

RF Exposure evaluation

FCC ID: 2A66O-APS200

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 Identification in Internal photos	Antenna type and antenna number	Operate frequency band	Maximum antenna gain (dBi)
Antenna 1	2.4G/5G Wifi Chain 1 Bluetooth	FPC antenna	2.4GHz – 2.5 GHz 5.1GHz – 5.8 GHz	2.4G:3.94 UNII 1: 3.50 UNII 3: 4.83
Antenna 2	2.4G/5G Wifi Chain 2	FPC antenna	2.4GHz – 2.5 GHz 5.1GHz – 5.8 GHz	2.4G:3.94 UNII 1: 3.50 UNII 3: 4.83

5. Manufacturing Tolerance

Bluetooth

GFSK (Peak)			
Channel	Channel 0	Channel 39	Channel 78
Target (dBm)	1.0	1.0	1.0
Tolerance ±(dB)	1.0	1.0	1.0
π/4DQPSK (Peak)			
Channel	Channel 0	Channel 39	Channel 78
Target (dBm)	1.0	1.0	1.0
Tolerance ±(dB)	1.0	1.0	1.0
8-DPSK (Peak)			
Channel	Channel 0	Channel 39	Channel 78
Target (dBm)	1.0	1.0	1.0
Tolerance ±(dB)	1.0	1.0	1.0
BLE GFSK			
Channel	Channel 0	Channel 19	Channel 39
Target (dBm)	-1.0	-1.0	-1.0
Tolerance ±(dB)	1.0	1.0	1.0

2.4GHz WLAN

<i>IEEE 802.11b (Peak)</i>						
Frequency (MHz)	Antenna 1			Antenna 2		
	2412	2437	2462	2412	2437	2462
Target (dBm)	15.0	18.0	16.0	15.0	18.0	16.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
<i>IEEE 802.11g (Peak)</i>						
Frequency (MHz)	Antenna 1			Antenna 2		
	2412	2437	2462	2412	2437	2462
Target (dBm)	22	24	24	22	24	24
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
<i>IEEE 802.11n HT20 (Peak)</i>						
Frequency (MHz)	Antenna 1			Antenna 2		
	2412	2437	2462	2412	2437	2462
Target (dBm)	22	25	25	21	23	23
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
<i>IEEE 802.11n HT40 (Peak)</i>						
Frequency (MHz)	Antenna 1			Antenna 2		
	2422	2437	2452	2422	2437	2452
Target (dBm)	22	24	24	22	23	23
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0

5GHz WLAN Band 1

<i>IEEE 802.11a (Average)</i>						
Frequency (MHz)	Antenna 1			Antenna 2		
	5180	5200	5240	5180	5200	5240
Target (dBm)	10.0	10.0	10.0	3.0	3.0	3.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
<i>IEEE 802.11n HT20 (Average)</i>						
Frequency (MHz)	Antenna 1			Antenna 2		
	5180	5200	5240	5180	5200	5240
Target (dBm)	10.0	10.0	10.0	10.0	10.0	10.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
<i>IEEE 802.11ac VHT20 (Average)</i>						
Frequency (MHz)	Antenna 1			Antenna 2		
	5180	5200	5240	5180	5200	5240
Target (dBm)	10.0	10.0	10.0	10.0	10.0	10.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
<i>IEEE 802.11n HT40 (Average)</i>						
Frequency (MHz)	Antenna 1		Antenna 2			
	5190	5230	5190	5230		
Target (dBm)	10.0	10.0	10.0	10.0		

Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0
<i>IEEE 802.11ac VHT40 (Average)</i>				
Frequency (MHz)	Antenna 1		Antenna 2	
	5190	5230	5190	5230
Target (dBm)	10.0	10.0	10.0	10.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0
<i>IEEE 802.11ac VHT80 (Average)</i>				
Frequency (MHz)	Antenna 1		Antenna 2	
	5210		5210	
Target (dBm)	10.0		10.0	
Tolerance $\pm$ (dB)	1.0		1.0	

5GHz WLAN Band 3

IEEE 802.11a (Average)						
Frequency (MHz)	Antenna 1			Antenna 2		
	5745	5785	5825	5745	5785	5825
Target (dBm)	10.0	10.0	7.0	2.0	2.0	1.0
Tolerance ± (dB)	1.0	1.0	1.0	1.0	1.0	1.0
IEEE 802.11n HT20 (Average)						
Frequency (MHz)	Antenna 1			Antenna 2		
	5745	5785	5825	5745	5785	5825
Target (dBm)	11.0	11.0	10.0	9.0	9.0	8.0
Tolerance ± (dB)	1.0	1.0	1.0	1.0	1.0	1.0
IEEE 802.11ac VHT20 (Average)						
Frequency (MHz)	Antenna 1			Antenna 2		
	5745	5785	5825	5745	5785	5825
Target (dBm)	11.0	11.0	10.0	11.0	11.0	10.0
Tolerance ± (dB)	1.0	1.0	1.0	1.0	1.0	1.0
IEEE 802.11n HT40 (Average)						
Frequency (MHz)	Antenna 1		Antenna 2			
	5755	5795	5755		5795	
Target (dBm)	11.0		11.0		10.0	
Tolerance ± (dB)	1.0		1.0		1.0	
IEEE 802.11ac VHT40 (Average)						
Frequency (MHz)	Antenna 1		Antenna 2			
	5755	5795	5755		5795	
Target (dBm)	11.0		11.0		11.0	
Tolerance ± (dB)	1.0		1.0		1.0	
IEEE 802.11ac VHT80 (Average)						
Frequency (MHz)	Antenna 1		Antenna 2			
	5775		5775			

Target (dBm)	11.0	11.0
Tolerance $\pm$ (dB)	1.0	1.0

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.

Bluetooth

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
GFSK	2.00	1.5849	3.94	2.4774	100%	0.0008	1.0000
$\pi/4$ DQPSK	2.00	1.5849	3.94	2.4774	100%	0.0008	1.0000
8-DPSK	2.00	1.5849	3.94	2.4774	100%	0.0008	1.0000
BLE GFSK	0.00	1.0000	3.94	2.4774	100%	0.0005	1.0000

2.4GHz WLAN

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 802.11b	19.00	79.4328	3.94	2.4774	100%	0.0391	1.0000
IEEE 802.11g	25.00	316.2278	3.94	2.4774	100%	0.1559	1.0000
IEEE 802.11n HT20	26.00	398.1072	3.94	2.4774	100%	0.1962	1.0000
IEEE 802.11n HT40	25.00	316.2278	3.94	2.4774	100%	0.1559	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 802.11b	19.00	79.4328	3.94	2.4774	100%	0.0391	1.0000
IEEE 802.11g	25.00	316.2278	3.94	2.4774	100%	0.1559	1.0000
IEEE 802.11n HT20	24.00	251.1886	3.94	2.4774	100%	0.1238	1.0000
IEEE 802.11n HT40	24.00	251.1886	3.94	2.4774	100%	0.1238	1.0000

5GHz WLAN Band 1

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	11.00	12.5893	3.50	2.2387	100%	0.0056	1.0000
IEEE 802.11n HT20	11.00	12.5893	3.50	2.2387	100%	0.0056	1.0000
IEEE 802.11ac VHT20	11.00	12.5893	3.50	2.2387	100%	0.0056	1.0000
IEEE 802.11n HT40	11.00	12.5893	3.50	2.2387	100%	0.0056	1.0000
IEEE 802.11ac VHT40	11.00	12.5893	3.50	2.2387	100%	0.0056	1.0000
IEEE 802.11ac VHT80	11.00	12.5893	3.50	2.2387	100%	0.0056	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	4.00	2.5119	3.50	2.2387	100%	0.0011	1.0000
IEEE 802.11n HT20	11.00	12.5893	3.50	2.2387	100%	0.0056	1.0000
IEEE 802.11ac VHT20	11.00	12.5893	3.50	2.2387	100%	0.0056	1.0000
IEEE 802.11n HT40	11.00	12.5893	3.50	2.2387	100%	0.0056	1.0000
IEEE 802.11ac VHT40	11.00	12.5893	3.50	2.2387	100%	0.0056	1.0000
IEEE 802.11ac VHT80	11.00	12.5893	3.50	2.2387	100%	0.0056	1.0000

5GHz WLAN Band 3

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	11.00	12.5893	4.83	3.0409	100%	0.0076	1.0000
IEEE 802.11n HT20	12.00	15.8489	4.83	3.0409	100%	0.0096	1.0000
IEEE 802.11ac VHT20	12.00	15.8489	4.83	3.0409	100%	0.0096	1.0000
IEEE 802.11n HT40	12.00	15.8489	4.83	3.0409	100%	0.0096	1.0000
IEEE 802.11ac VHT40	12.00	15.8489	4.83	3.0409	100%	0.0096	1.0000
IEEE 802.11ac VHT80	12.00	15.8489	4.83	3.0409	100%	0.0096	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	3.00	1.9953	4.83	3.0409	100%	0.0012	1.0000
IEEE 802.11n HT20	10.00	10.0000	4.83	3.0409	100%	0.0060	1.0000
IEEE 802.11ac VHT20	12.00	15.8489	4.83	3.0409	100%	0.0096	1.0000

IEEE 802.11n HT40	11.00	12.5893	4.83	3.0409	100%	0.0076	1.0000
IEEE 802.11ac VHT40	12.00	15.8489	4.83	3.0409	100%	0.0096	1.0000
IEEE 802.11ac VHT80	12.00	15.8489	4.83	3.0409	100%	0.0096	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

Modulation Type	Work Frequency Band	Transmit Antenna		Antenna 1 Antenna 2 Synchronization transmit
		Antenna 1	Antenna 2	
Bluetooth	2.4GHz	Yes	No	No
IEEE 802.11a	5.8G/5.2GHz	Yes	Yes	No
IEEE 802.11b	2.4GHz	Yes	Yes	No
IEEE 802.11g	2.4GHz	Yes	Yes	No
IEEE 802.11n HT20	2.4GHz	Yes	Yes	Yes
IEEE 802.11n HT20	5.8G/5.2GHz	Yes	Yes	Yes
IEEE 802.11n HT40	2.4GHz	Yes	Yes	Yes
IEEE 802.11n HT40	5.8G/5.2GHz	Yes	Yes	Yes
IEEE 802.11ac VHT20	5.8G/5.2GHz	Yes	Yes	Yes
IEEE 802.11ac VHT40	5.8G/5.2GHz	Yes	Yes	Yes
IEEE 802.11ac VHT80	5.8G/5.2GHz	Yes	Yes	Yes

8. Summary simultaneous transmission results

Antenna 1 and Antenna 2 for 2.4G WLAN

Modulation Type	MPE Antenna0 (mW/cm ²)	MPE Antenna1 (mW/cm ²)	ΣMPE ratios	Limit	Results
IEEE 802.11n HT20	0.1962	0.1238	0.3200	1.0	PASS
IEEE 802.11n HT40	0.1559	0.1238	0.2797	1.0	PASS

Antenna 1 and Antenna 2 for 5G WLAN Band 1

Modulation Type	MPE Antenna0 (mW/cm ²)	MPE Antenna1 (mW/cm ²)	ΣMPE ratios	Limit	Results
IEEE 802.11n HT20	0.0056	0.0056	0.0112	1.0	PASS
IEEE 802.11ac VHT20	0.0056	0.0056	0.0112	1.0	PASS
IEEE 802.11n HT40	0.0056	0.0056	0.0112	1.0	PASS
IEEE 802.11ac VHT40	0.0056	0.0056	0.0112	1.0	PASS
IEEE 802.11ac VHT80	0.0056	0.0056	0.0112	1.0	PASS

Antenna 1 and Antenna 2 for 5GWLAN Band 3

Modulation Type	MPE _{Antenna0} (mW/cm ²)	MPE _{Antenna1} (mW/cm ²)	ΣMPE ratios	Limit	Results
IEEE 802.11n HT20	0.0096	0.0060	0.0156	1.0	PASS
IEEE 802.11ac VHT20	0.0096	0.0096	0.0192	1.0	PASS
IEEE 802.11n HT40	0.0096	0.0076	0.0172	1.0	PASS
IEEE 802.11ac VHT40	0.0096	0.0096	0.0192	1.0	PASS
IEEE 802.11ac VHT80	0.0096	0.0096	0.0192	1.0	PASS

BT Antenna 1 and WIFI Antenna 2

Modulation Type	Max MPE _{BT} (mW/cm ²)	Max MPE _{WIFI} (mW/cm ²)	ΣMPE ratios	Limit	Results
WIFI+BT	0.0008	0.1559	0.1567	1.0	PASS

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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