UNIFIED COMPLIANCE LABORATORY

427 West 12800 South
Draper, UT 84020

Test Report

Certification

FCC ID	SWX-WAVELR
ISED ID	6545A-WAVELR
Equipment Under Test	Wave-LR
Test Report Serial Number	TR7130_02
Date of Tests	14, 28 February; 1, 16, 25 March 2022
Report Issue Date	11 May 2022

Test Specification	Applicant
47 CFR FCC Part 15, Subpart E	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

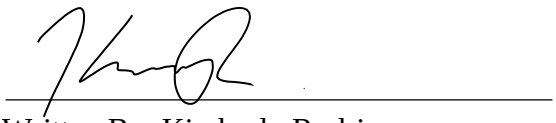
This report has been prepared by Unified Compliance Laboratory (UCL) to document compliance of the device described below with the requirement of Federal Communication Commissions (FCC) Part 15, Subpart E. This report may be reproduced in full. Partial reproduction of this report may only be made with 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	airFiber
Model Number	Wave-LR
FCC ID	SWX-WAVELR
ISED ID	6545A-WAVELR

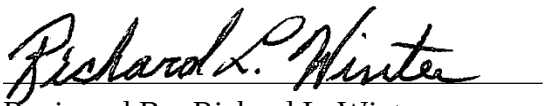
On this 11th day of May 2022, I individually and for Unified Compliance Laboratory certify that the statements made in this engineering report are true, complete, and correct to the best of my knowledge and are made in good faith.

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: Kimberly Rodriguez



Reviewed By: Richard L. Winter

Revision History		
Revision	**Description**	**Date**
01	Original Report Release	11 May 2022
02	Added Elevation Plot in Section 5.4	19 May 2022

Table of Contents

1 Client Information

1.1 Applicant

Company	Ubiquiti Inc. 685 Third Avenue New York, NY 10017 U.S.A.
Contact Name	Mark Feil
Title	Compliance Manager

1.2 Manufacturer

Company	Ubiquiti Inc. 685 Third Avenue New York, NY 10017 U.S.A.
Contact Name	Mark Feil
Title	Compliance Manager

2 Equipment Under Test (EUT)

2.1 Identification of EUT

Brand Name	airFiber
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.

Band	WiFi Mode	Modulation Bandwidth	Modulation Type	Frequency (MHz)
UNII-1	ax	20 MHz	HE	5165, 5175, 5185, 5200, 5210, 5220, 5230, 5240
	ax	40 MHz	HE	5175, 5185, 5200, 5215, 5230
	ax	80 MHz	HE	5195, 5200, 5205, 5210

This report covers the circuitry of the device subject to FCC Part 15, Subpart E. 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 on the following page.

Brand Name Model Number Serial Number	Description	Name of Interface Ports / Interface Cables
BN: airFiber 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 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	22.2-22.7 °C
Humidity	18.2-25.2 %
Barometric Pressure	1000 mBar

2.6 Operating Modes

The Wave-LR was tested using test software to enable a constant transmission. The measurements within this report are corrected to reference a 100% duty cycle. All emission modes of 802.11 ax were investigated. All measurements are reported with the worst-case mode (802.11ax) unless otherwise stated.

2.7 EUT Exercise Software

EUT firmware version 1.0 was used to operate the transmitter using a constant transmit mode.

2.8 Block Diagram of Test Configuration

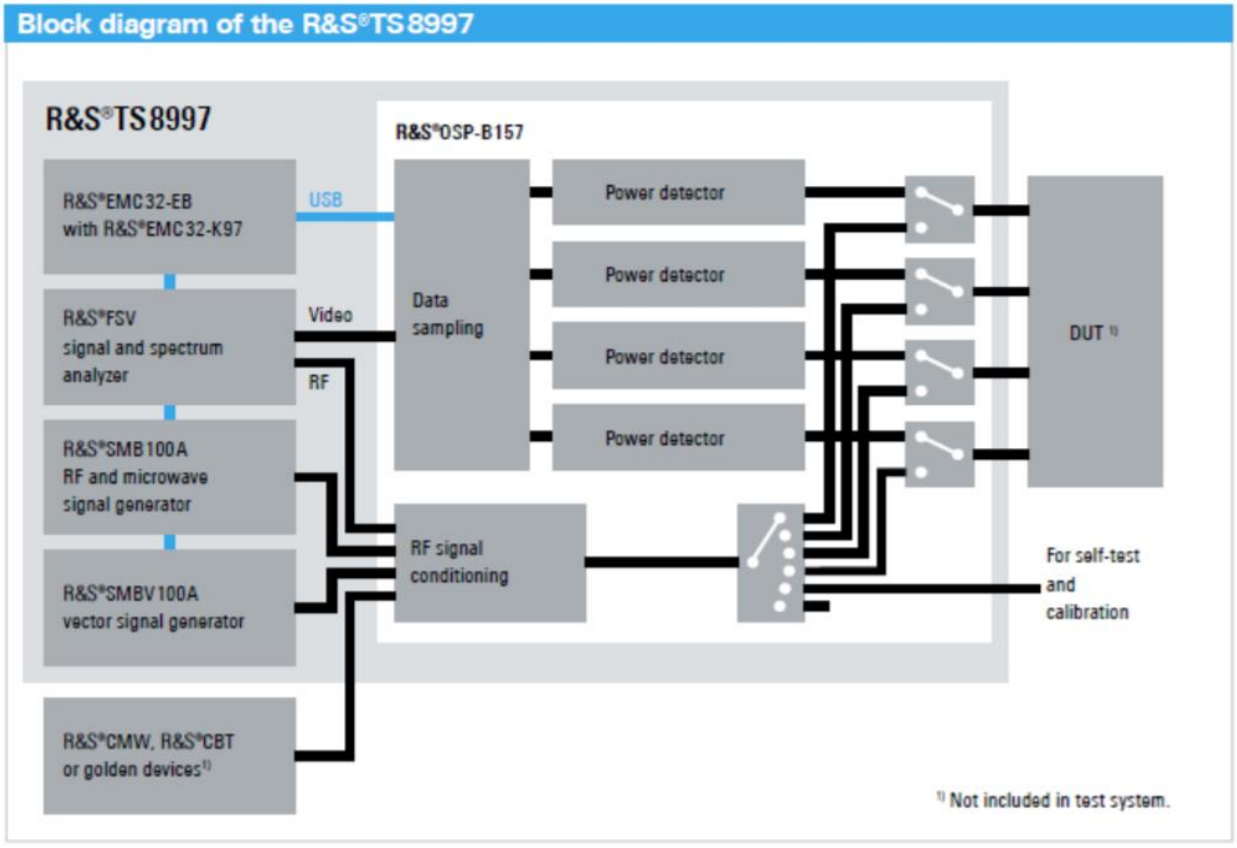


Diagram 1: Test Configuration Block Diagram

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 E, Section 15.407 Limits and methods of measurement of radio interference characteristics of Unlicensed National Information Infrastructure 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 15.407

See test standard for details.

3.3 FCC Part 15, Subpart E

3.3.1 Summary of Tests

FCC Section	ISED Section	Environmental Phenomena	Frequency Range (MHZ)	Result
15.407(a)	N/A	Antenna requirements	Structural Requirement	Compliant
15.407(b)	RSS-Gen	Conducted Disturbance at Mains Port	0.15 to 30	Compliant
15.407(c)	RSS-247 §6.2.2, §6.2.3	Bandwidth Requirement	5165 to 5240	Compliant
15.407(e)	RSS-247 §6.2.2, §6.2.3	Peak Output Power	5165 to 5240	Compliant
15.407(f)	RSS-247 §6.2.2, §6.2.3	Antenna Conducted Spurious Emissions	0.009 to 40000	N/A
15.407(g)	RSS-247 §6.2.2, §6.2.3	Radiated Spurious Emissions	30 to 40000	Compliant
15.407(h)	RSS-247 §6.2.2, §6.2.3	Peak Power Spectral Density	5165 to 5240	Compliant
The testing was performed according to the procedures in ANSI C63.10-2013, KDB 789033 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 as 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-6754	12/8/2021	12/8/2022
LISN	AFJ	LS16C/10	UCL-6749	12/6/2021	12/6/2023
Cat6 ISN	Teseq	ISN T8-Cat6	UCL-2971	1/30/2022	1/30/2023
ISN	Teseq	ISN T800	UCL-2974	6/4/2021	6/4/2022
LISN	Com-Power	LIN-120C	UCL-2612	1/6/2022	1/6/2023
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

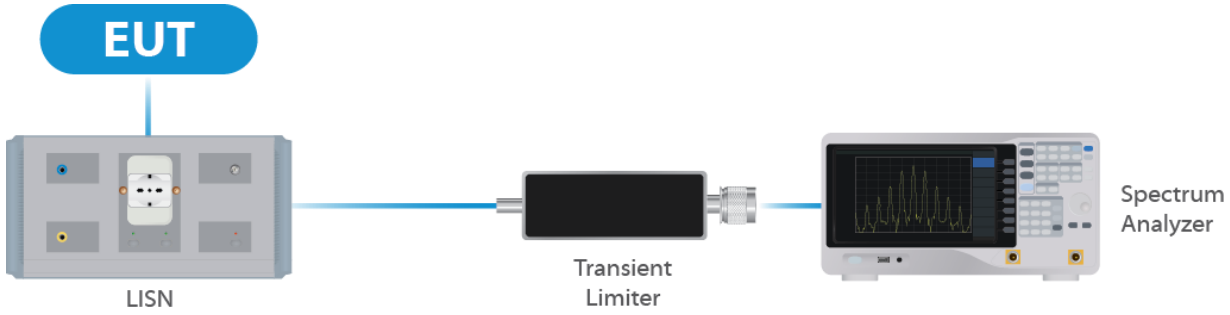


Figure 1: Conducted Emissions Test

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	1/03/2022	1/03/2023
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	1/03/2022	1/03/2023
Switch Extension	R&S	OSP-150W	UCL-2870	1/03/2022	1/03/2023

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

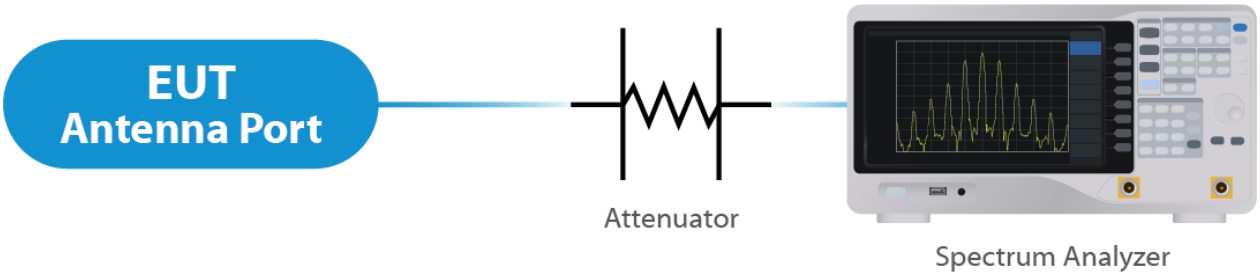


Figure 2: Direct Connect at the Antenna Port Test

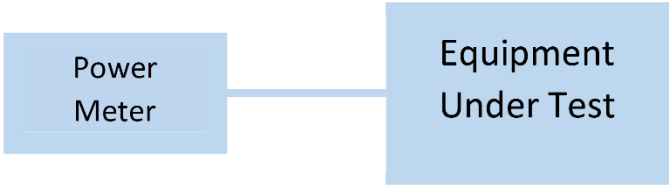


Figure 3: Output Power Measurement

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	6/21/2021	6/21/2022
Pre-Amplifier 9 kHz – 1 GHz	Sonoma Instruments	310N	UCL-2889	10/7/2021	10/7/2022
Broadband Antenna	Scwarzbeck	VULB 9163	UCL-3062	8/28/2020	8/27/2022
Broadband Antenna	Scwarzbeck	VULB 9163	UCL-3071	5/19/2020	5/19/2022
Double Ridge Horn Antenna	Scwarzbeck	BBHA 9120D	UCL-3065	7/8/2021	7/8/2022
Log Periodic	Scwarzbeck	STLP 9129	UCL-3068	11/16/2020	11/16/2022
15 - 40 GHz Horn Antenna	Scwarzbeck	BBHA 9170	UCL-2487	5/21/2020	5/21/2022
1 – 18 GHz Amplifier	Com-Power	PAM 118A	UCL-3833	10/7/2021	10/7/2022
Test Software	UCL	Revision 1	UCL-3108	N/A	N/A

Table 3: List of equipment used for Radiated Emissions

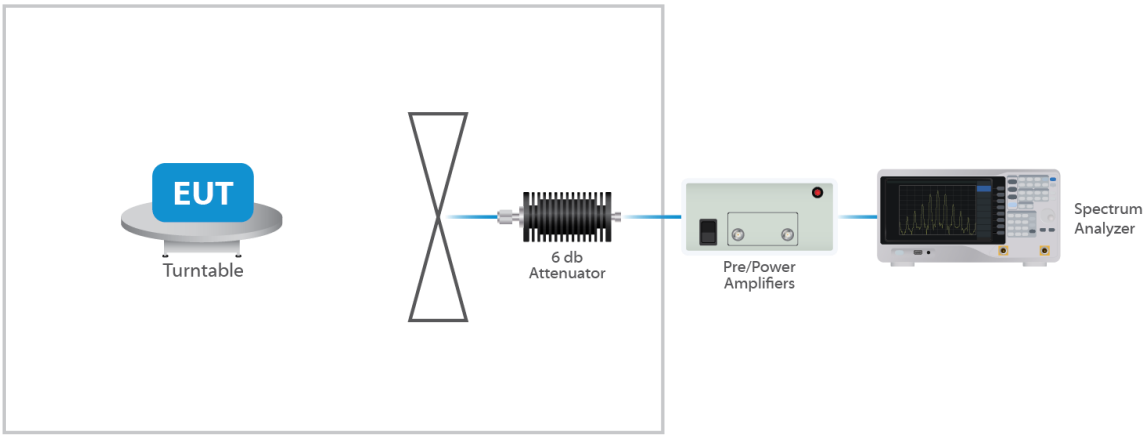


Figure 4: Radiated Emissions Test

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 folding antenna structure. The maximum gain of the antenna per chain is 21.2 dBi. This is an 802.11 device and utilizes CDD as described in KDB 662911 D01. The antenna is not user replaceable.

For power measurements on IEEE 802.11 devices, Array Gain = 0 dB for NANT ≤ 4;

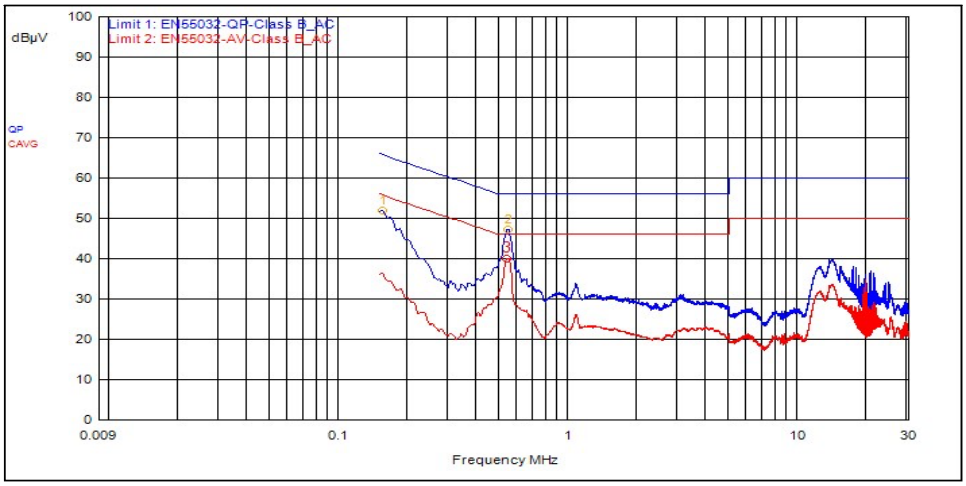
For PSD measurements when Nss=1: Array Gain = 10 log(Nant/Nss) dB = 6.02dB

Results

The EUT complied with the specification

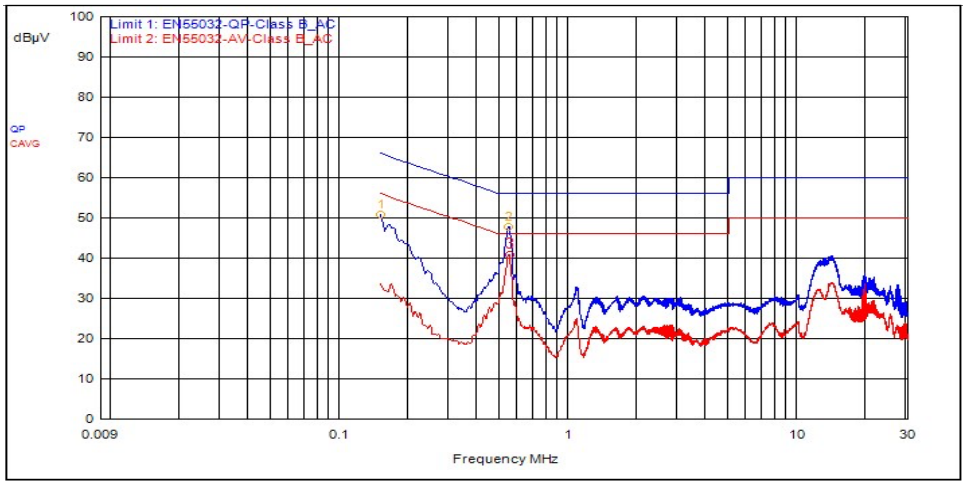
5.2 Conducted Emissions at Mains Ports Data

5.2.1 Line



ID	Frequency	Probe	Cable	Atten.	Detector	Meter Read	Meas Level	Limit 1	Limit 1 Dist.	Limit 2	Limit 2 Dist.
2	540,000kHz	9.5	0.1		QPeak	37.6	47.3	56.0	-8.7		
1	153,000kHz	9.5	0.0		QPeak	42.5	52.0	65.8	-13.9		
3	531,000kHz	9.5	0.1		C_AVG	30.3	40.0			46.0	-6.0

5.2.2 Neutral



ID	Frequency	Probe	Cable	Atten.	Detector	Meter Read	Meas Level	Limit 1	Limit 1 Dist.	Limit 2	Limit 2 Dist.
2	540,000kHz	9.5	0.1		QPeak	38.2	47.8	56.0	-8.2		
1	150,000kHz	9.5	0.0		QPeak	41.2	50.7	66.0	-15.3		
3	546,000kHz	9.5	0.1		C_AVG	31.2	40.9			46.0	-5.1

Result

The EUT complied with the specification limit.

5.3 §15.403(i) 26 dB Emissions Bandwidth

All chains were measured under the guidance of KDB 789033 Section II.C. and KDB 66291 D01. Please see associated annex for details on instrument settings.

Nominal BW (MHz)	Frequency (MHz)	99% Bandwidth (MHz)	Emissions 26 dB Bandwidth (MHz)
HE20	5165	18.90	20.60
HE20	5200	18.90	20.60
HE20	5240	18.90	20.20
HE40	5175	37.50	39.75
HE40	5200	37.50	39.60
HE40	5230	37.75	40.35
HE80	5195	76.50	82.00
HE80	5200	76.50	81.50
HE80	5210	77.00	81.00

Result

All chains were tested and the highest bandwidth per chain is reported above.

The 26 dB bandwidths are reported for information purposes. Please see Annex for all bandwidth measurements.

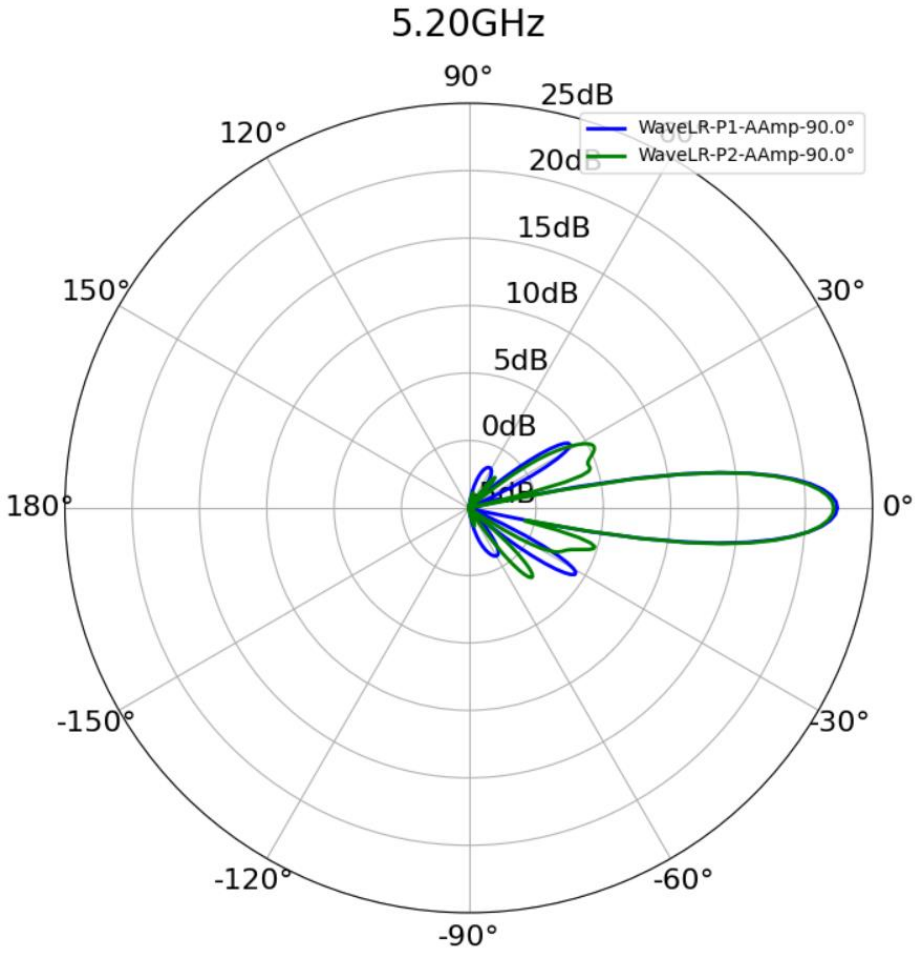
5.4 §15.407(a)(2) Maximum Average Output Power

All chains were measured and summed under the guidance of KDB 789033 Section II. E.2. and KDB 66291 D01. Please see associated annex for details on instrument settings.
The maximum average RF conducted output power measured for this device was 21.46 dBm or 139.96 mW. The limit is 30 dBm, or 1 Watt when using an antenna with 23 dBi (Fixed point to point) or less gain. The antenna has a gain of 21.2 dBi.

Modulation (BW)	Frequency (MHz)	Data Rate	TP Setting	Conducted Output Power	Measured EIRP	Measured PSD
HE 20	5165	Mcs0	24	14.50	35.70	1.99
HE 20	5200	Mcs0	27	21.70	42.90	8.33
HE 20	5240	Mcs0	36	21.20	42.40	7.67
HE 40	5175	Mcs0	27	16.40	37.60	0.30
HE 40	5200	Mcs0	33	19.80	41.00	4.06
HE 40	5230	Mcs0	36	21.46	42.66	5.55
HE 80	5195	Mcs0	13	9.10	30.30	-9.30
HE 80	5200	Mcs0	30	19.70	39.10	-0.33
HE 80	5210	Mcs0	30	18.00	39.20	-0.28

Result

In the configuration tested, the maximum summed average RF output power was less than 1 watt; therefore, the EUT compiled with the requirements of the specification (see spectrum analyzer plots in attached Annex).



Plot 1: Elevation Plot Greater Than 30-Degrees From Horizon

5.5 §15.407(b) Spurious Emissions

5.5.1 Conducted Spurious Emissions

The frequency range 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 graphs show the measurement data from spurious emissions noted across the frequency range when transmitting at the lowest frequency, middle and upper frequency. Shown below are plots with the EUT turned to the upper and lower channels with the antenna gain of 21.2 dBi accounted for. These demonstrate compliance with the provisions of this section at the band edges.

The emissions must be remain below -27 dBm EIRP.

Result

Conducted spurious emissions were below -27 dBm; therefore, the EUT complies with the specification.

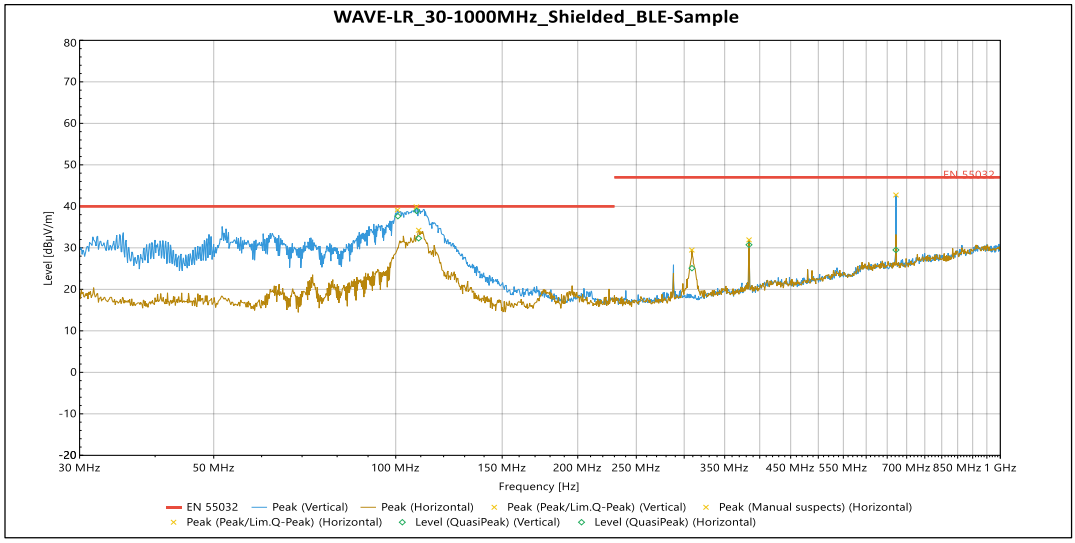
5.5.2 Radiated Spurious Emissions in the Restricted Bands of § 15.205

The EUT uses various power settings based on the channel in use. To reduce test time, the radiated spurious emissions at the lowest, middle, and highest channel were measured at the maximum power of TP38, as this setting was found to be worst case for spurious emissions. Power was subsequently reduced during in-band and band edge testing. The band edge at the restricted band ending at 5150 MHz was measured using radiated measurement or conducted at the antenna port methods. All emissions modes were tested, and the worst-case measurement are shown below. For frequencies above 1 GHz, a measurement of 3 meters was used. For frequencies below 1 GHz, a measurement distance of 10 meters was used.

Correction Factor = Antenna Factor + Cable Loss - Pre-Amplifier Gain, and is added to the Receiver reading.

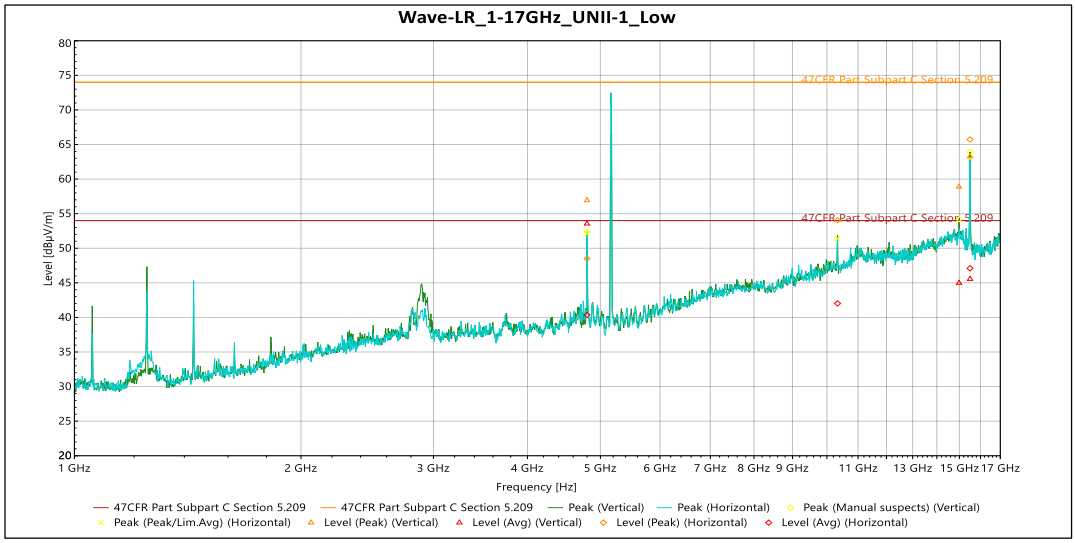
Result

All emissions in the restricted bands of § 15.205 met the limits specified in § 15.209; therefore, the EUT complies with the specification. All emissions me the limits specified in § 15.407(b). Representative band edge plots are included in this report.



Frequency	SR #	Level (dBµV/m)	Limit (dBµV/m)	Margin	Azimuth (°)	Height	Pol.	RBW (Hz)	Correction (dB)
100.83 MHz	QPeak	37.627	40	-2.373	340	1.378	Vertical	120000	-12.8
108.29 MHz	QPeak	38.899	40	-1.101	102	1.053	Vertical	120000	-13.591
671.94 MHz	QPeak	29.487	47	-17.513	301	2.656	Vertical	120000	-4.084
109.13 MHz	QPeak	32.305	40	-7.695	56	3.826	Horizontal	120000	-13.784
308.98 MHz	QPeak	25.1	47	-21.9	183	2.535	Horizontal	120000	-11.098
383.97 MHz	QPeak	30.743	47	-16.257	163	1.791	Horizontal	120000	-9.171

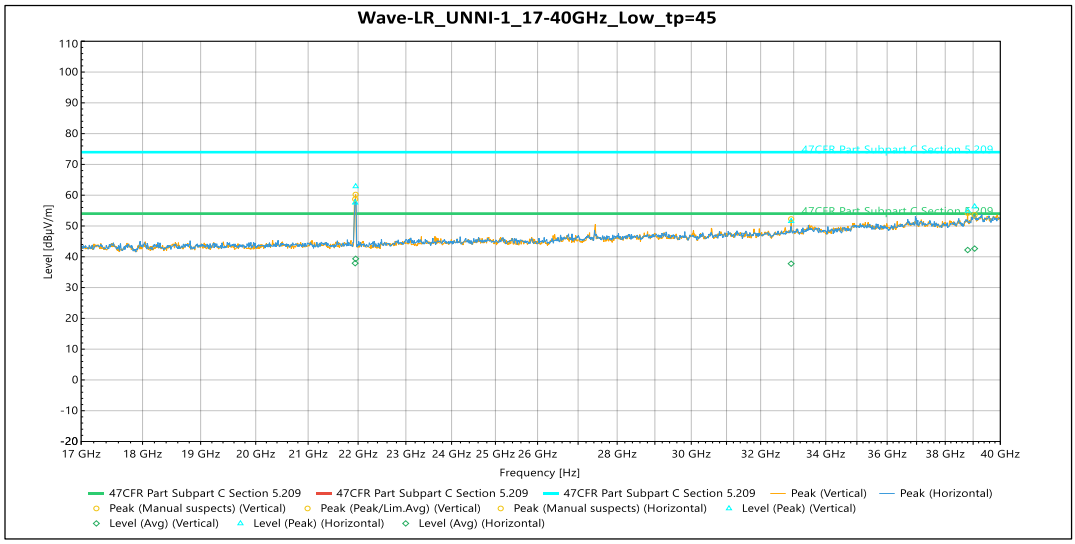
Table 4: Radiated Emission within 30 – 1000 MHz (worst case)



Frequency	SR #	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	Correction (dB)
4.7999 GHz	Peak	56.928	74	-17.072	185	2.174	Vertical	1.205
14.983 GHz	Peak	58.891	74	-15.109	343	3.107	Vertical	15.972
15.495 GHz	Peak	63.268	74	-10.732	358	1.5	Vertical	13.767
4.7999 GHz	AVG	53.551	54	-0.449	185	2.174	Vertical	1.205
14.983 GHz	AVG	44.984	54	-9.016	343	3.107	Vertical	15.972
15.495 GHz	AVG	45.553	54	-8.447	358	1.5	Vertical	13.767

Frequency	SR #	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	Correction (dB)
4.7998 GHz	Peak	48.498	74	-25.502	210	3.454	Horizontal	1.205
10.33 GHz	Peak	54.043	74	-19.957	6	3.282	Horizontal	12.102
15.495 GHz	Peak	65.72	74	-8.28	358	3.632	Horizontal	13.767
4.7998 GHz	AVG	40.35	54	-13.65	210	3.454	Horizontal	1.205
10.33 GHz	AVG	42.015	54	-11.985	6	3.282	Horizontal	12.102
15.495 GHz	AVG	47.105	54	-6.895	358	3.632	Horizontal	13.767

Table 5: Transmitting on the Low Frequency 5165 MHz



Frequency	SR	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Pol.	RBW	Correction (dB)
21.95 GHz	Peak	62.87	74	-11.13	130	Vertical	1000000	-5.691
32.923 GHz	Peak	51.586	74	-22.414	119	Vertical	1000000	0.206
38.804 GHz	Peak	54.926	74	-19.074	45	Vertical	1000000	2.387
21.95 GHz	AVG	39.35	54	-14.65	130	Vertical	1000000	-5.691
32.923 GHz	AVG	37.757	54	-16.243	119	Vertical	1000000	0.206
38.804 GHz	AVG	42.204	54	-11.796	45	Vertical	1000000	2.387
21.94 GHz	Peak	57.574	74	-16.426	126	Horizontal	1000000	-5.673
39.054 GHz	Peak	56.317	74	-17.683	237	Horizontal	1000000	3.188
21.94 GHz	AVG	37.905	54	-16.095	126	Horizontal	1000000	-5.673
39.054 GHz	AVG	42.659	54	-11.341	237	Horizontal	1000000	3.188

Table 6: Radiated Emissions within 17-40GHz Transmitting on the Lowest Frequency

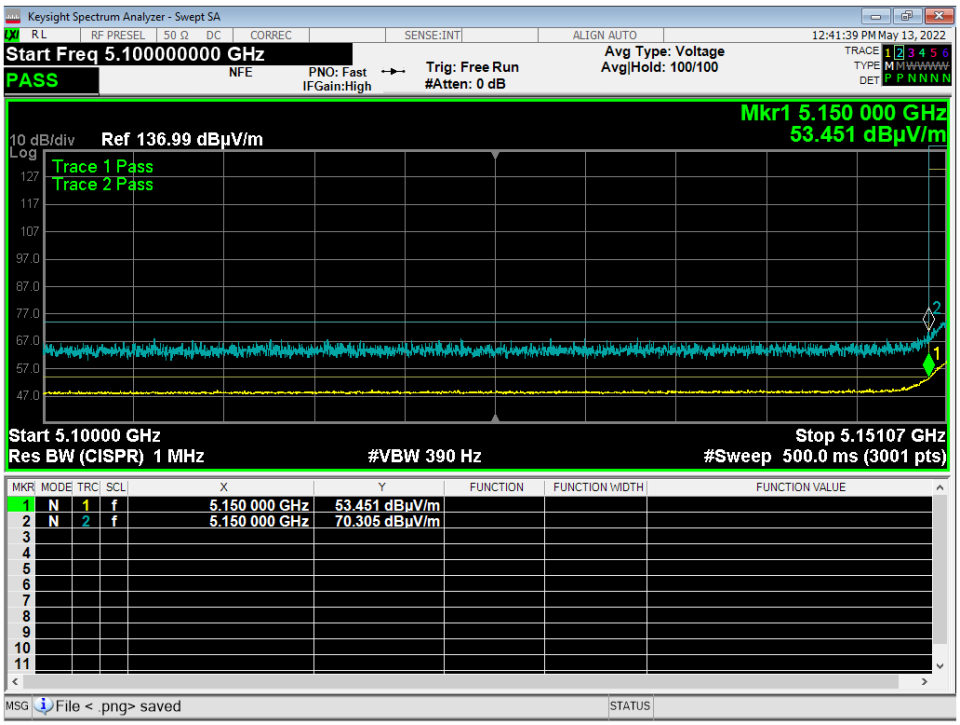


Figure 5: Band Edge Plot HE20 5165MHz

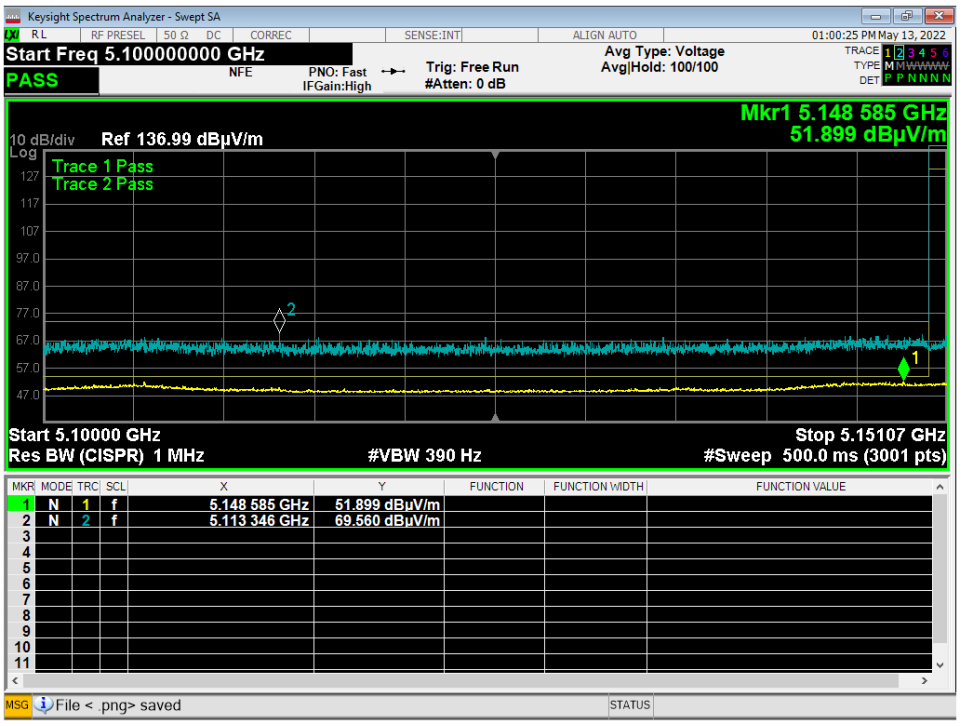


Figure 6: Band Edge Plot HE20 5200MHz

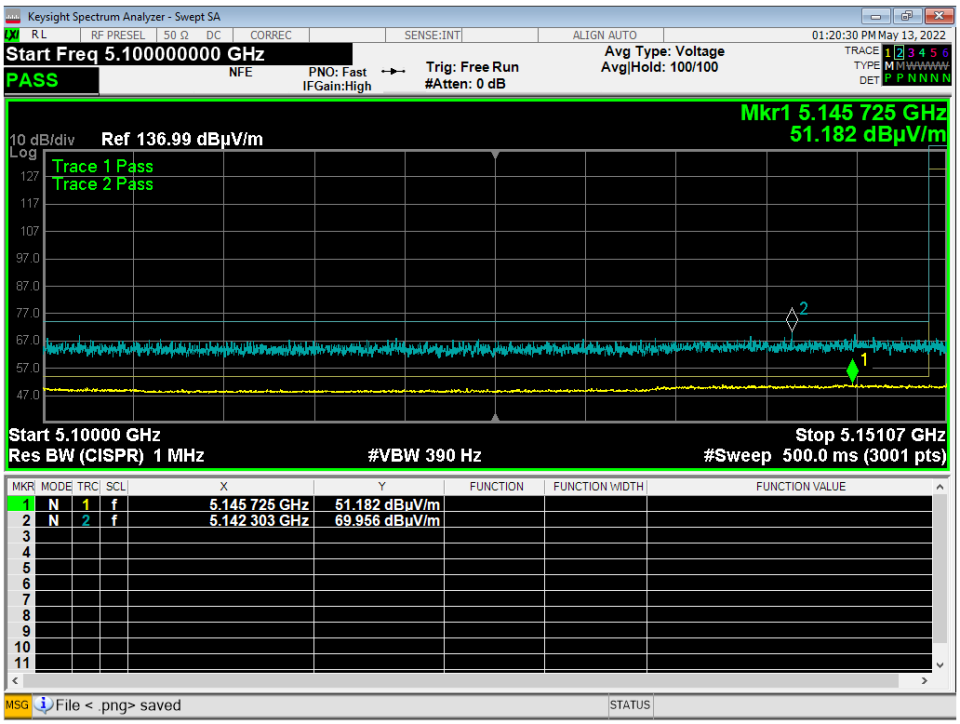


Figure 7: Band Edge Plot HE20 5240MHz

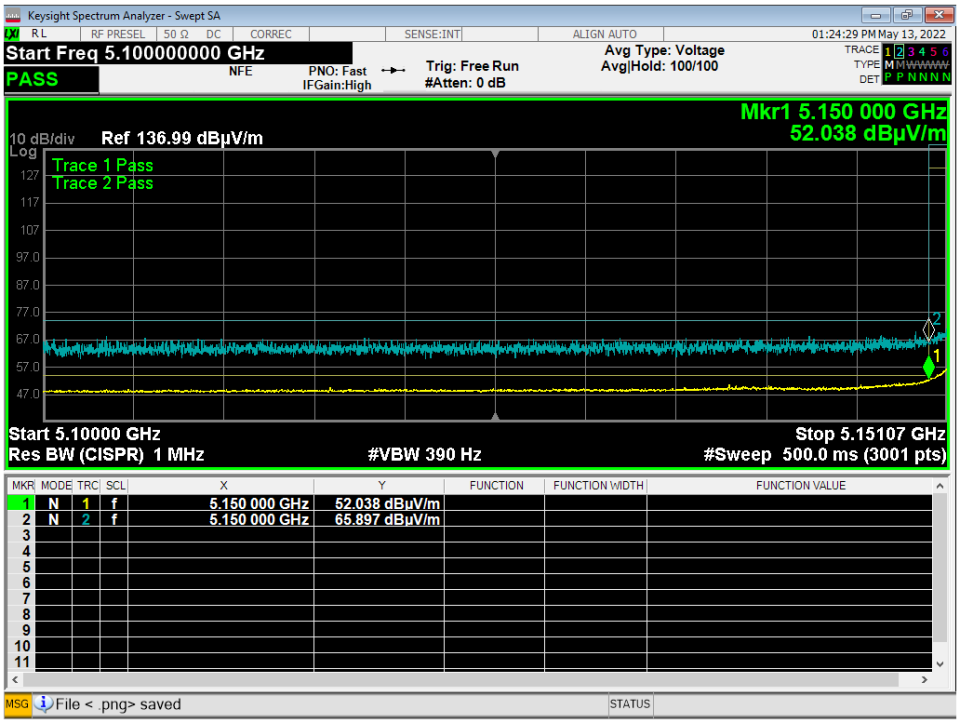


Figure 8: Band Edge Plot HE40 5175MHz

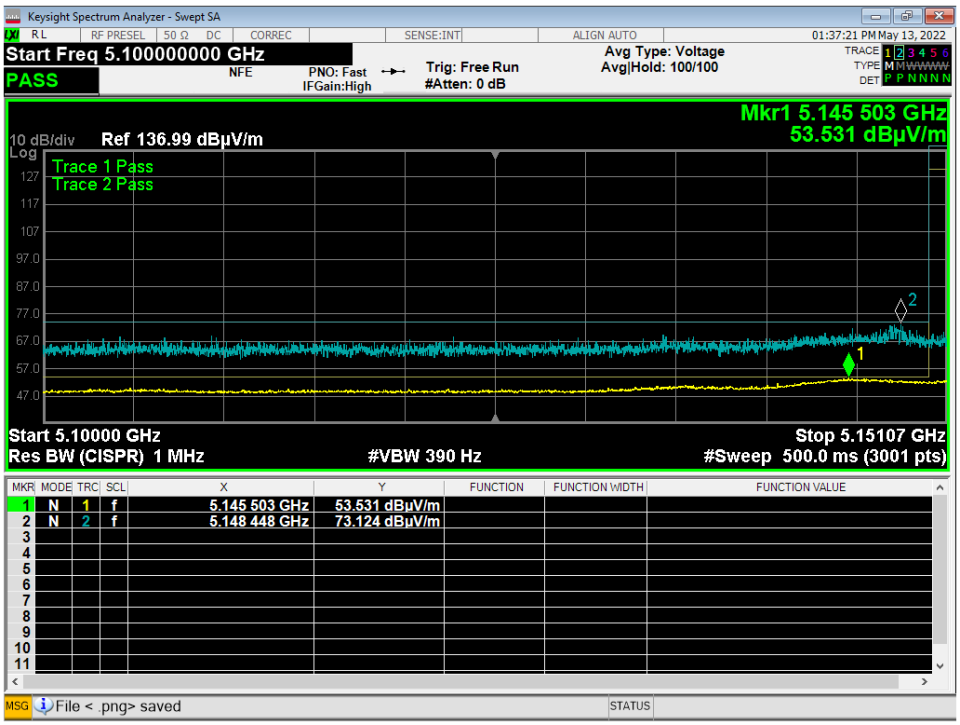


Figure 9: Band Edge Plot HE40 5200MHz

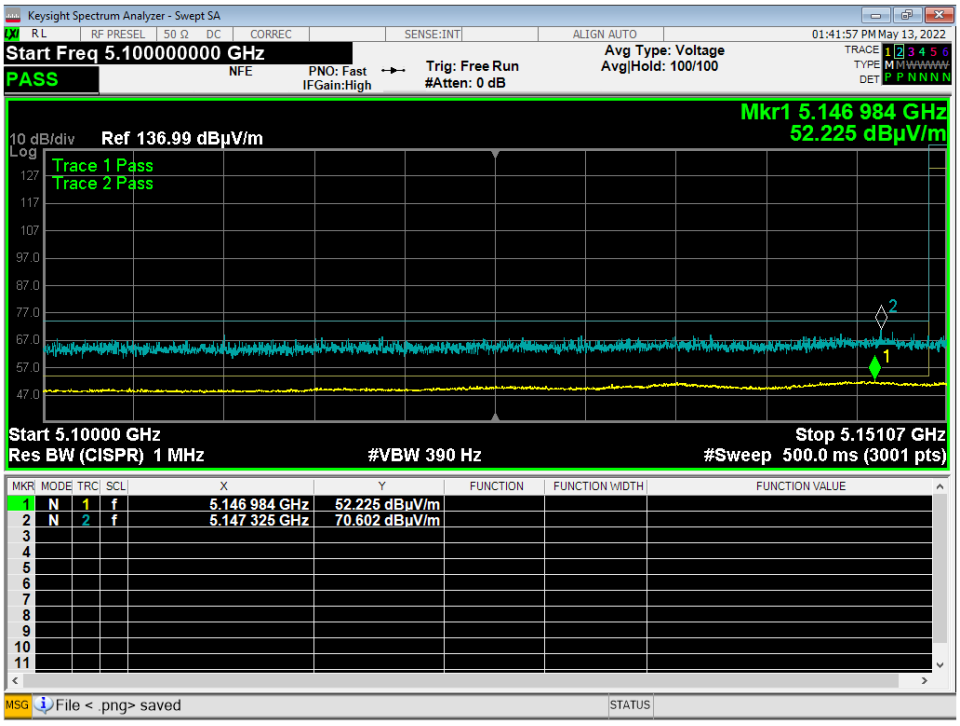


Figure 10: Band Edge Plot HE40 5230MHz

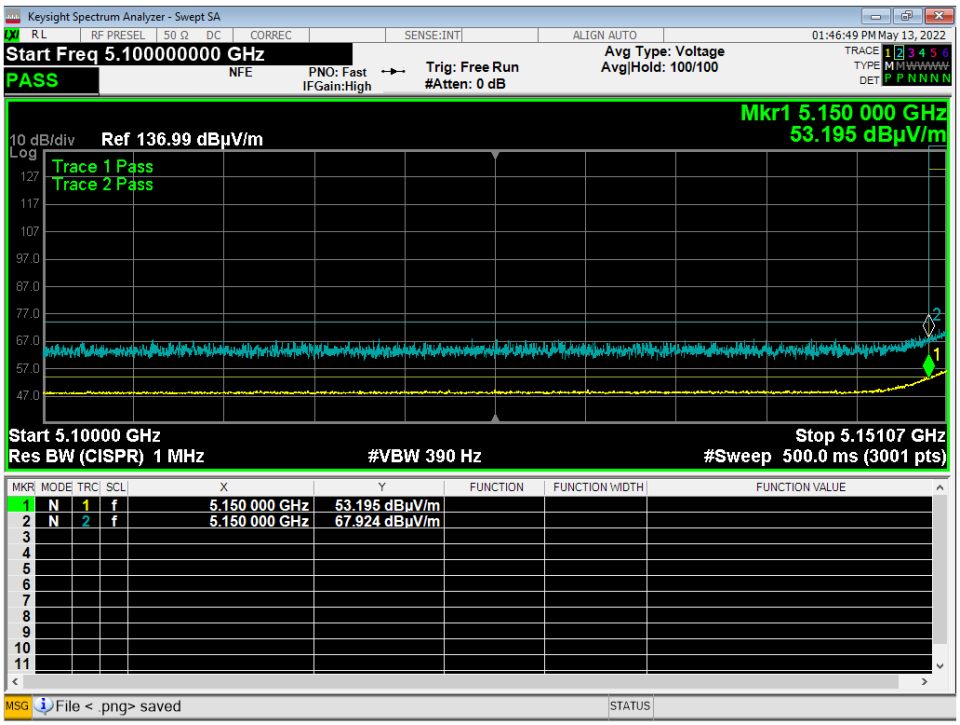


Figure 11: Band Edge Plot HE80 5195MHz

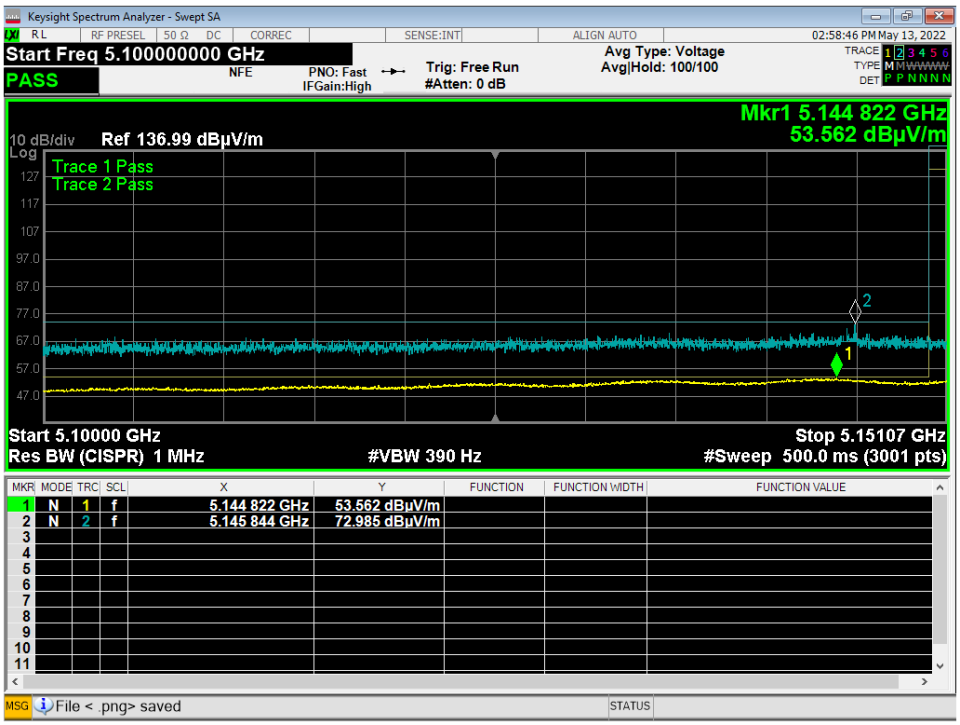


Figure 12: Band Edge Plot HE80 5200MHz

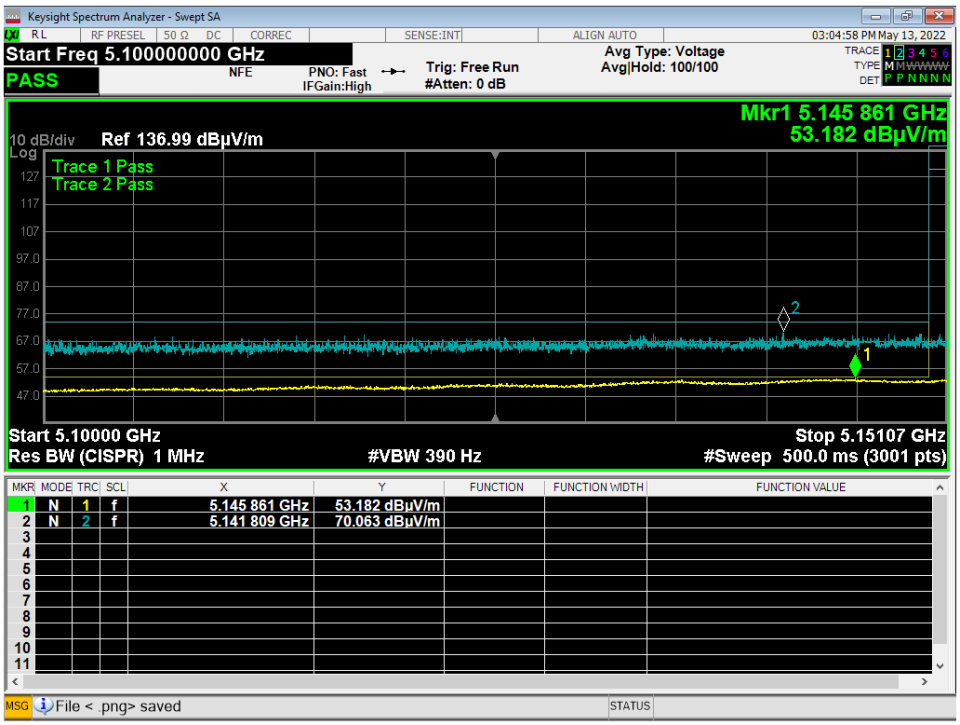


Figure 13: Band Edge Plot HE80 5210MHz

5.6 §15.407(a) Maximum Power Spectral Density

All chains were measured and summed under the guidance of KDB 789033 Section II. F. and KDB 66291 D01. Please see associated annex for details on instrument settings.

The maximum average power spectral density conducted from the intentional radiator of the antenna shall not be greater than 17 dBm in any 1 MHz band during any time interval of continuous transmission.
As per KDB 662911, when the EUT is using spatial-multiplexing in HT to HE modes, there is not additional array gain to accommodate.
Results of this testing are summarized.

Modulation (BW)	Frequency (MHz)	Data Rate	TP Setting	Measured PSD
HE 20	5165	Mcs0	24	1.99
HE 20	5200	Mcs0	27	8.33
HE 20	5240	Mcs0	36	7.67
HE 40	5175	Mcs0	27	0.30
HE 40	5200	Mcs0	33	4.06
HE 40	5230	Mcs0	36	5.55
HE 80	5195	Mcs0	13	-9.30

HE 80	5200	Mcs0	30	-0.33
HE 80	5210	Mcs0	30	-0.28

Result

The maximum summed average power spectral density was less than the limit of 17dBm; therefore, the EUT complies with the specification.

-- End of Test Report --