



MPE Report

Exposure category: General population/uncontrolled environment

EUT Type: Production Unit

Device Type: Mobile Device

Refer Standard: KDB 447498 D01 General RF Exposure Guidance D01

FCC Part 2 §2.1091

1. Evaluation method

Systems operating under the provisions of FCC 47 CFR 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.

In accordance with 47 CFR FCC Part 2 Subpart J, section 2.1091 this device has been defined as mobile device whereby a distance of 0.2m normally can be maintained between the user and the device, and below RF Permissible Exposure limit shall comply with.

In accordance with KDB447498D01 for Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneous transmitting antennas incorporated in a host device, based on the calculated/estimated, numerically modeled or measured field strengths or power density, is ≤ 1.0 . The MPE ratio of each antenna is determined at the minimum test separation distance required by the operating configurations and exposure conditions of the host device, according to the ratio of field strengths or power density to MPE limit, at the test frequency. Either the maximum peak or spatially averaged results from measurements or numerical simulations may be used to determine the MPE ratios. Spatial averaging does not apply when MPE is estimated using simple calculations based on far-field plane-wave equivalent conditions. The antenna installation and operating requirements for the host device must meet the minimum test separation distances required by all antennas, in both standalone and simultaneous transmission operations, to satisfy compliance.

2. Limits for General Population/Uncontrolled Exposure

(B) Limits for General Population / Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm ²)	Averaging Time E ² , H ² or S (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	(180/f)*	30
30-300	27.5	0.073	0.2	30
300-1500			F/1500	30
1500-100,000			1.0	30

Note: f = frequency in MHz ; *Plane-wave equivalent power density

3. 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



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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

From the EUT RF output power, the minimum mobile separation distance, $d=0.2m$, as well as the maximum gain of the used antenna as follow table, the RF power density can be obtained.

Frequency Band	Antenna type and antenna number	Internal Identification	Maximum antenna gain
2.4GHz	Antenna 0, Embedded Antenna	Antenna 0	2.3dBi
	Antenna 1, Embedded Antenna	Antenna 1	5.0dBi
	Antenna 2, Embedded Antenna	Antenna 2	2.0dBi
5.8GHz	Antenna 0, Embedded Antenna	Antenna 3	3.8dBi
	Antenna 1, Embedded Antenna	Antenna 4	3.8dBi
	Antenna 2, Embedded Antenna	Antenna 5	3.8dBi

4. Estimation Result

4.1 Conducted Power Results

2.4GHz WIFI

IEEE 802.11 b									
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2		
	2412	2437	2462	2412	2437	2462	2412	2437	2462
Average Conducted Output Power (dBm)	19.17	20.68	21.00	20.01	20.21	20.07	20.08	21.15	21.26
IEEE 802.11 g									
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2		
	2412	2437	2462	2412	2437	2462	2412	2437	2462
Average Conducted Output Power (dBm)	18.88	18.86	18.80	18.76	18.17	18.24	18.99	19.44	19.36
IEEE 802.11 n HT20									
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2		
	2412	2437	2462	2412	2437	2462	2412	2437	2462
Average Conducted Output Power (dBm)	14.02	14.63	15.44	13.91	14.57	14.39	14.99	14.83	15.25
IEEE 802.11 n HT40									
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2		
	2422	2437	2462	2422	2437	2462	2422	2437	2462
Average Conducted Output Power (dBm)	13.75	14.18	14.96	15.09	14.86	15.12	15.74	15.56	15.21

**5GHz WIFI****IEEE 802.11 a**

IEEE 802.11 a									
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5180	5200	5240	5180	5200	5240	5180	5200	5240
Average Conducted Output Power (dBm)	18.57	18.78	18.99	18.98	18.46	18.61	18.98	18.46	18.61
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5260	5300	5320	5260	5300	5320	5260	5300	5320
Average Conducted Output Power (dBm)	19.17	18.83	18.91	20.06	20.18	19.96	20.90	21.11	21.31
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5500	5580	5700	5500	5580	5700	5500	5580	5700
Average Conducted Output Power (dBm)	20.99	20.26	19.84	20.00	20.41	19.81	20.77	20.44	19.71
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5745	5785	5825	5745	5785	5825	5745	5785	5825
Average Conducted Output Power (dBm)	20.34	20.67	20.79	19.86	19.80	19.53	20.25	19.97	20.39
IEEE 802.11 n HT20									
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5180	5200	5240	5180	5200	5240	5180	5200	5240
Average Conducted Output Power (dBm)	8.61	9.29	9.64	8.42	8.28	7.95	9.17	9.07	8.84
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5260	5300	5320	5260	5300	5320	5260	5300	5320
Average Conducted Output Power (dBm)	14.50	15.51	14.51	15.68	15.27	15.80	16.78	16.71	16.78
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5500	5580	5700	5500	5580	5700	5500	5580	5700
Average Conducted Output Power (dBm)	15.98	15.29	15.99	14.85	15.02	15.69	16.13	16.01	15.43
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5745	5785	5825	5745	5785	5825	5745	5785	5825
Average Conducted Output Power (dBm)	19.15	18.92	18.81	18.80	18.27	18.03	19.44	19.11	18.97

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Report No: C160218Z03-RP1_MPE

FCC ID: VW7SR555A

Date of Issue: April 14, 2016

IEEE 802.11 n HT40									
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5190	---	5230	5190	---	5230	5190	---	5230
Average Conducted Output Power (dBm)	9.03	---	9.23	8.49	---	8.54	8.56	---	7.97
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5270	---	5310	5270	---	5310	5270	---	5310
Average Conducted Output Power (dBm)	14.45	---	14.83	15.96	---	15.83	16.98	---	16.86
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5510	5550	5670	5510	5550	5670	5510	5550	5670
Average Conducted Output Power (dBm)	16.38	15.55	15.69	15.00	15.55	15.75	16.39	16.59	16.25
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5755	---	5795	5755	---	5795	5755	---	5795
Average Conducted Output Power (dBm)	18.90	---	18.74	18.55	---	18.24	19.25	---	19.30
IEEE 802.11 ac 80									
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	---	5210	---	---	5210	---	---	5210	---
Average Conducted Output Power (dBm)	---	9.53	---	---	8.51	---	---	8.42	---
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	---	5290	---	---	5290	---	---	5290	---
Average Conducted Output Power (dBm)	---	10.99	---	---	12.35	---	---	13.33	---
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	---	5530	---	---	5530	---	---	5530	---
Average Conducted Output Power (dBm)	---	15.64	---	---	14.97	---	---	16.12	---
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	---	5775	---	---	5775	---	---	5775	---
Average Conducted Output Power (dBm)	---	16.70	---	---	16.12	---	---	17.09	---

**4.2 Manufacturing tolerance****2.4GHz WIFI**

IEEE 802.11 b (average)									
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2		
	2412	2437	2462	2412	2437	2462	2412	2437	2462
Target (dBm)	19.0	20.0	21.0	20.0	20.0	20.0	20.0	21.0	21.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
IEEE 802.11 g (average)									
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2		
	2412	2437	2462	2412	2437	2462	2412	2437	2462
Target (dBm)	18.0	18.0	18.0	18.0	18.0	18.0	19.0	19.0	19.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
IEEE 802.11 n HT20 (average)									
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2		
	2412	2437	2462	2412	2437	2462	2412	2437	2462
Target (dBm)	14.0	15.0	15.0	14.0	15.0	15.0	15.0	15.0	15.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
IEEE 802.11 n HT40 (average)									
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2		
	2422	2437	2462	2422	2437	2462	2422	2437	2462
Target (dBm)	14.0	14.0	14.0	15.0	15.0	15.0	15.0	15.0	15.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

5GHz WIFI

IEEE 802.11 a (average)									
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5180	5200	5240	5180	5200	5240	5180	5200	5240
Target (dBm)	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5260	5300	5320	5260	5300	5320	5260	5300	5320
Target (dBm)	19.0	18.0	19.0	20.0	20.0	20.0	20.0	21.0	21.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5500	5580	5700	5500	5580	5700	5500	5580	5700
Target (dBm)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5745	5785	5825	5745	5785	5825	5745	5785	5825
Target (dBm)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
IEEE 802.11 n HT20 (average)									



Compliance Certification Services (Shenzhen) Inc.

Report No: C160218Z03-RP1_MPE

FCC ID: VW7SR555A

Date of Issue: April 14, 2016

Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5180	5200	5240	5180	5200	5240	5180	5200	5240
Target (dBm)	9.0	9.0	9.0	8.0	8.0	8.0	9.0	9.0	9.0
Tolerance \pm (dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5260	5300	5320	5260	5300	5320	5260	5300	5320
Target (dBm)	15.0	15.0	15.0	15.0	15.0	15.0	16.0	16.0	16.0
Tolerance \pm (dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5500	5580	5700	5500	5580	5700	5500	5580	5700
Target (dBm)	16.0	16.0	16.0	15.0	15.0	15.0	16.0	16.0	16.0
Tolerance \pm (dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5745	5785	5825	5745	5785	5825	5745	5785	5825
Target (dBm)	19.0	18.0	18.0	18.0	18.0	18.0	19.0	19.0	19.0
Tolerance \pm (dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
IEEE 802.11 n HT40 (average)									
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5190	---	5230	5190	---	5230	5190	---	5230
Target (dBm)	9.0	---	9.0	8.0	---	8.0	8.0	---	8.0
Tolerance \pm (dB)	1.0	---	1.0	1.0	---	1.0	1.0	---	1.0
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5270	---	5310	5270	---	5310	5270	---	5310
Target (dBm)	14.0	---	14.0	15.0	---	15.0	16.0	---	16.0
Tolerance \pm (dB)	1.0	---	1.0	1.0	---	1.0	1.0	---	1.0
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5510	5550	5670	5510	5550	5670	5510	5550	5670
Target (dBm)	16.0	15.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
Tolerance \pm (dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	5755	---	5795	5755	---	5795	5755	---	5795
Target (dBm)	18.0	---	18.0	18.0	---	18.0	19.0	---	19.0
Tolerance \pm (dB)	1.0	---	1.0	1.0	---	1.0	1.0	---	1.0
IEEE 802.11 ac 80 (average)									
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	---	5210	---	---	5210	---	---	5210	---
Target (dBm)	---	9.0	---	---	9.0	---	---	9.0	---
Tolerance \pm (dB)	---	1.0	---	---	1.0	---	---	1.0	---
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	---	5290	---	---	5290	---	---	5290	---
Target (dBm)	---	10.0	---	---	12.0	---	---	13.0	---
Tolerance \pm (dB)	---	1.0	---	---	1.0	---	---	1.0	---



Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	---	5530	---	---	5530	---	---	5530	---
Target (dBm)	---	15.0	---	---	15.0	---	---	16.0	---
Tolerance \pm (dB)	---	1.0	---	---	1.0	---	---	1.0	---
Frequency (MHz)	Antenna 3			Antenna 4			Antenna 5		
	---	5775	---	---	5775	---	---	5775	---
Target (dBm)	---	17.0	---	---	17.0	---	---	17.0	---
Tolerance \pm (dB)	---	1.0	---	---	1.0	---	---	1.0	---

4.3 Measurement Results

4.3.1 Standalone MPE

2.4G WLAN

Antenna 0

Mode	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	(dBm)	(mW)					
IEEE 802.11 b	22.00	158.4893	2.30	1.6982	100%	0.0536	1.000
IEEE 802.11 g	19.00	79.4328	2.30	1.6982	100%	0.0269	1.000
IEEE 802.11 n HT20	16.00	39.8107	2.30	1.6982	100%	0.0135	1.000
IEEE 802.11 n HT40	15.00	31.6228	2.30	1.6982	100%	0.0107	1.000

Antenna 1

Mode	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	(dBm)	(mW)					
IEEE 802.11 b	21.00	125.8925	5.00	3.1623	100%	0.0792	1.000
IEEE 802.11 g	19.00	79.4328	5.00	3.1623	100%	0.0500	1.000
IEEE 802.11 n HT20	16.00	39.8107	5.00	3.1623	100%	0.0251	1.000
IEEE 802.11 n HT40	16.00	39.8107	5.00	3.1623	100%	0.0251	1.000

Antenna 2

Mode	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	(dBm)	(mW)					
IEEE 802.11 b	22.00	158.4893	2.00	1.5849	100%	0.0500	1.000
IEEE 802.11 g	20.00	100.0000	2.00	1.5849	100%	0.0315	1.000
IEEE 802.11 n HT20	16.00	39.8107	2.00	1.5849	100%	0.0126	1.000
IEEE 802.11 n HT40	16.00	39.8107	2.00	1.5849	100%	0.0126	1.000

**5GWLAN****Antenna 3**

Mode	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	(dBm)	(mW)					
IEEE 802.11 a	21.00	125.8925	3.80	2.3988	100%	0.0601	1.000
IEEE 802.11 n HT20	20.00	100.0000	3.80	2.3988	100%	0.0477	1.000
IEEE 802.11 n HT40	19.00	79.4328	3.80	2.3988	100%	0.0379	1.000
IEEE 802.11 ac 80	18.00	63.0957	3.80	2.3988	100%	0.0301	1.000

Antenna 4

Mode	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	(dBm)	(mW)					
IEEE 802.11 a	21.00	125.8925	3.80	2.3988	100%	0.0601	1.000
IEEE 802.11 n HT20	19.00	79.4328	3.80	2.3988	100%	0.0379	1.000
IEEE 802.11 n HT40	19.00	79.4328	3.80	2.3988	100%	0.0379	1.000
IEEE 802.11 ac 80	18.00	63.0957	3.80	2.3988	100%	0.0301	1.000

Antenna 5

Mode	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	(dBm)	(mW)					
IEEE 802.11 a	22.00	158.4893	3.80	2.3988	100%	0.0757	1.000
IEEE 802.11 n HT20	20.00	100.0000	3.80	2.3988	100%	0.0477	1.000
IEEE 802.11 n HT40	20.00	100.0000	3.80	2.3988	100%	0.0477	1.000
IEEE 802.11 ac 80	18.00	63.0957	3.80	2.3988	100%	0.0301	1.000

Remark:

1. Maximum average power including tune-up tolerance;
2. MPE use distance is 20cm from manufacturer declaration of user manual.

4.3.2 Simultaneous transmission MPE

According to KDB447498 for Transmitters used in mobile exposure conditions for simultaneous transmission operations;

\sum of MPE ratios ≤ 1.0

We evaluate 2 antennas simultaneous and 3 antennas simultaneous, recorded worst case at 3 antennas simultaneous.



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Antenna 0, Antenna 1 and Antenna 2 for 2.4GWLAN

Mode	MPE _{Antenna 0} (mW/cm ²)	MPE _{Antenna 1} (mW/cm ²)	MPE _{Antenna 2} (mW/cm ²)	∑ MPE ratios	Limit	Results
IEEE 802.11b	0.0536	0.0792	0.0500	N/A	1.000	Pass
IEEE 802.11g	0.0269	0.0500	0.0315	N/A	1.000	Pass
IEEE 802.11n HT20	0.0135	0.0251	0.0126	0.0512	1.000	Pass
IEEE 802.11n HT40	0.0107	0.0251	0.0126	0.0484	1.000	Pass

Antenna 3, Antenna 4 and Antenna 5 for 5GWLAN

Mode	MPE _{Antenna 3} (mW/cm ²)	MPE _{Antenna 4} (mW/cm ²)	MPE _{Antenna 5} (mW/cm ²)	∑ MPE ratios	Limit	Results
IEEE 802.11 a	0.0601	0.0601	0.0757	N/A	1.000	Pass
IEEE 802.11n HT20	0.0477	0.0379	0.0477	0.1349	1.000	Pass
IEEE 802.11n HT40	0.0379	0.0379	0.0477	0.1235	1.000	Pass
IEEE 802.11 ac 80	0.0301	0.0301	0.0301	0.0903	1.000	Pass

Maximum Simultaneous transmission MPE Ratio for 2.4GWLAN and 5GWLAN

Maximum MPE ratio _{2.4GWLAN}	Maximum MPE ratio _{5GWLAN}	∑ MPE ratios	Limit	Results
0.0792	0.1349	0.2141	1.000	Pass

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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