UNIFIED COMPLIANCE LABORATORY

427 West 12800 South
Draper, UT 84020

Test Report

Certification

FCC ID	SWX-WAVELR
IC ID	6545A-WAVELR
Equipment Under Test	Wave-LR
Test Report Serial Number	TR7005_04
Date of Tests	12 June 2023
Report Issue Date	22 June 2023

Test Specification	Applicant
47 CFR FCC Part 15, Subpart C RSS-Gen	Ubiquiti Inc. 685 Third Avenue New York, NY 10017 U.S.A.

NVLAP TESTING ilac-MRA

NVLAP LAB CODE 600241-0

Certification of Engineering Report

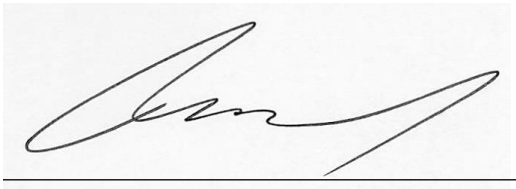
This report has been prepared by Unified Compliance Laboratory (UCL) to document compliance of the device described below with the requirement of Federal Communication Commissions (FCC) Part 15, Subpart C. This report may be reproduced in full. Partial reproduction of this report may only be made with the written consent of the laboratory. The results in this report apply only to the sample tested.

Applicant	Ubiquiti Inc.
Manufacturer	Ubiquiti Inc.
Brand Name	UBIQUITI
Model Number	Wave-LR
FCC ID	SWX-WAVELR
IC ID	6545A-WAVELR

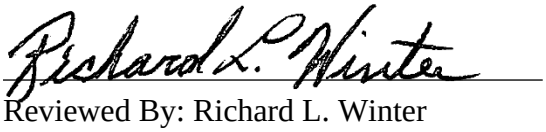
On this 22nd day of June 2023, I individually and for Unified Compliance Laboratory certify that the statements made in this engineering report are true, complete, and correct to the best of my knowledge and are made in good faith.

Although NVLAP has accredited the Unified Compliance Laboratory testing facilities, this report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST or any agency of the U.S. federal government.

Unified Compliance Laboratory



Written By: Clay Allred



Reviewed By: Richard L. Winter

Revision History		
Revision	**Description**	**Date**
01	Original Report Release	30 March 2022
02	Added all firmware versions	31 May 2022
03	Updated Antenna information and added new test data for RF Power, PSD, OBW and Spurious Emissions	16 June 2023
04	Corrected Test Date on cover page	22 June 2023

Table of Contents

1 Client Information

1.1 Applicant

Company	Ubiquiti Inc. 685 Third Avenue New York, NY 10017 U.S.A.
Contact Name	Alex Macon
Title	Compliance

1.2 Manufacturer

Company	Ubiquiti Inc. 685 Third Avenue New York, NY 10017 U.S.A.
Contact Name	Alex Macon
Title	Compliance

2 Equipment Under Test (EUT)

2.1 Identification of EUT

Brand Name	UBIQUITI
Model Number	Wave-LR
Serial Number	245A4C2F9F38
Dimensions (cm)	42.4 x 42.4 x 6.6

2.2 Description of EUT

The Wave-LR is a 60 GHz point-to-multipoint customer premise equipment that features wave technology with a 1.5+ Gbps throughput rate. The Wave-LR is also equipped with a 5 GHz WiFi 6 backup radio to sustain connectivity during a 60 GHz link disruption caused by inclement weather conditions. A Bluetooth LE transceiver is included for device management. The Wave-LR is an outdoor device and has an Ethernet port which is used for data transfer and to provide power using an Ubiquiti U-POE-at 48-volt PoE power adapter.

This report covers the circuitry of the device subject to FCC Part 15, Subpart C. The circuitry of the device subject to FCC Part 15 Subpart B was found to be compliant and is covered under a separate Unified Compliance Laboratory test report.

2.3 EUT and Support Equipment

The EUT and support equipment used during the test are listed below.

Brand Name **Model Number** **Serial Number**	**Description**	**Name of Interface Ports / Interface Cables**
BN: UBIQUITI MN: Wave-LR (Note 1) SN: 245A4C2F9F38	Wireless Access Point	See Section 2.4
BN: Ubiquiti MN: U-POE-at SN: N/A	PoE Power Adapter	Shielded or Un-shielded cat 5e cable
BN: Dell MN: XPS 13 SN: N/A	Laptop Computer	Shielded or Un-shielded cat 5e cable

Notes: (1) EUT
(2) Interface port connected to EUT (See Section 2.4)

The support equipment listed above was not modified in order to achieve compliance with this standard.

2.4 Interface Ports on EUT

Name of Ports	No. of Ports Fitted to EUT	Cable Description/Length
AC (PoE Injector)	1	3 conductor power cord/80cm
LAN (PoE Injector)	1	Shielded or Un-shielded cat 5e cable/1 meter
Data	1	Shielded or Un-shielded cat 5e cable/1 meter

2.5 Operating Environment

Power Supply	120 Volts ac to 48 Volts PoE
AC Mains Frequency	60 Hz
Temperature	22.0-22.7 °C
Humidity	18.7-22.9 %
Barometric Pressure	1000 mBar

2.6 Operating Modes

The Wave-LR was connected to a personal computer laptop and tested using test software in order to enable to constant duty cycle greater or equal to 98% of the Bluetooth transceiver.

2.7 EUT Exercise Software

EUT firmware version 1.0 was used to operate the transmitter using a constant transmit mode, while Wave-Nano BSP image v3 (spfll.4-csul) was used for all modes.

2.8 Block Diagram of Test Configuration

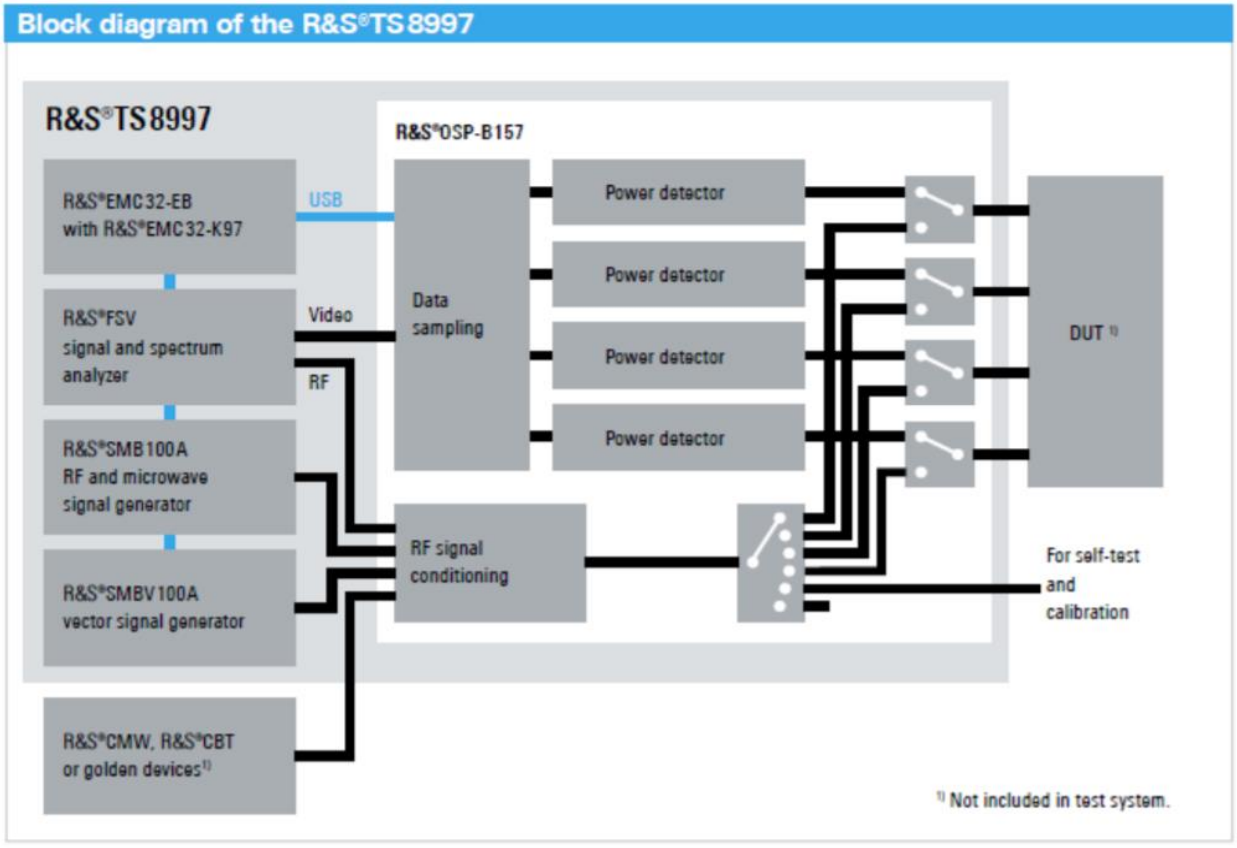


Diagram 1: Test Configuration Block Diagram

2.9 Modification Incorporated/Special Accessories on EUT

There were no modifications made to the EUT during testing to comply with the specification.

2.10 Deviation, Opinions Additional Information or Interpretations from Test Standard

There were no deviations, opinions, additional information or interpretations from the test specification.

3 Test Specification, Method and Procedures

3.1 Test Specification

Title	47 CFR FCC Part 15, Subpart C 15.203, 15.207 and 15.247 Limits and methods of measurement of radio interference characteristics of radio frequency devices.
Purpose of Test	The tests were performed to demonstrate initial compliance

3.2 Methods & Procedures

3.2.1 47 CFR FCC Part 15 Section 15.203

See test standard for details.

3.2.2 47 CFR FCC Part 15 Section 15.207

See test standard for details.

3.2.3 47 CFR FCC Part 15 Section 15.247

See test standard for details.

3.3 FCC Part 15, Subpart C

3.3.1 Summary of Tests

FCC Section	ISED Section	Environmental Phenomena	Frequency Range (MHZ)	Result
15.203	N/A	Antenna requirements	Structural Requirement	Compliant
15.207	RSS-Gen	Conducted Disturbance at Mains Port	0.15 to 30	Compliant
15.247(a)	RSS-247 § 5.2	Bandwidth Requirement	2400 to 2480	Compliant
15.247(b)	RSS-247 § 5.4	Peak Output Power	2400 to 2480	Compliant
15.247(d)	RSS-247 § 5.4	Antenna Conducted Spurious Emissions	0.009 to 40000	N/A
15.247(d)	RSS-247 § 5.4	Radiated Spurious Emissions	30 to 40000	Compliant
15.247(e)	RSS-247 § 5.2	Peak Power Spectral Density	2400 to 2480	Compliant
The testing was performed according to the procedures in ANSI C63.10-2013, KDB 558074 and 47 CFR Part 15. Where applicable, KDB 662911 was followed to sum required measurements.				

3.4 Results

In the configuration tested, the EUT complied with the requirements of the specification.

3.5 Test Location

Testing was performed at the Unified Compliance Laboratory 3-meter and 10-meter chamber located at 427 West 12800 South, Draper, UT 84020. Unified Compliance Laboratory is accredited by National Voluntary Laboratory Accreditation Program (NVLAP); NVLAP Code 600241-0 which is effective until 30 June 2022. This site has also been registered with Innovations, Science and Economic Development (ISED) department and was accepted under Appendix B, Phase 1 procedures of the APEC Tel MRA for Canadian recognition. ISED No.: 25346, effective until 30 June 2022. Unified Compliance Laboratory has been assigned Conformity Assessment Number US0223 by ISED.

4 Test Equipment

4.1 Conducted Emissions at Mains Ports

Type of Equipment	Manufacturer	Model Number	Asset Number	Date of Last Calibration	Due Date of Calibration
EMI Receiver	AFJ	FFT3010	UCL-2500	6/27/2022	6/27/2023
LISN	AFJ	LS16C/10	UCL-6749	12/6/2021	12/6/2023
ISN	Teseq	ISN T800	UCL-2974	6/27/2022	6/27/2023
LISN	Com-Power	LIN-120C	UCL-2612	1/24/2023	1/24/2024
AC Power Source	Laplace Instruments	AC1000A	UCL-2857	N/A	N/A
Test Software	UCL	Revision 1	UCL-3107	N/A	N/A

Table 1: List of equipment used for Conducted Emissions Testing at Mains Port

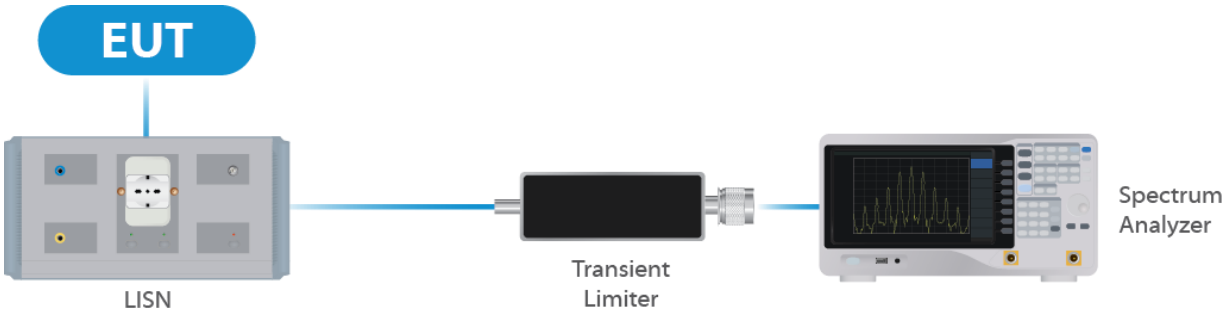


Figure 1: Conducted Emissions Test

4.2 Direct Connect at the Antenna Port Tests

Type of Equipment	Manufacturer	Model Number	Asset Number	Date of Last Calibration	Due Date of Calibration
Spectrum Analyzer	R&S	FSV40	UCL-2861	11/7/2022	11/7/2023
Signal Generator	R&S	SMB100A	UCL-2864	N/A	N/A
Vector Signal Generator	R&S	SMBV100A	UCL-2873	N/A	N/A
Switch Extension	R&S	OSP-B157WX	UCL-2867	2/22/2023	2/22/2024
Switch Extension	R&S	OSP-150W	UCL-2870	2/22/2023	2/22/2024

Table 2: List of equipment used for Direct Connect at the Antenna Port

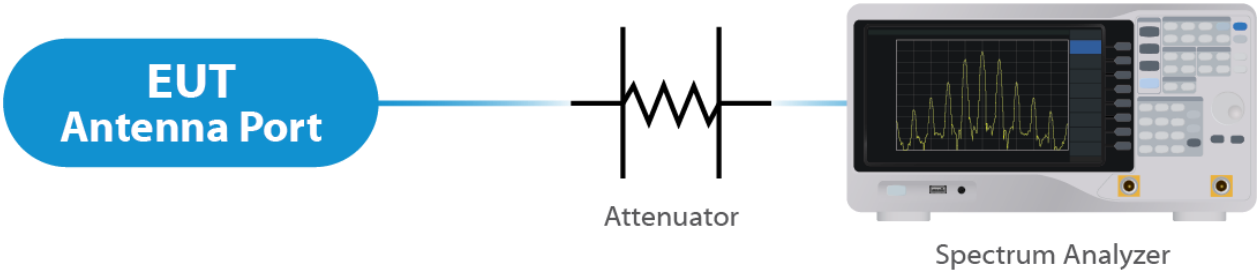


Figure 2: Direct Connect at the Antenna Port Test

4.3 Radiated Emissions

Type of Equipment	Manufacturer	Model Number	Asset Number	Date of Last Calibration	Due Date of Calibration
EMI Receiver	Keysight	N9038A	UCL-2778	1/27/2023	1/27/2024
Pre-Amplifier 9 kHz – 1 GHz	Sonoma Instruments	310N	UCL-2889	10/7/2021	10/7/2023
Broadband Antenna	Scwarzbeck	VULB 9163	UCL-3062	2/22/2023	2/22/2025
Broadband Antenna	Scwarzbeck	VULB 9163	UCL-3071	1/11/2023	1/11/2025
Double Ridge Horn Antenna	Scwarzbeck	BBHA 9120D	UCL-3065	9/22/2022	9/22/2024
Log Periodic	Scwarzbeck	STLP 9129	UCL-3068	1/27/2023	1/27/2025
15 - 40 GHz Horn Antenna	Scwarzbeck	BBHA 9170	UCL-2487	6/09/2022	6/09/2024
1 – 18 GHz Amplifier	Com-Power	PAM 118A	UCL-3833	12/9/2022	12/9/2023
Test Software	UCL	Revision 1	UCL-3108	N/A	N/A

Table 3: List of equipment used for Radiated Emissions

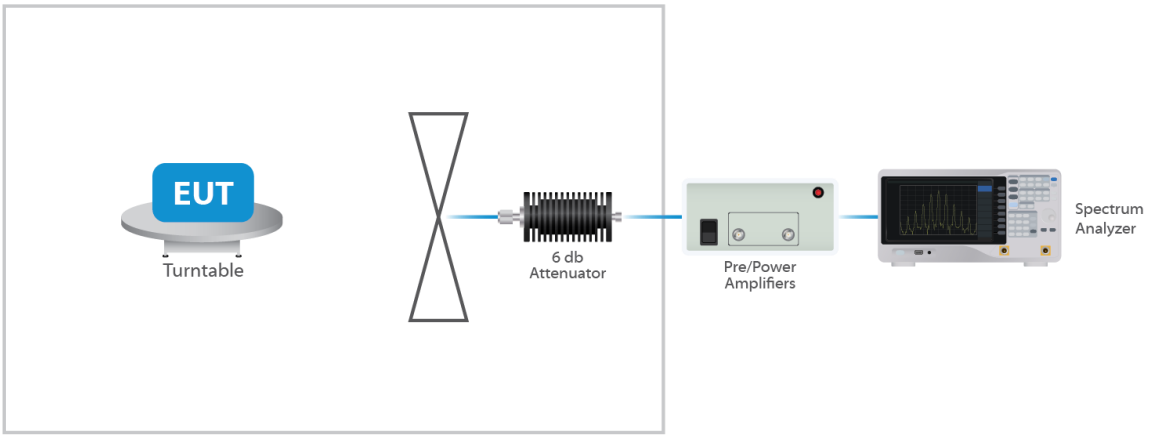


Figure 3: Radiated Emissions Test

4.4 Equipment Calibration

All applicable equipment is calibrated using either an independent calibration laboratory or Unified Compliance Laboratory personnel at intervals defined in ANSI C63.4:2014 following outlined calibration procedures. All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Supporting documentation relative to traceability is on file and is available for examination upon request.

4.5 Measurement Uncertainty

Test	Uncertainty (± dB)	Confidence (%)
Conducted Emissions	1.44	95
Radiated Emissions (9 kHz to 30 MHz)	2.50	95
Radiated Emissions (30 MHz to 1 GHz)	4.38	95
Radiated Emissions (1 GHz to 18 GHz)	4.37	95
Radiated Emissions (18 GHz to 40 GHz)	3.93	95
Direct Connect Tests	**K Factor**	**Value**
Emissions Bandwidth	2	2.0%
Output Power	2	1.0 dB
Peak Power Spectral Density	2	1.3 dB
Band Edge	2	0.8 dB
Transmitter Spurious Emissions	2	1.8 dB

5 Test Results

5.1 §15.203 Antenna Requirements

The EUT uses an integral antenna. The Maximum gain of the antenna is 6.8 dBi. The antenna is not user replaceable.

Results

The EUT complied with the specification

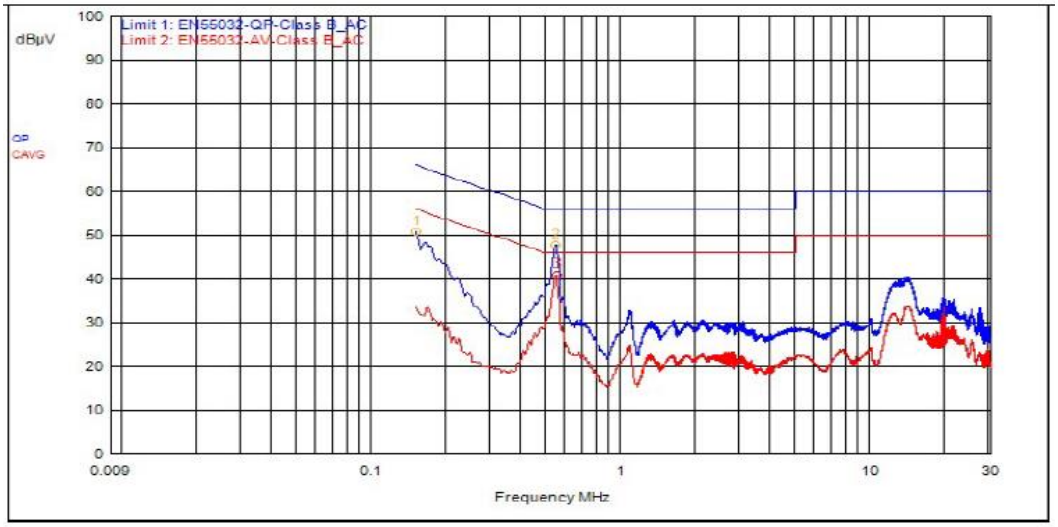
5.2 Conducted Emissions at Mains Ports Data

Frequency (MHZ)	AC Mains Lead	Detector	Measured Level (dBµV)	Limit (dBµV)	Margin (dB)
0.540	Hot Lead	Quasi-Peak (Note 2)	47.3	56.0	- 8.70
0.153	Hot Lead	Quasi-Peak (Note 2)	52.0	65.9	- 13.90
0.531	Hot Lead	Average (Note 2)	40.0	46.0	- 6.00
0.540	Neutral Lead	Quasi-Peak (Note 2)	47.8	56.0	- 8.20
0.150	Neutral Lead	Quasi-Peak (Note 2)	50.7	66.0	- 15.30
0.546	Neutral Lead	Average (Note 2)	40.9	46.0	- 5.10

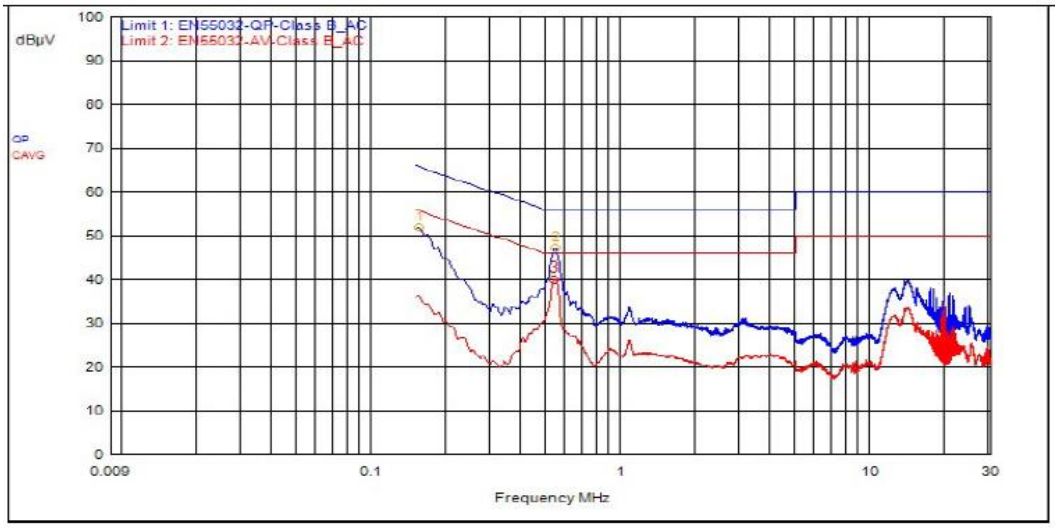
Note 1: The reference detector used for the measurements was Quasi-Peak or Peak and the data was compared to the average limit: therefore, the EUT was deemed to meet both the average and quasi-peak limits.
Note 2: The reference detector used for the measurements was quasi-peak and average and the data was compared to the respective limits.
Note 3: The device the transceiver is in is a Class A device and the limits shown are from §15.207 which are the same as the limits for a Class B device under §15.107. These emissions were investigated and were found to be at the same level regardless of whether the transceivers of the device were not powered, powered and idle, or powered and active, therefore, the conducted emissions of the transceivers were deemed compliant with the requirements of the standard.

Result

The EUT complied with the specification limit.



Graph 1: Conducted Emissions Plot - Neutral



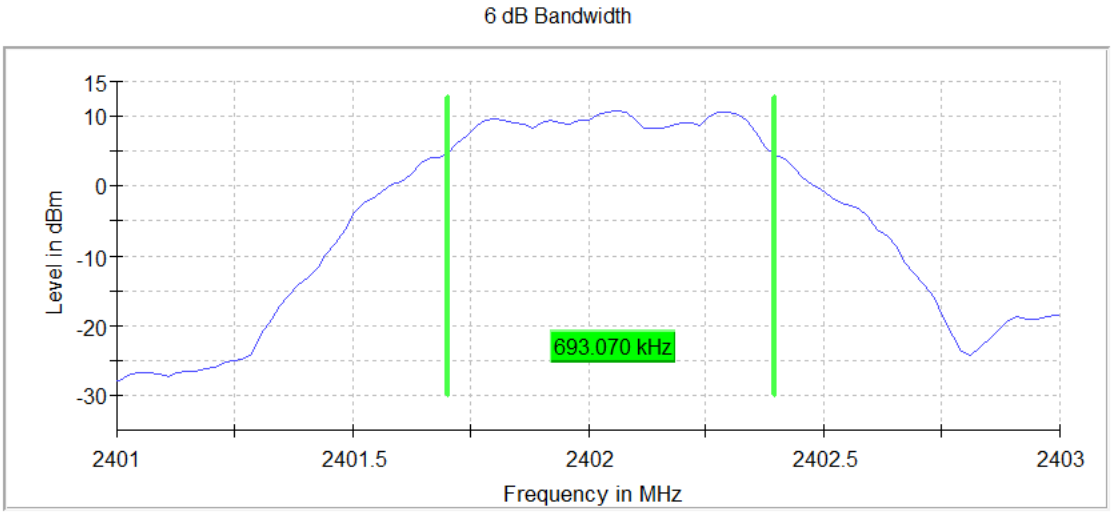
Graph 2: Conducted Emissions Plot – Line 1

5.3 §15.247(a)(2) Emissions Bandwidth

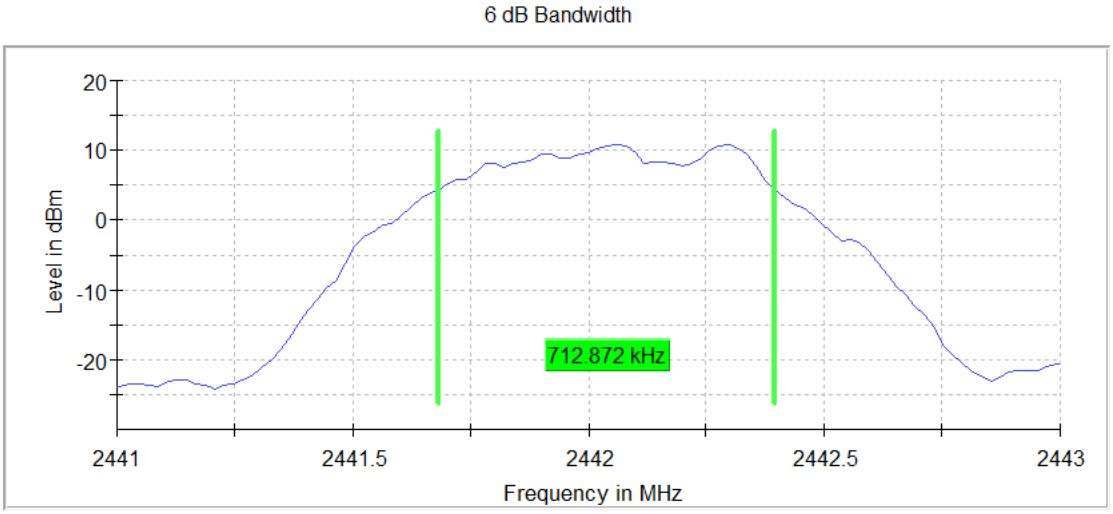
Frequency (MHz)	Emissions 6 dB Bandwidth (MHz)	Emissions 99% Bandwidth (MHz)
2402	0.69	1.03
2442	0.71	1.03
2480	0.71	1.02

Result

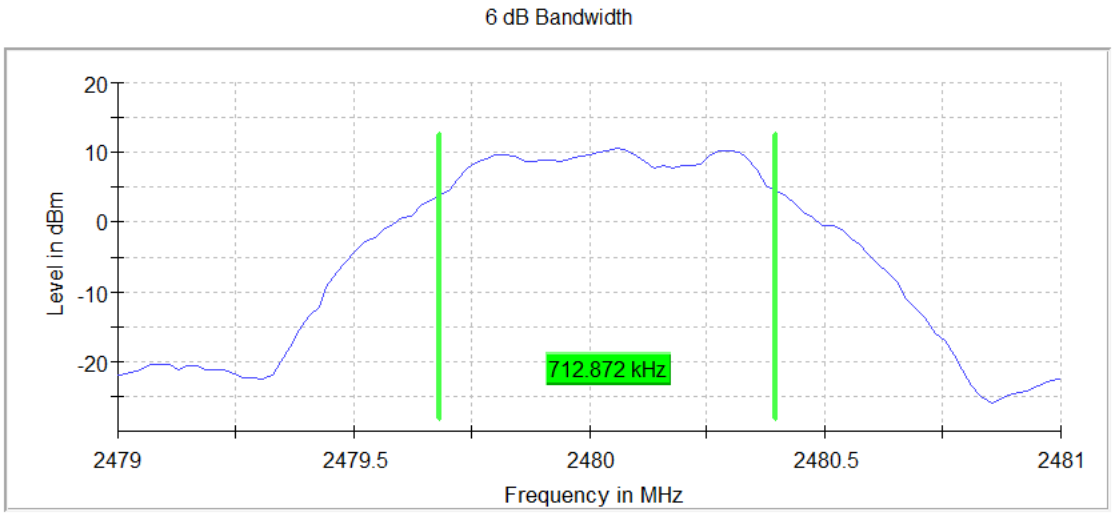
In the configuration tested, the 6 dB bandwidth was greater than 500 kHz; therefore, the EUT complied with the requirements of the specification (see spectrum analyzer plot within the Annex).



Graph 3: OBW Plot – 2402 MHz



Graph 4: OBW Plot – 2442 MHz



Graph 5: OBW Plot – 2480 MHz

5.4 §15.247(b)(3) Maximum Average Output Power

The maximum average RF conducted output power measured for this device was 12.32 dBm or 17.3 mW. The limit is 30 dBm or 1 Watt when using antennas with 6 dBi or less gain. The antenna has a gain of 6.8 dBi, therefore the limit was reduced to 29.2dBm and 831.8mW

Frequency (MHz)	Measured Output Power (dBm)	Output Power (mW)
2402	12.16	16.4
2442	12.13	16.3
2480	12.06	16.1

Result

In the configuration tested, the maximum average RF output power was less than 0.831W; therefore, the EUT complied with the requirements of the specification (see spectrum analyzer plot within the Annex).

5.5 §15.247(d) Spurious Emissions

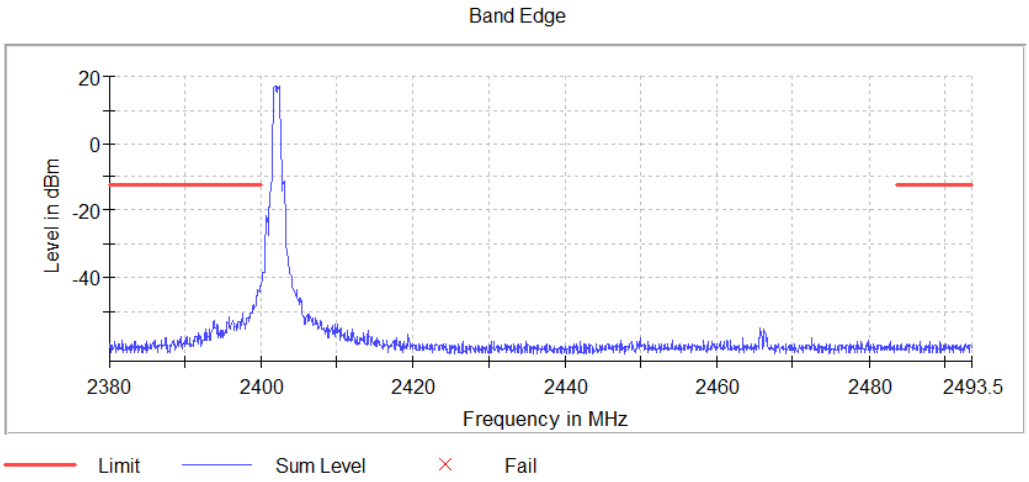
5.5.1 Conducted Spurious Emissions

The frequency range is from the lowest frequency generated or used in the device to the tenth harmonic of the highest fundamental frequency was investigated to measure any antenna-conducted emissions. The table show the measurement data from spurious emissions noted across the frequency range when transmitting at the lowest frequency, middle frequency and upper frequency. Shown within the Annex are plots with the EUT tuned to the upper and lower channels. These demonstrate compliance with the provisions of this section at the band edges.

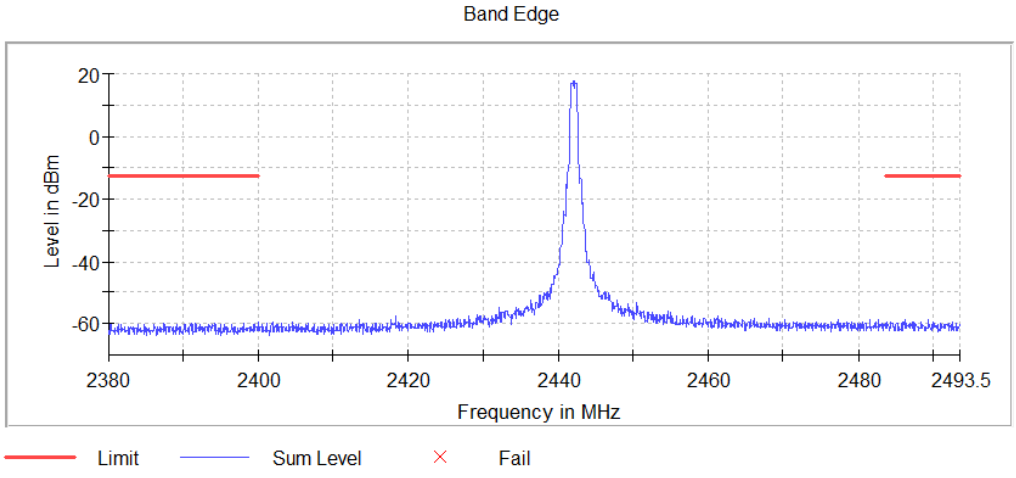
The emissions must be attenuated 30 dB below the highest power spectral density level measured within the authorized band as measured with a 100 kHz RBW.

Result

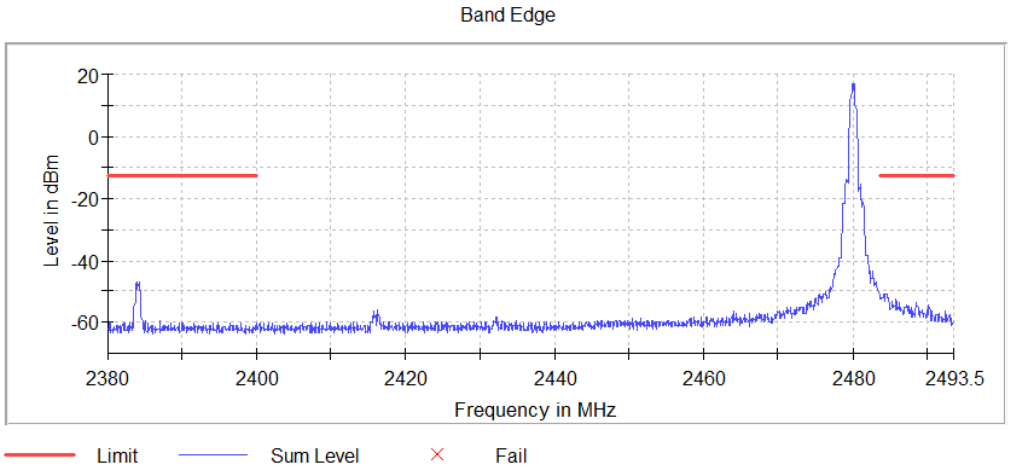
Conducted spurious emissions were attenuated 30 dB or more below the fundamental; therefore, the EUT complies with the specification. (see Annex for complete data)



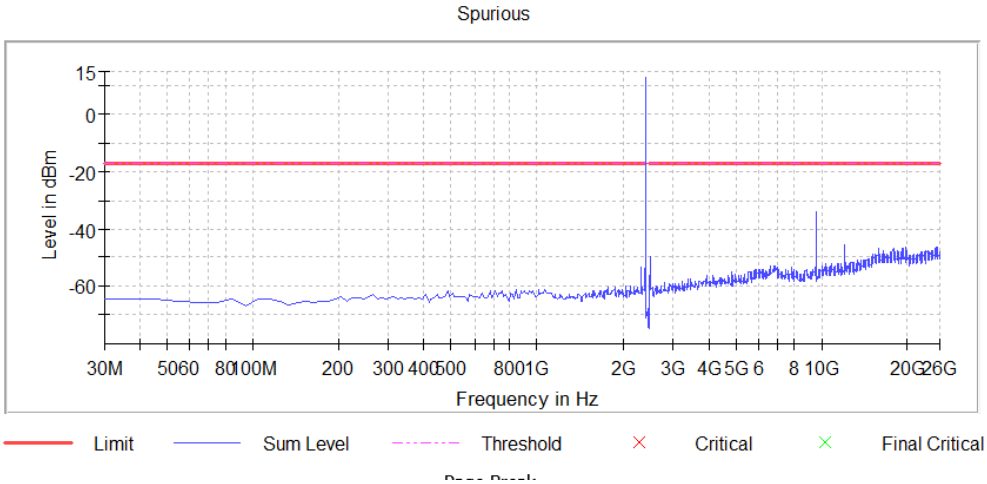
Graph 6: Band Edge Plot 2402 MHz



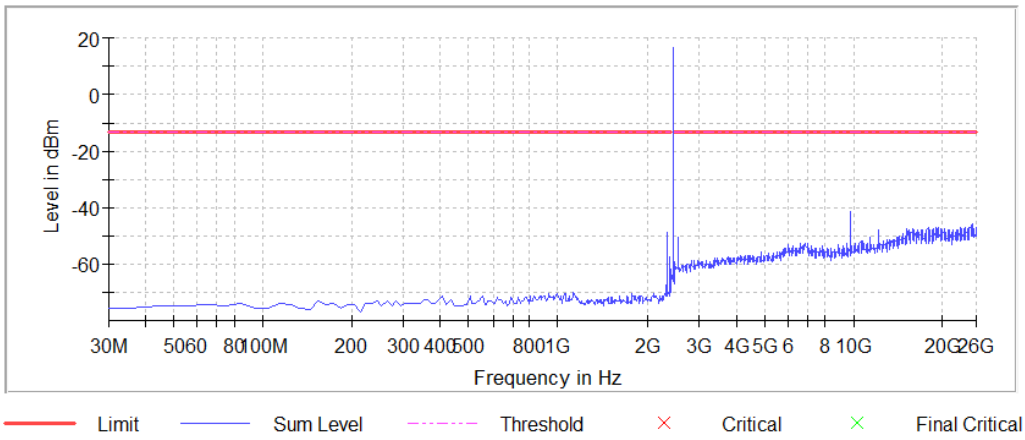
Graph 7: Band Edge Plot 2442 MHz



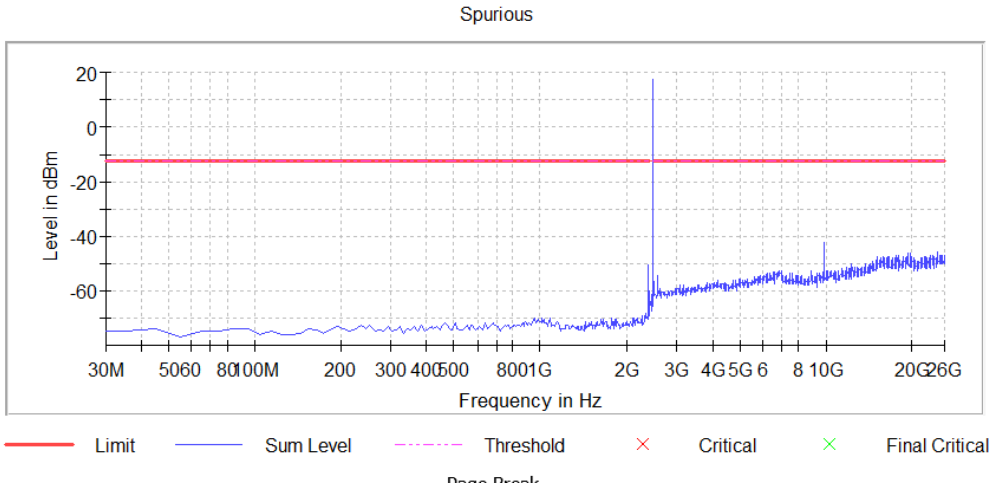
Graph 8: Band Edge Plot 2480 MHz



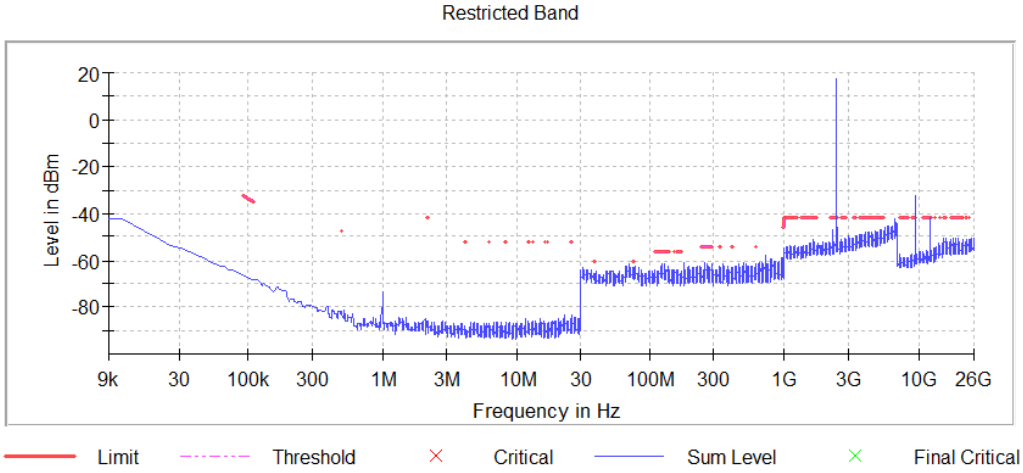
Graph 9: TX Spurious Plot 2402 MHz



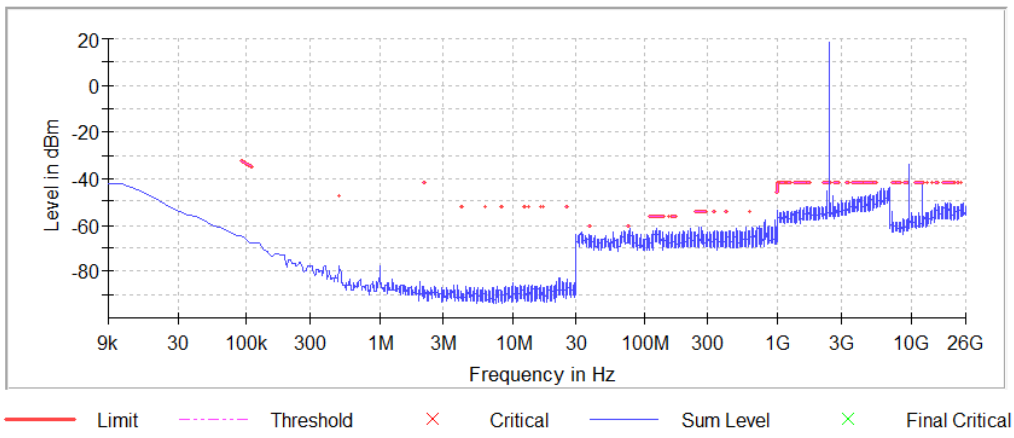
Graph 10: TX Spurious Plot 2442 MHz



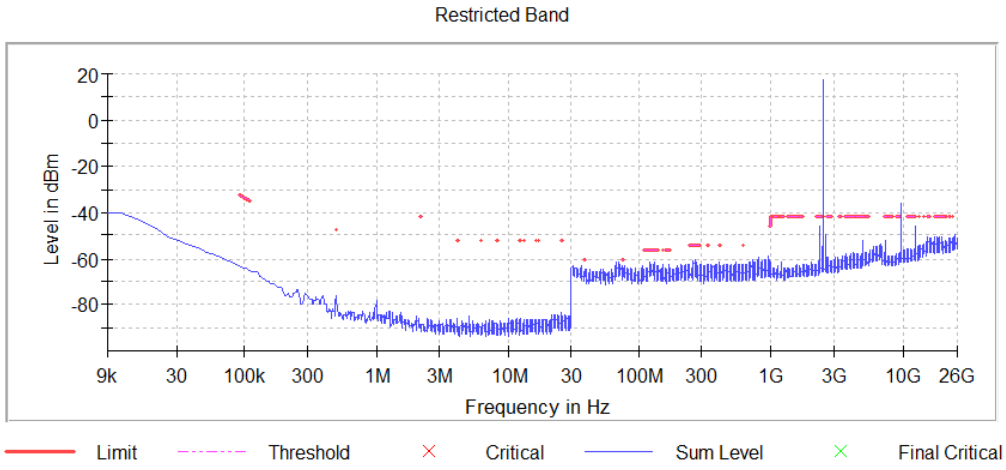
Graph 11: TX Spurious Plot 2480 MHz



Graph 12: Emissions in restricted frequency bands Plot 2402 MHz



Graph 13: Emissions in restricted frequency bands Plot 2442 MHz



Graph 14: Emissions in restricted frequency bands Plot 2480 MHz

5.6 §15.247(e) Maximum Average Power Spectral Density

The maximum average power spectral density conducted from the intentional radiator of the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. Results of this testing are summarized.

Frequency (MHz)	Measurement (dBm)	Criteria (dBm)
2402	1.19	8.0
2442	1.29	8.0
2480	1.15	8.0

Result

The maximum average power spectral density was less than the limit of 8 dBm; therefore, the EUT complies with the specification.

-- End of Test Report --