

RF EXPOSURE EVALUATION

According to FCC 1.1310: The criteria listed in the following table shall be used to evaluate the environment impact of human exposure to radio frequency(RF) Radiation as specified in §1.1307(b)

Limits for Maximum Permissible Exposure (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposure				
0.3-3.0	614	1.63	*100	6
3.0-30	1842/f	4.89/f	*900/f ²	6
30-300	61.4	0.163	1.0	6
300-1,500			f/300	6
1,500-100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*100	30
1.34-30	824/f	2.19/f	*180/f ²	30
30-300	27.5	0.073	0.2	30
300-1,500			f/1500	30
1,500-100,000			1.0	30

f = frequency in MHz * = Plane-wave equivalent power density

MPE Calculation Method

$$E \text{ (V/m)} = \frac{\sqrt{30 * P * G}}{d} \qquad \text{Power Density: } Pd \text{ (W/m}^2\text{)} = \frac{E^2}{377}$$

E = Electric field (V/m)

P = Average RF output power (W)

G = EUT Antenna numeric gain (numeric)

d = Separation distance between radiator and human body (m)

The formula can be changed to

$$Pd = \frac{30 * P * G}{377 * D^2}$$

From the EUT RF output power, the minimum mobile separation distance, d=0.2m, as well as the gain of the used antenna, the RF power density can be obtained.

Measurement Result

Operation Frequency: BT: 2402-2480MHz,WIFI:2412-2462MHz

Power density limited: 1mW/ cm²

Antenna Type: FPC Antenna

Antenna gain:

BLE: ANT0:4.70dBi, ANT1:4.91dBi, ANT2:5.06dBi

WIFI:7.95dBi

R=20cm

BLE Module 1

Channel Freq. (MHz)	modulation	conducted power (dBm)	Tune-up power (dBm)	Max		Antenna		Evaluation result (mW/cm ²)	Power density (mW/cm ²)
				tune-up power		Gain			
				(dBm)	(mW)	(dBi)	Numeric		
2402	BLE(1M)	0.38	1±1	2	1.585	4.70	2.95	0.0009	1
2440		0.18	1±1	2	1.585	4.70	2.95	0.0009	1
2480		1.13	1±1	2	1.585	4.70	2.95	0.0009	1
2402	BLE(2M)	0.24	1±1	2	1.585	4.70	2.95	0.0009	1
2440		0.04	1±1	2	1.585	4.70	2.95	0.0009	1
2480		1.01	1±1	2	1.585	4.70	2.95	0.0009	1

BLE Module 2

Channel Freq. (MHz)	modulation	conducted power (dBm)	Tune-up power (dBm)	Max		Antenna		Evaluation result (mW/cm ²)	Power density (mW/cm ²)
				tune-up power		Gain			
				(dBm)	(mW)	(dBi)	Numeric		
2402	BLE(1M)	-0.32	0±1	1	1.259	4.91	3.10	0.0008	1
2440		-0.22	0±1	1	1.259	4.91	3.10	0.0008	1
2480		1.25	1±1	2	1.585	4.91	3.10	0.0010	1
2402	BLE(2M)	-0.34	0±1	1	1.259	4.91	3.10	0.0008	1
2440		-0.23	0±1	1	1.259	4.91	3.10	0.0008	1
2480		1.24	1±1	2	1.585	4.91	3.10	0.0010	1

BLE Module 3

Channel Freq. (MHz)	modulation	conducted power (dBm)	Tune-up power (dBm)	Max		Antenna		Evaluation result (mW/cm ²)	Power density (mW/cm ²)
				tune-up power		Gain			
				(dBm)	(mW)	(dBi)	Numeric		
2402	BLE(1M)	0.71	1±1	2	1.585	5.06	3.21	0.0010	1
2440		0.84	1±1	2	1.585	5.06	3.21	0.0010	1
2480		1.77	1±1	2	1.585	5.06	3.21	0.0010	1
2402	BLE(2M)	0.72	1±1	2	1.585	5.06	3.21	0.0010	1
2440		0.86	1±1	2	1.585	5.06	3.21	0.0010	1
2480		1.81	1±1	2	1.585	5.06	3.21	0.0010	1

WIFI:

Channel Freq. (MHz)	modulation	conducted power	Tune-up power (dBm)	Max		Antenna		Evaluation result	Power density
				tune-up power		Gain			
		(dBm)		(dBm)	(dBm)	(mW)	(dBi)	Numeric	(mW/cm ²)
2412	802.11 b (ANT1)	16.49	16±1	17	50.119	7.95	6.24	0.0622	1
2437		16.16	16±1	17	50.119	7.95	6.24	0.0622	1
2462		16.78	16±1	17	50.119	7.95	6.24	0.0622	1
2412	802.11 b (ANT2)	15.45	16±1	17	50.119	7.95	6.24	0.0622	1
2437		16.45	16±1	17	50.119	7.95	6.24	0.0622	1
2462		16.42	16±1	17	50.119	7.95	6.24	0.0622	1
2412	802.11 g (ANT1)	13.28	13±1	14	25.119	7.95	6.24	0.0312	1
2437		13.1	13±1	14	25.119	7.95	6.24	0.0312	1
2462		13.07	13±1	14	25.119	7.95	6.24	0.0312	1
2412	802.11 g (ANT2)	13.72	13±1	14	25.119	7.95	6.24	0.0312	1
2437		13.18	13±1	14	25.119	7.95	6.24	0.0312	1
2462		13.19	13±1	14	25.119	7.95	6.24	0.0312	1
2412	802.11 n20 (ANT1)	11.67	12±1	13	19.953	7.95	6.24	0.0248	1
2437		12.16	12±1	13	19.953	7.95	6.24	0.0248	1
2462		11.7	12±1	13	19.953	7.95	6.24	0.0248	1
2412	802.11 n20 (ANT2)	12.59	12±1	13	19.953	7.95	6.24	0.0248	1
2437		12.2	12±1	13	19.953	7.95	6.24	0.0248	1
2462		12.06	12±1	13	19.953	7.95	6.24	0.0248	1
2422	802.11 n40 (ANT1)	11.71	12±1	13	19.953	7.95	6.24	0.0248	1
2437		11.91	12±1	13	19.953	7.95	6.24	0.0248	1
2452		11.84	12±1	13	19.953	7.95	6.24	0.0248	1
2422	802.11 n40 (ANT2)	12.9	12±1	13	19.953	7.95	6.24	0.0248	1
2437		11.78	12±1	13	19.953	7.95	6.24	0.0248	1
2452		11.88	12±1	13	19.953	7.95	6.24	0.0248	1

SIMULTANEOUS TRANSMISSIONS

When a number of sources at different frequencies, and/or broadband sources, contribute to the total exposure, it becomes necessary to weigh each contribution relative to the MPE. To comply with the MPE, the fraction of the MPE in terms of E^2 , H^2 (or power density) incurred within each frequency interval should be determined and the sum of all such fractions should not exceed unity. In order to ensure compliance with the MPE for a controlled environment, the sum of the ratios of the power density to the corresponding MPE should not exceed unity. That is

$$\sum_{i=1}^n \frac{S_i}{MPE_i} \leq 1$$

Max. SIMULTANEOUS TRANSMISSIONS for BLE Module + Wi-Fi Module

Band	S (mW/cm ²)	MPE Limit (mW/cm ²)	Calculation result	Conclusion
BLE Module 0	0.0009	1	0.0651	Pass
BLE Module 1	0.0010	1		
BLE Module 2	0.0010	1		
WIFI 2.4	0.0622	1		

Note:

NO simultaneous transmissions are possible for this device of Wi-Fi 1 Ant1 + Wi-Fi 2 Ant2
WIFI module has two antenna ports, usually antenna port 1 is used, antenna port 2 is a spare antenna, and antenna port 2 is used in some specific cases

Conclusion:

For the max result : $0.0651 \leq 1.0$ for Max Power Density, compliance RF exposure..



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