

# RF Exposure Exhibit

**EUT Name:** Home Wi-Fi Router

**Model No.:** A010001

CFR Part 1.1310 and RSS 102

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# 1 Test Methodology

In this document, we evaluate the RF Exposure to human body due the intentional transmission from the transmitter (EUT). The limit for Maximum Permissible Exposure (MPE) specified in FCC 1.1310 is followed. 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 a far field assumption, the calculated result of that is an over-prediction for near field power density. We will take that as the worst case to specify the safety range.

## 1.1 RF Exposure Limit

According to FCC 1.1310 table 1: 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)

### 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> )	Average Time (minutes)
<b>(A)Limits For Occupational / Control Exposures</b>				
0.3-1.34	614	1.63	*(100)	6
1.34-30	1842/f	4.89/f	*(900/f <sup>2</sup> )	6
30-300	61.4	0.163	1.0	6
30-1500	...	...	F/300	6
1500-100000	...	...	1.0	6
<b>(B)Limits For General Population / Uncontrolled Exposure</b>				
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
30-1500	...	...	F(MHz)/1500MHz	30
1500-100000	...	...	1.0	30

F = Frequency in MHz

\*=Plane wave equivalent density

According to RSS-102 Issue 5: The criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation

**RF FIELD STRENGTH LIMITS FOR DEVICES USED BY THE GENERAL PUBLIC  
 (UNCONTROLLED ENVIRONMENT)**

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/ <i>f</i>	-	6**
1.1-10	87/ <i>f</i> <sup>0.5</sup>	-	-	6**
10-20	27.46	0.0728	2	6
20-48	58.07/ <i>f</i> <sup>0.25</sup>	0.1540/ <i>f</i> <sup>0.25</sup>	8.944/ <i>f</i> <sup>0.5</sup>	6
48-300	22.06	0.05852	1.291	6
300-6000	3.142 <i>f</i> <sup>0.3417</sup>	0.008335 <i>f</i> <sup>0.3417</sup>	0.02619 <i>f</i> <sup>0.6834</sup>	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	616000/ <i>f</i> <sup>1.2</sup>
150000-300000	0.158 <i>f</i> <sup>0.5</sup>	4.21 x 10 <sup>-4</sup> <i>f</i> <sup>0.5</sup>	6.67 x 10 <sup>-5</sup> <i>f</i>	616000/ <i>f</i> <sup>1.2</sup>
<p><b>Note:</b> <i>f</i> is frequency in MHz.            *Based on nerve stimulation (NS).            ** Based on specific absorption rate (SAR).</p>				

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## 1.2 EUT Operating Condition

The Model A010001, is a Wi-Fi router for the home capable of operating in the 2.4 GHz and 5 GHz frequency bands over 20 MHz, 40 MHz and 80 MHz channels.

## 1.3 MPE calculation

### 1.3.1 Antenna Gain

The antenna used are:

1. Wifi 2.4 GHz Stamp Metal (PIFA) Integrated Antenna peak gain: +1.50 dBi or 1.41 (numeric).
2. Bluetooth 2.4 GHz Stamp Metal (PIFA) Integrated Antenna peak gain: +2.51 dBi or 1.78 (numeric).
3. Wifi 5.2 GHz Monopole Integrated Antenna peak gain: +2.13 dBi or 1.63 (numeric).
4. Wifi 5.785 GHz Monopole Integrated Antenna peak gain: +2.24 dBi or 1.68 (numeric).

### 1.3.2 Conducted Output Power

1. Wifi 2.4 GHz, TUV Test Report 31563403.001, total power (summed 2 chains): 29.57 dBm (905.733 mW)
2. Bluetooth 2.4 GHz, TUV Test Report 31562963.001, maximum power: -4.15 dBm (0.385 mW)
3. Wifi 5.2 GHz, TUV Test Report 31562807.001, total power for FCC (summed 2 chains): 27.038 dBm (505.599 mW)
4. Wifi 5.2 GHz, TUV Test Report 31562807.001, total power for RSS (summed 2 chains): 18.544 dBm (71.522 mW)
5. Wifi 5.785 GHz, TUV Test Report 31563404.001, total power (summed 2 chains): 28.32 dBm (679.204 mW)

### 1.3.3 Output Power into Antenna & RF Exposure value at distance 20cm

Calculations for this report are based on highest power measurement, therefore 2.447 GHz.

Corrected (including cal factors) Measurement:	29.57	dBm	
The Gain of the antenna:	1.50	dBi	
Type of Measurement:	Conducted		Direct measurement at Antenna Port
Impedance:	50.00	$\Omega$	
Measuring Distance:	0.00	m	Not used for Direct measurements.
Time weighted Duty Cycle:	100.00	%	

The Power Out would be: 0.905732601 Watts  
 or: 905.73260 mW  
 or: 905732.60  $\mu$ W  
 or: 29.57 dBm

Frequency range from 10 MHz to 40 GHz:

Frequency:	2.447	GHz
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Power output with DC and antenna Gain (EiRP):

Power (dBm):	31.07
Power (mW):	1279.381
Power (W):	1.279381

R = distance in	20	cm
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FCC:

Controlled Exposures - Limit =	5	mW/cm <sup>2</sup>
Uncontrolled Exposures - Limit =	1	mW/cm <sup>2</sup>
Pd =	0.2545248	mW/cm <sup>2</sup>
Controlled Margin to Limit =	4.7455	mW/cm <sup>2</sup>
Uncontrolled Margin to Limit =	0.7455	mW/cm <sup>2</sup>

Note: \* = Plane-wave equivalent power density

IC:

Controlled Exposures to Limit =	31.93105231	W/m <sup>2</sup>
Uncontrolled Exposures Limit =	5.419109831	W/m <sup>2</sup>
Pd =	2.545248	W/m <sup>2</sup>
Controlled Margin to Limit =	29.3858	W/m <sup>2</sup>
Uncontrolled Margin to Limit =	2.8739	W/m <sup>2</sup>

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

### 1.3.4 Output Power into Antenna & RF Exposure value at distance 20cm

Calculations for this report are based on highest power measurement, therefore 5.785 GHz.

Corrected (including cal factors) Measurement:	28.32	dBm	
The Gain of the antenna:	2.24	dBi	
Type of Measurement:	Conducted		Direct measurement at Antenna Port
Impedance:	50.00	$\Omega$	
Measuring Distance:	0.00	m	Not used for Direct measurements.
Time weighted Duty Cycle:	100.00	%	

The Power Out would be: 0.679203633 Watts  
 or: 679.20363 mW  
 or: 679203.63  $\mu$ W  
 or: 28.32 dBm

Frequency range from 10 MHz to 40 GHz:

Frequency:	5.785	GHz
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Power output with DC and antenna Gain (EIRP):

Power (dBm):	30.56
Power (mW):	1137.627
Power (W):	1.137627

R = distance in	20	cm
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FCC:

Controlled Exposures - Limit =	5	mW/cm <sup>2</sup>
Uncontrolled Exposures - Limit =	1	mW/cm <sup>2</sup>
Pd =	0.2263238	mW/cm <sup>2</sup>
Controlled Margin to Limit =	4.7737	mW/cm <sup>2</sup>
Uncontrolled Margin to Limit =	0.7737	mW/cm <sup>2</sup>

Note: \* = Plane-wave equivalent power density

IC:

Controlled Exposures to Limit =	49.09620552	W/m <sup>2</sup>
Uncontrolled Exposures Limit =	9.756490295	W/m <sup>2</sup>
Pd =	2.263238	W/m <sup>2</sup>
Controlled Margin to Limit =	46.8330	W/m <sup>2</sup>
Uncontrolled Margin to Limit =	7.4933	W/m <sup>2</sup>

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

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### 1.3.5 Simultaneous Operation RF Exposure value at distance 20cm

Calculations for 2.447 GHz and 5.785 GHz E.I.R.P. combined.

Limit for MPE (from FCC part 1.1310 table1) is 1.0 mW/cm<sup>2</sup>

The highest measured total power is +29.57 dBm or 905.73 mW (summed 2 chains) for 2.447 GHz.

The highest measured total power is +28.32 dBm or 679.20 mW (summed 2 chains) for 5.785 GHz.

The highest antenna gain are: +1.50 dBi or 1.41 (numeric) for 2.447 GHz

and +2.24 dBi or 1.68 (numeric) for 5.785 GHz.

Using the Friss transmission formula, the EIRP is  $P_{out} * G$ , and R is 20cm.

$P_d = ((905.73 * 1.41) + (679.20 * 1.68)) / (1600\pi) = 0.48085 \text{ mW/cm}^2$ , which is 0.51915 mW/cm<sup>2</sup> below to the limit.



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### 1.3.6 Sample Calculation

The 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

$\pi \approx 3.1416$

$R$  = distance between observation point and center of the radiator in cm

Ref. : David K. Cheng, *Field and Wave Electromagnetics*, Second Edition, Page 640, Eq. (11-133).