RF Exposure Exhibit

EUT Name: Wi-Fi Router

Model No.: J010001

CFR Part 1.1310 and RSS 102

Prepared for:

eero LLC
660 3rd Street
San Francisco, CA 94107 U.S.A.
Tel: (415) 738-7972

Prepared by:

TUV Rheinland of North America, Inc.

1279 Quarry Lane
Pleasanton, CA 94566
Tel: (925) 249-9123
Fax: (925) 249-9124
http://www.tuv.com/

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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^2)	Average Time (minutes)
(A)Limits For Occupational / Control Exposures				
0.3-1.34	614	1.63	*(100)	6
1.34-30	1842/f	4.89/f	*($900/f^2$)	6
30-300	61.4	0.163	1.0	6
30-1500	…	…	F/300	6
1500-100000	…	…	1.0	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
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^2)**	**Reference Period (minutes)**
0.003-10[21]	83	90	-	Instantaneous*
0.1-10	-	$0.73/f$	-	6**
1.1-10	$87/f^{0.5}$	-	-	6**
10-20	27.46	0.0728	2	6
20-48	$58.07/f^{0.25}$	$0.1540/f^{0.25}$	$8.944/f^{0.5}$	6
48-300	22.06	0.05852	1.291	6
300-6000	$3.142 f^{0.3417}$	$0.008335 f^{0.3417}$	$0.02619 f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/f^{1.2}$
150000-300000	$0.158 f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-5} f$	$616000/f^{1.2}$

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

1.2 EUT Operating Condition

The Model J010001, 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 antennas used are:

1. Bluetooth LE 2.4 GHz Flex PCB Antenna peak gain: +4.15 dBi or 2.60 (numeric).
2. Wifi 2.4 GHz Flex PCB Antenna peak gain: +3.40 dBi or 2.19 (numeric). Total directional gain: 6.41 dBi
3. Wifi 5.15-5.25 GHz Flex PCB Antenna peak gain: +3.11 dBi or 2.05 (numeric). Total directional gain: 6.12 dBi
4. Wifi 5.25-5.35 GHz Flex PCB Antenna peak gain: +3.96 dBi or 2.49 (numeric). Total directional gain: 6.97 dBi
5. Wifi 5.470-5.725 GHz Flex PCB Antenna peak gain: +4.25 dBi or 2.66 (numeric). Total directional gain: 7.26 dBi
6. Wifi 5.725-5.850 GHz Flex PCB Antenna peak gain: +3.97 dBi or 2.49 (numeric). Total directional gain: 6.98 dBi

1.3.2 Conducted Output Power

1. Bluetooth LE 2.440 GHz, TUV Test Report 31962538.001, maximum power: 7.16 dBm (5.20 mW)
2. Wifi 2.437 GHz, TUV Test Report 31962535.001, max power for non-beamforming: 25.45 dBm (350.75 mW) and for beamforming: 28.13 dBm (650.13 mW)
3. Wifi 5.22 GHz, TUV Test Report 31962534.001, max power for FCC: 22.88 dBm (194.09 mW) and for beamforming: 25.80 dBm (379.87 mW)
4. Wifi 5.22 GHz, TUV Test Report 31962534.001, max power for RSS: 19.52 dBm (89.54 mW) and for beamforming: 22.84 dBm (192.31 mW)
5. Wifi 5.825 GHz, TUV Test Report 31962534.001, max power: 24.14 dBm (259.42 mW) and for beamforming: 27.06 dBm (508.16 mW)

1.3.3 Output Power into Antenna & RF Exposure value (Non-Beamforming Mode)

Calculations for this report are based on highest power measurement and its antenna gain, therefore 2.437 GHz. Result below is Non-Beamforming Mode.

FCC:

Corrected (including cal factors) Measurment:	25.45	dBm
The Gain of the antenna:	3.40	dBi
Type of Measurment:	Conducted	Direct measurement at Antenna Port
Impedance:	50.00	Ω
Measuring Distance:	0.00	m
Time weighted Duty Cycle:	100.00	%

The Power Out would be:	0.350751874	Watts
or:	350.75187	mW
or:	350751.87	µW
or:	25.45	dBm

Frequency range from 10 MHz to 40 GHz:

Frequency:	2.437	GHz

Power output with DC and antenna Gain (EiRP):

Power (dBm):	28.85
Power (mW):	767.361
Power (W):	0.767361

R = distance in	20	cm

FCC:		
Controlled Exposures - Limit =	5	mW/cm^2
Uncontrolled Exposures - Limit =	1	mW/cm^2
Pd =	0.1526617	mW/cm^2
Controlled Margin to Limit =	4.8473	mW/cm^2
Uncontrolled Margin to Limit =	0.8473	mW/cm^2

IC:

Corrected (including cal factors) Measurment:	25.45	dBm
The Gain of the antenna:	3.40	dBi
Type of Measurment:	Conducted	Direct measurement at Antenna Port
Impedance:	50.00	Ω
Measuring Distance:	0.00	m
Time weighted Duty Cycle:	100.00	%

The Power Out would be:	0.350751874	Watts
or:	350.75187	mW
or:	350751.87	µW
or:	25.45	dBm

Frequency range from 10 MHz to 40 GHz:

Frequency:	2.437	GHz

Power output with DC and antenna Gain (EiRP):

Power (dBm):	28.85
Power (mW):	767.361
Power (W):	0.767361

R = distance in	20	cm

IC:

Controlled Exposures to Limit =	31.86574021	W/m^2
Uncontrolled Exposures Limit =	5.403965492	W/m^2
Pd =	1.526617	W/m^2
Controlled Margin to Limit =	30.3391	W/m^2
Uncontrolled Margin to Limit =	3.8773	W/m^2

Calculations for this report are based on highest power measurement and its antenna gain, therefore 5.22 GHz. Result below is Non-Beamforming Mode.

FCC:

Corrected (including cal factors) Measurment:	22.88	dBm	
The Gain of the antenna:	3.11	dBi	
Type of Measurment:	Conducted		Direct measurement at Antenna Port
Impedance:	50.00	Ω	
Measuring Distance:	0.00	m	
Time weighted Duty Cycle:	100.00	%	

The Power Out would be:	0.194088588	Watts
or:	194.08859	mW
or:	194088.59	µW
or:	22.88	dBm

Frequency range from 10 MHz to 40 GHz:

Frequency:	5.22	GHz

Power output with DC and antenna Gain (EiRP):

Power (dBm):	25.99
Power (mW):	397.192
Power (W):	0.397192

R = distance in	20	cm

FCC:		
Controlled Exposures - Limit =	5	mW/cm^2
Uncontrolled Exposures - Limit =	1	mW/cm^2
Pd =	0.0790187	mW/cm^2
Controlled Margin to Limit =	4.9210	mW/cm^2
Uncontrolled Margin to Limit =	0.9210	mW/cm^2

IC:

Corrected (including cal factors) Measurment:	19.52	dBm
The Gain of the antenna:	3.11	dBi
Type of Measurment:	Conducted	Direct measurement at Antenna Port
Impedance:	50.00	Ω
Measuring Distance:	0.00	m
Time weighted Duty Cycle:	100.00	%

The Power Out would be:	0.089536477	Watts
or:	89.53648	mW
or:	89536.48	µW
or:	19.52	dBm

Frequency range from 10 MHz to 40 GHz:

Frequency:	5.22	GHz

Power output with DC and antenna Gain (EiRP):

Power (dBm):	22.63
Power (mW):	183.231
Power (W):	0.183231

R = distance in	20	cm

IC:

Controlled Exposures to Limit =	46.6370958	W/m^2
Uncontrolled Exposures Limit =	9.094765804	W/m^2
Pd =	0.364527	W/m^2
Controlled Margin to Limit =	46.2726	W/m^2
Uncontrolled Margin to Limit =	8.7302	W/m^2

Calculations for this report are based on highest power measurement and its antenna gain, therefore 5.825 GHz. Result below is Non-Beamforming Mode.

FCC:

Corrected (including cal factors) Measurment:	24.14	dBm	
The Gain of the antenna:	3.97	dBi	
Type of Measurment:	Conducted		Direct measurement at Antenna Port
Impedance:	50.00	Ω	
Measuring Distance:	0.00	m	
Time weighted Duty Cycle:	100.00	%	

The Power Out would be:	0.259417936	Watts
or:	259.41794	mW
or:	259417.94	µW
or:	24.14	dBm

Frequency range from 10 MHz to 40 GHz:

Frequency:	5.825	GHz

Power output with DC and antenna Gain (EiRP):

Power (dBm):	28.11
Power (mW):	647.143
Power (W):	0.647143

R = distance in	20	cm

FCC:		
Controlled Exposures - Limit =	5	mW/cm^2
Uncontrolled Exposures - Limit =	1	mW/cm^2
Pd =	0.1287449	mW/cm^2
Controlled Margin to Limit =	4.8713	mW/cm^2
Uncontrolled Margin to Limit =	0.8713	mW/cm^2

IC:

Corrected (including cal factors) Measurment:	24.14	dBm
The Gain of the antenna:	3.97	dBi
Type of Measurment:	Conducted	Direct measurement at Antenna Port
Impedance:	50.00	Ω
Measuring Distance:	0.00	m
Time weighted Duty Cycle:	100.00	%

The Power Out would be:	0.259417936	Watts
or:	259.41794	mW
or:	259417.94	µW
or:	24.14	dBm

Frequency range from 10 MHz to 40 GHz:

Frequency:	5.825	GHz

Power output with DC and antenna Gain (EiRP):

Power (dBm):	28.11
Power (mW):	647.143
Power (W):	0.647143

R = distance in	20	cm

IC:

Controlled Exposures to Limit =	49.26564935	W/m^2
Uncontrolled Exposures Limit =	9.802542565	W/m^2
Pd =	1.287449	W/m^2
Controlled Margin to Limit =	47.9782	W/m^2
Uncontrolled Margin to Limit =	8.5151	W/m^2

1.3.4 RF Exposure value when 3 radios operating simultaneously (Non-Beamforming Mode)

Non-Beamforming Exposure result (FCC)

Operating Frequency (MHz)	Power Density (mW/cm²)	
2437	0.1527	
5220	0.0790	
5825	0.1287	
	0.3604	**Total Power Density (mW/cm²)**
	1.0000	**Uncontrolled Exposure Limit (mW/cm²)**
	-0.6396	**Margin (mW/cm²)**
Note: Result were calculated at a distance from the user is 20 cm		

Non-Beamforming Exposure result (IC)

Operating Frequency (MHz)	Power Density (W/cm²)	Limit (W/cm²)	Ratio	
2437	1.5266	5.4040	0.2825	
5220	0.3645	9.0948	0.0401	
5825	1.2874	9.8025	0.1313	
			0.4539	**∑ ratio**
Note: 1. The MPE calculation for simultaneous transmission is less than 1. **2. Result were calculated at a distance from the user is 20 cm**				

1.3.5 Output Power into Antenna & RF Exposure value (Beamforming Mode)

Calculations for this report are based on highest power measurement (summed 2 chains) and its antenna gain, therefore 2.437 GHz. Result below is Beamforming Mode.

FCC:

Corrected (including cal factors) Measurment:	28.13	dBm	
The Gain of the antenna:	6.41	dBi	
Type of Measurment:	Conducted		Direct measurement at Antenna Port
Impedance:	50.00	Ω	
Measuring Distance:	0.00	m	
Time weighted Duty Cycle:	100.00	%	

The Power Out would be:	0.650129690	Watts
or:	650.12969	mW
or:	650129.69	µW
or:	28.13	dBm

Frequency range from 10 MHz to 40 GHz:

Frequency:	2.437	GHz

Power output with DC and antenna Gain (EiRP):

Power (dBm):	34.54
Power (mW):	2844.461
Power (W):	2.844461

R = distance in	26	cm

FCC:		
Controlled Exposures - Limit =	5	mW/cm^2
Uncontrolled Exposures - Limit =	1	mW/cm^2
Pd =	0.3348447	mW/cm^2
Controlled Margin to Limit =	4.6652	mW/cm^2
Uncontrolled Margin to Limit =	0.6652	mW/cm^2

IC:

Corrected (including cal factors) Measurment:	28.13	dBm
The Gain of the antenna:	6.41	dBi
Type of Measurment:	Conducted	Direct measurement at Antenna Port
Impedance:	50.00	Ω
Measuring Distance:	0.00	m
Time weighted Duty Cycle:	100.00	%

The Power Out would be:	0.650129690	Watts
or:	650.12969	mW
or:	650129.69	µW
or:	28.13	dBm

Frequency range from 10 MHz to 40 GHz:

Frequency:	2.437	GHz

Power output with DC and antenna Gain (EiRP):

Power (dBm):	34.54
Power (mW):	2844.461
Power (W):	2.844461

R = distance in	27	cm

IC:		
Controlled Exposures to Limit =	31.86574021	W/m^2
Uncontrolled Exposures Limit =	5.403965492	W/m^2
Pd =	3.105007	W/m^2
Controlled Margin to Limit =	28.7607	W/m^2
Uncontrolled Margin to Limit =	2.2990	W/m^2

Calculations for this report are based on highest power measurement (summed 2 chains) and its antenna gain, therefore 5.22 GHz. Result below is Beamforming Mode.

FCC:

Corrected (including cal factors) Measurment:	25.80	dBm	
The Gain of the antenna:	6.97	dBi	
Type of Measurment:	Conducted		Direct measurement at Antenna Port
Impedance:	50.00	Ω	
Measuring Distance:	0.00	m	
Time weighted Duty Cycle:	100.00	%	

The Power Out would be:	0.380189396	Watts
or:	380.18940	mW
or:	380189.40	µW
or:	25.80	dBm

Frequency range from 10 MHz to 40 GHz:

Frequency:	5.22	GHz

Power output with DC and antenna Gain (EiRP):

Power (dBm):	32.77
Power (mW):	1892.344
Power (W):	1.892344

R = distance in	26	cm

FCC:		
Controlled Exposures - Limit =	5	mW/cm^2
Uncontrolled Exposures - Limit =	1	mW/cm^2
Pd =	0.2227632	mW/cm^2
Controlled Margin to Limit =	4.7772	mW/cm^2
Uncontrolled Margin to Limit =	0.7772	mW/cm^2

IC:

Corrected (including cal factors) Measurment:	22.80	dBm
The Gain of the antenna:	6.97	dBi
Type of Measurment:	Conducted	Direct measurement at Antenna Port
Impedance:	50.00	Ω
Measuring Distance:	0.00	m
Time weighted Duty Cycle:	100.00	%

The Power Out would be:	0.190546072	Watts
or:	190.54607	mW
or:	190546.07	µW
or:	22.80	dBm

Frequency range from 10 MHz to 40 GHz:

Frequency:	5.22	GHz

Power output with DC and antenna Gain (EiRP):

Power (dBm):	29.77
Power (mW):	948.418
Power (W):	0.948418

R = distance in	27	cm

IC:		
Controlled Exposures to Limit =	46.6370958	W/m^2
Uncontrolled Exposures Limit =	9.094765804	W/m^2
Pd =	1.035291	W/m^2
Controlled Margin to Limit =	45.6018	W/m^2
Uncontrolled Margin to Limit =	8.0595	W/m^2

Calculations for this report are based on highest power measurement (summed 2 chains) and its antenna gain, therefore 5.825 GHz. Result below is Beamforming Mode.

FCC:

Corrected (including cal factors) Measurment:	27.06	dBm	
The Gain of the antenna:	6.98	dBi	
Type of Measurment:	Conducted		Direct measurement at Antenna Port
Impedance:	50.00	Ω	
Measuring Distance:	0.00	m	
Time weighted Duty Cycle:	100.00	%	

The Power Out would be:	0.508159443	Watts
or:	508.15944	mW
or:	508159.44	µW
or:	27.06	dBm

Frequency range from 10 MHz to 40 GHz:

Frequency:	5.825	GHz

Power output with DC and antenna Gain (EiRP):

Power (dBm):	34.04
Power (mW):	2535.129
Power (W):	2.535129

R = distance in	26	cm

FCC:		
Controlled Exposures - Limit =	5	mW/cm^2
Uncontrolled Exposures - Limit =	1	mW/cm^2
Pd =	0.2984307	mW/cm^2
Controlled Margin to Limit =	4.7016	mW/cm^2
Uncontrolled Margin to Limit =	0.7016	mW/cm^2

IC:

Corrected (including cal factors) Measurment:	27.06	dBm
The Gain of the antenna:	6.98	dBi
Type of Measurment:	Conducted	Direct measurement at Antenna Port
Impedance:	50.00	Ω
Measuring Distance:	0.00	m
Time weighted Duty Cycle:	100.00	%

The Power Out would be:	0.508159443	Watts
or:	508.15944	mW
or:	508159.44	µW
or:	27.06	dBm

Frequency range from 10 MHz to 40 GHz:

Frequency:	5.825	GHz

Power output with DC and antenna Gain (EiRP):

Power (dBm):	34.04
Power (mW):	2535.129
Power (W):	2.535129

R = distance in	27	cm

IC:		
Controlled Exposures to Limit =	49.26564935	W/m^2
Uncontrolled Exposures Limit =	9.802542565	W/m^2
Pd =	2.767341	W/m^2
Controlled Margin to Limit =	46.4983	W/m^2
Uncontrolled Margin to Limit =	7.0352	W/m^2

1.3.6 RF Exposure value when 3 radios operating simultaneously (Beamforming Mode)

Beamforming Mode Exposure result (FCC)

Frequency (MHz)	Power Density (mW/cm²)	
2437	0.3348	
5220	0.2228	
5825	0.2984	
	0.8560	**Total Power Density (mW/cm²)**
	1.0000	**Uncontrolled Exposure Limit (mW/cm²)**
	-0.1440	**Margin (mW/cm²)**
Note: Result were calculated at a distance from the user is 26 cm		

Beamforming Mode Exposure result (IC)

Operating Frequency (MHz)	Power Density (W/cm²)	Limit (W/cm²)	Ratio	
2437	3.1050	5.4040	0.5746	
5220	1.0353	9.0948	0.1138	
5825	2.7673	9.8025	0.2823	
			0.9707	**∑ ratio**
Note: 1. The MPE calculation for simultaneous transmission is less than 1. **2. Result were calculated at a distance from the user is 27 cm**				

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

FCC: Result were calculated at a distance from the user is 26 cm.

IC: Result were calculated at a distance from the user is 27 cm.

1.3.7 Sample Calculation

The Friss transmission formula: $Pd = (Pout*G) / (4*\pi*R^2)$

Where;

Pd = power density in mW/cm^2
Pout = 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).