

RF Exposure evaluation

FCC ID: 2AVE7-L005N

Exposure category: General population/uncontrolled environment

EUT Type: Production Unit

Device Type: Mobile Device

1. Reference

According to §1.1307(b)(1), 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 level in excess of the Commission's guidelines.

According to §1.1310 and §2.1091 RF exposure is calculated.

KDB447498 D01: Mobile and Portable Devices RF Exposure Procedures and Equipment Authorization Policies

2. Limit

Limits for Maximum Permissible Exposure (MPE)/Controlled Exposure

Frequency Range(MHz)	Electric Field Strength(V/m)	Magnetic Field Strength(A/m)	Power Density (mW/cm ²)	Averaging Time (minute)
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 – 1500	/	/	f/300	6
1500 – 100,000	/	/	5	6

Limits for Maximum Permissible Exposure (MPE)/Uncontrolled Exposure

Frequency Range(MHz)	Electric Field Strength(V/m)	Magnetic Field Strength(A/m)	Power Density (mW/cm ²)	Averaging Time (minute)
Limits for Occupational/Controlled Exposure				
0.3 – 3.0	614	1.63	(100) *	30
3.0 – 30	824/f	2.19/f	(180/f ²)*	30
30 – 300	27.5	0.073	0.2	30
300 – 1500	/	/	f/1500	30
1500 – 100,000	/	/	1.0	30

F=frequency in MHz

*=Plane-wave equivalent power density

3. MPE Calculation Method

Predication of MPE limit at a given distance

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

$$S=PG/4\pi R^2$$

Where: S=power density

P=power input to antenna

G=power gain of the antenna in the direction of interest relative to an isotropic radiator

R=distance to the center of radiation of the antenna

4. Antenna Information

The device can only use antennas certificated as follows provided by manufacturer.

Internal Identification	Antenna type and antenna number	Operate frequency band	Maximum antenna gain	Directional gain:
WIFI ANT 1	FPC antenna	2.4GHz – 2.5 GHz 5.1GHz – 5.8 GHz	2.29dBi 1.95dBi	2.4G: 5.30 dBi 5G: 4.96 dBi
WIFI ANT 2	FPC antenna	2.4GHz – 2.5 GHz 5.1GHz – 5.8 GHz	2.29dBi 1.95dBi	
BT ANT	FPC antenna	2.4GHz – 2.5 GHz	2.56dBi	

5. Conducted power

[2.4GHz BT]

Mode	Channel	Frequency(MHz)	Peak Conducted Output Power (dBm)	Tune_Up
GFSK	00	2402	2.46	3±1
	39	2441	3.54	3±1
	78	2480	2.56	3±1
π/4DQPSK	00	2402	5.92	6.5±1
	39	2441	7.12	6.5±1
	78	2480	6.16	6.5±1
8-DPSK	00	2402	6.40	6.5±1
	39	2441	6.07	6.5±1
	78	2480	6.59	6.5±1
BLE_1Mbps	00	2402	2.40	3±1
	19	2440	3.51	3±1
	39	2480	2.52	3±1
BLE_2Mbps	00	2402	2.48	3±1
	19	2440	6.39	6±1
	39	2480	2.59	3±1

[2.4GHz WLAN Mode]

Mode	TX Type	Frequency (MHz)	Maximum Average Conducted Output Power (dBm)		Tune-Up	
			ANT1	ANT2	ANT1	ANT2
802.11b	SISO	2412	14.46	12.82	14±1	12±1
		2437	14.63	12.39	14±1	12±1
		2462	13.91	11.82	14±1	12±1
802.11g	SISO	2412	14.36	14.24	14±1	14±1
		2437	14.51	14.18	14±1	14±1
		2462	13.51	13.47	14±1	14±1
802.11n (HT20)	SISO	2412	14.04	15.57	14±1	15±1
		2437	14.35	14.72	14±1	15±1
		2462	13.49	14.03	14±1	15±1
802.11n (HT40)	SISO	2422	15.13	14.78	15±1	15±1
		2437	15.32	15.05	15±1	15±1
		2452	14.41	14.40	15±1	15±1
802.11n (HT20)	MIMO	2412	10.28	9.54	10±1	9±1
		2437	10.40	9.67	10±1	9±1
		2462	9.76	8.73	10±1	9±1
802.11n (HT40)	MIMO	2422	9.19	8.33	10±1	9±1
		2437	9.41	8.32	10±1	9±1
		2452	9.04	8.08	10±1	9±1

[5GHz WLAN Band 1]

Mode	TX Type	Frequency (MHz)	Maximum Average Conducted Output Power (dBm)		Tune-Up	
			ANT1	ANT2	ANT1	ANT2
802.11a	SISO	5180	12.56	11.79	12±1	11±1
		5200	12.27	11.73	12±1	11±1
		5240	11.28	11.22	12±1	11±1
802.11n (HT20)	SISO	5180	11.76	11.22	11±1	11±1
		5200	11.99	11.68	11±1	11±1
		5240	10.71	10.91	11±1	11±1
802.11n (HT40)	SISO	5190	11.97	11.61	11±1	11±1
		5230	11.29	11.40	11±1	11±1
802.11n (HT20)	MIMO	5180	10.90	10.48	10±1	10±1
		5200	10.96	10.84	10±1	10±1
		5240	9.82	10.03	10±1	10±1
802.11n (HT40)	MIMO	5190	11.21	11.05	11±1	11±1
		5230	10.54	10.94	11±1	11±1
802.11ac (VHT20)	SISO	5180	11.59	11.20	11±1	11±1
		5200	11.78	11.55	11±1	11±1
		5240	10.65	10.99	11±1	11±1

802.11ac (VHT40)	SISO	5190	11.93	11.58	11±1	11±1
		5230	11.45	11.58	11±1	11±1
802.11ac (VHT80)	SISO	5210	12.24	11.86	12±1	12±1
802.11ac (VHT20)	MIMO	5180	11.31	11.12	11±1	11±1
		5200	11.32	11.47	11±1	11±1
		5240	10.37	10.87	11±1	11±1
802.11ac (VHT40)	MIMO	5190	11.58	11.42	11±1	11±1
		5230	11.36	11.47	11±1	11±1
802.11ac (VHT80)	MIMO	5210	12.25	11.61	12±1	12±1

[5GHz WLAN Band 3]

Mode	TX Type	Frequency (MHz)	Maximum Average Conducted Output Power (dBm)		Tune Up	
			ANT1	ANT2	ANT1	ANT2
802.11a	SISO	5745	11.49	11.44	11±1	11±1
		5785	10.71	11.13	11±1	11±1
		5825	9.54	10.85	10±1	10±1
802.11n (HT20)	SISO	5745	11.45	11.45	11±1	11±1
		5785	10.89	11.16	11±1	11±1
		5825	10.19	10.92	10±1	10±1
802.11n (HT40)	SISO	5755	11.55	11.65	11±1	11±1
		5795	10.52	10.78	11±1	11±1
802.11n (HT20)	MIMO	5745	10.69	10.77	10±1	10±1
		5785	10.02	10.16	10±1	10±1
		5825	9.41	10.04	10±1	10±1
802.11n (HT40)	MIMO	5755	10.87	11.23	11±1	11±1
		5795	9.74	10.39	10±1	10±1
802.11ac (VHT20)	SISO	5745	12.59	12.00	12±1	12±1
		5785	11.63	11.47	11±1	11±1
		5825	10.92	11.36	11±1	11±1
802.11ac (VHT40)	SISO	5755	11.93	12.01	12±1	12±1
		5795	10.87	11.31	11±1	11±1
802.11ac (VHT80)	SISO	5775	11.16	11.56	11±1	11±1
802.11ac (VHT20)	MIMO	5745	11.30	11.22	11±1	11±1
		5785	10.42	10.87	11±1	11±1
		5825	9.93	10.47	10±1	10±1
802.11ac (VHT40)	MIMO	5755	11.27	11.70	11±1	11±1
		5795	10.54	10.67	10±1	10±1
802.11ac (VHT80)	MIMO	5775	11.49	10.79	11±1	11±1

6. Standalone MPE Result

As declared by the Applicant, the EUT is a wireless device used in a fix application, at least 20 cm from any body part of the user or nearby persons; from the maximum EUT RF output power, the minimum separation distance, $r=20\text{cm}$, as well as the gain of the used antenna, the RF power density can be obtained.

BT

Modulation Type	Max. Output power with Tune_up		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
BR/EDR	7.50	5.6234	2.56	1.8030	100%	0.0020	1.0000
BLE	7.00	5.0119	2.56	1.8030	100%	0.0018	1.0000

2.4GHz WLAN SISO MODE

Antenna 1

Modulation Type	Max. Output power with Tune_up		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
IEEE 802.11b	15.00	31.6228	2.29	1.6943	100%	0.0107	1.0000
IEEE 802.11g	15.00	31.6228	2.29	1.6943	100%	0.0107	1.0000
IEEE 802.11n HT20	15.00	31.6228	2.29	1.6943	100%	0.0107	1.0000
IEEE 802.11n HT40	16.00	39.8107	2.29	1.6943	100%	0.0134	1.0000

Antenna 2

Modulation Type	Max. Output power with Tune_up		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
IEEE 802.11b	13.00	19.9526	2.29	1.6943	100%	0.0067	1.0000
IEEE 802.11g	15.00	31.6228	2.29	1.6943	100%	0.0107	1.0000
IEEE 802.11n HT20	16.00	39.8107	2.29	1.6943	100%	0.0134	1.0000
IEEE 802.11n HT40	16.00	39.8107	2.29	1.6943	100%	0.0134	1.0000

5GHz WLAN Band 1 SISO MODE

Antenna 1

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
IEEE 802.11a	13.00	19.9526	1.95	1.5668	100%	0.0062	1.0000
IEEE 802.11n HT20	12.00	15.8489	1.95	1.5668	100%	0.0049	1.0000
IEEE 802.11n HT40	12.00	15.8489	1.95	1.5668	100%	0.0049	1.0000
IEEE 802.11ac VHT20	12.00	15.8489	1.95	1.5668	100%	0.0049	1.0000
IEEE 802.11ac VHT40	12.00	15.8489	1.95	1.5668	100%	0.0049	1.0000
IEEE 802.11ac VHT80	13.00	19.9526	1.95	1.5668	100%	0.0062	1.0000

Antenna 2

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
IEEE 802.11a	12.00	15.8489	1.95	1.5668	100%	0.0049	1.0000
IEEE 802.11n HT20	12.00	15.8489	1.95	1.5668	100%	0.0049	1.0000
IEEE 802.11n HT40	12.00	15.8489	1.95	1.5668	100%	0.0049	1.0000
IEEE 802.11ac VHT20	12.00	15.8489	1.95	1.5668	100%	0.0049	1.0000
IEEE 802.11ac VHT40	12.00	15.8489	1.95	1.5668	100%	0.0049	1.0000
IEEE 802.11ac VHT80	13.00	19.9526	1.95	1.5668	100%	0.0062	1.0000

5GHz WLAN Band 3 SISO MODE

Antenna 1

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
IEEE 802.11a	12.00	15.8489	1.95	1.5668	100%	0.0049	1.0000
IEEE 802.11n HT20	12.00	15.8489	1.95	1.5668	100%	0.0049	1.0000
IEEE 802.11n HT40	12.00	15.8489	1.95	1.5668	100%	0.0049	1.0000
IEEE 802.11ac VHT20	13.00	19.9526	1.95	1.5668	100%	0.0062	1.0000
IEEE 802.11ac VHT40	13.00	19.9526	1.95	1.5668	100%	0.0062	1.0000
IEEE 802.11ac VHT80	12.00	15.8489	1.95	1.5668	100%	0.0049	1.0000

Antenna 2

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
IEEE 802.11a	12.00	15.8489	1.95	1.5668	100%	0.0049	1.0000
IEEE 802.11n HT20	12.00	15.8489	1.95	1.5668	100%	0.0049	1.0000
IEEE 802.11n HT40	12.00	15.8489	1.95	1.5668	100%	0.0049	1.0000
IEEE 802.11ac VHT20	13.00	19.9526	1.95	1.5668	100%	0.0062	1.0000
IEEE 802.11ac VHT40	13.00	19.9526	1.95	1.5668	100%	0.0062	1.0000
IEEE 802.11ac VHT80	12.00	15.8489	1.95	1.5668	100%	0.0049	1.0000

Remark:

1. Output power (Average) including turn-up tolerance;
2. Output power was adjust to duty cycle at 100% if measured duty cycle less than 98%;
3. MPE evaluate distance is 20cm from user manual provide by manufacturer.

2.4GHz WLAN MIMO MODE

Antenna 1

Modulation Type	Max. Output power with Tune_up		Directional gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
IEEE 802.11n HT20	11.00	12.5893	5.30	3.3884	100%	0.0085	1.0000
IEEE 802.11n HT40	11.00	12.5893	5.30	3.3884	100%	0.0085	1.0000

Antenna 2

Modulation Type	Max. Output power with Tune_up		Directional gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
IEEE 802.11n HT20	10.00	10.0000	5.30	3.3884	100%	0.0067	1.0000
IEEE 802.11n HT40	10.00	10.0000	5.30	3.3884	100%	0.0067	1.0000

5GHz WLAN Band 1 MIMO MODE

Antenna 1

Modulation Type	Output power		Directional gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
IEEE 802.11n HT20	11.00	12.5893	4.96	3.1333	100%	0.0078	1.0000
IEEE 802.11n HT40	12.00	15.8489	4.96	3.1333	100%	0.0099	1.0000
IEEE 802.11ac VHT20	12.00	15.8489	4.96	3.1333	100%	0.0099	1.0000
IEEE 802.11ac VHT40	12.00	15.8489	4.96	3.1333	100%	0.0099	1.0000
IEEE 802.11ac VHT80	13.00	19.9526	4.96	3.1333	100%	0.0124	1.0000

Antenna 2

Modulation Type	Output power		Directional gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
IEEE 802.11n HT20	11.00	12.5893	4.96	3.1333	100%	0.0078	1.0000
IEEE 802.11n HT40	12.00	15.8489	4.96	3.1333	100%	0.0099	1.0000
IEEE 802.11ac VHT20	12.00	15.8489	4.96	3.1333	100%	0.0099	1.0000
IEEE 802.11ac VHT40	12.00	15.8489	4.96	3.1333	100%	0.0099	1.0000
IEEE 802.11ac VHT80	13.00	19.9526	4.96	3.1333	100%	0.0124	1.0000

5GHz WLAN Band 3 MIMO MODE

Antenna 1

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
IEEE 802.11n HT20	11.00	12.5893	4.96	3.1333	100%	0.0078	1.0000
IEEE 802.11n HT40	12.00	15.8489	4.96	3.1333	100%	0.0099	1.0000
IEEE 802.11ac VHT20	12.00	15.8489	4.96	3.1333	100%	0.0099	1.0000
IEEE 802.11ac VHT40	12.00	15.8489	4.96	3.1333	100%	0.0099	1.0000
IEEE 802.11ac VHT80	12.00	15.8489	4.96	3.1333	100%	0.0099	1.0000

Antenna 2

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
IEEE 802.11n HT20	11.00	12.5893	4.96	3.1333	100%	0.0078	1.0000
IEEE 802.11n HT40	12.00	15.8489	4.96	3.1333	100%	0.0099	1.0000
IEEE 802.11ac VHT20	12.00	15.8489	4.96	3.1333	100%	0.0099	1.0000
IEEE 802.11ac VHT40	12.00	15.8489	4.96	3.1333	100%	0.0099	1.0000
IEEE 802.11ac VHT80	12.00	15.8489	4.96	3.1333	100%	0.0099	1.0000

Remark:

1. Output power (Average) including turn-up tolerance;
2. Output power was adjust to duty cycle at 100% if measured duty cycle less than 98%;
3. MPE evaluate distance is 20cm from user manual provide by manufacturer.

7. Summary simultaneous transmission information

The device two WIFI antenna and one BT antenna, WIFI Ant1 and Ant2 can transmit simultaneously in 802.11xx MIMO mode. BT and WIFI can transmit simultaneously. WIFI 2.4G and WIFI5G cannot transmit simultaneously.

8. Summary simultaneous transmission results

WIFI Antenna 1 + Antenna 2 for 2.4G WLAN MIMO MODE

Modulation Type	MPE _{Antenna1} (mW/cm ²)	MPE _{Antenna2} (mW/cm ²)	ΣMPE ratios	Limit	Results
IEEE 802.11n HT20	0.0085	0.0067	0.0152	1.0	PASS
IEEE 802.11n HT40	0.0085	0.0067	0.0152	1.0	PASS

Antenna 1 + Antenna 2 for 5G WLAN Band 1 MIMO MODE

Modulation Type	MPE _{Antenna1} (mW/cm ²)	MPE _{Antenna2} (mW/cm ²)	ΣMPE ratios	Limit	Results
IEEE 802.11n HT20	0.0078	0.0078	0.0156	1.0	PASS
IEEE 802.11n HT40	0.0099	0.0099	0.0198	1.0	PASS
IEEE 802.11ac VHT20	0.0099	0.0099	0.0198	1.0	PASS
IEEE 802.11ac VHT40	0.0099	0.0099	0.0198	1.0	PASS
IEEE 802.11ac VHT80	0.0124	0.0124	0.0248	1.0	PASS

Antenna 1 + Antenna 2 for 5G WLAN Band 3 MIMO MODE

Modulation Type	MPE _{Antenna1} (mW/cm ²)	MPE _{Antenna2} (mW/cm ²)	ΣMPE ratios	Limit	Results
IEEE 802.11n HT20	0.0078	0.0078	0.0156	1.0	PASS
IEEE 802.11n HT40	0.0099	0.0099	0.0198	1.0	PASS
IEEE 802.11ac VHT20	0.0099	0.0099	0.0198	1.0	PASS
IEEE 802.11ac VHT40	0.0099	0.0099	0.0198	1.0	PASS
IEEE 802.11ac VHT80	0.0099	0.0099	0.0198	1.0	PASS

WIFI +BT

Modulation Type	Max MPE _{WIFI} (mW/cm ²)	Max MPE _{BT} (mW/cm ²)	ΣMPE ratios	Limit	Results
WIFI+BT	0.0248	0.0020	0.0268	1.0	PASS

Remark:

- 1. Output power including turn-up tolerance;*
- 2. Output power was adjust to duty cycle at 100% if measured duty cycle less than 98%;*
- 3. MPE evaluate distance is 20cm from user manual provide by manufacturer.*

9. Conclusion

The measurement results comply with the FCC Limit per 47 CFR 2.1091 for the uncontrolled RF Exposure of mobile device.

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