



## 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  $\leq 1.0$ . 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 <sup>2</sup> )	Averaging Time  E  <sup>2</sup> , H  <sup>2</sup> 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 3.5dBi at 2.4GHz, 2.9dBi for UNII-1 and UNII-2A band, 3.1dBi for UNII-2C and 3.3dBi for UNII-3, as follows, the RF power density can be obtained.

#### 4. Estimation Result

##### 4.1 Conducted Power Results

##### 2.4GHz WIFI

Antenna	Mode	Frequency(MHz)	Average Conducted Output Power (dBm)
Antenna 0	IEEE 802.11b	2412	17.76
		2437	17.58
		2462	17.13
Antenna 1		2412	20.18
		2437	20.63
		2462	20.57
Antenna 0	IEEE 802.11g	2412	16.09
		2437	15.67
		2462	15.38
Antenna 1		2412	19.47
		2437	19.79
		2462	19.65
Antenna 0	IEEE 802.11n HT20	2412	14.37
		2437	14.21
		2462	13.59
Antenna 1		2412	16.52
		2437	16.95
		2462	16.87
Antenna 0	IEEE 802.11n HT40	2422	13.46
		2437	13.20
		2452	13.51
Antenna 1		2422	16.25
		2437	16.29
		2452	16.85



**5GHz WIFI**

Antenna	Mode	Frequency(MHz)	Average Conducted Output Power (dBm)
Antenna 0	IEEE 802.11a	5180	11.76
		5200	10.23
		5240	10.47
		5260	15.08
		5300	14.83
		5320	14.83
		5500	14.64
		5580	15.08
		5700	14.49
		5745	14.94
		5785	14.73
		5825	14.76
		Antenna 1	IEEE 802.11a
5200	14.94		
5240	14.69		
5260	14.71		
5300	14.78		
5320	14.58		
5500	15.60		
5580	14.85		
5700	14.60		
5745	15.17		
5785	15.03		
5825	14.44		
Antenna 0	IEEE 802.11n HT20		
		5200	13.58
		5240	13.61
		5260	15.19
		5300	15.63
		5320	15.66
		5500	13.17
		5580	12.31
		5700	13.07
		5745	17.42
		5785	14.95
		5825	15.27
		Antenna 1	



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		5200	11.05
		5240	12.03
		5260	15.06
		5300	15.17
		5320	15.31
		5500	15.01
		5580	15.14
		5700	15.32
		5745	15.08
		5785	15.89
		5825	14.93
Antenna 0	IEEE 802.11n HT40	5190	14.34
		5230	14.01
		5270	14.52
		5310	14.86
		5510	14.77
		5550	13.95
		5670	14.41
		5755	15.63
		5795	14.19
Antenna 1	IEEE 802.11n HT40	5190	14.61
		5230	15.50
		5270	15.50
		5310	14.51
		5510	14.46
		5550	14.50
		5670	14.54
		5755	14.28
	5795	14.47	
Antenna 0	IEEE 802.11ac 80	5210	13.62
		5290	11.94
		5530	13.15
		5775	13.82
Antenna 1	IEEE 802.11ac 80	5210	12.43
		5290	12.52
		5530	12.58
		5775	12.54



4.2 Manufacturing tolerance

**2.4GHz WIFI**

<b>IEEE 802.11 b (Average)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
		2412	2437	2462	2412	2437
Target (dBm)	17.00	17.00	17.00	20.00	20.00	20.00
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0

<b>IEEE 802.11 g (Average)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
		2412	2437	2462	2412	2437
Target (dBm)	16.00	15.00	15.00	19.00	19.00	19.00
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0

<b>IEEE 802.11 n HT 20 (Average)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
		2412	2437	2462	2412	2437
Target (dBm)	14.00	14.00	13.00	16.00	17.00	16.00
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0

<b>IEEE 802.11 n HT 40 (Average)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
		2412	2437	2462	2412	2437
Target (dBm)	13.00	13.00	13.00	16.00	16.00	16.00
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0

**5GHz WIFI**

<b>IEEE 802.11 a (Average)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
		5180	5200	5240	5180	5200
Target (dBm)	11.00	10.00	10.00	14.00	15.00	14.00
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
<b>IEEE 802.11 a (Average)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
		5260	5300	5320	5260	5300
Target (dBm)	15.00	14.00	14.00	14.00	14.00	14.00
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
<b>IEEE 802.11 a (Average)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
		5500	5580	5700	5500	5580
Target (dBm)	14.00	15.00	14.00	15.00	14.00	14.00
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
<b>IEEE 802.11 a (Average)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
		5745	5785	5825	5745	5785
Target (dBm)	15.00	14.00	14.00	15.00	15.00	14.00
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0

<b>IEEE 802.11n HT20 (Average)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
		5180	5200	5240	5180	5200
Target (dBm)	12.00	13.00	13.00	8.00	11.00	12.00
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
<b>IEEE 802.11n HT20 (Average)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
		5260	5300	5320	5260	5300
Target (dBm)	15.00	15.00	15.00	15.00	15.00	15.00
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
<b>IEEE 802.11n HT20 (Average)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
		5500	5580	5700	5500	5580
Target (dBm)	13.00	12.00	13.00	15.00	15.00	15.00
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
<b>IEEE 802.11n HT20 (Average)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
		5745	5785	5825	5745	5785
Target (dBm)	17.00	15.00	15.00	15.00	15.00	15.00



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Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0
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<b>IEEE 802.11n HT40 (Average)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
		5190	---	5230	5190	---
Target (dBm)	14.00		14.00	14.00		15.00
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0
<b>IEEE 802.11n HT40 (Average)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
		5270	---	5310	5270	---
Target (dBm)	14.00		14.00	15.00		14.00
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0
<b>IEEE 802.11n HT40 (Average)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
		5510	5550	5670	5510	5550
Target (dBm)	14.00	14.00	14.00	14.00	14.00	14.00
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0
<b>IEEE 802.11n HT40 (Average)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
		5755	---	5795	5755	---
Target (dBm)	15.00		14.00	14.00		14.00
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0

<b>IEEE 802.11n HT80 (Average)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
		5210	5290	5530	5210	5290
Target (dBm)	13.00	12.00	12.00	12.00	12.00	12.00
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0
<b>IEEE 802.11n HT80 (Average)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
		5775	---	---	5775	---
Target (dBm)	13.00			12.00		
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0



### 4.3 Measurement Results

#### Antenna 0

##### 2.4G WLAN

Mode	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm <sup>2</sup> )
	(dBm)	(mW)				
IEEE 802.11 b	18.0	63.0957	3.5	2.2387	100%	0.0281
IEEE 802.11 g	17.0	50.1187	3.5	2.2387	100%	0.0223
IEEE 802.11 n HT20	15.0	31.6228	3.5	2.2387	100%	0.0141
IEEE 802.11 n HT40	14.0	25.1189	3.5	2.2387	100%	0.0112

##### 5G WLAN

Mode	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm <sup>2</sup> )
	(dBm)	(mW)				
IEEE 802.11 a	16.0	39.8107	3.3	2.1380	100%	0.0169
IEEE 802.11 n HT20	14.0	25.1189	3.3	2.1380	100%	0.0107
IEEE 802.11 n HT40	16.0	39.8107	3.3	2.1380	100%	0.0169
IEEE 802.11 ac 80	14.0	25.1189	3.3	2.1380	100%	0.0107

#### Antenna 1

##### 2.4G WLAN

Mode	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm <sup>2</sup> )
	(dBm)	(mW)				
IEEE 802.11 b	21.0	125.8925	3.5	2.2387	100%	0.0561
IEEE 802.11 g	20.0	100.0000	3.5	2.2387	100%	0.0446
IEEE 802.11 n HT20	18.0	63.0957	3.5	2.2387	100%	0.0281
IEEE 802.11 n HT40	17.0	50.1187	3.5	2.2387	100%	0.0223

##### 5G WLAN

Mode	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm <sup>2</sup> )
	(dBm)	(mW)				
IEEE 802.11 a	16.0	39.8107	3.3	2.1380	100%	0.0169
IEEE 802.11 n HT20	13.0	19.9526	3.3	2.1380	100%	0.0085
IEEE 802.11 n HT40	16.0	39.8107	3.3	2.1380	100%	0.0169
IEEE 802.11 ac 80	13.0	19.9526	3.3	2.1380	100%	0.0085





*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.*
4. *We choose maximum antenna gain 3.3dBi for 5GHz WLAN band as maximum antenna gain is 2.9dBi at 5.2GHz and 3.3dBi at 5.8GHz.*

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

$\Sigma$  of MPE ratios  $\leq$  1.0

Mode	MPE <sub>Antenna 0</sub> (mW/cm <sup>2</sup> )	MPE <sub>Antenna 1</sub> (mW/cm <sup>2</sup> )	$\Sigma$ MPE ratios	Limit	Results
IEEE 802.11a	0.0169	0.0169	N/A	1.000	Pass
IEEE 802.11b	0.0281	0.0561	N/A	1.000	Pass
IEEE 802.11g	0.0223	0.0446	N/A	1.000	Pass
IEEE 802.11n HT20	0.0141	0.0281	0.0422	1.000	Pass
IEEE 802.11n HT40	0.0169	0.0213	0.0382	1.000	Pass
IEEE 802.11ac 80	0.0107	0.0085	0.0192	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.