

## \* 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 <sup>2</sup> ]	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 <sup>2</sup>	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 <sup>2</sup>	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 ½
- 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

Prediction 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<sup>2</sup>]

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<sub>d</sub> (5th column) at a distance of 20 cm calculated from the friis transmission Formula is far below the limit of 1 mW/cm<sup>2</sup>.

2. Unequal antenna gains, with equal transmit powers. For antenna gains given by G1, G2, ..., GN dBi (i) If transmit signals are correlated, then

Directional gain = 10 log[(10G<sub>1</sub> / 20 + 10G<sub>2</sub> / 20 + ... + 10G<sub>N</sub> / 20)<sup>2</sup> / 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	2.4 GHz	5 GHz (UNII-1)	5 GHz (UNII-2A)	5 GHz (UNII-2C)	5 GHz (UNII-3)
ANT 1	1.90	1.50	1.60	1.80	2.00
ANT 2	1.90	1.60	1.50	2.00	1.70
ANT 3	1.90	1.60	1.50	2.00	1.70
ANT 4	-	1.70	1.60	1.70	1.60
MIMO	1.90	1.70	1.60	2.00	2.00

**Calculation Result of RF Exposure**
**Worst Case**
**WLAN (2.4 GHz)**

Antenna	Mode	Frequency [MHz]	Max Tune-up Power [dBm]	Max Tune-up Power [mW]	Ant Gain [dBi]	Power density at 20 cm [mW/cm <sup>2</sup> ]	Limit [mW/cm <sup>2</sup> ]
SISO ANT 0	802.11g	2 412	17.50	56.23	1.90	0.017 33	1.00
SISO ANT 1	802.11g	2 412	17.50	56.23	1.90	0.017 33	1.00
SISO ANT 2	802.11g	2 412	17.50	56.23	1.90	0.017 33	1.00
MIMO	802.11b	2 412	21.00	125.89	1.90	0.038 79	1.00

**WLAN (5 GHz)**

Mode			Frequency [MHz]	Max Tune-up Power [dBm]	Max Tune-up Power [mW]	Ant Gain [dBi]	Power density at 20 cm [mW/cm <sup>2</sup> ]	Limit [mW/cm <sup>2</sup> ]
UNII-1	ANT 0	802.11a	5 240	23.00	199.53	1.60	0.056 07	1.00
	ANT 1	802.11a	5 240	24.00	251.19	1.60	0.072 23	1.00
	ANT 2	802.11a	5 240	23.00	199.53	1.60	0.057 38	1.00
	ANT 3	802.11a	5 240	22.00	158.49	1.70	0.046 64	1.00
	MIMO	802.11ac VHT20	5 240	26.00	398.11	1.70	0.117 15	1.00
UNII-2A	ANT 0	802.11a	5 260	21.00	125.89	1.60	0.036 20	1.00
	ANT 1	802.11n HT20	5 300	22.00	158.49	1.50	0.044 54	1.00
	ANT 2	802.11a	5 300	21.00	125.89	1.50	0.035 38	1.00
	ANT 3	802.11ac VHT20	5 300	20.00	100.00	1.60	0.028 76	1.00
	MIMO	802.11n HT40	5 270	23.00	199.53	1.60	0.057 38	1.00
UNII-2C	ANT 0	802.11ac VHT20	5 580	21.00	125.89	1.80	0.037 91	1.00
	ANT 1	802.11n HT20	5 580	22.00	158.49	2.00	0.049 97	1.00
	ANT 2	802.11n HT20	5 580	21.00	125.89	2.00	0.039 69	1.00
	ANT 3	802.11ac VHT20	5 580	21.00	125.89	1.70	0.037 05	1.00
	MIMO	802.11ac VHT80	5 690	24.00	251.19	2.00	0.079 20	1.00
UNII-3	ANT 0	802.11n HT20	5 745	23.00	199.53	2.00	0.062 91	1.00
	ANT 1	802.11n HT20	5 745	23.00	199.53	1.70	0.058 71	1.00
	ANT 2	802.11n HT20	5 745	23.00	199.53	1.70	0.058 71	1.00
	ANT 3	802.11n HT20	5 745	22.00	158.49	1.60	0.045 58	1.00
	MIMO	802.11n HT20	5 745	29.00	794.33	2.00	0.250 46	1.00

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**- Simultaneous Transmission (Worst configuration)**

Mode	Frequency [MHz]	Max Tune-up Power [dBm]	Ant Gain [dBi]	Power density at 20 cm [mW/cm <sup>2</sup> ]	Limit [mW/cm <sup>2</sup> ]
WLAN 2.4 GHz (MIMO 11b 2 412 MHz) + WLAN 5 GHz (MIMO 11n_HT20 5 745 MHz)				0.289 25	1.00

**Note.**

- 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<sup>2</sup>.
- Simultaneous transmission of RF Exposure test exclusion for worst case configuration.
  - 2.4G WLAN: the ratio is 0.038 79 / 1
  - 5G WLAN: the ratio is 0.250 46 / 1
  - 2.4G WLAN + 5G WLAN Power density: ((0.038 79 / 1) + (0.250 46 / 1))