

* RF Exposure

1. Regulation

Regulation

This document is prepared to show compliance with the RF Exposure requirements as required in §1.1310 of the FCC rules and Regulations.

The limit for Maximum Permissible Exposure (MPE), specified in FCC §1.1310, is listed in Table 1-1. According to FCC §1.1310: the criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in §1.1307(b).

Table 1 – 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 [minute]
(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 ~ 15 000	/	/	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/1 500	30
1 500 ~ 15 000	/	/	1.0	30

f=frequency in MHz, *= plane-wave equivalent power density

Per the guidance of KDB 680106, the E-field and H-field limits shown in the table above are extended down to 100 kHz

in Appendix C):

- 1) For test separation distances > 50 mm and < 200 mm, the power threshold at the corresponding test separation distance at 100 MHz in step b) is multiplied by $[1 + \log(100/f(\text{MHz}))]$
- 2) For test separation distances ≤ 50 mm, the power threshold determined by the equation in c) 1) for 50 mm and 100 MHz is multiplied by 1/2
- 3) SAR measurement procedures are not established below 100 MHz.
When SAR test exclusion cannot be applied, a KDB inquiry is required to determine SAR evaluation requirements for any SAR test results below 100 MHz to be acceptable.

2. Result

MPE (Maximum Permissible Exposure) Prediction

Predication of MPE limit at a given distance: Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = PG/4\pi R^2 \quad (\Rightarrow R = \sqrt{PG/4\pi S})$$

S = power density [mW/cm^2]

P = Power input to antenna [mW]

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 [cm]

RF Exposure Compliance Issue

The information should be included in the user's manual:

This appliance and its antenna must not be co-located or operation is conjunction with any other antenna or transmitter. A minimum separation distance of 20 cm must be maintained between the antenna and the person for this appliance to satisfy the RF exposure requirements.

Note.

1. The power density P_d (5th column) at a distance of 20 cm calculated from the friis transmission Formula is far below the limit of 1 mW/cm^2 .

2. Unequal antenna gains, with equal transmit powers. For antenna gains given by G_1, G_2, \dots, G_N dBi (i) If transmit signals are correlated, then

Directional gain = $10 \log[(10G_1/20 + 10G_2/20 + \dots + 10G_N/20)^2/NANT]$ dB i [Note the "20"s in the denominator of each exponent and the square of the sum of terms; the object is to combine the signal levels coherently.]

Antenna gain

Antenna \ Band	BT	BLE	2.4 GHz	5 GHz (UNII-1)
ANT 1	2.80	2.80	-	1.51
ANT 2	-	-	2.80	1.51
MIMO	-	-	-	1.51

Calculation Result of RF Exposure

BT_ANT 1

Mode	Frequency [MHz]	Max Tune-up Power [dBm]	Max Tune-up Power [mW]	Ant Gain [dBi]	Power density at 20 cm [mW/cm ²]	Limit [mW/cm ²]
GFSK	2 440	1.00	1.26	2.80	0.000 48	1.00

BLE_ANT 1

Mode	Frequency [MHz]	Max Tune-up Power [dBm]	Max Tune-up Power [mW]	Ant Gain [dBi]	Power density at 20 cm [mW/cm ²]	Limit [mW/cm ²]
BLE/ 1 Mbps/ Packet 37	2 440	4.50	2.82	2.80	0.001 07	1.00

WLAN (2.4 GHz)_ANT 2

Mode	Frequency [MHz]	Max Tune-up Power [dBm]	Max Tune-up Power [mW]	Ant Gain [dBi]	Power density at 20 cm [mW/cm ²]	Limit [mW/cm ²]
802.11b	2 462	14.50	28.18	2.80	0.010 68	1.00

WLAN (5 GHz)_UNII-1_ANT 1/ ANT 2/ MIMO

ANT	Mode	Frequency [MHz]	Max Tune-up Power [dBm]	Max Tune-up Power [mW]	Ant Gain [dBi]	Power density at 20 cm [mW/cm ²]	Limit [mW/cm ²]
ANT 1	802.11ac80	5 210	8.00	6.31	1.51	0.001 78	1.00
ANT 2	802.11a	5 180	11.50	14.13	1.51	0.003 98	1.00
MIMO	802.11ac80	5 210	11.00	12.59	1.51	0.003 55	1.00

- Simultaneous Transmission

Mode	Frequency [MHz]	Max Tune-up Power [dB m]	Max Tune-up Power [mW]	Ant Gain [dB i]	Power density at 20 _{cm} [mW/cm ²]	Limit [mW/cm ²]
5 GHz WIFI ANT 1 + BT ANT 1					0.002 26	1.00
5 GHz WIFI ANT 2 + BT ANT 1					0.004 46	1.00
5 GHz WIFI MIMO + BT ANT 1					0.004 03	1.00
5 GHz WIFI ANT 1 + BLE ANT 1					0.002 85	1.00
5 GHz WIFI ANT 2 + BLE ANT 1					0.005 05	1.00
5 GHz WIFI MIMO + BLE ANT 1					0.004 62	1.00

Note.

1. The power density P_d (5th column) at a distance of 20_{cm} calculated from the friis transmission

Formula is far below the limit of 1 mW/cm².

2. Simultaneous transmission of RF Exposure test exclusion for worst case configuration.

- 5GHz WIFI ANT 1 : the ratio is 0.001 78 / 1

- 5GHz WIFI ANT 2 : the ratio is 0.003 98 / 1

- 5GHz WIFI MIMO : the ratio is 0.003 55 / 1

- BT ANT 1: the ratio is 0.000 48 / 1

- BLE ANT 1: the ratio is 0.001 07 / 1

- 5 GHz WIFI ANT 1 + BT ANT 1 Power density: ((0.001 78 / 1) + (0.000 48 / 1))

- 5 GHz WIFI ANT 2 + BT ANT 1 Power density: ((0.003 98 / 1) + (0.000 48 / 1))

- 5 GHz WIFI MIMO + BT ANT 1 Power density: ((0.003 55 / 1) + (0.000 48 / 1))

- 5 GHz WIFI ANT 1 + BLE ANT 1 Power density: ((0.001 78 / 1) + (0.001 07 / 1))

- 5 GHz WIFI ANT 2 + BLE ANT 1 Power density: ((0.003 98 / 1) + (0.001 07 / 1))

- 5 GHz WIFI MIMO + BLE ANT 1 Power density: ((0.003 55 / 1) + (0.001 07 / 1))