

# 1 RF Exposure

## 1.1 RF Exposure Compliance Requirement

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.

Exemption limits for Routine Evaluation is applied according to RSS- 102 issue 5, section 2.5.2.

## 1.2 RF Exposure Limits:

### 1.2.1 For FCC

1. According to FCC Part 1 Subpart I 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) showed in Table 1.

Table 1: Limits for Maximum Permissible Exposure (MPE) as per FCC			
Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm <sup>2</sup> )
<b>Limits for Occupational / controlled Exposures</b>			
300 - 1500	--	--	F/300
1500 - 100000	--	--	5.0
<b>Limits for General population / Uncontrolled Exposure</b>			
300 - 1500	--	--	F/1500
1500 - 100000	--	--	1.0

F or *f* = Frequency in MHz

### Friss Formula

Friss Transmission Formula:  $P_d = (P_{out} * G) / (4 * \pi * r^2)$

Where

$P_d$  = power density in mW/cm<sup>2</sup>

$P_{out}$  = 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.

**Test Results:**

Manufacturer has declared the tune-up value as  $\pm 1$  dB is considered in MPE calculation.

**Antenna Gain: 5dBi**

Protocol	Frequency (MHz)	Maximum measured RF output power at antenna terminal (dBm)	Tune-up tolerance (dB)	Max power including tune-up tolerance * (mW)	Min Separation distance (CM)	Power Density (Pd) (mW/cm <sup>2</sup> )	FCC Limit (mW/cm <sup>2</sup> )
BLE	2402	3.94	$\pm 1$	3.11	20	0.0019	1.00
IEEE 802.15.4 (Anchor 1)	2440	17.93	$\pm 1$	78.16	20	0.0491	1.00
Proprietary (Anchor 1)	2442.5	17.32	$\pm 1$	67.92	20	0.0427	1.00
Proprietary (Anchor 1)	2476	14.22	$\pm 1$	33.26	20	0.0209	1.00

**Antenna Gain: 8dBi**

Protocol	Frequency (MHz)	Maximum measured RF output power at antenna terminal (dBm)	Tune-up tolerance (dB)	Max power including tune-up tolerance * (mW)	Min Separation distance (CM)	Power Density (Pd) (mW/cm <sup>2</sup> )	FCC Limit (mW/cm <sup>2</sup> )
BLE	2402	3.94	$\pm 1$	3.11	20	0.0039	1.00
IEEE 802.15.4 (Anchor 1)	2440	17.93	$\pm 1$	78.16	20	0.0980	1.00
Proprietary (Anchor 1)	2442.5	17.32	$\pm 1$	67.92	20	0.0853	1.00
Proprietary (Anchor 1)	2476	14.22	$\pm 1$	33.26	20	0.0418	1.00

**Simultaneous Calculation**

BLE	IEEE 802.15.4 (Anchor 1+Anchor 2)	Proprietary (Anchor 1+Anchor 2)	Proprietary (Anchor 1+Anchor 2)	Total	Ratio	Limit
0.0039	2 x 0.0980	2 x 0.0853	2 x 0.0418	0.45	0.45	1.00

**RF Exposure**

**Reference test Report No:  
ULR-TC56882230000038F**

**1.2.2 For IC**

According to IC RSS 102 : 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 section 4 showed in Table 4.

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m <sup>2</sup> )	Reference Period (minutes)
0.003-10 <sup>21</sup>	83	90	-	Instantaneous*
0.1-10	-	0.73/ f	-	6**
1.1-10	87/ f <sup>0.5</sup>	-	-	6**
10-20	27.46	0.0728	2	6
20-48	58.07/ f <sup>0.25</sup>	0.1540/ f <sup>0.25</sup>	8.944/ f <sup>0.5</sup>	6
48-300	22.06	0.05852	1.291	6
300-6000	3.142 f <sup>0.3417</sup>	0.008335 f <sup>0.3417</sup>	0.02619 f <sup>0.6834</sup>	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	616000/ f <sup>1.2</sup>
150000-300000	0.158 f <sup>0.5</sup>	4.21 x 10 <sup>-4</sup> f <sup>0.5</sup>	6.67 x 10 <sup>-5</sup> f	616000/f <sup>1.2</sup>

**Note:** f is frequency in MHz.  
\* Based on nerve stimulation (NS).  
\*\* Based on specific absorption rate (SAR).

**Antenna Gain: 5dBi**

Protocol	Frequency (MHz)	Maximum measured RF output power at antenna terminal (dBm)	Tune-up tolerance (dB)	Max power including tune up tolerance* (mW)	Power Density (Pd) (mW/cm <sup>2</sup> )	IC Limit (mW/cm <sup>2</sup> )
BLE	2402	3.94	±1	3.11	0.0019	0.53
IEEE 802.15.4 (Anchor 1)	2440	17.93	±1	78.16	0.0491	0.54
Proprietary (Anchor 1)	2442.5	17.32	±1	67.92	0.0427	0.54
Proprietary (Anchor 1)	2476	14.22	±1	33.26	0.0209	0.54

**Antenna Gain: 8dBi**

Protocol	Frequency (MHz)	Maximum measured RF output power at antenna terminal (dBm)	Tune-up tolerance (dB)	Max power including tune up tolerance * (mW)	Power Density (Pd) (mW/cm <sup>2</sup> )	IC Limit (mW/cm <sup>2</sup> )
BLE	2440	3.94	±1	3.11	0.0039	0.54
IEEE 802.15.4 (Anchor 1)	2440	17.93	±1	78.16	0.0980	0.54
Proprietary (Anchor 1)	2442.5	17.32	±1	67.92	0.0853	0.54
Proprietary (Anchor 1)	2476	14.22	±1	33.26	0.0418	0.54

**Simultaneous Calculation**

BLE	IEEE 802.15.4 (Anchor 1+Anchor 2)	Proprietary (Anchor 1+Anchor 2)	Proprietary (Anchor 1+Anchor 2)	Total	Ratio	Limit
0.0039	2x0.0980	2x0.0853	2x0.0418	0.454	0.84	1.00

**Note:**

1. Tune up tolerance of ± 1 dB is considered for MPE calculation, this value is declared by manufacturer.
2. Calculation is performed for 20 cm separation distance
3. Calculation is performed for highest antenna gain of 5dBi and 8dBi.

**1.3 Conclusion**

The Power density of the EUT is less than defined limit as shown above, hence EUT is exempted from routine SAR.