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 v06
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

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 3.5dBi for for 2.4GWLAN and 5.8GWLAN, the RF power density can be obtained.

Frequency Band	Antenna type and antenna number	Internal Identification	Maximum antenna gain
2.4GHz	Omni-directional antenna	Antenna 0	3.5dBi
		Antenna 1	3.5dBi
		Antenna 2	3.5dBi
5.8GHz	Omni-directional antenna	Antenna 0	3.5dBi
		Antenna 1	3.5dBi
		Antenna 2	3.5dBi
		Antenna 3	3.5dBi

4. Estimation Result

4.1 Conducted Power Results

2.4GHz WIFI

Antenna	Mode	Frequency(MHz)	AVG Conducted Output Power (dBm)
Antenna 0	IEEE 802.11b	2412	16.61
		2437	16.48
		2462	16.39
Antenna 1		2412	16.72
		2437	16.71
		2462	16.32
Antenna 2		2412	16.18
		2437	16.15
		2462	16.11
Antenna 0	IEEE 802.11g	2412	19.75
		2437	19.85
		2462	19.83
Antenna 1		2412	19.32
		2437	19.63
		2462	19.41
Antenna 2		2412	18.33
		2437	19.43
		2462	19.42
Antenna 0	IEEE 802.11n HT20	2412	15.63
		2437	15.67
		2462	15.88

Antenna 1		2412	15.61
		2437	15.79
		2462	15.55
Antenna 2		2412	15.53
		2437	15.86
		2462	15.43
Antenna 0	IEEE 802.11n HT40	2422	15.87
		2437	15.21
		2452	15.93
Antenna 1		2422	15.91
		2437	15.33
		2452	15.97
Antenna 2		2422	15.85
		2437	15.88
		2452	15.74

5GHz WIFI

Antenna	Mode	Frequency(MHz)	AVG Conducted Output Power (dBm)
Antenna 0	IEEE 802.11a	5180	17.56
		5200	19.27
		5240	17.24
		5260	17.33
		5300	17.30
		5320	17.52
		5500	19.50
		5580	19.54
		5700	19.49
		5745	22.46
		5785	22.57
		5825	22.26
Antenna 1		5180	17.26
		5200	19.31
		5240	19.15
		5260	17.46
		5300	17.54
		5320	17.61
		5500	19.13
		5580	18.94
		5700	18.83
		5745	22.14
		5785	22.02

		5825	22.25
Antenna 2		5180	17.51
		5200	19.21
		5240	19.06
		5260	17.24
		5300	17.57
		5320	17.29
		5500	19.35
		5580	19.13
		5700	19.22
		5745	22.54
		5785	22.45
		5825	22.24
Antenna 3		5180	17.71
		5200	19.42
		5240	19.28
		5260	17.41
		5300	17.15
		5320	17.25
		5500	19.71
		5580	19.52
		5700	19.38
		5745	22.11
		5785	22.07
		5825	22.02
Antenna 0	IEEE 802.11n HT20	5180	11.46
		5200	13.54
		5240	13.38
		5260	13.76
		5300	13.47
		5320	13.7
		5500	13.65
		5580	13.61
		5700	13.81
		5745	17.03
		5785	17.19
		5825	17.25
Antenna 1		5180	11.28
		5200	13.27
		5240	13.38
		5260	13.51

		5300	13.45
		5320	13.32
		5500	13.45
		5580	13.43
		5700	13.89
		5745	17.33
		5785	17.09
		5825	17.08
Antenna 2		5180	11.93
		5200	13.77
		5240	13.35
		5260	13.73
		5300	13.67
		5320	13.41
		5500	13.46
		5580	13.61
		5700	13.89
		5745	17.51
		5785	17.53
		5825	17.45
Antenna 3		5180	12.39
		5200	15.31
		5240	15.25
		5260	13.72
		5300	13.98
		5320	13.76
		5500	13.72
		5580	13.69
		5700	13.72
		5745	17.77
		5785	17.76
		5825	17.53
Antenna 0	IEEE 802.11n HT40	5190	10.58
		5230	11.02
		5270	14
		5310	14.17
		5510	14.23
		5550	14.87
		5670	14.26
		5755	18.33
		5795	18.28

Antenna 1		5190	10.98
		5230	11.31
		5270	14.2
		5310	14.26
		5510	14.14
		5550	14.27
		5670	14.15
		5755	18.23
		5795	18.41
Antenna 2		5190	11.14
		5230	11.17
		5270	14.05
		5310	14.25
		5510	14.12
		5550	14.14
		5670	14.18
		5755	18.43
		5795	18.35
Antenna 3		5190	11.77
		5230	11.68
		5270	14.15
		5310	14.11
		5510	14.02
		5550	14.11
		5670	14.18
		5755	18.03
		5795	18.27
Antenna 0	IEEE 802.11ac 80	5210	11.58
		5290	13.96
		5530	13.75
		5775	18.03
Antenna 1		5210	11.28
		5290	13.36
		5530	13.87
		5775	18.05
Antenna 2		5210	11.03
		5290	13.78
		5530	13.83
		5775	18.32
Antenna 3		5210	11.41
		5290	13.62

		5530	13.86
		5775	18.39

4.2 Manufacturing tolerance

2.4GHz WIFI

IEEE 802.11 b (AVG)									
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2		
	2412	2437	2462	2412	2437	2462	2412	2437	2462
Maximum Output power (dBm)	16.61	16.48	16.39	16.72	16.71	16.32	16.18	16.15	16.11

IEEE 802.11 g (AVG)									
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2		
	2412	2437	2462	2412	2437	2462	2412	2437	2462
Maximum Output power (dBm)	19.75	19.85	19.83	19.32	19.63	19.41	18.33	19.43	19.42

IEEE 802.11 n HT20 (AVG)									
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2		
	2412	2437	2462	2412	2437	2462	2412	2437	2462
Maximum Output power (dBm)	15.63	15.67	15.88	15.61	15.79	15.55	15.53	15.86	15.43

IEEE 802.11 n HT40 (AVG)									
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2		
	2422	2437	2452	2412	2437	2462	2422	2437	2452
Maximum Output power (dBm)	15.87	15.21	15.93	15.91	15.33	15.97	15.85	15.88	15.74

5GHz WIFI

IEEE 802.11 a (AVG)												
Frequency	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
(MHz)	5180	5200	5240	5180	5200	5240	5180	5200	5240	5180	5200	5240
Maximum Output power (dBm)	17.56	19.27	17.24	17.26	19.31	19.31	17.51	19.21	19.06	17.71	19.42	19.28
Frequency	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
(MHz)	5260	5300	5320	5260	5300	5320	5260	5300	5320	5260	5300	5320
Maximum Output power (dBm)	17.33	17.30	17.52	17.46	17.46	17.61	17.24	17.57	17.29	17.41	17.15	17.25
Frequency	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
(MHz)	5500	5580	5700	5500	5580	5700	5500	5580	5700	5500	5580	5700
Maximum Output power (dBm)	19.50	19.54	19.49	19.13	18.94	18.83	19.35	19.13	19.22	19.71	19.52	19.38
Frequency	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
(MHz)	5745	5785	5825	5745	5785	5825	5745	5785	5825	5745	5785	5825
Maximum Output power (dBm)	22.46	22.57	22.26	22.14	22.02	22.25	22.54	22.45	22.24	22.11	22.07	22.02

IEEE 802.11n HT20 (AVG)												
Frequency	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
(MHz)	5180	5200	5240	5180	5200	5240	5180	5200	5240	5180	5200	5240
Maximum Output power (dBm)	11.46	13.54	13.38	11.28	13.27	13.38	11.93	13.77	13.35	12.39	15.31	15.25
Frequency	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
(MHz)	5260	5300	5320	5260	5300	5320	5260	5300	5320	5260	5300	5320
Maximum Output power (dBm)	13.76	13.47	13.70	13.51	13.45	13.32	13.73	13.67	13.41	13.72	13.98	13.76
Frequency	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
(MHz)	5500	5580	5700	5500	5580	5700	5500	5580	5700	5500	5580	5700
Maximum Output power (dBm)	13.65	13.61	13.81	13.45	13.43	13.89	13.46	13.61	13.89	13.72	13.69	13.72
Frequency	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
(MHz)	5745	5785	5825	5745	5785	5825	5745	5785	5825	5745	5785	5825
Maximum Output power (dBm)	17.03	17.19	17.25	17.33	17.09	17.08	13.89	17.53	17.45	17.77	17.76	17.53

IEEE 802.11n HT40 (AVG)												
Frequency	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
(MHz)	5190	---	5230	5190	---	5230	5190	---	5230	5190	---	5230
Maximum Output power (dBm)	10.58	---	11.02	10.98	---	11.31	11.14	---	11.17	11.77	---	11.68
Frequency	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
(MHz)	5270	---	5310	5270	---	5310	5270	---	5310	5270	---	5310
Maximum Output power (dBm)	14.00	---	14	14.20	---	14.26	14.05	---	14.25	14.15	---	14.11
Frequency	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
(MHz)	5510	5550	5670	5510	5550	5670	5510	5550	5670	5510	5550	5670
Maximum Output power (dBm)	14.23	14.87	14.26	14.14	14.27	14.15	14.12	14.14	14.18	14.02	14.11	14.18
Frequency	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
(MHz)	5755	---	5795	5755	---	5795	5755	---	5795	5755	---	5795
Maximum Output power (dBm)	18.33	---	18.28	18.23	---	18.41	18.43	---	18.35	18.03	---	18.27

IEEE 802.11ac 80 (AVG)												
Frequency	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
(MHz)	5210	---	5290	5210	---	5290	5210	---	5290	5210	---	5290
Maximum Output power (dBm)	11.58	---	13.96	11.28	---	13.36	11.03	---	13.83	11.41	---	13.86
Frequency	Antenna 0			Antenna 1						Antenna 2		
(MHz)	5530	---	5775	5530	---	5775	5530	---	5775	5530	---	5775
Maximum Output power (dBm)	13.75	---	18.03	13.87	---	18.05	13.78	---	18.32	13.62	---	18.39

4.3 Measurement Results

4.3.1 Standalone MPE

2.4GWLAN

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	16.61	45.8142	3.5000	2.2387	100%	0.0204	1.0000
IEEE 802.11 g	19.85	96.6051	3.5000	2.2387	100%	0.0430	1.0000
IEEE 802.11 n HT20	15.88	38.7258	3.5000	2.2387	100%	0.0173	1.0000
IEEE 802.11 n HT40	15.93	39.1742	3.5000	2.2387	100%	0.0175	1.0000

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	16.72	46.9894	3.5000	2.2387	100%	0.0209	1.0000
IEEE 802.11 g	19.63	91.8333	3.5000	2.2387	100%	0.0409	1.0000
IEEE 802.11 n HT20	15.79	37.9315	3.5000	2.2387	100%	0.0169	1.0000
IEEE 802.11 n HT40	15.97	39.5367	3.5000	2.2387	100%	0.0176	1.0000

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	16.18	41.4954	3.5000	2.2387	100%	0.0185	1.0000
IEEE 802.11 g	19.43	87.7001	3.5000	2.2387	100%	0.0391	1.0000
IEEE 802.11 n HT20	15.86	38.5478	3.5000	2.2387	100%	0.0172	1.0000
IEEE 802.11 n HT40	15.88	38.7258	3.5000	2.2387	100%	0.0173	1.0000

5GWLAN

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 a	22.57	180.7174	3.5000	2.2387	100%	0.0805	1.0000
IEEE 802.11 n HT20	17.25	53.0884	3.5000	2.2387	100%	0.0237	1.0000
IEEE 802.11 n HT40	18.33	68.0769	3.5000	2.2387	100%	0.0303	1.0000
IEEE 802.11 ac 80	18.03	63.5331	3.5000	2.2387	100%	0.0283	1.0000

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 a	22.25	167.8804	3.5000	2.2387	100%	0.0748	1.0000
IEEE 802.11 n HT20	17.33	54.0754	3.5000	2.2387	100%	0.0241	1.0000
IEEE 802.11 n HT40	18.41	69.3426	3.5000	2.2387	100%	0.0309	1.0000
IEEE 802.11 ac 80	18.05	63.8263	3.5000	2.2387	100%	0.0284	1.0000

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 a	22.54	179.4734	3.5000	2.2387	100%	0.0800	1.0000
IEEE 802.11 n HT20	17.53	56.6239	3.5000	2.2387	100%	0.0252	1.0000
IEEE 802.11 n HT40	18.43	69.6627	3.5000	2.2387	100%	0.0310	1.0000
IEEE 802.11 ac 80	18.32	67.9204	3.5000	2.2387	100%	0.0303	1.0000

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	22.11	162.5549	3.5000	2.2387	100%	0.0724	1.0000
IEEE 802.11 n HT20	17.77	59.8412	3.5000	2.2387	100%	0.0267	1.0000
IEEE 802.11 n HT40	18.27	67.1429	3.5000	2.2387	100%	0.0299	1.0000
IEEE 802.11 ac 80	18.39	69.0240	3.5000	2.2387	100%	0.0308	1.0000

Remark:

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

According to KDB447498 for Transmitters used in mobile exposure conditions for simultaneous transmission operations;
∑ of MPE ratios ≤ 1.0

We first evaluate single mode WLAN simultaneous transmission and later evaluate dual-mode WLAN simultaneous transmission;

Antenna 0 and Antenna 1, Antenna 2 for 2.4GWLAN

Band	Mode	MPE Ratio Antenna 0	MPE Ratio Antenna 1	MPE Ratio Antenna 2	∑ MPE ratios	Limit	Results
2.4G	IEEE 802.11b	0.0204	0.0209	0.0185	N/A	1.000	Pass
	IEEE 802.11g	0.0430	0.0409	0.0391	N/A	1.000	Pass
	IEEE 802.11n HT20	0.0173	0.0169	0.0172	0.051	1.000	Pass
	IEEE 802.11n HT40	0.0175	0.0176	0.0173	0.052	1.000	Pass

Antenna 0 and Antenna 1, Antenna 2, Antenna 3 for 5GWLAN

Band	Mode	MPE Ratio Antenna 0	MPE Ratio Antenna 1	MPE Ratio Antenna 2	MPE Ratio Antenna 3	∑ MPE ratios	Limit	Results
5G	IEEE 802.11a	0.0805	0.0748	0.0800	0.0724	N/A	1.000	Pass
	IEEE 802.11n HT20	0.0237	0.0241	0.0252	0.0267	0.0997	1.000	Pass
	IEEE 802.11n HT40	0.0303	0.0309	0.0310	0.0299	0.1221	1.000	Pass
	IEEE 802.11ac 80	0.0283	0.0284	0.0303	0.0308	0.1178	1.000	Pass

Maximum Simultaneous transmission MPE Ratio for WLAN

Maximum MPE ratio $2.4G_{WLAN}$	Maximum MPE ratio $5G_{WLAN}$	∑ MPE ratios	Limit	Results
0.051	0.1221	0.1731	1.000	Pass

Note: The estimation distance is 20cm

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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