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 anisotropic 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 following information, 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	3.38dBi
		Antenna 1	3.38dBi
		Antenna 2	3.38dBi
		Antenna 3	3.38dBi
5GHz	WLAN Antenna	Antenna 0	4.52dBi
		Antenna 1	4.52dBi
		Antenna 2	4.52dBi
		Antenna 3	4.52dBi

4. Estimation Result

4.1 Conducted Power Results

2.4GHz WIFI

Antenna	Mode	Frequency(MHz)	Peak Conducted Output Power (dBm)
Antenna 0	IEEE 802.11b	2412	25.78
		2437	26.26
		2462	25.50
	IEEE 802.11g	2412	26.07
		2437	26.17
		2462	26.26
	IEEE 802.11n HT20	2412	20.40
		2437	20.64
		2462	20.45
	IEEE 802.11n HT40	2422	20.06
		2437	20.38
		2452	20.52

Antenna	Mode	Frequency(MHz)	Peak Conducted Output Power (dBm)
Antenna 1	IEEE 802.11b	2412	25.73
		2437	26.27
		2462	26.38
	IEEE 802.11g	2412	26.07
		2437	26.11
		2462	26.38
	IEEE 802.11n HT20	2412	20.28
		2437	20.24

		2462	20.69
	IEEE 802.11n HT40	2422	20.26
		2437	20.51
		2452	20.26

Antenna	Mode	Frequency(MHz)	Peak Conducted Output Power (dBm)
Antenna 2	IEEE 802.11b	2412	25.07
		2437	25.62
		2462	25.70
	IEEE 802.11g	2412	25.95
		2437	26.23
		2462	20.66
	IEEE 802.11n HT20	2412	20.71
		2437	21.31
		2462	20.66
	IEEE 802.11n HT40	2422	20.68
		2437	20.36
		2452	20.97

Antenna	Mode	Frequency(MHz)	Peak Conducted Output Power (dBm)
Antenna 3	IEEE 802.11b	2412	25.26
		2437	25.53
		2462	25.83
	IEEE 802.11g	2412	26.28
		2437	26.09
		2462	26.21
	IEEE 802.11n HT20	2412	21.45
		2437	20.87
		2462	21.47
	IEEE 802.11n HT40	2422	21.31
		2437	21.75
		2452	21.32

5GHz WIFI

Antenna	Mode	Frequency(MHz)	Average Conducted Output Power (dBm)
Antenna 0	IEEE 802.11a	5180	17.27
		5200	17.17
		5240	17.56
		5745	20.80
		5785	20.62
		5825	20.93
	IEEE 802.11n HT20	5180	11.48
		5200	13.13
		5240	13.04
		5745	18.26
		5785	19.49
		5825	18.17
	IEEE 802.11n HT40	5190	13.85
		5230	13.85
		5755	18.70
		5795	18.28
	IEEE 802.11ac 80	5210	13.52
		5775	18.35

Antenna	Mode	Frequency(MHz)	Average Conducted Output Power (dBm)
Antenna 1	IEEE 802.11a	5180	16.67
		5200	16.73
		5240	17.70
		5745	21.93
		5785	21.50
		5825	21.41
	IEEE 802.11n HT20	5180	13.12
		5200	13.18
		5240	13.55
		5745	18.35
		5785	18.61
		5825	17.96
	IEEE 802.11n HT40	5190	13.20
		5230	13.17
		5755	18.02
		5795	18.20
	IEEE 802.11ac 80	5210	14.01
		5775	18.26

Antenna	Mode	Frequency(MHz)	Average Conducted Output Power (dBm)
Antenna 3	IEEE 802.11a	5180	16.63
		5200	17.59
		5240	17.27
		5745	20.92
		5785	20.78
		5825	20.91
	IEEE 802.11n HT20	5180	13.63
		5200	12.34
		5240	13.30
		5745	17.73
		5785	19.16
		5825	18.61
	IEEE 802.11n HT40	5190	13.28
		5230	13.39
		5755	17.74
		5795	18.82
	IEEE 802.11ac 80	5210	13.44
		5775	17.87

Antenna	Mode	Frequency(MHz)	Average Conducted Output Power (dBm)
Antenna 4	IEEE 802.11a	5180	17.34
		5200	17.38
		5240	18.23
		5745	21.04
		5785	20.45
		5825	21.02
	IEEE 802.11n HT20	5180	13.12
		5200	12.97
		5240	13.02
		5745	17.94
		5785	17.97
		5825	18.52
	IEEE 802.11n HT40	5190	13.90
		5230	12.60
		5755	17.83
		5795	17.84
	IEEE 802.11ac 80	5210	13.98
		5775	17.99

4.2 Manufacturing tolerance

2.4GHz WIFI

(Peak) IEEE 802.11b												
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
	2412	2437	2462	2412	2437	2462	2412	2437	2462	2412	2437	2462
Target (dBm)	25.0	26.0	25.0	25.0	26.0	26.0	25.0	25.0	25.0	25.0	25.0	25.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

(Peak) IEEE 802.11g												
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
	2412	2437	2462	2412	2437	2462	2412	2437	2462	2412	2437	2462
Target (dBm)	26.0	26.0	26.0	26.0	26.0	26.0	25.0	26.0	20.0	26.0	26.0	26.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

(Peak) IEEE 802.11 n HT20												
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
	2412	2437	2462	2412	2437	2462	2412	2437	2462	2412	2437	2462
Target (dBm)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	21.0	20.0	21.0	20.0	21.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

(Peak) IEEE 802.11 n HT40												
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
	2422	2437	2452	2422	2437	2452	2422	2437	2452	2422	2437	2452
Target (dBm)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	21.0	21.0	21.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

5GHz WIFI

(Average) IEEE 802.11a												
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
	5180	5200	5240	5180	5200	5240	5180	5200	5240	5180	5200	5240
Target (dBm)	17.0	17.0	17.0	16.0	16.0	17.0	16.0	17.0	17.0	17.0	17.0	18.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
	5745	5785	5825	5745	5785	5825	5745	5785	5825	5745	5785	5825
Target (dBm)	20.0	20.0	20.0	21.0	21.0	21.0	20.0	20.0	20.0	21.0	20.0	21.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

(Average) IEEE 802.11n HT20												
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
	5180	5200	5240	5180	5200	5240	5180	5200	5240	5180	5200	5240
Target (dBm)	11.0	13.0	13.0	13.0	13.0	13.0	13.0	12.0	13.0	13.0	12.0	13.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
	5745	5785	5825	5745	5785	5825	5745	5785	5825	5745	5785	5825
Target (dBm)	18.0	19.0	18.0	18.0	18.0	17.0	17.0	19.0	18.0	17.0	17.0	18.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

(Average) IEEE 802.11n HT40												
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
	5190	---	5230	5190	---	5230	5190	---	5230	5190	---	5230
Target (dBm)	13.0	---	13.0	13.0	---	13.0	13.0	---	13.0	13.0	---	12.0
Tolerance ±(dB)	1.0	---	1.0	1.0	---	1.0	1.0	---	1.0	1.0	---	1.0
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
	5755	---	5795	5755	---	5795	5755	---	5795	5755	---	5795
Target (dBm)	18.0	---	18.0	18.0	---	18.0	17.0	---	18.0	17.0	---	17.0
Tolerance ±(dB)	1.0	---	1.0	1.0	---	1.0	1.0	---	1.0	1.0	---	1.0

(Average) IEEE 802.11ac 80												
Frequency (MHz)	Antenna 0			Antenna 1			Antenna 2			Antenna 3		
	5210	---	5775	5210	---	5775	5210	---	5775	5210	---	5775
Target (dBm)	13.0	---	18.0	14.0	---	18.0	13.0	---	17.0	13.0	---	17.0
Tolerance ±(dB)	1.0	---	1.0	1.0	---	1.0	1.0	---	1.0	1.0	---	1.0

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	27.00	501.1872	3.38	2.1777	100%	0.21725	1.0000
IEEE 802.11 g	27.00	501.1872	3.38	2.1777	100%	0.21725	1.0000
IEEE 802.11 n HT20	21.00	125.8925	3.38	2.1777	100%	0.05457	1.0000
IEEE 802.11 n HT40	21.00	125.8925	3.38	2.1777	100%	0.05457	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	27.00	501.1872	3.38	2.1777	100%	0.21725	1.0000
IEEE 802.11 g	27.00	501.1872	3.38	2.1777	100%	0.21725	1.0000
IEEE 802.11 n HT20	21.00	125.8925	3.38	2.1777	100%	0.05457	1.0000
IEEE 802.11 n HT40	21.00	125.8925	3.38	2.1777	100%	0.05457	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	26.00	398.1072	3.38	2.1777	100%	0.17256	1.0000
IEEE 802.11 g	27.00	501.1872	3.38	2.1777	100%	0.21725	1.0000
IEEE 802.11 n HT20	22.00	158.4893	3.38	2.1777	100%	0.06870	1.0000
IEEE 802.11 n HT40	21.00	125.8925	3.38	2.1777	100%	0.05457	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 b	26.00	398.1072	3.38	2.1777	100%	0.17256	1.0000
IEEE 802.11 g	27.00	501.1872	3.38	2.1777	100%	0.21725	1.0000
IEEE 802.11 n HT20	22.00	158.4893	3.38	2.1777	100%	0.06870	1.0000
IEEE 802.11 n HT40	22.00	158.4893	3.38	2.1777	100%	0.06870	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	21.0	125.8925	4.52	2.8314	100%	0.0709	1.0000
IEEE 802.11 n HT20	20.0	100.0000	4.52	2.8314	100%	0.0564	1.0000
IEEE 802.11 n HT40	19.0	79.4328	4.52	2.8314	100%	0.0448	1.0000
IEEE 802.11 ac 80	19.0	79.4328	4.52	2.8314	100%	0.0448	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	22.0	158.4893	4.52	2.8314	100%	0.0893	1.0000
IEEE 802.11 n HT20	19.0	79.4328	4.52	2.8314	100%	0.0448	1.0000
IEEE 802.11 n HT40	19.0	79.4328	4.52	2.8314	100%	0.0448	1.0000
IEEE 802.11 ac 80	19.0	79.4328	4.52	2.8314	100%	0.0448	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	21.0	125.8925	4.52	2.8314	100%	0.0709	1.0000
IEEE 802.11 n HT20	20.0	100.0000	4.52	2.8314	100%	0.0564	1.0000
IEEE 802.11 n HT40	19.0	79.4328	4.52	2.8314	100%	0.0448	1.0000
IEEE 802.11 ac 80	18.0	63.0957	4.52	2.8314	100%	0.0356	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	22.0	158.4893	4.52	2.8314	100%	0.0893	1.0000
IEEE 802.11 n HT20	19.0	79.4328	4.52	2.8314	100%	0.0448	1.0000
IEEE 802.11 n HT40	18.0	63.0957	4.52	2.8314	100%	0.0356	1.0000
IEEE 802.11 ac 80	18.0	63.0957	4.52	2.8314	100%	0.0356	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

The sample support 4T4R MIMO antennas, 2.4GHz and 5GHz share same antenna.

Antenna 0 and Antenna 1 and Antenna 2 for 2.4GWLAN and 5GWLAN

Band	Mode	MPE Ratio Antenna 0	MPE Ratio Antenna 1	MPE Ratio Antenna 2	MPE Ratio Antenna 3	∑MPE ratios	Limit	Results
2.4G	IEEE 802.11b	0.21725	0.21725	0.17256	0.17256	N/A	1.000	Pass
	IEEE 802.11g	0.21725	0.21725	0.21725	0.21725	N/A	1.000	Pass
	IEEE 802.11n HT20	0.05457	0.05457	0.06870	0.06870	0.24648	1.000	Pass
	IEEE 802.11n HT40	0.05457	0.05457	0.05457	0.06870	0.23241	1.000	Pass

Band	Mode	MPE Ratio Antenna 4	MPE Ratio Antenna 5	MPE Ratio Antenna 6	MPE Ratio Antenna 7	∑MPE ratios	Limit	Results
5G	IEEE 802.11a	0.0709	0.0893	0.0709	0.0893	N/A	1.000	Pass
	IEEE 802.11n HT20	0.0564	0.0448	0.0564	0.0448	0.2024	1.000	Pass
	IEEE 802.11n HT40	0.0448	0.0448	0.0448	0.0356	0.1700	1.000	Pass
	IEEE 802.11ac 80	0.0448	0.0448	0.0356	0.0356	0.1608	1.000	Pass

Remark:

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

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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