurious Emission limits of § 15.247(d) and § 15.209. From 30MHz-1GHz emissions were measured without pre-amp. From 1GHz-18GHz emissions were measured using high pass filter, 2.4GHz band notch filter and pre-amp. From 18Ghz-25GHz emissions were measured using only pre-amp. In all frequency ranges tested, emissions close to limit line were re-evaluated under narrow span, applicable detectors and bandwidth. Plots shown are cumulative outcome of receiving antenna polarizations and EUT's emissions along 3 orthogonal axes

Test Engineer(s): Deepak Giri

Test Date(s): 12/30/2020

Radiated Spurious Emissions, Test Results

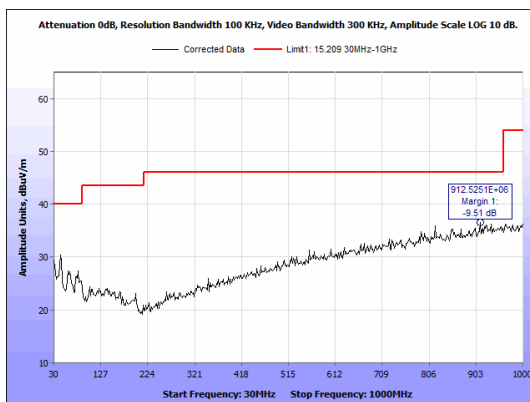


Figure 14: Radiated Spurious Emission. IEEE 15.4 Low Channel 30MHz-1GHz

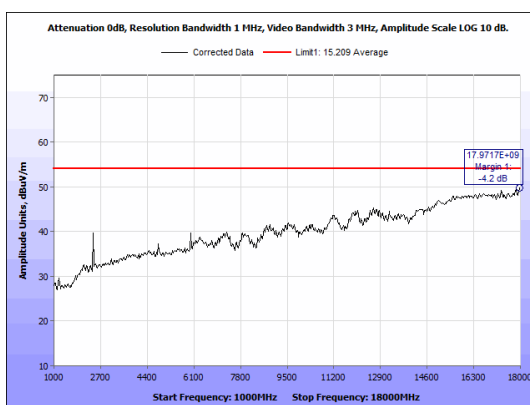


Figure 15: Radiated Emission Average. IEEE 15.4 Low Channel 1GHz-18GHz

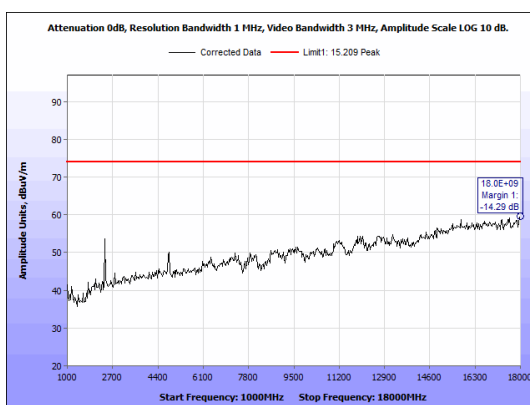


Figure 16: Radiated Emission Peak. IEEE 15.4 Low Channel 1GHz-18GHz

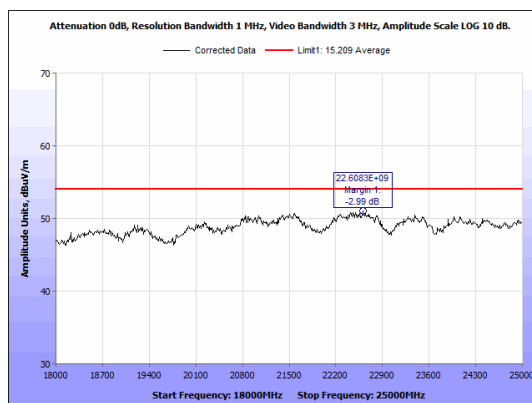


Figure 17: Radiated Emission Average. IEEE 15.4 Low Channel 18GHz-25GHz

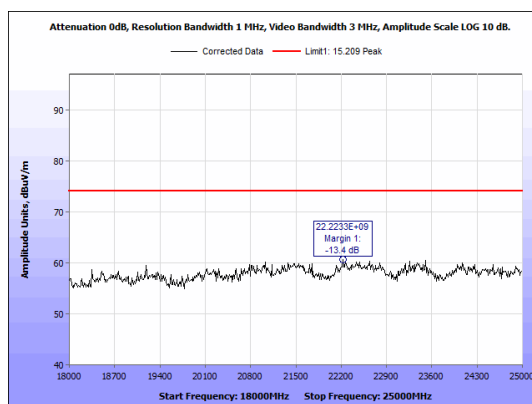


Figure 18: Radiated Emission Peak. IEEE 15.4 Low Channel 18GHz-25GHz

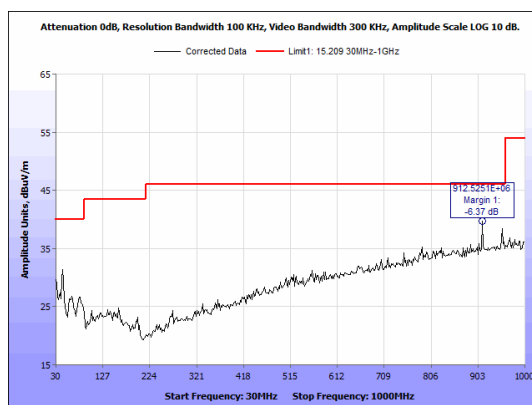


Figure 19: Radiated Spurious Emission. IEEE 15.4 Mid Channel 30MHz-1GHz

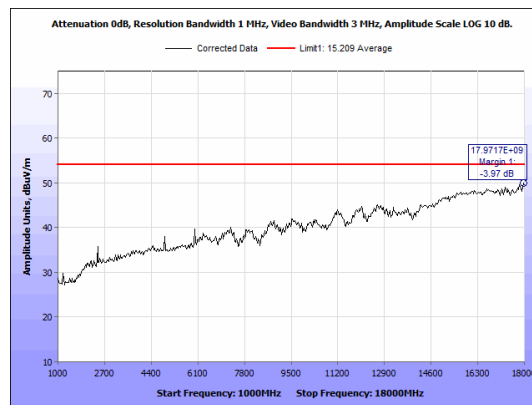


Figure 20: Radiated Emission Average. IEEE 15.4 Mid Channel 1GHz-18GHz

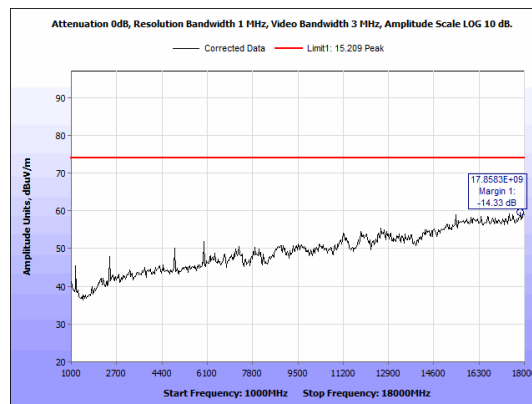


Figure 21: Radiated Emission Peak. IEEE 15.4 Mid Channel 1GHz-18GHz

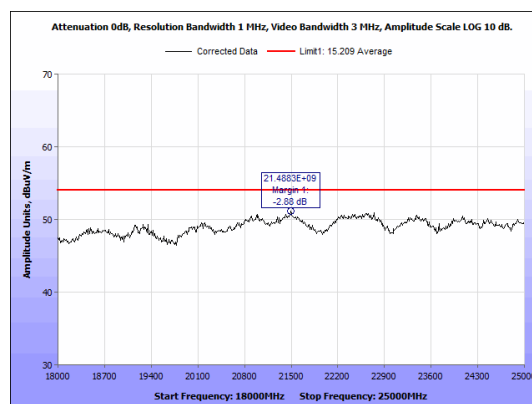


Figure 22: Radiated Emission Average. IEEE 15.4 Mid Channel 18GHz-25GHz

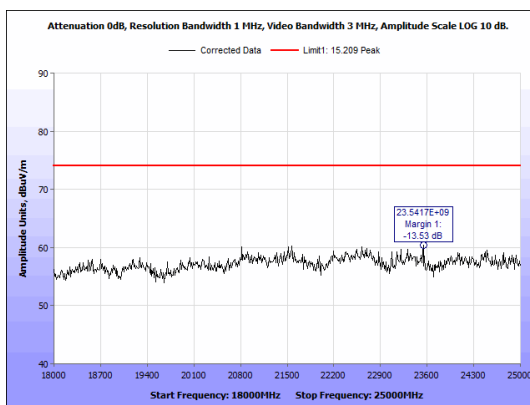


Figure 23: Radiated Emission Peak. IEEE 15.4 Mid Channel 18GHz-25GHz

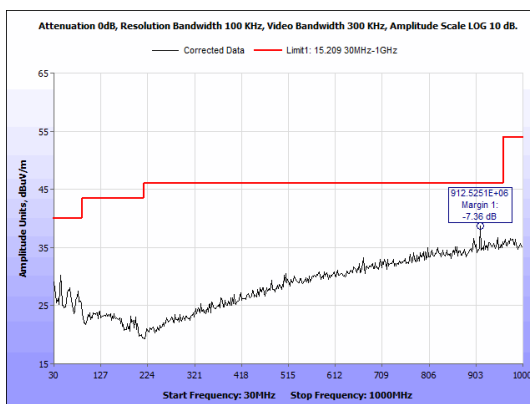


Figure 24: Radiated Spurious Emission. IEEE 15.4 High Channel 30MHz-1GHz

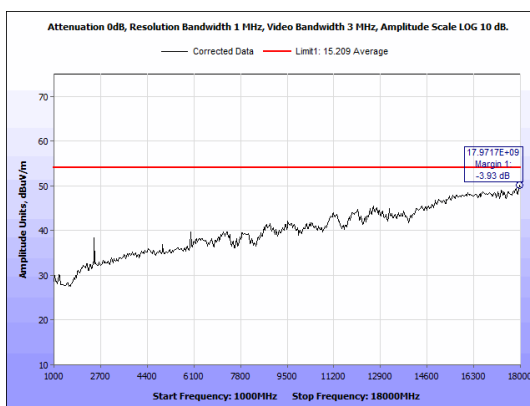


Figure 25: Radiated Emission Average. IEEE 15.4 High Channel 1GHz-18GHz

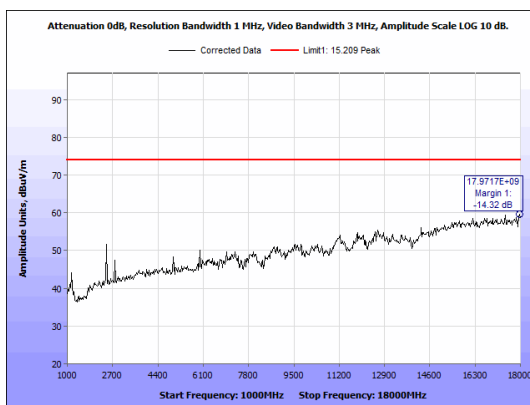


Figure 26: Radiated Emission Peak. IEEE 15.4 High Channel 1GHz-18GHz

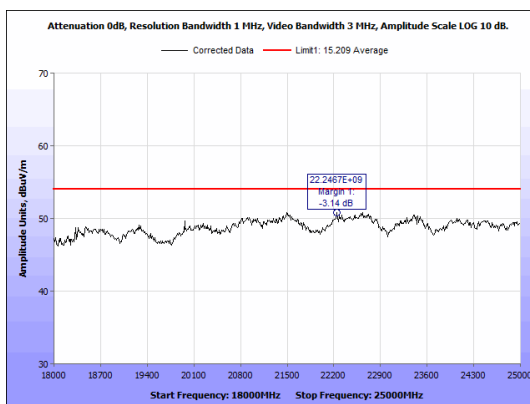


Figure 27: Radiated Emission Average. IEEE 15.4 High Channel 18GHz-25GHz

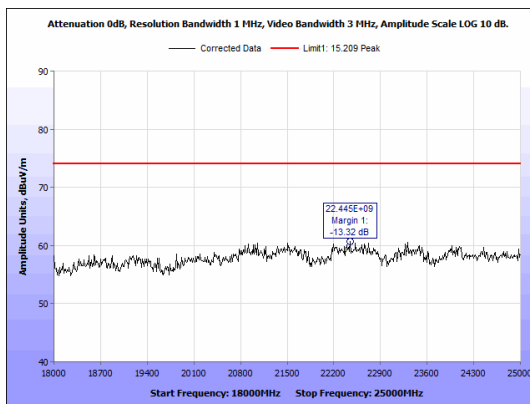


Figure 28: Radiated Emission Peak. IEEE 15.4 High Channel 18GHz-25GHz

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. Procedure defined in 6.3, 6.5 and 6.6 of ANSI C63.10 2013 were used. Band edge was measured using procedure defined in 6.10.5.2 of ANSI C63.10 2013. Plots shown are cumulative outcome of receiving antenna polarizations and EUT's emissions along 3 orthogonal axes.

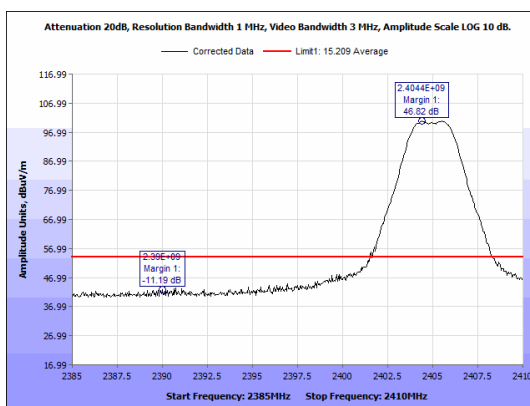


Figure 29: Radiated Restricted Band Edge Average. IEEE 15.4 Low Channel

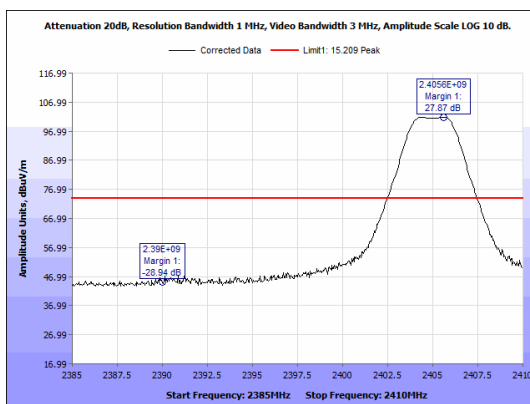


Figure 30: Radiated Restricted Band Edge Peak. IEEE 15.4 Low Channel

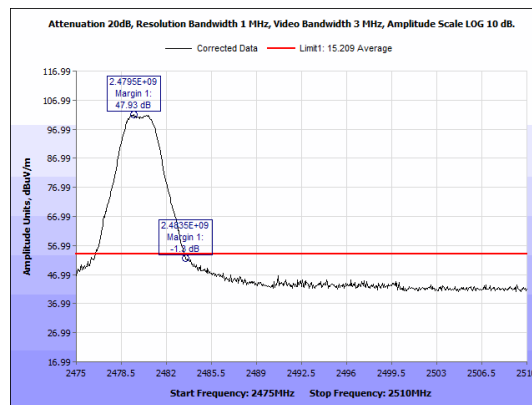


Figure 31: Radiated Restricted Band Edge Average. IEEE 15.4 High Channel

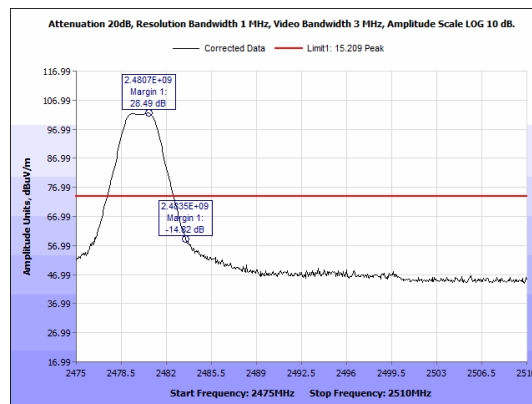


Figure 32: Radiated Restricted Band Edge Peak. IEEE 15.4 High Channel

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:	Measurement were performed using the procedure defined in 11.11.2 of ANSI C63.10 2013 to measure the reference level. 11.11.3 of ASNI C63.10 2013 was used to measure the spurious emission in the non- restricted band. Since Peak conducted output power and Peak power spectral density were measured, the reference level was set to 20dB below the peak emission. Low, mid and high channel were used for testing
Test Results:	The EUT was compliant with the Spurious Emission limits of §15.247(d) . Conducted test set up was used.
Test Engineer(s):	Deepak Giri
Test Date(s):	12/30/2020

Spurious Emissions in Non-restricted Bands, Test Results

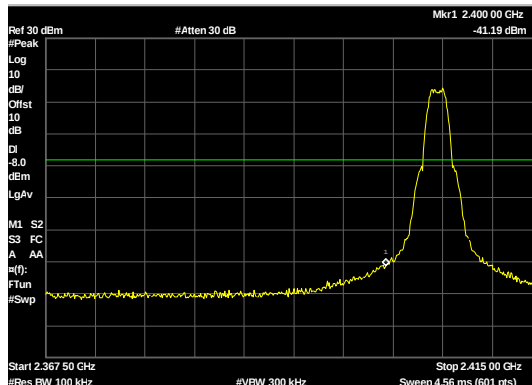


Figure 33: Conducted Spurious Emission Band Edge IEEE 15.4 Low Channel Plot

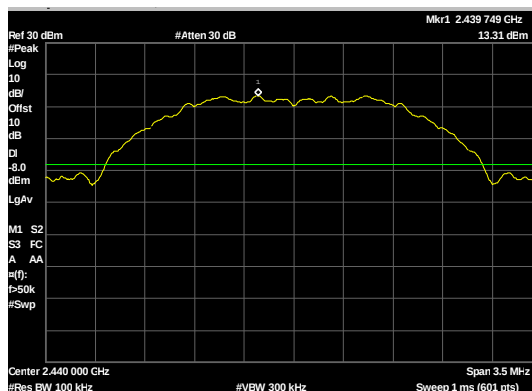


Figure 34: Conducted Spurious Emission Reference Level IEEE 15.4 Mid Channel

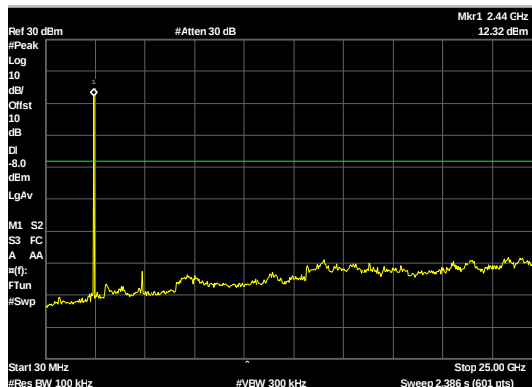


Figure 35: Conducted Spurious Emission IEEE 15.4 Mid Channel 30MHz - 25GHz

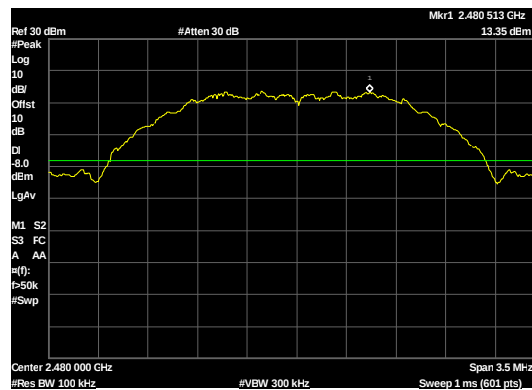


Figure 36: Conducted Spurious Emission Reference Level IEEE 15.4 High Channel Plot

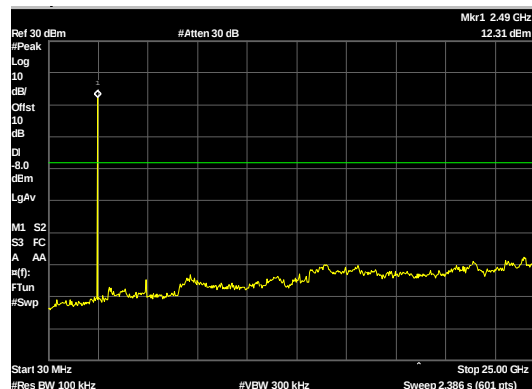


Figure 37: Conducted Spurious Emission IEEE 15.4 High Channel 30MHz - 25GHz Plot

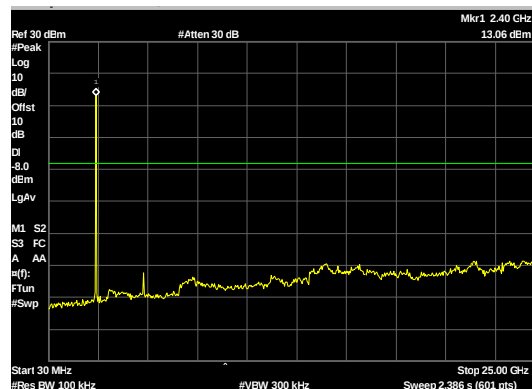


Figure 38: Conducted Spurious Emission IEEE 15.4 Low Channel 30MHz - 25GHz Plot

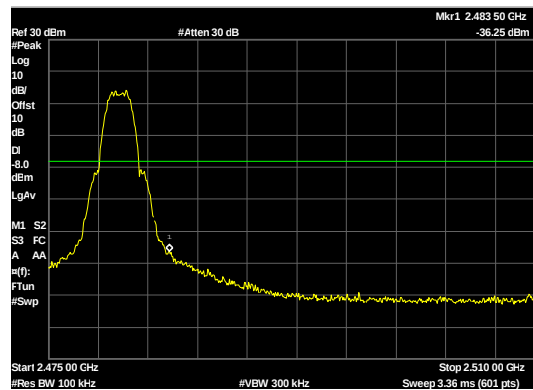


Figure 39: Conducted Spurious Emission Band Edge IEEE 15.4 High Channel Plot

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(e) Peak 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: Test method specified in 11.10.2 to measure Peak power spectral density was used to perform the measurement since Peak conducted output power measurement method was used to measure the conducted power. Measurement were performed on low, mid and high channel.

Test Results: The EUT was 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: 12/30/2020

Peak Power Spectral Density Test Results

Frequency (MHz)	Mode	Peak PSD measured (dBm)	PSD limit (dBm)	Margin
2405	IEEE 15.4	2.01	8	-5.99
2440		2.04	8	-5.96
2480		2.35	8	-5.65

Table 18. Peak Power Spectral Density, Test Results

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.

MPE Limit: EUT's operating frequencies @ 2400-2483.5 MHz; **Limit for Uncontrolled exposure: 1 mW/cm² or 10 W/m²**

Equation from page 18 of OET 65, Edition 97-01

$$S = PG / 4\pi R^2 \quad \text{or} \quad R = \sqrt{(PG / 4\pi S)}$$

where, S = Power Density (mW/cm²)
P = Power Input to antenna (mW)
G = Antenna Gain (numeric value)
R = Distance (cm)

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
2402	19.5	89.125	-1	0.794	0.01408	1	0.98592	20	Pass

Worst-case manufacturing power including tolerance.

The safe distance where Power Density is less than the MPE Limit listed above was found to be 20 cm. Tolerance is 1dBm.

IV. Test Equipment

Test Equipment

Calibrated test equipment utilized during testing was maintained in a current state of calibration per the requirements of ISO/IEC 17025:2005.

MET Asset #	Equipment	Manufacturer	Model	Last Cal Date	Cal Due Date
1T4771	PSA Spectrum Analyzer	Agilent Technologies	E4446A	02/26/2020	08/26/2021
1T4757	Antenna; Horn	ETS-Lindgren	3117	06/29/2020	12/29/2021
1T8743	Preamplifier	A.H. Systems, Inc.	PAM-0118P	Func Verify	
1T4612	Spectrum Analyzer	Agilent Technologies	E4407B	03/04/2020	09/04/2021
1T4875	LISN	Com-Power	LI-150A	11/12/2019	05/12/2021
1T4795	LISN	Com-Power	LI-150A	11/11/2019	05/11/2021
1T4409	EMI Receiver	Rohde & Schwarz	ESIB7	01/04/2019	01/04/2021
1T4771	PSA Spectrum Analyzer	Agilent Technologies	E4446A	02/26/2020	08/26/2021
1T4681	Spectrum Analyzer	Agilent Technologies	E4448A	04/07/2020	04/07/2021
1T4757	Antenna; Horn	ETS-Lindgren	3117	06/29/2020	12/29/2021
1A1161	DRG Horn Antenna	ETS Lindgren	3116C-PA	06/03/2020	06/03/2022
1T4751	Antenna - Bilog	Sunol Sciences	JB6	05/02/2019	01/02/2021
1T8743	Preamplifier	A.H. Systems, Inc.	PAM-0118P	Func Verify	

Table 19. Test Equipment List

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

V. Certification & User's Manual Information

Certification & User's Manual Information

A. Certification Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 2, Subpart I — Marketing of Radio frequency devices:

§ 2.801 Radio-frequency device defined.

As used in this part, a radio-frequency device is any device which in its operation is capable of Emitting radio-frequency energy by radiation, conduction, or other means. Radio- frequency devices include, but are not limited to:

- (a) The various types of radio communication transmitting devices described throughout this chapter.
- (b) *The incidental, unintentional and intentional radiators defined in Part 15 of this chapter.*
- (c) The industrial, scientific, and medical equipment described in Part 18 of this chapter.
- (d) Any part or component thereof which in use emits radio-frequency energy by radiation, conduction, or other means.

§ 2.803 Marketing of radio frequency devices prior to equipment authorization.

- (a) Except as provided elsewhere in this chapter, no person shall sell or lease, or offer for sale or lease (including advertising for sale or lease), or import, ship or distribute for the purpose of selling or leasing or offering for sale or lease, any radio frequency device unless:
 - (1) In the case of a device subject to certification, such device has been authorized by the Commission in accordance with the rules in this chapter and is properly identified and labeled as required by §2.925 and other relevant sections in this chapter; or
 - (2) In the case of a device that is not required to have a grant of equipment authorization issued by the Commission, but which must comply with the specified technical standards prior to use, such device also complies with all applicable administrative (including verification of the equipment or authorization under a Declaration of Conformity, where required), technical, labeling and identification requirements specified in this chapter.
- (d) Notwithstanding the provisions of paragraph (a) of this section, the offer for sale solely to business, commercial, industrial, scientific or medical users (but not an offer for sale to other parties or to end users located in a residential environment) of a radio frequency device that is in the conceptual, developmental, design or pre-production stage is permitted prior to equipment authorization or, for devices not subject to the equipment authorization requirements, prior to a determination of compliance with the applicable technical requirements *provided* that the prospective buyer is advised in writing at the time of the offer for sale that the equipment is subject to the FCC rules and that the equipment will comply with the appropriate rules before delivery to the buyer or to centers of distribution.

- (e)(1) Notwithstanding the provisions of paragraph (a) of this section, prior to equipment authorization or determination of compliance with the applicable technical requirements any radio frequency device may be operated, but not marketed, for the following purposes and under the following conditions:
- (i) *Compliance testing;*
 - (ii) Demonstrations at a trade show provided the notice contained in paragraph (c) of this section is displayed in a conspicuous location on, or immediately adjacent to, the device;
 - (iii) Demonstrations at an exhibition conducted at a business, commercial, industrial, scientific or medical location, but excluding locations in a residential environment, provided the notice contained in paragraphs (c) or (d) of this section, as appropriate, is displayed in a conspicuous location on, or immediately adjacent to, the device;
 - (iv) Evaluation of product performance and determination of customer acceptability, provided such operation takes place at the manufacturer's facilities during developmental, design or pre-production states; or
 - (v) Evaluation of product performance and determination of customer acceptability where customer acceptability of a radio frequency device cannot be determined at the manufacturer's facilities because of size or unique capability of the device, provided the device is operated at a business, commercial, industrial, scientific or medical user's site, but not at a residential site, during the development, design or pre-production stages.
- (e)(2) For the purpose of paragraphs (e)(1)(iv) and (e)(1)(v) of this section, the term *manufacturer's facilities* includes the facilities of the party responsible for compliance with the regulations and the manufacturer's premises, as well as the facilities of other entities working under the authorization of the responsible party in connection with the development and manufacture, but not the marketing, of the equipment.
- (f) For radio frequency devices subject to verification and sold solely to business, commercial, industrial, scientific and medical users (excluding products sold to other parties or for operation in a residential environment), parties responsible for verification of the devices shall have the option of ensuring compliance with the applicable technical specifications of this chapter at each end user's location after installation, provided that the purchase or lease agreement includes a proviso that such a determination of compliance be made and is the responsibility of the party responsible for verification of the equipment.

Certification & User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 2, Subpart J — Equipment Authorization Procedures:

§ 2.901 Basis and Purpose

- (a) In order to carry out its responsibilities under the Communications Act and the various treaties and international regulations, and in order to promote efficient use of the radio spectrum, the Commission has developed technical standards for radio frequency equipment and parts or components thereof. The technical standards applicable to individual types of equipment are found in that part of the rules governing the service wherein the equipment is to be operated.¹ *In addition to the technical standards provided, the rules governing the service may require that such equipment be verified by the manufacturer or importer, be authorized under a Declaration of Conformity, or receive an equipment authorization from the Commission by one of the following procedures: certification or registration.*
- (b) The following sections describe the verification procedure, the procedure for a Declaration of Conformity, and the procedures to be followed in obtaining certification from the Commission and the conditions attendant to such a grant.

§ 2.907 Certification.

- (a) Certification is an equipment authorization issued by the Commission, based on representation and test data submitted by the applicant.
- (b) Certification attaches to all units subsequently marketed by the grantee which are identical (see Section 2.908) to the sample tested except for permissive changes or other variations authorized by the Commission pursuant to Section 2.1043.

¹ In this case, the equipment is subject to the rules of Part 15. More specifically, the equipment falls under Subpart B (of Part 15), which deals with unintentional radiators.

Certification & User's Manual Information

§ 2.948 Description of measurement facilities.

- (a) Each party making measurements of equipment that is subject to an equipment authorization under Part 15 or Part 18 of this chapter, regardless of whether the measurements are filed with the Commission or kept on file by the party responsible for compliance of equipment marketed within the U.S. or its possessions, shall compile a description of the measurement facilities employed.
 - (1) If the measured equipment is subject to the verification procedure, the description of the measurement facilities shall be retained by the party responsible for verification of the equipment.
 - (i) *If the equipment is verified through measurements performed by an independent laboratory, it is acceptable for the party responsible for verification of the equipment to rely upon the description of the measurement facilities retained by or placed on file with the Commission by that laboratory. In this situation, the party responsible for the verification of the equipment is not required to retain a duplicate copy of the description of the measurement facilities.*
 - (ii) If the equipment is verified based on measurements performed at the installation site of the equipment, no specific site calibration data is required. It is acceptable to retain the description of the measurement facilities at the site at which the measurements were performed.
 - (2) If the equipment is to be authorized by the Commission under the certification procedure, the description of the measurement facilities shall be filed with the Commission's Laboratory in Columbia, Maryland. The data describing the measurement facilities need only be filed once but must be updated as changes are made to the measurement facilities or as otherwise described in this section. At least every three years, the organization responsible for filing the data with the Commission shall certify that the data on file is current.

Certification & User's Manual Information

1. Label and User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 15, Subpart A — General:

§ 15.19 Labeling requirements.

(a) *In addition to the requirements in Part 2 of this chapter, a device subject to certification or verification shall be labeled as follows:*

- (1) Receivers associated with the operation of a licensed radio service, e.g., FM broadcast under Part 73 of this chapter, land mobile operation under Part 90, etc., shall bear the following statement in a conspicuous location on the device:

This device complies with Part 15 of the FCC Rules. Operation is subject to the condition that this device does not cause harmful interference.

- (2) A stand-alone cable input selector switch, shall bear the following statement in a conspicuous location on the device:

This device is verified to comply with Part 15 of the FCC Rules for use with cable television service.

- (3) All other devices shall bear the following statement in a conspicuous location on the device:

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

- (4) Where a device is constructed in two or more sections connected by wires and marketed together, the statement specified under paragraph (a) of this section is required to be affixed only to the main control unit.

- (5) When the device is so small or for such use that it is not practicable to place the statement specified under paragraph (a) of this section on it, the information required by this paragraph shall be placed in a prominent location in the instruction manual or pamphlet supplied to the user or, alternatively, shall be placed on the container in which the device is marketed. However, the FCC identifier or the unique identifier, as appropriate, must be displayed on the device.

§ 15.21 Information to user.

The user's manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Verification & User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 15, Subpart B — Unintentional Radiators:

§ 15.105 Information to the user.

- (a) For a Class A digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at own expense.

- (b) For a Class B digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a residential environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

End of Report