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 3.0dBi 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	WIFI	WLAN Antenna	Antenna 0	3dBi
			Antenna 1	3dBi
	BT	BT Antenna	Antenna 0	3dBi
5.8GHz	WLAN Antenna		Antenna 0	3dBi
			Antenna 1	3dBi

4. Estimation Result

4.1 Conducted Power Results

Bluetooth

Mode	Channel	Frequency(MHz)	Conducted Output Power (dBm)
GFSK-BLE	0	2402	4.69
	19	2440	5.53
	39	2480	6.22
GFSK	0	2402	-6.42
	39	2441	-5.03
	78	2480	-4.71
8DPSK	0	2402	-4.73
	39	2441	-8.82
	78	2480	-8.91
π/4-DQPSK	0	2402	-6.96
	39	2441	-5.31
	78	2480	-8.91

2.4GHz WIFI

Antenna	Mode	Frequency(MHz)	Conducted Output Power (dBm)
Antenna 0	IEEE 802.11b	2412	15.02
		2437	15.18
		2462	15.42
Antenna 1		2412	15.04
		2437	15.04
		2462	14.71

Antenna 0	IEEE 802.11g	2412	9.92
		2437	10.36
		2462	10.28
Antenna 1		2412	11.25
		2437	11.37
		2462	11.27
Antenna 0	IEEE 802.11n HT20	2412	9.81
		2437	10.14
		2462	10.25
Antenna 1		2412	10.60
		2437	10.37
		2462	10.59
Antenna 0	IEEE 802.11n HT40	2422	10.58
		2437	10.68
		2452	10.50
Antenna 1		2422	10.53
		2437	10.46
		2452	10.41

5GHz WIFI

Antenna	Mode	Frequency(MHz)	Conducted Output Power (dBm)
Antenna 0	IEEE 802.11a	5180	18.54
		5200	18.27
		5240	18.02
		5260	17.48
		5300	17.83
		5320	17.19
		5500	17.20
		5580	17.56
		5700	17.43
		5745	17.30
		5785	17.37
		5825	17.35
Antenna 1		5180	18.53
		5200	18.24
		5240	18.53
		5260	17.36
		5300	17.93
		5320	17.15
		5500	17.09

		5580	17.37
		5700	17.42
		5745	17.24
		5785	17.17
		5825	17.23
Antenna 0	IEEE 802.11n HT20	5180	13.11
		5200	12.88
		5240	12.70
		5260	12.79
		5300	12.85
		5320	12.78
		5500	12.58
		5580	12.85
		5700	12.67
		5745	13.44
		5785	12.96
		5825	13.25
Antenna 1		5180	13.07
		5200	12.85
		5240	12.74
		5260	12.45
		5300	12.98
		5320	12.97
		5500	12.38
		5580	12.95
		5700	12.73
		5745	12.98
		5785	12.74
		5825	13.04
Antenna 0	IEEE 802.11n HT40	5190	13.52
		5230	13.18
		5270	13.09
		5310	13.27
		5510	13.07
		5550	12.91
		5670	13.21
		5755	13.32
		5795	13.15
Antenna 1		5190	13.43
		5230	13.41

		5270	13.08
		5310	13.25
		5510	12.99
		5550	12.87
		5670	13.37
		5755	13.14
		5795	13.05
Antenna 0	IEEE 802.11ac 80	5210	12.44
		5290	12.53
		5530	12.39
		5775	12.59
Antenna 1		5210	12.61
		5290	12.71
		5530	12.18
		5775	12.41

4.2 Manufacturing tolerance

Bluetooth

GFSK -BLE			
Channel	Channel 00	Channel 19	Channel 39
Target (dBm)	4.0	5.0	6.0
Tolerance ±(dB)	1.0	1.0	1.0
GFSK			
Channel	Channel 00	Channel 39	Channel 78
Target (dBm)	-6.0	-5.0	-4.0
Tolerance ±(dB)	1.0	1.0	1.0
8DPSK			
Channel	Channel 00	Channel 39	Channel 78
Target (dBm)	-4.0	-8.0	-8.0
Tolerance ±(dB)	1.0	1.0	1.0
π/4-DQPSK			
Channel	Channel 00	Channel 39	Channel 78
Target (dBm)	-6.0	-5.0	-8.0
Tolerance ±(dB)	1.0	1.0	1.0

2.4GHz WIFI

IEEE 802.11 b						
Frequency (MHz)	Antenna 0			Antenna 1		
	2412	2437	2462	2412	2437	2462
Target (dBm)	15.0	15.0	15.0	15.0	15.0	14.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0

IEEE 802.11 g						
Frequency (MHz)	Antenna 0			Antenna 1		
	2412	2437	2462	2412	2437	2462
Target (dBm)	9.0	10.0	10.0	11.0	11.0	11.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0

IEEE 802.11 n HT20						
Frequency (MHz)	Antenna 0			Antenna 1		
	2412	2437	2462	2412	2437	2462
Target (dBm)	9.0	10.0	10.0	10.0	10.0	10.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0

IEEE 802.11 n HT40						
Frequency (MHz)	Antenna 0			Antenna 1		
	2422	2437	2452	2422	2437	2452
Target (dBm)	10.0	10.0	10.0	10.0	10.0	10.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0

5GHz WIFI

IEEE 802.11 a						
Frequency (MHz)	Antenna 0			Antenna 1		
	5180	5200	5240	5180	5200	5240
Target (dBm)	18.0	18.0	18.0	18.0	18.0	18.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0
Frequency (MHz)	Antenna 0			Antenna 1		
	5260	5300	5320	5260	5300	5320
Target (dBm)	17.0	17.0	17.0	17.0	17.0	17.0
Tolerance ±(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)	17.0	17.0	17.0	17.0	17.0	17.0
Tolerance ±(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)	17.0	17.0	17.0	17.0	17.0	17.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0

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

IEEE 802.11n HT40						
Frequency (MHz)	Antenna 0			Antenna 1		
	5190	---	5230	5190	---	5230
Target (dBm)	13.0		13.0	13.0		13.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0
Frequency (MHz)	Antenna 0			Antenna 1		
	5270	---	5310	5270	---	5310
Target (dBm)	13.0		13.0	13.0		13.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0
Frequency (MHz)	Antenna 0			Antenna 1		
	5510	5550	5670	5510	5550	5670
Target (dBm)	13.0	12.0	13.0	12.0	12.0	13.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0
Frequency (MHz)	Antenna 0			Antenna 1		
	5755	---	5795	5755	---	5795
Target (dBm)	13.0		13.0	13.0		13.0

Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0

IEEE 802.11ac 80						
Frequency (MHz)	Antenna 0			Antenna 1		
	5210	---	5290	5210	---	5290
Target (dBm)	12.0		12.0	12.0		12.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0
Frequency (MHz)	Antenna 0			Antenna 1		
	5530	---	5775	5530	---	5775
Target (dBm)	12.0		12.0	12.0		12.0
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^2)	MPE Limits (mW/cm^2)
	(dBm)	(mW)					
GFSK-LE	7.0	5.0119	3	1.9953	100%	0.00199	1.0000
GFSK	-3.0	0.5012	3	1.9953	100%	0.00020	1.0000
8DPSK	-3.0	0.5012	3	1.9953	100%	0.00020	1.0000
π/4-DQPSK	-4.0	0.3981	3	1.9953	100%	0.00016	1.0000

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	16.0	39.8107	3	1.9953	100%	0.01581	1.0000
IEEE 802.11 g	11.0	12.5893	3	1.9953	100%	0.00500	1.0000
IEEE 802.11 n HT20	11.0	12.5893	3	1.9953	100%	0.00500	1.0000
IEEE 802.11 n HT40	11.0	12.5893	3	1.9953	100%	0.00500	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	16.0	39.8107	3	1.9953	100%	0.01581	1.0000
IEEE 802.11 g	12.0	15.8489	3	1.9953	100%	0.00629	1.0000
IEEE 802.11 n HT20	11.0	12.5893	3	1.9953	100%	0.00500	1.0000
IEEE 802.11 n HT40	11.0	12.5893	3	1.9953	100%	0.00500	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	19.0	79.4328	3	1.9953	100%	0.03155	1.0000
IEEE 802.11 n HT20	14.0	25.1189	3	1.9953	100%	0.00998	1.0000
IEEE 802.11 n HT40	14.0	25.1189	3	1.9953	100%	0.00998	1.0000
IEEE 802.11 ac 80	13.0	19.9526	3	1.9953	100%	0.00792	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	19.0	79.4328	3	1.9953	100%	0.03155	1.0000
IEEE 802.11 n HT20	14.0	25.1189	3	1.9953	100%	0.00998	1.0000
IEEE 802.11 n HT40	14.0	25.1189	3	1.9953	100%	0.00998	1.0000
IEEE 802.11 ac 80	13.0	19.9526	3	1.9953	100%	0.00792	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;

$\sum$ of MPE ratios ≤ 1.0

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

Antenna 0 and Antenna 1 for 2.4GWLAN and 5GWLAN

Band	Mode	MPE Ratio Antenna 0	MPE Ratio Antenna 1	∑ MPE ratios	Limit	Results
2.4G	IEEE 802.11b	0.01581	0.01581	N/A	1.000	Pass
	IEEE 802.11g	0.00500	0.00629	N/A	1.000	Pass
	IEEE 802.11n HT20	0.00500	0.00500	0.01000	1.000	Pass
	IEEE 802.11n HT40	0.00500	0.00500	0.01000	1.000	Pass
5G	IEEE 802.11a	0.03155	0.03155	N/A	1.000	Pass
	IEEE 802.11n HT20	0.03155	0.03155	0.06310	1.000	Pass
	IEEE 802.11n HT40	0.00998	0.00998	0.01996	1.000	Pass
	IEEE 802.11ac VHT80	0.00998	0.00998	0.01996	1.000	Pass

Maximum Simultaneous transmission MPE Ratio for Antenna 0 and Antenna 1

Maximum MPE ratio antenna 0	Maximum MPE ratio antenna 1	∑ MPE ratios	Limit	Results
0.00998	0.00998	0.02	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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