



## 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 3dBi for Bluetooth and 3.0dBi 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	Antenna 0, BT Antenna	Antenna 0	3.0dBi
	Antenna 1, WLAN Antenna	Antenna 1	3.0dBi
	Antenna 2, WLAN Antenna	Antenna 2	3.0dBi
5.8GHz	Antenna 1, WLAN Antenna	Antenna 1	3.0dBi
	Antenna 2, WLAN Antenna	Antenna 2	3.0dBi

## 4. Estimation Result

### 4.1 Conducted Power Results

#### *Bluetooth*

Mode	Channel	Frequency(MHz)	AVG Conducted Output Power (dBm)
GFSK-BLE	00	2402	-1.42
	19	2440	-1.33
	39	2480	-0.32
GFSK	00	2402	7.70
	39	2441	7.74
	78	2480	7.75
8DPSK	00	2402	4.98
	39	2441	4.88
	78	2480	5.18
$\pi/4$ DQPSK	00	2402	4.63
	39	2441	4.56
	78	2480	4.49

#### *2.4GHz WIFI*

Antenna	Mode	Frequency(MHz)	AVG Conducted Output Power (dBm)
Antenna 0	IEEE 802.11b	2412	17.33
		2437	17.97
		2462	18.57
Antenna 1		2412	18.65
		2437	18.12



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		2462	17.81	
Antenna 0	IEEE 802.11g	2412	15.66	
		2437	18.04	
		2462	14.42	
Antenna 1		2412	17.73	
		2437	18.04	
		2462	16.61	
Antenna 0		IEEE 802.11n HT20	2412	14.46
			2437	17.17
			2462	15.79
Antenna 1	2412		14.14	
	2437		17.09	
	2462		15.05	
Antenna 0	IEEE 802.11n HT40		2422	12.97
			2437	16.92
			2452	15.33
Antenna 1		2422	12.38	
		2437	17.43	
		2452	14.46	

### 5GHz WIFI

Antenna	Mode	Frequency(MHz)	AVG Conducted Output Power (dBm)
Antenna 0	IEEE 802.11a	5180	11.39
		5200	11.31
		5240	11.41
		5260	12.54
		5300	12.46
		5320	12.83
		5500	14.15
		5580	14.14
		5700	14.20
		5745	14.49
		5785	17.97
		5825	18.21
		Antenna 1	5180
5200	11.32		
5240	11.36		
5260	11.26		
5300	11.66		
5320	11.63		



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		5500	11.61
		5580	11.92
		5700	15.61
		5745	14.85
		5785	18.15
		5825	18.07
Antenna 0	IEEE 802.11n HT20	5180	11.03
		5200	10.64
		5240	10.94
		5260	12.62
		5300	12.31
		5320	12.49
		5500	11.66
		5580	12.32
		5700	11.75
		5745	14.05
		5785	16.41
		5825	16.61
Antenna 1	IEEE 802.11n HT20	5180	11.38
		5200	11.28
		5240	11.07
		5260	11.82
		5300	12.34
		5320	11.69
		5500	11.44
		5580	11.57
		5700	11.32
		5745	13.68
		5785	16.49
		5825	16.44
Antenna 0	IEEE 802.11n HT40	5190	14.12
		5230	14.20
		5270	16.73
		5310	15.22
		5510	14.63
		5550	14.78
		5670	16.35
		5755	13.65
		5795	16.85
Antenna 1		5190	14.59



		5230	15.97
		5270	15.42
		5310	14.25
		5510	14.87
		5550	16.31
		5670	16.28
		5755	13.59
		5795	16.70
Antenna 0	IEEE 802.11ac 80	5210	12.98
		5290	12.11
		5530	14.69
		5775	12.77
Antenna 1		5210	12.55
		5290	10.90
		5530	14.65
		5775	14.56

#### 4.2 Manufacturing tolerance

##### *Bluetooth*

GFSK -BLE(AVG)			
Channel	Channel 00	Channel 19	Channel 39
Target (dBm)	-1.0	-1.0	0.0
Tolerance ±(dB)	1.0	1.0	1.0
GFSK (AVG)			
Channel	Channel 00	Channel 39	Channel 78
Target (dBm)	7.0	7.0	7.0
Tolerance ±(dB)	1.0	1.0	1.0
8DPSK (AVG)			
Channel	Channel 00	Channel 39	Channel 78
Target (dBm)	4.0	4.0	5.0
Tolerance ±(dB)	1.0	1.0	1.0
π/4DQPSK (AVG)			
Channel	Channel 00	Channel 39	Channel 78
Target (dBm)	4.0	4.0	4.0
Tolerance ±(dB)	1.0	1.0	1.0

##### *2.4GHz WIFI*

IEEE 802.11 b (AVG)						
Frequency (MHz)	Antenna 0			Antenna 1		
	2412	2437	2462	2412	2437	2462
Target (dBm)	17.0	17.0	18.0	18.0	18.0	18.0



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Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
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IEEE 802.11 g (AVG)						
Frequency (MHz)	Antenna 0			Antenna 1		
		2412	2437	2462	2412	2437
Target (dBm)	15.0	18.0	14.0	17.0	18.0	17.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0

IEEE 802.11 n HT20 (AVG)						
Frequency (MHz)	Antenna 0			Antenna 1		
		2412	2437	2462	2412	2437
Target (dBm)	14.0	17.0	15.0	14.0	17.0	15.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0

IEEE 802.11 n HT40 (AVG)						
Frequency (MHz)	Antenna 0			Antenna 1		
		2422	2437	2452	2422	2437
Target (dBm)	12.0	16.0	15.0	12.0	17.0	14.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0

## 5GHz WIFI

IEEE 802.11 a (AVG)						
Frequency (MHz)	Antenna 0			Antenna 1		
		5180	5200	5240	5180	5200
Target (dBm)	11.0	11.0	11.0	11.0	11.0	11.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
Frequency (MHz)	Antenna 0			Antenna 1		
	5260	5300	5320	5260	5300	5320
Target (dBm)	12.0	12.0	12.0	11.0	11.0	11.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
Frequency (MHz)	Antenna 0			Antenna 1		
	5500	5580	5700	5500	5580	5700
Target (dBm)	14.0	14.0	14.0	11.0	11.0	15.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
Frequency (MHz)	Antenna 0			Antenna 1		
	5745	5785	5825	5745	5785	5825
Target (dBm)	14.0	17.0	18.0	14.0	18.0	18.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0



<b>IEEE 802.11n HT20 (AVG)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
	5180	5200	5240	5180	5200	5240
Target (dBm)	11.0	11.0	11.0	11.0	11.0	11.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
<b>IEEE 802.11n HT20 (AVG)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
	5260	5300	5320	5260	5300	5320
Target (dBm)	12.0	12.0	12.0	11.0	12.0	11.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
<b>IEEE 802.11n HT20 (AVG)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
	5500	5580	5700	5500	5580	5700
Target (dBm)	11.0	12.0	11.0	11.0	11.0	11.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
<b>IEEE 802.11n HT20 (AVG)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
	5745	5785	5825	5745	5785	5825
Target (dBm)	14.0	16.0	16.0	13.0	16.0	16.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0

<b>IEEE 802.11n HT40 (AVG)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
	5190	---	5230	5190	---	5230
Target (dBm)	14.0		14.0	14.0		15.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
<b>IEEE 802.11n HT40 (AVG)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
	5270	---	5310	5270	---	5310
Target (dBm)	16.0		15.0	15.0		14.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
<b>IEEE 802.11n HT40 (AVG)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
	5510	5550	5670	5510	5550	5670
Target (dBm)	14.0	14.0	16.0	14.0	16.0	16.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0	1.0	1.0	1.0
<b>IEEE 802.11n HT40 (AVG)</b>						
Frequency (MHz)	Antenna 0			Antenna 1		
	5755	---	5795	5755	---	5795
Target (dBm)	13.0		16.0	13.0		16.0



Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0
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IEEE 802.11ac 80 (AVG)						
Frequency (MHz)	Antenna 0			Antenna 1		
		5210	---	5290	5210	---
Target (dBm)	12.0		12.0	12.0		10.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0
IEEE 802.11ac 80 (AVG)						
Frequency (MHz)	Antenna 0			Antenna 1		
		5530	---	5775	5530	---
Target (dBm)	14.0		12.0	14.0		14.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0

### 4.3 Measurement Results

#### 4.3.1 Standalone MPE

##### Bluetooth

##### Antenna 0

Mode	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm <sup>2</sup> )	MPE Limits (mW/cm <sup>2</sup> )
	(dBm)	(mW)					
GFSK-LE	1.00	1.2589	3.00	1.9953	100%	0.0005	1.0000
GFSK	8.00	6.3096	3.00	1.9953	100%	0.0025	1.0000
π/4DQPSK	5.00	3.1623	3.00	1.9953	100%	0.0013	1.0000
8DPSK	6.00	3.9811	3.00	1.9953	100%	0.0016	1.0000

##### 2.4GWLAN

##### Antenna 1

Mode	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm <sup>2</sup> )	MPE Limits (mW/cm <sup>2</sup> )
	(dBm)	(mW)					
IEEE 802.11 b	19.00	79.4328	3.00	1.9953	100%	0.0315	1.0000
IEEE 802.11 g	19.00	79.4328	3.00	1.9953	100%	0.0315	1.0000
IEEE 802.11 n HT20	18.00	63.0957	3.00	1.9953	100%	0.0251	1.0000
IEEE 802.11 n HT40	17.00	50.1187	3.00	1.9953	100%	0.0199	1.0000





**Antenna 2**

Mode	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm <sup>2</sup> )	MPE Limits (mW/cm <sup>2</sup> )
	(dBm)	(mW)					
IEEE 802.11 b	19.00	79.4328	3.00	1.9953	100%	0.0315	1.0000
IEEE 802.11 g	19.00	79.4328	3.00	1.9953	100%	0.0315	1.0000
IEEE 802.11 n HT20	18.00	63.0957	3.00	1.9953	100%	0.0251	1.0000
IEEE 802.11 n HT40	18.00	63.0957	3.00	1.9953	100%	0.0251	1.0000

**5GWLAN**

**Antenna 1**

Mode	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm <sup>2</sup> )	MPE Limits (mW/cm <sup>2</sup> )
	(dBm)	(mW)					
IEEE 802.11 a	19.00	79.4328	3.00	1.9953	100%	0.0315	1.0000
IEEE 802.11 n HT20	17.00	50.1187	3.00	1.9953	100%	0.0199	1.0000
IEEE 802.11 n HT40	17.00	50.1187	3.00	1.9953	100%	0.0199	1.0000
IEEE 802.11 ac 80	15.00	31.6228	3.00	1.9953	100%	0.0126	1.0000

**Antenna 2**

Mode	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm <sup>2</sup> )	MPE Limits (mW/cm <sup>2</sup> )
	(dBm)	(mW)					
IEEE 802.11 a	19.00	79.4328	3.00	1.9953	100%	0.0315	1.0000
IEEE 802.11 n HT20	17.00	50.1187	3.00	1.9953	100%	0.0199	1.0000
IEEE 802.11 n HT40	17.00	50.1187	3.00	1.9953	100%	0.0199	1.0000
IEEE 802.11 ac 80	15.00	31.6228	3.00	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 2402 MHz for Bluetooth and 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  $\leq 1.0$

We first evaluate WLAN simultaneous transmission and later evaluate BT and WLAN simultaneous transmission;



**Antenna 1 and Antenna 2 for 2.4GWLAN**

Mode	MPE <sub>Antenna 0</sub> (mW/cm <sup>2</sup> )	MPE <sub>Antenna 1</sub> (mW/cm <sup>2</sup> )	∑ MPE ratios	Limit	Results
IEEE 802.11a	0.0315	0.0315	N/A	1.000	Pass
IEEE 802.11b	0.0315	0.0315	N/A	1.000	Pass
IEEE 802.11g	0.0315	0.0315	N/A	1.000	Pass
IEEE 802.11n HT20	0.0251	0.0251	0.0502	1.000	Pass
IEEE 802.11n HT40	0.0199	0.0251	0.0450	1.000	Pass
IEEE 802.11ac 80	0.0126	0.0126	0.0252	1.000	Pass

**Maximum Simultaneous transmission MPE Ratio for WLAN and BT**

Maximum MPE ratio <sub>WLAN</sub>	Maximum MPE ratio <sub>BT</sub>	∑ MPE ratios	Limit	Results
0.05	0.01	0.1	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.

----- END OF REPORT -----