

# RF Exposure Report

FCC-ID: 2AQ7Q-DB71455

## 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 <sup>2</sup> )
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<sup>2</sup>

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
$\pi/4$ -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/cm <sup>2</sup> )	Limit (mW/cm <sup>2</sup> )
GFSK	1.585	5.5	3.5481	0.00112	1
$\pi/4$ -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
$\pi/4$ -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/cm <sup>2</sup> )	Limit (mW/cm <sup>2</sup> )
GFSK	1.679	10	10.0000	0.00334	1
$\pi/4$ -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/cm <sup>2</sup> )	Limit (mW/cm <sup>2</sup> )
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
	IEEE 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 <sup>2</sup> )	Limit (mW/cm <sup>2</sup> )
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

## 6G WIFI WORST CASE

Operation Frequency:	IEEE 802.11ax(HE20): 5.935GHz-7.115GHz IEEE 802.11ax(HE40): 5.969GHz-7.085GHz IEEE 802.11ax(HE80): 5.985GHz-7.025GHz IEEE 802.11ax(HE160): 6.025GHz-6.985GHz
Modulation Type:	802.11ax:OFDM-BPSK,QPSK,16-QAM,64-QAM, 256-QAM and 1024QAM
Antenna Designation:	Please refer to the Note 3.
Antenna Gain	ANT 1: 2.22 ANT 2: 2.22 MIMO: 5.23
MAX EIRP power	
802.11 ax20	4.6dBm
802.11 ax40	8.46dBm
802.11 ax80	10.97dBm
802.11 ax160	13.79dbm

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	EIRP (dBm)	EIRP (mW)	Power Density (mW/cm <sup>2</sup> )	Limit (mW/cm <sup>2</sup> )
802.11 ax20	4.6	2.8840	0.00057	1
802.11 ax40	8.46	7.0146	0.00140	1
802.11 ax80	10.97	12.5026	0.00249	1
802.11 ax160	13.79	23.9332	0.00476	1

The max MPE of BT & WIFI simultaneous transmission:

$0.00208(\text{ESP32 BT}) + 0.00334(\text{OPS BT}) + 0.06840(2.4\text{GHz Wi-Fi}) + 0.09999(5\text{G Wi-Fi}) + 0.00476 = 0.17857 < 1$

According to the maximum gain of the antenna and the total output power to the antenna, through calculation, we will know max MPE value 0.18969 at distance 20cm. This is less than the limit 1. So SAR testing is not required.