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 as follows, the RF power density can be obtained.

Frequency Band	Antenna type and antenna number	Internal Identification	Maximum antenna gain
2.4GHz	WLAN Antenna	Antenna 0	2.0dBi
		Antenna 1	2.0dBi
5GHz	WLAN Antenna	Antenna 2	3.0dBi
		Antenna 3	3.0dBi
		Antenna 4	3.0dBi

4. Estimation Result

4.1 Conducted Power Results

Antenna	Mode	Frequency(MHz)	Conducted Output Power (dBm)
Antenna 0	IEEE 802.11b	2412	15.97
		2437	16.14
		2462	15.82
	IEEE 802.11g	2412	15.67
		2437	15.76
		2462	15.64
	IEEE 802.11n HT20	2412	14.92
		2437	16.99
		2462	14.91
	IEEE 802.11n HT40	2422	14.00
		2437	16.47
		2452	13.93

Antenna	Mode	Frequency(MHz)	Conducted Output Power (dBm)
Antenna 1	IEEE 802.11b	2412	16.05
		2437	16.28
		2462	15.80
	IEEE 802.11g	2412	15.72
		2437	15.56
		2462	15.73
	IEEE 802.11n HT20	2412	15.07
		2437	16.80

		2462	14.97
	IEEE 802.11n HT40	2422	13.97
		2437	16.27
		2452	13.95

5GHz WIFI

Antenna	Mode	Frequency(MHz)	Conducted Output Power (dBm)
Antenna 0	IEEE 802.11a	5180	15.94
		5200	16.12
		5240	16.39
		5260	19.04
		5300	19.18
		5320	19.12
		5500	18.18
		5580	18.33
		5700	18.05
		5745	18.55
		5785	18.42
		5825	18.38
	IEEE 802.11n HT20	5180	7.41
		5200	7.40
		5240	7.34
		5260	12.61
		5300	12.46
		5320	12.42
		5500	16.67
		5580	16.28
		5700	16.40
		5745	16.58
		5785	16.60
		5825	16.33
	IEEE 802.11n HT40	5190	10.52
		5230	10.46
		5270	13.83
		5310	14.03
		5510	16.69
		5550	16.67
		5670	16.73
		5755	16.74
		5795	16.77

	IEEE 802.11ac 80	5210	13.10
		5290	15.62
		5530	16.42
		5775	16.36

Antenna	Mode	Frequency(MHz)	Conducted Output Power (dBm)
Antenna 1	IEEE 802.11a	5180	16.13
		5200	16.09
		5240	16.30
		5260	19.09
		5300	18.91
		5320	18.81
		5500	18.05
		5580	18.23
		5700	18.05
		5745	18.61
		5785	18.39
		5825	18.42
	IEEE 802.11n HT20	5180	7.88
		5200	7.58
		5240	7.61
		5260	12.84
		5300	12.43
		5320	12.41
		5500	16.39
		5580	16.37
		5700	16.10
		5745	16.55
		5785	16.48
		5825	16.33
	IEEE 802.11n HT40	5190	10.23
		5230	10.04
		5270	14.14
		5310	13.94
		5510	16.96
		5550	16.94
		5670	16.61
		5755	16.64
		5795	16.75
	IEEE 802.11ac 80	5210	13.23
		5290	15.54

		5530	16.45
		5775	16.72

Antenna	Mode	Frequency(MHz)	Conducted Output Power (dBm)
Antenna 2	IEEE 802.11a	5180	15.55
		5200	15.56
		5240	15.68
		5260	18.81
		5300	18.54
		5320	18.67
		5500	18.44
		5580	18.40
		5700	18.35
		5745	18.74
		5785	18.74
		5825	18.65
	IEEE 802.11n HT20	5180	8.00
		5200	8.04
		5240	7.96
		5260	16.66
		5300	16.60
		5320	16.55
		5500	15.80
		5580	15.85
		5700	15.81
		5745	16.35
		5785	16.14
		5825	16.25
	IEEE 802.11n HT40	5190	10.68
		5230	10.86
		5270	15.96
		5310	15.94
		5510	14.53
		5550	14.12
		5670	14.13
		5755	14.18
		5795	14.12
	IEEE 802.11ac 80	5210	13.05
		5290	14.01
		5530	14.22
		5775	14.15

4.2 Manufacturing tolerance

2.4GHz WIFI

IEEE 802.11 b						
Frequency (MHz)	Antenna 0			Antenna 1		
	2412	2437	2462	2412	2437	2462
Maximum Output Power (dBm)	15.97	16.14	15.82	16.05	16.28	15.80

IEEE 802.11 g						
Frequency (MHz)	Antenna 0			Antenna 1		
	2412	2437	2462	2412	2437	2462
Maximum Output Power (dBm)	15.67	15.76	15.64	15.72	15.56	15.73

IEEE 802.11 n HT20						
Frequency (MHz)	Antenna 0			Antenna 1		
	2412	2437	2462	2412	2437	2462
Maximum Output Power (dBm)	14.92	16.99	14.91	15.07	16.80	14.97

IEEE 802.11 n HT40						
Frequency (MHz)	Antenna 0			Antenna 1		
	2412	2437	2462	2412	2437	2462
Maximum Output Power (dBm)	14.00	16.47	13.93	13.97	16.27	13.95

5GHz WIFI

IEEE 802.11 a									
Frequency (MHz)	Antenna 2			Antenna 3			Antenna 4		
	5180	5200	5240	5180	5200	5240	5180	5200	5240
Maximum Output Power (dBm)	15.94	16.12	16.39	16.13	16.09	16.30	15.55	15.56	15.68
Frequency (MHz)	Antenna 2			Antenna 3			Antenna 4		
	5260	5300	5320	5260	5300	5320	5260	5300	5320
Maximum Output Power (dBm)	19.04	19.18	19.12	19.09	18.91	18.81	18.81	18.54	18.67

Frequency (MHz)	Antenna 2			Antenna 3			Antenna 4		
	5500	5580	5700	5500	5580	5700	5500	5580	5700
Maximum Output Power (dBm)	18.18	18.33	18.05	18.05	18.23	18.05	18.44	18.40	18.35
Frequency (MHz)	Antenna 2			Antenna 3			Antenna 4		
	5745	5785	5825	5745	5785	5825	5745	5785	5825
Maximum Output Power (dBm)	18.55	18.42	18.38	18.61	18.39	18.42	18.74	18.74	18.65

IEEE 802.11n HT20									
Frequency (MHz)	Antenna 2			Antenna 3			Antenna 4		
	5180	5200	5240	5180	5200	5240	5180	5200	5240
Maximum Output Power (dBm)	7.41	7.40	7.34	7.88	7.58	7.61	8.00	8.04	7.96
Frequency (MHz)	Antenna 2			Antenna 3			Antenna 4		
	5260	5300	5320	5260	5300	5320	5260	5300	5320
Maximum Output Power (dBm)	12.61	12.46	12.42	12.81	12.43	12.41	16.66	16.60	16.55
Frequency (MHz)	Antenna 2			Antenna 3			Antenna 4		
	5500	5580	5700	5500	5580	5700	5500	5580	5700
Maximum Output Power (dBm)	16.67	16.28	16.40	16.39	16.37	16.10	15.80	15.85	15.81
Frequency (MHz)	Antenna 2			Antenna 3			Antenna 4		
	5745	5785	5825	5745	5785	5825	5745	5785	5825
Maximum Output Power (dBm)	16.58	16.60	16.33	16.55	16.48	16.33	16.35	16.14	16.25

IEEE 802.11n HT40									
Frequency (MHz)	Antenna 2			Antenna 3			Antenna 4		
	5190	---	5230	5190	---	5230	5190	---	5230
Maximum Output Power (dBm)	10.52	---	10.46	10.23	---	10.04	10.68	---	10.86
Frequency (MHz)	Antenna 2			Antenna 3			Antenna 4		
	5270	---	5310	5270	---	5310	5270	---	5310
Maximum Output Power (dBm)	13.83	---	14.03	14.14	---	13.94	15.96	---	10.94
Frequency (MHz)	Antenna 2			Antenna 3			Antenna 4		
	5510	5550	5670	5510	5550	5670	5510	5550	5670
Maximum Output Power (dBm)	16.69	16.67	16.73	16.96	16.94	16.61	14.53	14.12	14.13
Frequency (MHz)	Antenna 2			Antenna 3			Antenna 4		
	5755	---	5795	5755	---	5795	5755	---	5795
Maximum Output Power (dBm)	16.74	---	16.77	16.64	---	16.75	14.18	---	14.12

IEEE 802.11ac 80									
Frequency (MHz)	Antenna 2			Antenna 3			Antenna 4		
	5210	---	5290	5210	---	5290	5210	---	5290
Maximum Output Power (dBm)	13.10	---	15.62	13.23	---	15.54	13.05	---	14.01
Frequency (MHz)	Antenna 2			Antenna 3			Antenna 4		
	5530	---	5775	5530	---	5775	5530	---	5775
Maximum Output Power (dBm)	16.42	---	16.36	16.45	---	16.72	14.22	---	14.15

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 (W/m^2)	MPE Limits (W/m^2)
	(dBm)	(W)					
IEEE 802.11 b	16.14	41.1150	2.0000	1.5849	100%	0.1297	5.3478
IEEE 802.11 g	15.76	37.6704	2.0000	1.5849	100%	0.1188	5.3478
IEEE 802.11 n HT20	16.99	50.0035	2.0000	1.5849	100%	0.1577	5.3478
IEEE 802.11 n HT40	16.47	44.3609	2.0000	1.5849	100%	0.1399	5.3478

Antenna 1

Mode	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (W/m^2)	MPE Limits (W/m^2)
	(dBm)	(W)					
IEEE 802.11 b	16.28	42.4620	2.0000	1.5849	100%	0.1340	5.3478
IEEE 802.11 g	15.73	37.4111	2.0000	1.5849	100%	0.1180	5.3478
IEEE 802.11 n HT20	16.80	47.8630	2.0000	1.5849	100%	0.1510	5.3478
IEEE 802.11 n HT40	16.27	42.3643	2.0000	1.5849	100%	0.1336	5.3478

5GWLAN

Antenna 2

Mode	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (W/m^2)	MPE Limits (W/m^2)
	(dBm)	(W)					
IEEE 802.11 a	19.18	0.0828	3.0000	1.9953	100%	0.3288	9.0112
IEEE 802.11 n HT20	16.67	0.0465	3.0000	1.9953	100%	0.1845	9.0112
IEEE 802.11 n HT40	16.77	0.0475	3.0000	1.9953	100%	0.1888	9.0112
IEEE 802.11 ac 80	16.42	0.0439	3.0000	1.9953	100%	0.1742	9.0112

Antenna 3

Mode	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (W/m^2)	MPE Limits (W/m^2)
	(dBm)	(W)					
IEEE 802.11 a	19.09	0.0811	3.0000	1.9953	100%	0.3221	9.0112
IEEE 802.11 n HT20	16.55	0.0452	3.0000	1.9953	100%	0.1795	9.0112
IEEE 802.11 n HT40	16.96	0.0497	3.0000	1.9953	100%	0.1972	9.0112
IEEE 802.11 ac 80	16.72	0.0470	3.0000	1.9953	100%	0.1866	9.0112

Antenna 4

Mode	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (W/m^2)	MPE Limits (W/m^2)
	(dBm)	(W)					
IEEE 802.11 a	18.81	0.0760	3.0000	1.9953	100%	0.3020	9.0112
IEEE 802.11 n HT20	16.66	0.0463	3.0000	1.9953	100%	0.1841	9.0112
IEEE 802.11 n HT40	15.96	0.0394	3.0000	1.9953	100%	0.1567	9.0112
IEEE 802.11 ac 80	14.22	0.0264	3.0000	1.9953	100%	0.1049	9.0112

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 dual mode WLAN simultaneous transmission and later evaluate dual mode WLAN simultaneous transmission;

Antenna 0 and Antenna 1 for 2.4GWLAN

Band	Mode	MPE Ratio Antenna 0	MPE Ratio Antenna 1	∑ MPE ratios	Limit	Results
2.4G	IEEE 802.11b	0.0243	0.0251	N/A	1.000	Pass
	IEEE 802.11g	0.0222	0.0221	N/A	1.000	Pass
	IEEE 802.11n HT20	0.0295	0.0282	0.1	1.000	Pass
	IEEE 802.11n HT40	0.0262	0.0250	0.1	1.000	Pass

Antenna 2, Antenna 3 and Antenna 4 for 5GWLAN

Band	Mode	MPE Ratio Antenna 2	MPE Ratio Antenna 3	MPE Ratio Antenna 4	∑ MPE ratios	Limit	Results
5G	IEEE 802.11a	0.0365	0.0357	0.0335	N/A	1.000	Pass
	IEEE 802.11n HT20	0.0205	0.0199	0.0204	0.1	1.000	Pass
	IEEE 802.11n HT40	0.0210	0.0219	0.0174	0.1	1.000	Pass
	IEEE 802.11ac 80	0.0193	0.0207	0.0116	0.1	1.000	Pass

Maximum MPE Ratios for 2.4GHz and 5GHz WLAN simultaneous transmission

Maximum MPE $Ratio_{2.4GHzWLAN}$	Maximum MPE $Ratio_{5GHzWLAN}$	∑ MPE ratios	Limit	Results
0.0577	0.0608	0.1	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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