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 antenna is 3dBi for 5G WLAN and 2.4G WLAN the RF power density can be obtained.

Frequency Band	Antenna type and antenna number	Internal Identification	Maximum antenna gain
2.4GHz	Antenna 0 WLAN Antenna	Antenna 0	3dBi
	Antenna 1 WLAN Antenna	Antenna 1	3dBi
	Antenna 2 WLAN Antenna	Antenna 2	3dBi
5.8GHz	Antenna 0 WLAN Antenna	Antenna 0	3dBi
	Antenna 1 WLAN Antenna	Antenna 1	3dBi
	Antenna 2 WLAN Antenna	Antenna 2	3dBi

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	18.6
		2437	18.6
		2462	18.5
Antenna 1	IEEE 802.11b	2412	18.8
		2437	18.4
		2462	18.2
Antenna 2	IEEE 802.11b	2412	17.9
		2437	18.3
		2462	17.9
Antenna 0	IEEE 802.11g	2412	18.6
		2437	18.6
		2462	18.3
Antenna 1	IEEE 802.11g	2412	18.7
		2437	18.3
		2462	18.6
Antenna 2	IEEE 802.11g	2412	17.6
		2437	18.1
		2462	18.1
Antenna 0	IEEE 802.11n HT20	2412	13.7
		2437	13.7
		2462	13.7
Antenna 1	IEEE 802.11n HT20	2412	13.9
		2437	13.5
		2462	13.2
Antenna 2	IEEE 802.11n HT20	2412	12.9
		2437	13.3
		2462	13.0
Antenna 0	IEEE 802.11n HT40	2422	13.5
		2437	13.3
		2452	13.6
Antenna 1	IEEE 802.11n HT40	2422	13.2
		2437	12.9
		2452	12.2
Antenna 2	IEEE 802.11n HT40	2422	12.2
		2437	12.8
		2452	12.6

5GHz WIFI

Antenna	Mode	Frequency(MHz)	AVG Conducted Output Power (dBm)
Antenna 0	IEEE 802.11a	5180	16.0
		5200	16.3
		5240	16.7
		5745	18.0
		5785	17.8
		5825	17.6
Antenna 1	IEEE 802.11a	5180	17.8
		5200	18.0
		5240	18.6
		5745	15.5
		5785	16.2
		5825	15.8
Antenna 2	IEEE 802.11a	5180	18.8
		5200	18.8
		5240	18.7
		5745	14.1
		5785	14.6
		5825	15.3
Antenna 0	IEEE 802.11 HT20	5180	10.0
		5200	10.4
		5240	10.5
		5745	12.7
		5785	13.1
		5825	12.4
Antenna 1	IEEE 802.11 HT20	5180	12.4
		5200	11.9
		5240	12.5
		5745	11.1
		5785	10.5
		5825	10.2
Antenna 2	IEEE 802.11 HT20	5180	11.2
		5200	11.5
		5240	11.3
		5745	10.3
		5785	11.1
		5825	11.5
Antenna 0	IEEE 802.11n HT40	5190	9.8
		5230	10.3
		5755	12.5

		5795	12.5
Antenna 1	IEEE 802.11n HT40	5190	11.4
		5230	11.9
		5755	10.1
		5795	10.0
Antenna 2	IEEE 802.11n HT40	5190	10.9
		5230	11.2
		5755	10.1
		5795	10.8
Antenna 0	IEEE 802.11ac 80	5210	14.8
		5775	14.5
Antenna 1	IEEE 802.11ac 80	5210	14.8
		5775	14.6
Antenna 2	IEEE 802.11ac 80	5210	14.9
		5775	14.6

4.2 Manufacturing tolerance

2.4GHz WIFI

IEEE 802.11 b (AVG)									
Antenna 0				Antenna 1			Antenna2		
Frequency (MHz)	2412	2437	2462	2412	2437	2462	2412	2437	2462
Target (dBm)	18.0	18.0	18.0	18.0	18.0	18.0	17.0	18.0	17.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

IEEE 802.11 g (AVG)									
Antenna 0				Antenna 1			Antenna2		
Frequency (MHz)	2412	2437	2462	2412	2437	2462	2412	2437	2462
Target (dBm)	18.0	18.0	18.0	18.0	18.0	18.0	17.0	18.0	18.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

IEEE 802.11 n HT20 (AVG)									
Antenna 0				Antenna 1			Antenna2		
Frequency (MHz)	2412	2437	2462	2412	2437	2462	2412	2437	2462
Target (dBm)	13.0	13.0	13.0	13.0	13.0	13.0	12.0	13.0	13.0
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 (AVG)									
Antenna 0				Antenna 1			Antenna2		
Frequency (MHz)	2422	2437	2452	2422	2437	2452	2422	2437	2452
Target (dBm)	13.0	13.0	13.0	13.0	12.0	12.0	12.0	12.0	12.0
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 (AVG)									
Antenna 0				Antenna 1			Antenna 2		
Frequency (MHz)	5180	5200	5240	5180	5200	5240	5180	5200	5240
Target (dBm)	16.0	16.0	16.0	17.0	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)	5745	5785	5825	5745	5785	5825	5745	5785	5825
Target (dBm)	18.0	17.0	17.0	15.0	16.0	15.0	14.0	14.0	15.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

IEEE 802.11n HT20 (AVG)									
Antenna 0				Antenna 1			Antenna 2		
Frequency (MHz)	5180	5200	5240	5180	5200	5240	5180	5200	5240
Target (dBm)	10.0	10.0	10.0	12.0	11.0	12.0	11.0	11.0	11.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Frequency (MHz)	5745	5785	5825	5745	5785	5825	5745	5785	5825
Target (dBm)	12.0	13.0	12.0	11.0	10.0	100	10.0	11.0	11.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

IEEE 802.11n HT40(AVG)									
Antenna 0				Antenna 1			Antenna 2		
Frequency (MHz)	5190	---	5230	5190	---	5230	5190	---	5230
Target (dBm)	9.0		10.0	11.0		11.0	10.0		11.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Frequency (MHz)	5755	---	5795	5755	---	5795	5755	---	5795
Target (dBm)	12.0		12.0	10.0		10.0	10.0		10.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

IEEE 802.11ac 80 (AVG)									
Antenna 0				Antenna 1			Antenna 2		
Frequency (MHz)	5210	---	---	5210	---	---	5210	---	---
Target (dBm)	14.0			14.0			14.0		
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Frequency (MHz)	5775	---	---	5775	---	---	5775	---	---
Target (dBm)	14.0			14.0			14.0		
Tolerance ±(dB)	1.0	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	19	79.4328	3	1.9953	100%	0.0315	1.0000
IEEE 802.11 g	19	79.4328	3	1.9953	100%	0.0315	1.0000
IEEE 802.11 n HT20	14	25.1189	3	1.9953	100%	0.0100	1.0000
IEEE 802.11 n HT40	14	25.1189	3	1.9953	100%	0.0100	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	19	79.4328	3	1.9953	100%	0.0315	1.0000
IEEE 802.11 g	19	79.4328	3	1.9953	100%	0.0315	1.0000
IEEE 802.11 n HT20	14	25.1189	3	1.9953	100%	0.0100	1.0000
IEEE 802.11 n HT40	14	25.1189	3	1.9953	100%	0.0100	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	19	79.4328	3	1.9953	100%	0.0315	1.0000
IEEE 802.11 g	19	79.4328	3	1.9953	100%	0.0315	1.0000
IEEE 802.11 n HT20	14	25.1189	3	1.9953	100%	0.0100	1.0000
IEEE 802.11 n HT40	13	19.9526	3	1.9953	100%	0.0079	1.0000

5GWLAN

Antenna 0

Mode	Output power (Including tune-up tolerance)		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm^2)	MPE Limits (mW/cm^2)
	(dBm)	(mW)					
IEEE 802.11 a	19	79.4328	3	1.9953	100%	0.0315	1.0000
IEEE 802.11 n HT20	14	25.1189	3	1.9953	100%	0.0100	1.0000
IEEE 802.11 n HT40	13	19.9526	3	1.9953	100%	0.0079	1.0000
IEEE 802.11ac 80	15	31.6228	3	1.9953	100%	0.0126	1.0000

Antenna 1

Mode	Output power (Including tune-up tolerance)		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm^2)	MPE Limits (mW/cm^2)
	(dBm)	(mW)					
IEEE 802.11 a	19	79.4328	3	1.9953	100%	0.0315	1.0000
IEEE 802.11 n HT20	13	19.9526	3	1.9953	100%	0.0079	1.0000
IEEE 802.11 n HT40	12	15.8489	3	1.9953	100%	0.0063	1.0000
IEEE 802.11ac 80	15	31.6228	3	1.9953	100%	0.0126	1.0000

Antenna 2

Mode	Output power (Including tune-up tolerance)		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm^2)	MPE Limits (mW/cm^2)
	(dBm)	(mW)					
IEEE 802.11 a	19	79.4328	3	1.9953	100%	0.0315	1.0000
IEEE 802.11 n HT20	12	15.8489	3	1.9953	100%	0.0063	1.0000
IEEE 802.11 n HT40	12	15.8489	3	1.9953	100%	0.0063	1.0000
IEEE 802.11ac 80	15	31.6228	3	1.9953	100%	0.0126	1.0000

Remark:

1. *Maximum average power including tune-up tolerance;*
2. *MPE use distance is 20cm from manufacturer declaration of user manual.*
3. *We choose 2412MHz (lowest frequency operate at 2.4GHz) and 5180MHz (lowest frequency operate at 5GHz) to calculate MPE limit as higher frequency will have higher MPE limits.*

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

2.4GWLAN

Mode	$\sum$ MPE Antenna 0 (mW/cm^2)	$\sum$ MPE Antenna 1 (mW/cm^2)	$\sum$ MPE Antenna 2 (mW/cm^2)	$\sum$ MPE ratios (mW/cm^2)	Limit	Results
IEEE 802.11 b	0.0315	0.0315	0.0315	N/A	1.000	Pass
IEEE 802.11 g	0.0315	0.0315	0.0315	N/A	1.000	Pass
IEEE 802.11 n HT20	0.0100	0.0100	0.0100	0.0300	1.000	Pass
IEEE 802.11 n HT40	0.0100	0.0100	0.0079	0.0179	1.000	Pass

5GWLAN

Mode	∑ MPE Antenna 0 (mW/cm^2)	∑ MPE Antenna 1 (mW/cm^2)	∑ MPE Antenna 2 (mW/cm^2)	∑ MPE ratios (mW/cm^2)	Limit	Results
IEEE 802.11 a	0.0315	0.0315	0.0315	N/A	1.000	Pass
IEEE 802.11 n HT20	0.0100	0.0079	0.0063	0.0242	1.000	Pass
IEEE 802.11 n HT40	0.0079	0.0063	0.0063	0.0205	1.000	Pass
IEEE 802.11ac 80	0.0126	0.0126	0.0126	0.0378	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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