FCC RF Exposure Report

FCC ID: 2BCGWAX72V2

Report No.	:	BTL-FCCP-4-2407G044
Equipment	:	AX5400 Wi-Fi 6 Router
Model Name	:	Archer AX72
Brand Name	:	tp-link
Applicant	:	TP-LINK CORPORATION PTE. LTD.
Address	:	7 Temasek Boulevard #29-03 Suntec Tower One, Singapore 038987
Standard(s)	:	47 CFR § 2.1091 FCC Guidelines for Human Exposure IEEE C95.1
Date of Receipt	:	2024/8/1
Date of Test	:	2024/8/2 ~ 2024/9/3
Issued Date	:	2024/9/24

The above equipment has been tested and found in compliance with the requirement of the above standards by BTL Inc.

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Testing Laboratory 0659

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REVISION HISTORY

Report No.	Version	Description	Issued Date	Note
BTL-FCCP-4-2407G044	R00	Original Report.	2024/9/24	Valid

1. LIMITS

According to § 1.1310 Radiofrequency radiation exposure limits.

(a) Specific absorption rate (SAR) shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in § 1.1307(b) of this part within the frequency range of 100 kHz to 6 GHz (inclusive).

(b) The SAR limits for occupational/controlled exposure are 0.4 W/kg, as averaged over the whole body, and a peak spatial-average SAR of 8 W/kg, averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube). Exceptions are the parts of the human body treated as extremities, such as hands, wrists, feet, ankles, and pinnae, where the peak spatial-average SAR limit for occupational/controlled exposure is 20 W/kg, averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube). Exposure may be averaged over a time period not to exceed 6 minutes to determine compliance with occupational/controlled SAR limits.

(c) The SAR limits for general population/uncontrolled exposure are 0.08 W/kg, as averaged over the whole body, and a peak spatial-average SAR of 1.6 W/kg, averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube). Exceptions are the parts of the human body treated as extremities, such as hands, wrists, feet, ankles, and pinnae, where the peak spatial-average SAR limit is 4 W/kg, averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube). Exposure may be averaged over a time period not to exceed 30 minutes to determine compliance with general population/uncontrolled SAR limits.

(e) Limits for Maximum Permissible Exposure (MPE) to radiofrequency electromagnetic fields (Table 1).

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(i) Limits for Occupational/Controlled Exposure				
0.3-3.0	614	1.63	*(100)	≤6
3.0-30	1842/f	4.89/f	*($900/f^2$)	<6
30-300	61.4	0.163	1.0	<6
300-1.500			f/300	<6
1.500-100.000			5	<6
(ii) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*(100)	<30
1.34-30	824/f	2.19/f	*($180/f^2$)	<30
30-300	27.5	0.073	0.2	<30
300-1.500			f/1500	<30
1.500-100.000			1.0	<30

f = frequency in MHz. * = Plane-wave equivalent power density.

2. APPLIED EXEMPTION CRITERIA

Refer to KDB 447498 D04, ticked item is applied:

For RF Exposure Test Exemptions for Single Source:

☐ 1-mW Test Exemption

Per § 1.1307(b)(3)(i)(A), a single RF source is exempt RF device (from the requirement to show data demonstrating compliance to RF exposure limits, as previously mentioned) if the available maximum time-averaged power is no more than 1 mW, regardless of separation distance.

This exemption applies to all operating configurations and exposure conditions, for the frequency range 100 kHz to 100 GHz, regardless of fixed, mobile, or portable device exposure conditions. This is a standalone exemption, and it cannot be applied in conjunction with any other test exemption.

☐ SAR-Based Exemption

A more comprehensive exemption, considering a variable power threshold that depends on both the separation distance and power, is provided in § 1.1307(b)(3)(i)(B). This exemption is applicable to the frequency range between 300 MHz and 6 GHz, with test separation distances between 0.5 cm and 40 cm, and for all RF sources in fixed, mobile, and portable device exposure conditions.

Accordingly, a RF source is considered an RF exempt device if its available maximum time-averaged (matched conducted) power or its effective radiated power (ERP), whichever is greater, are below a specified threshold. This exemption threshold was derived based on general population 1-g SAR requirements and is detailed in Appendix C.

§ 1.1307(b)(3)(i)(B):

Or the available maximum time-averaged power or effective radiated power (ERP), whichever is greater, is less than or equal to the threshold P_{th} (mW) described in the following formula. This method shall only be used at separation distances (cm) from 0.5 centimeters to 40 centimeters and at frequencies from 0.3 GHz to 6 GHz (inclusive). P_{th} is given by:

$$P_{th}\ (\text{mW}) = \begin{cases} ERP_{20\ cm}(d/20\ \text{cm})^{x} & d \le 20\ \text{cm} \\ ERP_{20\ cm} & 20\ \text{cm} < d \le 40\ \text{cm} \end{cases}$$

Where

$$x = -\log_{10}\left(\frac{60}{ERP_{20\ cm}\sqrt{f}}\right) \text{ and } f \text{ is in GHz;}$$

and

$$ERP_{20\ cm}\ (\text{mW}) = \begin{cases} 2040f & 0.3\ \text{GHz} \le f < 1.5\ \text{GHz} \\ 3060 & 1.5\ \text{GHz} \le f \le 6\ \text{GHz} \end{cases}$$

d = the separation distance (cm);

☒ MPE-Based Exemption

An alternative to the SAR-based exemption is provided in § 1.1307(b)(3)(i)(C), for a much wider frequency range, from 300 kHz to 100 GHz, applicable for separation distances greater or equal to λ/2π, where λ is the free-space operating wavelength in meters. The MPE-based test exemption condition is in terms of ERP, defined as the product of the maximum antenna gain and the delivered maximum time-averaged power.10 For this case, a RF source is an RF exempt device if its ERP (watts) is no more than a frequency-dependent value, as detailed tabular form in Appendix B. These limits have been derived based on the basic specifications on Maximum Permissible Exposure (MPE) considered for the FCC rules in § 1.1310(e)(1).

§ 1.1307(b)(3)(i)(C):

Or using Table 1 and the minimum separation distance (R in meters) from the body of a nearby person for the frequency (f in MHz) at which the source operates, the ERP (watts) is no more than the calculated value prescribed for that frequency. For the exemption in Table 1 to apply, R must be at least λ/2π, where λ is the free-space operating wavelength in meters. If the ERP of a single RF source is not easily obtained, then the available maximum time-averaged power may be used in lieu of ERP if the physical dimensions of the radiating structure(s) do not exceed the electrical length of λ/4 or if the antenna gain is less than that of a half-wave dipole (1.64 linear value).

RF Source frequency (MHz)	Threshold ERP (watts)
0.3-1.34	1920 R^2.
1.34-30	3450 R^2/f^2.
30-300	3.83 R^2.
300-1500	0.0128 R^2f.
1500-100000	19.2R^2.

For RF Exposure Test Exemptions for Simultaneous Transmission Sources

☐ 1-mW Test Exemption for Multiple Sources

As discussed in § 1.1307(b)(3)(ii)(A), the 1-mW exemption intended for single transmitters may be also applied to simultaneous transmission conditions, within the same host device, according one of the following criteria:

a) When maximum available power each individual transmitting antenna within the same time averaging period is ≤ 1 mW, and the nearest parts of the antenna structures of the simultaneously operating transmitters are separated by at least 2 cm.

b) When the aggregate maximum available power of all transmitting antennas is ≤ 1 mW in the same time-averaging period.

This exemption may not be combined with any other exemption.

☒ Simultaneous Transmission with both SAR-based and MPE-Based Test Exemptions

This case is described in detail in § 1.1307(b)(3)(ii)(B) and covers the situations where both SAR-based and MPE-based exemption may be considered for test exemption in fixed, mobile, or portable device exposure conditions. For these cases, a device with multiple RF sources transmitting simultaneously will be considered an RF exempt device if the condition of Formula (1) is satisfied.

$$\sum_{i=1}^{a} \frac{P_i}{P_{th,i}} + \sum_{j=1}^{b} \frac{ERP_j}{ERP_{th,j}} + \sum_{k=1}^{c} \frac{Evaluated_k}{Exposure\ Limit_k} \leq 1 \qquad (1)$$

Where:

a	number of fixed, mobile, or portable RF sources claiming exemption using the § 1.1307(b)(3)(i)(B) formula for P_{th}, including existing exempt transmitters and those being added.
b	number of fixed, mobile, or portable RF sources claiming exemption using the applicable § 1.1307(b)(3)(i)(C) Table 1 formula for Threshold ERP, including existing exempt transmitters and those being added.
c	number of existing fixed, mobile, or portable RF sources with known evaluation for the specified minimum distance.
P_i	the available maximum time-averaged power or the ERP, whichever is greater, for fixed, mobile, or portable RF source *i* at a distance between 0.5 cm and 40 cm (inclusive).
$P_{th,i}$	the exemption threshold power (Pth) according to the § 1.1307(b)(3)(i)(B) formula for fixed, mobile, or portable RF source *i*.
ERP_j	the available maximum time-averaged power or the ERP, whichever is greater, of fixed, mobile, or portable RF source *j*.
$ERP_{th,j}$	exemption threshold ERP for fixed, mobile, or portable RF source *j*, at a distance of at least λ/2π, according to the applicable § 1.1307(b)(3)(i)(C) Table 1 formula at the location in question.
$Evaluated_k$	the maximum reported SAR or MPE of fixed, mobile, or portable RF source *k* either in the device or at the transmitter site from an existing evaluation.
$Exposure\ Limit_k$	either the general population/uncontrolled maximum permissible exposure (MPE) or specific absorption rate (SAR) limit for each fixed, mobile, or portable sources, as applicable

The sum of the ratios of the applicable terms for SAR-based, MPE-based and measured SAR or MPE shall be less than 1, to determine simultaneous transmission exposure compliance.

3. EVALUATION FACILITY

The test locations stated below are under the TAF Accreditation Number 0659.
The test location(s) used to collect the test data in this report are:
No. 72, Ln. 169, Sec. 2, Datong Rd., Xizhi Dist., New Taipei City 221, Taiwan
(FCC DN: TW0659)

4. TABLE FOR FILED ANTENNA:

For WLAN 2.4GHz:

Ant.	Manufacturer	P/N	Type	Connector	Gain (dBi)
1	TP-LINK CORPORATION PTE. LTD.	3101504303	Dipole	N/A	2
2	TP-LINK CORPORATION PTE. LTD.	3101504304	Dipole	N/A	1.98

Note: This EUT supports CDD, any transmit signals are correlated with each other,
so Directional gain= G_{ANT}+Array Gain,
For power measurements, Array Gain=0dB ($N_{ANT} \leqslant 4$), so the Directional gain=2.
The Direction gain is less than 6 dBi, so output power limits will not be reduced.
For power spectral density measurements, N_{ANT}=2, N_{SS} = 1.
So the Directional gain=G_{ANT}+Array Gain=G_{ANT}+10log(N_{ANT}/ N_{SS})dBi=2+10log(2/1)dBi=5.01.

Beamforming: 3dB, so the Directional gain=2+3=5.
The Direction gain is less than 6 dBi, so output power limits will not be reduced.

For RLAN 5GHz:

Ant.	Manufacturer	P/N	Type	Connector	Gain (dBi)
1	TP-LINK CORPORATION PTE. LTD.	3101503968	Dipole	N/A	2.06
2	TP-LINK CORPORATION PTE. LTD.	3101504306	Dipole	N/A	2.30
3	TP-LINK CORPORATION PTE. LTD.	3101505497	Dipole	N/A	1.91
4	TP-LINK CORPORATION PTE. LTD.	3101504306	Dipole	N/A	2.50

Note: This EUT supports CDD, any transmit signals are correlated with each other,
so Directional gain= G_{ANT}+Array Gain,

For power measurements, Array Gain=0dB ($N_{ANT} \leqslant 4$), so the Directional gain=2.50.
The Direction gain is less than 6 dBi, so output power limits will not be reduced.

For power spectral density measurements, N_{ANT}=4, N_{SS} = 1.
So the Directional gain=G_{ANT}+Array Gain=G_{ANT}+10log(N_{ANT}/ N_{SS})dBi=2.5+10log(4/1)dBi=8.52.

Beamforming: 6dB, so the Directional gain=2.50+6=8.50

*The above Antenna information are derived from the antenna data sheet provided by manufacturer and for more detailed features description, please refer to the manufacturer's specifications, the laboratory shall not be held responsible.

Table for Antenna Configuration:

For WLAN 2.4GHz:
Non Beamforming:

Operating Mode / TX Mode	2TX
IEEE 802.11b	V(Ant. 1 + Ant. 2)
IEEE 802.11g	V(Ant. 1 + Ant. 2)
IEEE 802.11n(HT20)	V(Ant. 1 + Ant. 2)
IEEE 802.11n(HT40)	V(Ant. 1 + Ant. 2)
IEEE 802.11ax(HE20)	V(Ant. 1 + Ant. 2)
IEEE 802.11ax(HE40)	V(Ant. 1 + Ant. 2)

Beamforming:

Operating Mode / TX Mode	2TX
IEEE 802.11n(HT20)	V(Ant. 1 + Ant. 2)
IEEE 802.11n(HT40)	V(Ant. 1 + Ant. 2)
IEEE 802.11ax(HE20)	V(Ant. 1 + Ant. 2)
IEEE 802.11ax(HE40)	V(Ant. 1 + Ant. 2)

For RLAN 5GHz:
Non Beamforming:

Operating Mode / TX Mode	4TX
IEEE 802.11a	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)
IEEE 802.11n (HT20)	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)
IEEE 802.11n (HT40)	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)
IEEE 802.11ac (VHT20)	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)
IEEE 802.11ac (VHT40)	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)
IEEE 802.11ac (VHT80)	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)
IEEE 802.11ac (VHT160)	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)
IEEE 802.11ax (HE20)	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)
IEEE 802.11ax (HE40)	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)
IEEE 802.11ax (HE80)	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)
IEEE 802.11ax (HE160)	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)

Beamforming:

Operating Mode / TX Mode	4TX
IEEE 802.11n (HT20)	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)
IEEE 802.11n (HT40)	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)
IEEE 802.11ac (VHT20)	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)
IEEE 802.11ac (VHT40)	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)
IEEE 802.11ac (VHT80)	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)
IEEE 802.11ac (VHT160)	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)
IEEE 802.11ax (HE20)	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)
IEEE 802.11ax (HE40)	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)
IEEE 802.11ax (HE80)	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)
IEEE 802.11ax (HE160)	V (Ant. 1+Ant. 2+ Ant. 3+Ant. 4)

5. MAXIMUM RF OUTPUT POWER:

Non Beamforming Mode	Maximum Output Power (dBm)
WLAN 2.4G	29.32
RLAN 5G	27.56

Beamforming Mode	Maximum Output Power (dBm)
WLAN 2.4G	28.62
RLAN 5G	26.86

6. CALCULATED RESULTS

Non Beamforming Mode

Operation Mode	Minimum Frequency (MHz)	Maximum Output Power (dBm)	Directional Gain (dBi)	ERP (dBm)	ERP (mW)	Distance (cm)	Threshold ERP Limit (mW)	Ratio	Result
WLAN 2.4 GHz	2437.00	29.32	2.00	29.17	826.04	43.00	3550.08	0.2327	Pass
RLAN 5 GHz	5200.00	27.56	2.50	27.91	618.02	43.00	3550.08	0.1741	Pass

Beamforming Mode

Operation Mode	Minimum Frequency (MHz)	Maximum Output Power (dBm)	Directional Gain (dBi)	ERP (dBm)	ERP (mW)	Distance (cm)	Threshold ERP Limit (mW)	Ratio	Result
WLAN 2.4 GHz	2437.00	28.62	5.00	31.47	1402.81	43.00	3550.08	0.3951	Pass
RLAN 5 GHz	5230.00	26.86	8.50	33.21	2094.11	43.00	3550.08	0.5899	Pass

Note:

(1) The lowest operating frequency is applied to get the severe limit.

(2) The calculation result is below exemption criteria and/or MPE Threshold ERP limits, therefore the device is compliant FCC RF exposure requirements.

7. COLLOCATED SIMULTANEOUS TRANSMISSION CALCULATIONS

Maximum Bluetooth MPE Ratio	Maximum WIFI MPE Ratio
0.3951	0.5899
Σ(All MPE Ratios)	
0.9850	
Limit	
≤ 1.0	

The sum of the simultaneous transmission results has not over Limit, which is in compliance.

End of Test Report