

427 West 12800 South Draper, UT 84020

Test Report

Certification

FCC ID	SWX-WAVEPRO
ISED ID	6545A-WAVEPRO
Equipment Under Test	Wave-Pro
Test Report Serial Number	TR7808_02
Date of Test(s)	19, 20 July; 3, 17 August 2022
Report Issue Date	10 January 2023

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





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-Pro
FCC ID	SWX-WAVEPRO
ISED ID	6545A-WAVEPRO

On this 10th day of January 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: Joseph W. Jackson

Keviewed By: Richard L. Winter



Revision History			
Revision Description Date			
01	Original Report Release	10 January 2023	
02	Amended Section 5.1	9 May 2023	



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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	airFiber	
Model Number	Wave-Pro	
Serial Number	A26196	
Dimensions (cm)	42.4 x 42.4 x 16.6	

2.2 Description of EUT

The Wave-Pro is a client 60 GHz point-to-point customer premise equipment that features wave technology with a 2.5 Gbps throughput rate. The Wave-Pro 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-Pro 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.

The table below show the channels used within the different modulation bandwidths.

Band	WiFi Mode	Modulation Bandwidth	Modulation Type	Frequency (MHz)
	ax	20 MHz	HE	5740, 5790, 5835
UNII-3	ax	40 MHz	HE	5750, 5790, 5825
	ax	80 MHz	HE	5770, 5790, 5805

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 below.

Brand Name Model Number Serial Number	Description	Name of Interface Ports / Interface Cables
BN: airFiber MN: Wave-Pro (Note 1) SN: A26196	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
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Notes: (1) EUT

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	22.5 – 24.4 °C
Humidity	24.1 – 36.1 %
Barometric Pressure	1011 mBar

2.6 Operating Modes

The Wave-Pro was tested using test software in order 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.

2.7 EUT Exercise Software

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

⁽²⁾ Interface port connected to EUT (See Section 2.4)



2.8 Block Diagram of Test Configuration

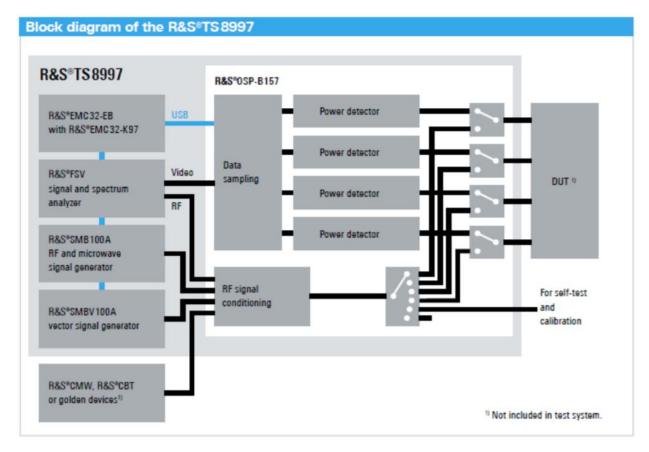


Diagram 1: Test Configuration Block Diagram

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	5725 to 5850	Compliant
15.407(e)	RSS-247 §6.2.2, §6.2.3	Peak Output Power	5725 to 5850	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	0.009 to 40000	Compliant
15.407(h)	RSS-247 §6.2.2, §6.2.3	Peak Power Spectral Density	5725 to 5850	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 chambers 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 2023. 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 2023. 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
Cat6 ISN	Teseq	ISN T8- Cat6	UCL-2971	1/30/2022	1/30/2023
ISN	Teseq	ISN T800	UCL-2974	6/27/2022	6/27/2023
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

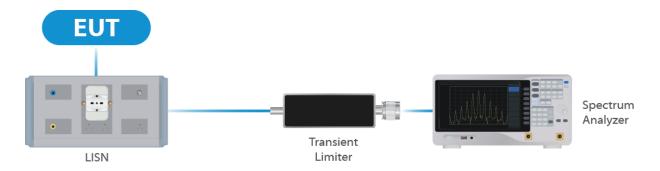


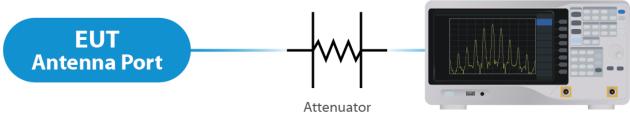
Figure 1: Conducted Emissions Test

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	2/03/2023
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	2/03/2023
Switch Extension	R&S	OSP-150W	UCL-2870	1/03/2022	2/03/2023

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





Spectrum Analyzer

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	1/4/2022	1/4/2023
Pre-Amplifier 9 kHz – 1 GHz	Sonoma Instruments	310N	UCL-2889	10/7/2021	11/7/2022
Broadband Antenna	Scwarzbeck	VULB 9163	UCL-3062	9/13/2022	9/13/2024
Broadband Antenna	Scwarzbeck	VULB 9163	UCL-3071	6/08/2022	6/22/2024
Double Ridge Horn Antenna	Scwarzbeck	BBHA 9120D	UCL-3065	9/22/2022	9/22/2024
Log Periodic	Scwarzbeck	STLP 9129	UCL-3068	11/16/2020	11/16/2022
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



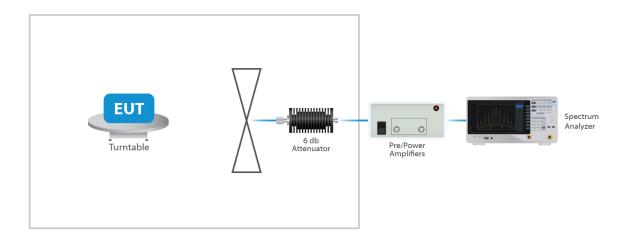


Figure 4: Radiated Emissions Test

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 (<u>+</u> 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

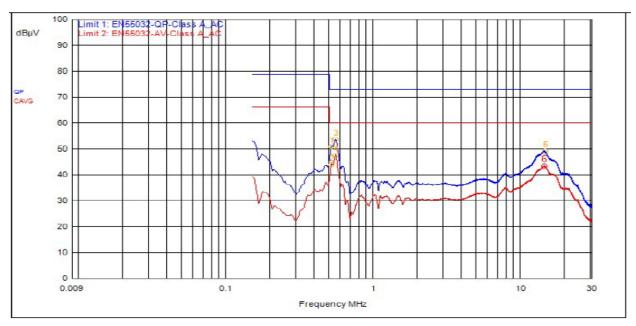
The EUT uses an integral antenna. The maximum gain of the antenna is 22.0 dBi. This is an 802.11 device and utilizes CDD as described in KDB 662911 D01. The antenna is not user replaceable.

For power measurements on IEEE 802.11 devices, Array Gain = 0 dB for NANT \leq 4; For PSD measurements when Nss=1: Array Gain = $10 \log(\text{Nant/Nss}) \, dB = 3.01 dB$ **Results**

The EUT complied with the specification

5.2 Conducted Emissions at Mains Ports Data

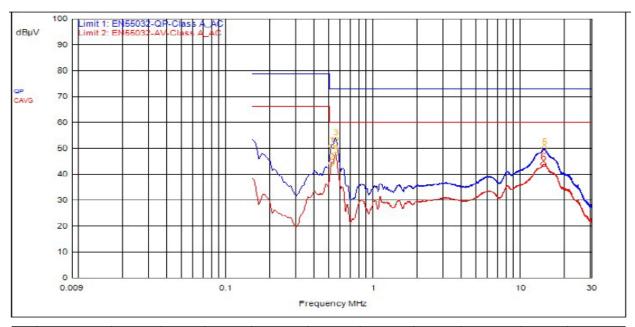
5.2.1 Line



ID	Frequency	Probe	Cable	Atten.	Detector	Meter Read	Meas Level	Limit 1	Limit 1 Dist.	Limit 2	Limit 2 Dist.
3	546,000kHz	9.5	0.1		QPeak	43.8	53.5	73.0	-19.5		
1	516,000kHz	9.5	0.1		QPeak	41.2	50.8	73.0	-22.2		
5	14.385MHz	9.7	0.2		QPeak	39.4	49.3	73.0	-23.7		
2	513,000kHz	9.5	0.1		C_AVG	34.4	44.0			60.0	-16.0
4	549,000kHz	9.5	0.1		C_AVG	38.0	47.6			60.0	-12.4
6	14.334MHz	9.7	0.2		C_AVG	33.5	43.4			60.0	-16.6



5.2.2 Neutral



ID	Frequency	Probe	Cable	Atten.	Detector	Meter Read	Meas Level	Limit 1	Limit 1 Dist.	Limit 2	Limit 2 Dist.
3	549,000kHz	9.5	0.1		QPeak	44.1	53.7	73.0	-19.3		
1	513,000kHz	9.5	0.1		QPeak	41.1	50.8	73.0	-22.2		
5	14.319MHz	9.6	0.2		QPeak	40.0	49.9	73.0	-23.1		
2	513,000kHz	9.5	0.1		C_AVG	34.4	44.1			60.0	-15.9
4	549,000kHz	9.5	0.1		C_AVG	38.0	47.7			60.0	-12.3
6	14.154MHz	9.6	0.2		C_AVG	34.2	44.0			60.0	-16.0

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)	26 dB Bandwidth (MHz)
20	5740	30.6	50.8
20	5790	41.1	56.0
20	5835	32.4	50.8
40	5750	38.3	56.0
40	5790	46.5	84.6
40	40 5825 38.0		49.1
80	5770	77.0	83.5
80	5790	77.0	84.5
80	5805	77.5	83.5

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)(3) 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 27.57 dBm or 571.48 mW. The limit is 30 dBm, or 1 Watt when using antennas with 6 dBi or less gain. The antenna has a gain of 22.0 dBi.

Modulation (BW)	Frequency (MHz)	Data Rate	TP Setting	Conducted Output Power	Measured EIRP	Measured PSD
HE 20	5740	Mcs0	49	26.82	48.82	8.46
HE 20	5790	Mcs0	51	27.57	49.57	8.25
HE 20	5835	Mcs0	49	26.26	48.26	7.81
HE 40	5750	Mcs0	45	24.88	46.88	3.62
HE 40	5790	Mcs0	47	26.01	48.01	4.55
HE 40	5825	Mcs0	44	23.99	45.99	2.21
HE 80	5770	Mcs0	40	22.36	44.36	-2.09
HE 80	5790	Mcs0	40	22.25	44.25	-2.16
HE 80	5805	Mcs0	39	21.56	43.56	-2.78

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).

^{*} Gated EIRP shown in the Annex is the conducted measurement



5.5 §15.407(b)(7) Spurious Emissions

5.5.1 Conducted Spurious Emissions

The frequency ranges 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 frequency and upper frequency. Shown within the annex are plots with the EUT turned to the upper and lower channels with the antenna gain of 22.0 dBi accounted for. These demonstrate compliance with the provisions of this section at the band edges.

All emissions shall be limited to a level of -27 dBm/MHz at 75 MHz or more above or below the band edge increasing linearly to 10 dBm/MHz at 25 MHz above or below the band edge, and from 25 MHz above or below the band edge increasing linearly to a level of 15.6 dBm/MHz at 5 MHz above or below the band edge, and from 5 MHz above or below the band edge increasing linearly to a level of 27 dBm/MHz at the band edge.

Result

Conducted spurious emissions were attenuated below the limit; therefore, the EUT complies with the specification.

5.5.2 Radiated Spurious Emissions in the Restricted Bands of § 15.205

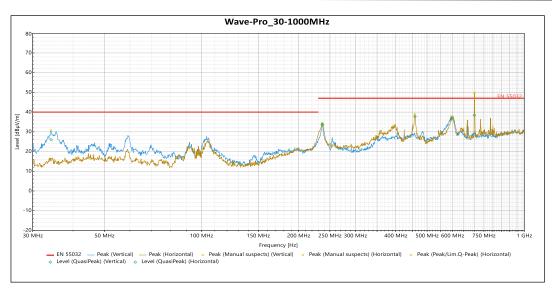
The EUT uses various power settings based on the channel in use. In order to reduce test time, the radiated spurious emissions at the lowest, middle, and highest channel were measured at the maximum power of TP51.

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. See Annex for Conducted Band edge plots. are included in this report. See Annex for Conducted Band edge plots.



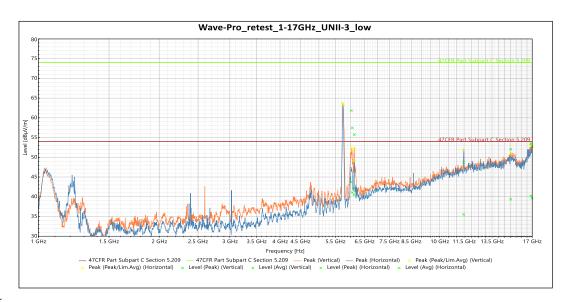


QuasiPeak

Frequency	Level (dBµV/m)	Limit (dBµV/m)	Margin	Azimuth (°)	Height	Pol.	Correction (dB)
34.199 MHz	26.004	40	-13.996	79	1.063	Vertical	-14.947
236.8 MHz	33.945	47	-13.055	115	1.004	Vertical	-12.533
595.17 MHz	36.5	47	-10.5	137	2.317	Vertical	-4.79
236.75 MHz	33.447	47	-13.553	166	3.863	Horizontal	-12.536
458.53 MHz	37.758	47	-9.242	118	1.849	Horizontal	-7.95
700.94 MHz	38.441	47	-8.559	153	1.218	Horizontal	-3.922

Table 4: Radiated Emissions 30 - 1000 MHz





Peak

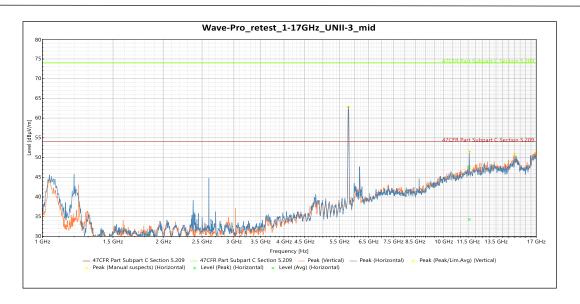
Frequency	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	Correction (dB)
6.0248 GHz	61.842	74	-12.158	348	2.146	Vertical	-8.452
6.0538 GHz	57.474	74	-16.526	344	2.146	Vertical	-8.215
6.1281 GHz	55.741	74	-18.259	343	2.146	Vertical	-8.075
16.873 GHz	53.467	74	-20.533	180	4	Vertical	9.71
6.1181 GHz	40.543	74	-33.457	324	3.307	Horizontal	-8.276
11.474 GHz	48.613	74	-25.387	292	2.324	Horizontal	3.62
15.025 GHz	52.025	74	-21.975	173	4	Horizontal	8.131
16.98 GHz	52.672	74	-21.328	95	3.802	Horizontal	9.281

Avg

Frequency	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	Correction (dB)
6.0248 GHz	43.74	54	-10.26	348	2.146	Vertical	-8.452
6.0538 GHz	41.093	54	-12.907	344	2.146	Vertical	-8.215
6.1281 GHz	42.134	54	-11.866	343	2.146	Vertical	-8.075
16.873 GHz	40.261	54	-13.739	180	4	Vertical	9.71
6.1181 GHz	27.396	54	-26.604	324	3.307	Horizontal	-8.276
11.474 GHz	35.507	54	-18.493	292	2.324	Horizontal	3.62
15.025 GHz	39.371	54	-14.629	173	4	Horizontal	8.131
16.98 GHz	39.614	54	-14.386	95	3.802	Horizontal	9.281

Table 5: Radiated Emissions Transmitting on the Lowest Frequency 5740 MHz 1 – 17 GHz





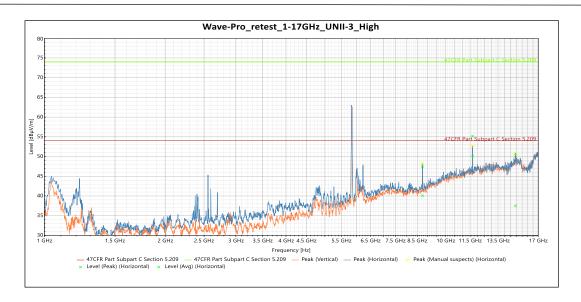
No Significant Emissions Were Noted in The Vertical

Peak

Frequency	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	Correction (dB)
11.579 GHz	47.532	74	-26.468	61	2.325	Horizontal	3.427
11.579 GHz	34.315	54	-19.685	61	2.325	Horizontal	3.427

Table 6: Radiated Emissions Transmitting on the Middle Frequency 5790 MHz 1 – 17 GHz





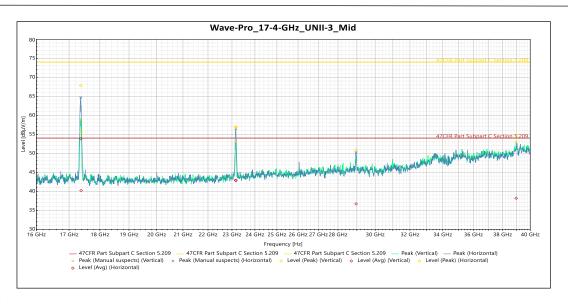
No Significant Emissions Were Noted in The Vertical

Peak

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Frequency	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	Correction (dB)	
8.7524 GHz	47.396	74	-26.604	235	1.5	Horizontal	-3.029	
11.67 GHz	55.171	74	-18.829	270	3.149	Horizontal	3.426	
14.923 GHz	50.257	74	-23.743	196	3.307	Horizontal	7.136	
8.7524 GHz	40.058	54	-13.942	235	1.5	Horizontal	-3.029	
11.67 GHz	50.092	54	-3.908	270	3.149	Horizontal	3.426	
14.923 GHz	37.505	54	-16.495	196	3.307	Horizontal	7.136	

Table 7: Radiated Emissions Transmitting on the Highest Frequency 5835 MHz 1 – 17 GHz





Peak

Frequency	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Pol.	Correction (dB)
17.385 GHz	55.699	74	-18.301	249	Vertical	-5.271
23.163 GHz	56.706	74	-17.294	140	Vertical	-4.892
38.973 GHz	54.574	74	-19.426	65	Vertical	3.924
17.374 GHz	67.82	74	-6.18	267	Horizontal	-5.219
23.166 GHz	56.952	74	-17.048	278	Horizontal	-4.875
28.957 GHz	50.859	74	-23.141	240	Horizontal	-4.075

Avg

Frequency	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Pol.	Correction (dB)
17.385 GHz	40.185	54	-13.815	249	Vertical	-5.271
23.163 GHz	42.919	54	-11.081	140	Vertical	-4.892
38.973 GHz	38.174	54	-15.826	65	Vertical	3.924
17.374 GHz	53.812	54	-0.188	267	Horizontal	-5.219
23.166 GHz	42.813	54	-11.187	278	Horizontal	-4.875
28.957 GHz	36.686	54	-17.314	240	Horizontal	-4.075

Table 8: Radiated Emissions Transmitting on the Middle Frequency 5790 MHz 17 – 40 GHz (worse case)



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 30 dBm in any 500 kHz band during any time interval of continuous transmission. Results of this testing are summarized.

As per KDB 662911, When the EUT is using spatial-multiplexing in HE modes, there is not additional array gain to accommodate.

Modulation (BW)	Frequency (MHz)	Data Rate	TP Setting	Measured PSD
HE 20	5740	Mcs0	12	8.46
HE 20	5790	Mcs0	40	8.25
HE 20	5835	Mcs0	48	7.81
HE 40	5750	Mcs0	18	3.62
HE 40	5790	Mcs0	29	4.55
HE 40	5825	Mcs0	39	2.21
HE 80	5770	Mcs0	17	-2.09
HE 80	5790	Mcs0	19	-2.16
HE 80	5805	Mcs0	22	-2.78

Result

The maximum summed average power spectral density was less than the limit of 30 dBm; therefore, the EUT complies with the specification.



-- End of Test Report --