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 1.8dBi for Bluetooth and 3.2dBi / 2.8dBi for 2.4GWLAN and 3.5dBi / 3.1dBi 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, WLAN Antenna	Antenna 0	3.2dBi
	Antenna 1, WLAN Antenna	Antenna 1	2.8dBi
	Antenna 2, BT Antenna	Antenna 2	1.8dBi
5.8GHz	Antenna 0, WLAN Antenna	Antenna 0	3.5dBi
	Antenna 1, WLAN Antenna	Antenna 1	3.1dBi

4. Estimation Result

4.1 Conducted Power Results

Bluetooth

Mode	Channel	Frequency(MHz)	AVG Conducted Output Power (dBm)
GFSK-BLE	00	2402	-4.58
	19	2440	-4.83
	39	2480	-4.28
GFSK	00	2402	0.33
	39	2441	0.45
	78	2480	1.10
8DPSK	00	2402	-2.03
	39	2441	-1.46
	78	2480	-1.05

2.4GHz WIFI

Antenna	Mode	Frequency(MHz)	Average Conducted Output Power (dBm)
Antenna 0	IEEE 802.11b	2412	16.95
		2437	17.11
		2462	17.23
Antenna 1		2412	17.12
		2437	17.29
		2462	17.52
Antenna 0	IEEE 802.11g	2412	11.18
		2437	11.32
		2462	11.48

Antenna 1		2412	11.45
		2437	11.61
		2462	11.92
Antenna 0	IEEE 802.11n HT20	2412	10.58
		2437	11.11
		2462	10.91
Antenna 1		2412	11.97
		2437	12.09
		2462	12.05
Antenna 0	IEEE 802.11n HT40	2422	10.38
		2437	11.08
		2452	10.79
Antenna 1		2422	11.71
		2437	11.22
		2452	10.38

5GHz WIFI

Antenna	**Mode**	**Frequency(MHz)**	**Average Conducted Output Power (dBm)**
Antenna 0	IEEE 802.11a	5180	15.71
		5200	15.93
		5240	15.43
		5745	16.51
		5785	16.42
		5825	16.62
Antenna 1		5180	15.79
		5200	15.28
		5240	15.56
		5745	16.04
		5785	16.47
		5825	16.27
Antenna 0	IEEE 802.11n HT20	5180	15.25
		5200	14.93
		5240	15.39
		5745	16.12
		5785	16.04
		5825	15.81
Antenna 1		5180	15.28
		5200	14.92
		5240	15.33
		5745	15.74

		5785	15.67
		5825	15.82
Antenna 0	IEEE 802.11n HT40	5190	14.55
		5230	14.53
		5755	15.47
		5795	15.47
Antenna 1		5190	14.35
		5230	14.28
		5755	15.08
		5795	15.64

4.2 Manufacturing tolerance

Bluetooth

GFSK -BLE(AVG)			
Channel	Channel 00	Channel 19	Channel 39
Target (dBm)	-4.0	-4.0	-4.0
Tolerance ±(dB)	1.0	1.0	1.0
GFSK (AVG)			
Channel	Channel 00	Channel 39	Channel 78
Target (dBm)	0.0	0.0	1.0
Tolerance ±(dB)	1.0	1.0	1.0
8DPSK (AVG)			
Channel	Channel 00	Channel 39	Channel 78
Target (dBm)	-2.0	-1.0	-1.0
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)	16.0	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 802.11 g (AVG)						
Frequency (MHz)	Antenna 0			Antenna 1		
	2412	2437	2462	2412	2437	2462
Target (dBm)	11.0	11.0	11.0	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 (AVG)		
Frequency	Antenna 0	Antenna 1

(MHz)	2412	2437	2462	2412	2437	2462
Target (dBm)	10.0	11.0	10.0	11.0	12.0	12.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0

IEEE 802.11 n HT40 (AVG)						
Frequency	Antenna 0			Antenna 1		
(MHz)	2422	2437	2452	2422	2437	2452
Target (dBm)	10.0	11.0	10.0	11.0	11.0	10.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0

5GHz WIFI

IEEE 802.11 a (AVG)						
Frequency	Antenna 0			Antenna 1		
(MHz)	5180	5200	5240	5180	5200	5240
Target (dBm)	15.0	15.0	15.0	15.0	15.0	15.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0
Frequency	Antenna 0			Antenna 1		
(MHz)	5745	5785	5825	5745	5785	5825
Target (dBm)	16.0	16.0	16.0	16.0	16.0	16.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0

IEEE 802.11n HT20 (AVG)						
Frequency	Antenna 0			Antenna 1		
(MHz)	5180	5200	5240	5180	5200	5240
Target (dBm)	15.0	14.0	15.0	15.0	14.0	15.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0
Frequency	Antenna 0			Antenna 1		
(MHz)	5745	5785	5825	5745	5785	5825
Target (dBm)	16.0	16.0	15.0	15.0	15.0	15.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0

IEEE 802.11n HT40 (AVG)						
Frequency	Antenna 0			Antenna 1		
(MHz)	5190	---	5230	5190	---	5230
Target (dBm)	14.0		14.0	14.0		14.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0
Frequency	Antenna 0			Antenna 1		
(MHz)	5755	---	5795	5755	---	5795

Target (dBm)	15.0		15.0	15.0		15.0
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 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)					
GFSK-LE	-3.00	0.5012	1.8	1.5136	100%	0.0002	1.0000
GFSK	2.00	1.5849	1.8	1.5136	100%	0.0005	1.0000
8DPSK	0.00	1.0000	1.8	1.5136	100%	0.0003	1.0000

2.4GWLAN

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 b	18.00	63.0957	3.2	2.0893	100%	0.0262	1.0000
IEEE 802.11 g	12.00	15.8489	3.2	2.0893	100%	0.0066	1.0000
IEEE 802.11 n HT20	11.00	12.5893	3.2	2.0893	100%	0.0052	1.0000
IEEE 802.11 n HT40	12.00	15.8489	3.2	2.0893	100%	0.0066	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	18.00	63.0957	2.8	1.9055	100%	0.0239	1.0000
IEEE 802.11 g	12.00	15.8489	2.8	1.9055	100%	0.0060	1.0000
IEEE 802.11 n HT20	13.00	19.9526	2.8	1.9055	100%	0.0076	1.0000
IEEE 802.11 n HT40	12.00	15.8489	2.8	1.9055	100%	0.0060	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	17.00	50.1187	3.50	2.2387	100%	0.0223	1.0000
IEEE 802.11 n HT20	17.00	50.1187	3.50	2.2387	100%	0.0223	1.0000

IEEE 802.11 n HT40	16.00	39.8107	3.50	2.2387	100%	0.0177	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	17.00	50.1187	3.10	2.0417	100%	0.0204	1.0000
IEEE 802.11 n HT20	16.00	39.8107	3.10	2.0417	100%	0.0162	1.0000
IEEE 802.11 n HT40	16.00	39.8107	3.10	2.0417	100%	0.0162	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 ≤ 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

Mode	MPE $_{Antenna\ 0}$ (mW/cm^2)	MPE $_{Antenna\ 1}$ (mW/cm^2)	$\sum$ MPE ratios	Limit	Results
IEEE 802.11a	0.0223	0.0204	N/A	1.000	Pass
IEEE 802.11b	0.0262	0.0239	N/A	1.000	Pass
IEEE 802.11g	0.0066	0.0060	N/A	1.000	Pass
IEEE 802.11n HT20	0.0223	0.0162	0.0385	1.000	Pass
IEEE 802.11n HT40	0.0177	0.0162	0.0339	1.000	Pass

Maximum Simultaneous transmission MPE Ratio for WLAN and BT

Maximum MPE ratio $_{WLAN}$	Maximum MPE ratio $_{BT}$	$\sum$ MPE ratios	Limit	Results
0.004	$9.3*e^{-5}$	0.004	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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