RF Exposure Report

FCC-ID: 2AQ7QDB71455

RF Exposure Measurement

The limit for Maximum Permissible Exposure (MPE) specified in FCC 1.1310 is followed. The gain of the antennas used in the product is extracted from the Antenna data sheets provided and also the maximum total power input to the antenna is measured. Through the Friis transmission formula and the maximum gain of the antenna, we can calculate the distance, away from the product, where the limit of MPE is reached.
Although the Friis Transmission formula is far field assumption, the calculated result of that is an over-prediction for near field power density. It is taken as worst case to specify the safety range.

RF Exposure Limit

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

Limits for Maximum Permissible Exposure (MPE)
F= Frequency in MHz

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)
Limits for Occupational / controlled Exposures			
300 - 1500	--	--	F/300
1500 – 100000	--	--	5.0
Limits for General population / Uncontrolled Exposure			
300 - 1500	--	--	F/1500
1500 – 100000	--	--	1.0

Friss Formula

Friss Transmission Formula: $Pd = (Pout * G) / (4*pi*r^2)$
Where
Pd = power density in mW/cm^2
Pout = output power to antenna in mW
G = gain of antenna in linear scale
Pi = 3.1416
R = Distance between observation point and the center of radiator in cm
If we know the maximum gain of the antenna and the total output power to the antenna, through calculation, we will know MPE value at distance 20cm.

EUT Operation condition

EUT was enabled to transmit and receive at lowest, middle and highest channels.

Classification

The antenna of this product, under normal use condition, is at least 20cm away from the body of the user. Warning statement to the user for keeping at least 20cm or more separation distance from the antenna should be included in the User manual. So, this device is classified as Mobile device.

ESP 32

Mode	Bluetooth+BLE
Detector	PEAK
Ant Gain(dBi)	2
GFSK	4.5±1dBm
π/4-DQPSK	6.7±1dBm
8DPSK	7.2±1dBm
BLE1M	4.5±1dBm

ANT Gain (G)

Antenna A gain: 2dBi

(gain of antenna in linear scale=1.585)

Protocol	ANT Gain(gain of antenna in linear scale)	Output Power to Antenna (dBm)	Output Power to Antenna (mW)	Power Density (mW/cm²)	Limit (mW/cm²)
GFSK	1.585	5.5	3.5481	0.00112	1
π/4-DQPSK	1.585	7.7	5.8884	0.00186	1
8DPSK	1.585	8.2	6.6069	0.00208	1
BLE1M	1.585	5.5	3.5481	0.00112	1

OPS

Mode	Bluetooth+BLE(1M PHY and 2M PHY)
Detector	PEAK
Ant Gain(dBi)	2
GFSK	9±1dBm
π/4-DQPSK	6.5±1dBm
8DPSK	7.5±1dBm
BLE1M	4.5±1dBm
BLE2M	5±1dBm

ANT Gain (G)

Antenna A gain: 2.25dBi

(gain of antenna in linear scale=1.679)

Protocol	ANT Gain(gain of antenna in linear scale)	Output Power to Antenna (dBm)	Output Power to Antenna (mW)	Power Density (mW/cm²)	Limit (mW/cm²)
GFSK	1.679	10	10.0000	0.00334	1
π/4-DQPSK	1.679	7.5	5.6234	0.00188	1
8DPSK	1.679	8.5	7.0795	0.00237	1
BLE1M	1.679	5.5	3.5481	0.00119	1
BLE2M	1.679	6	3.9811	0.00133	1

2.4G WIFI WORST CASE

Mode	802.11b/g/n/ax 20:2412-2462MHz 802.11n/ax 40:2422-2452MHz	
Detector	PEAK	
802.11b	ANT1=15±1dBm	ANT2=15±1dBm
802.11g	ANT1=18.5±1dBm	ANT2=18.5±1dBm
802.11n20	MIMO=16.6±1dBm	
802.11ax20	MIMO=19.00±1dBm	
802.11n40	MIMO=15±1dBm	
802.11ax40	MIMO=19.1±1dBm	

ANT Gain (G)
Antenna number: 2
Antenna A gain: 2.5dBi
Antenna B gain: 2.5dBi
(gain of antenna in linear scale=1.779)
MIMO technology Directional gain= 5.26dBi
(gain of antenna in linear scale=3.358)

Protocol	ANT Gain(gain of antenna in linear scale)	Output Power to Antenna (dBm)	Output Power to Antenna (mW)	Power Density (mW/cm²)	Limit (mW/cm²)
802.11 b	1.779	16	39.8107	0.01410	1
802.11 g	1.779	19.5	89.1251	0.03156	1
802.11 n20	3.358	17.6	57.5440	0.03846	1
802.11 n40	3.358	16	39.8107	0.02661	1
802.11 ax20	3.358	20	100.0000	0.06684	1
802.11 ax40	3.358	20.1	102.3293	0.06840	1

5G WIFI WORST CASE

ANT Gain (G)

Mode	IEEE 802.11a/n(HT20)/ac(VHT20): 5.180GHz-5.240GHz IEEE 802.11n(HT40)/ac(VHT40): 5.190GHz-5.230GHz IEEE 802.11ac(VHT80): 5.210GHz IEEE 802.11ac(VHT160):5.250GHz-5.570GHz
	EEE 802.11a/n(HT20)/ac(VHT20): 5.260GHz-5.320GHz IEEE 802.11 n(HT40)/ac(VHT40): 5.270GHz-5.310GHz IEEE 802.11ac(VHT80): 5.290GHz IEEE 802.11ac(VHT160):5.250GHz-5.570GHz
	I IEEE 802.11a/n(HT20)/ac(VHT20): 5.500GHz-5.700GHz IEEE 802.11 n(HT40)/ac(VHT40): 5.510GHz-5.670GHz IEEE 802.11ac(VHT80): 5.530GHz-5.610GHz IEEE 802.11ac(VHT160):5.250GHz-5.570GHz
	I IEEE 802.11a/n(HT20)/ac(VHT20): 5.745GHz-5.825GHz

	IEEE 802.11a/n(HT40)/ac(VHT40): 5.755GHz-5.795GHz IEEE 802.11ac(VHT80): 5.775GHz
Detector	AVG
802.11 a	14±1dBm
802.11 n/ac20	13±1dBm
802.11 n/ac40	14±1dBm
802.11 ac80	14±1dBm
802.11 ac160	10.2±1dBm

Antenna number: 2
Antenna A gain: 2.22dBi
Antenna B gain: 2.22dBi
(gain of antenna in linear scale=1.667)
MIMO technology Directional gain= 5.23dBi
(gain of antenna in linear scale=3.334)

Protocol	ANT Gain(gain of antenna in linear scale)	Output Power to Antenna (dBm)	Output Power to Antenna (mW)	Power Density (mW/cm^2)	Limit (mW/cm^2)
802.11 a	1.667	15	31.6228	0.09999	1
802.11 n/ac20	3.334	14	25.1189	0.00833	1
802.11 n/ac40	3.334	15	31.6228	0.02099	1
802.11 ac80	3.334	15	31.6228	0.02099	1
802.11 ac160	3.334	10.2	10.4713	0.00695	1

The max MPE of BT & WIFI simultaneous transmission:
0.00208(ESP32 BT) + 0.00334(OPS BT) +0.06840(2.4GHz Wi-Fi) + 0.09999(5G Wi-Fi) = 0.17381 ＜ 1

According to the maximum gain of the antenna and the total output power to the antenna, through calculation, we will know max MPE value 0.17381 at distance 20cm. This is less than the limit 1.So SAR testing is not required.