

# 1 Human Exposure Assessment

## 1.1 Maximum Permissible Exposure

### 1.1.1 Limit of Maximum Permissible Exposure

Limits for Occupational / Controlled Exposure				
Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/ cm <sup>2</sup> )	Averaging Time  E  <sup>2</sup> , H  <sup>2</sup> or S (minutes)
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
300-1500	-	-	F/300	6
1500-100,000	-	-	5	6
Limits for General Population / Uncontrolled Exposure				
Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/ cm <sup>2</sup> )	Averaging Time  E  <sup>2</sup> , H  <sup>2</sup> or S (minutes)
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
300-1500	-	-	F/1500	30
1500-100,000	-	-	1.0	30
Note 1: f = frequency in MHz ; *Plane-wave equivalent power density				
Note 2: For the applicable limit, see FCC 1.1310				

RF Field Strength Limits for Controlled Use Devices (Controlled Environment)				
Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m <sup>2</sup> )	Averaging Time (minutes)
0.003-1	600	4.9	-	6
1-10	600/ <i>f</i>	4.9/ <i>f</i>	-	6
10-30	60	4.9/ <i>f</i>	-	6
30-300	60	0.163	10*	6
300-1500	3.54 <i>f</i> <sup>0.5</sup>	0.0094 <i>f</i> <sup>0.5</sup>	<i>f</i> /30	6
1500-15000	137	0.364	50	6
15000-150000	137	0.364	50	616000/ <i>f</i> <sup>1.2</sup>
150000-300000	0.354 <i>f</i> <sup>0.5</sup>	9.4 x 10 <sup>-4</sup> <i>f</i> <sup>0.5</sup>	3.33 x 10 <sup>-4</sup> <i>f</i>	616000/ <i>f</i> <sup>1.2</sup>
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> )	Averaging Time (minutes)
0.003-1	280	2.19	-	6
1-10	280/ <i>f</i>	2.19/ <i>f</i>	-	6
10-30	28	2.19/ <i>f</i>	-	6
30-300	28	0.073	2*	6
300-1500	1.585 <i>f</i> <sup>0.5</sup>	0.0042 <i>f</i> <sup>0.5</sup>	<i>f</i> /150	6
1500-15000	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>
Note 1: <i>f</i> is frequency in MHz.				
Note 2: For the applicable limit, see IC RSS-102				

### 1.1.2 MPE Calculation Method

$$E \text{ (V/m)} = \frac{\sqrt{30 \times P \times G}}{d}$$

**E** = Electric field (V/m)

**G** = EUT Antenna numeric gain (numeric)

The formula can be changed to

$$Pd = \frac{30 \times P \times G}{377 \times d^2}$$

$$\text{Power Density: } Pd \text{ (W/m}^2\text{)} = \frac{E^2}{377}$$

**P** = RF output power (W)

**d** = Separation distance between radiator and human body (m)

**1.1.3 Result of Maximum Permissible Exposure (2.4G)**

Transmitter Chains & Receiver Chains Information					
IEEE Std. 802.11 Protocol	Number of Transmit Chains ( $N_{TX}$ )	Number of Receive Chains ( $N_{RX}$ )	Correlation Signals with Multiple $N_{TX}$	RF Output Power (dBm)	Co-location
b	1	1	Correlated	21.46	Yes
g	1	1	Correlated	22.53	Yes
n (HT20)	3	3	Uncorrelated	23.42	Yes
n (HT40)	3	3	Uncorrelated	18.72	Yes

Note 1: RF output power specifies that Maximum Conducted (Average) Output Power.

Worst Maximum RF Output Power Result								
Exposure Environment		General Population / Uncontrolled Exposure						
Separation Distance (cm)		20						
Power Level	1	RF Output Power (dBm)						
Modulation Mode	$N_{TX}$	Chain-Port 1	Chain-Port 2	Chain-Port 3	Sum Chain	Gain (dBi)	EIRP Power	PD (S) (mW/cm <sup>2</sup> )
b	1	21.46	-	-	21.46	2.40	23.86	0.04839
g	1	22.53	-	-	22.53	2.40	24.93	0.06191
n (HT20)	3	18.71	17.58	19.45	23.42	7.17	30.59	0.22785
n (HT40)	3	13.69	14.14	14.01	18.72	7.17	25.89	0.07728
Maximum Permissible Exposure Limit (mW/cm <sup>2</sup> )								1

Note 1:  $N_{TX}$  = Number of Transmit Chains

**1.1.4 Result of Maximum Permissible Exposure (5.8G)**

Transmitter Chains & Receiver Chains Information					
IEEE Std. 802.11 Protocol	Number of Transmit Chains (N <sub>TX</sub> )	Number of Receive Chains (N <sub>RX</sub> )	Correlation Signals with Multiple N <sub>TX</sub>	RF Output Power (dBm)	Co-location
a	1	1	Correlated	21.33	Yes
n(HT20)	3	3	Uncorrelated	21.06	Yes
n(HT40)	3	3	Uncorrelated	22.98	Yes
ac(VHT20)	3	3	Uncorrelated	20.70	Yes
ac(VHT40)	3	3	Uncorrelated	22.99	Yes
ac(VHT80)	3	3	Uncorrelated	14.87	Yes
Note 1: Co-location, Co-location is generally defined as simultaneously transmitting (co-transmitting) antennas within 20 cm of each other. (i.e., EUT has simultaneously co-transmitting that operating 2.4GHz and 5GHz.) Note 2: RF output power specifies that Maximum Conducted (Average) Output Power.					

Worst Maximum RF Output Power Result								
Exposure Environment		General Population / Uncontrolled Exposure						
Separation Distance (cm)		20						
Power Level	1	RF Output Power (dBm)						
Modulation Mode	N <sub>TX</sub>	Chain-Port 1	Chain-Port 2	Chain-Port 3	Sum Chain	Gain (dBi)	EIRP Power	PD (S) (mW/cm <sup>2</sup> )
a	1	21.33	-	-	21.33	2.58	23.91	0.04895
n(HT20)	3	16.05	17.74	14.48	21.06	7.35	28.41	0.13811
n(HT40)	3	18.17	19.33	16.75	22.98	7.35	30.33	0.21474
ac(VHT20)	3	15.85	16.73	15.05	20.70	7.35	28.05	0.12707
ac(VHT40)	3	18.19	19.36	16.71	22.99	7.35	30.34	0.21524
ac(VHT80)	3	10.07	11.21	8.66	14.87	7.35	22.22	0.03321
Maximum Permissible Exposure Limit (mW/cm <sup>2</sup> )								1
Note 1: N <sub>TX</sub> = Number of Transmit Chains								

**1.1.5 Result of Maximum Permissible Exposure(5.2G)**

Transmitter Chains & Receiver Chains Information					
IEEE Std. 802.11 Protocol	Number of Transmit Chains (N <sub>TX</sub> )	Number of Receive Chains (N <sub>RX</sub> )	Correlation Signals with Multiple N <sub>TX</sub>	RF Output Power (dBm)	Co-location
a	1	1	Correlated	23.71	Yes
n(HT20)	3	3	Uncorrelated	26.74	Yes
n(HT40)	3	3	Uncorrelated	27.24	Yes
ac(VHT20)	3	3	Uncorrelated	26.78	Yes
ac(VHT40)	3	3	Uncorrelated	27.29	Yes
ac(VHT80)	3	3	Uncorrelated	17.40	Yes
Note 1: Co-location, Co-location is generally defined as simultaneously transmitting (co-transmitting) antennas within 20 cm of each other. (i.e., EUT has simultaneously co-transmitting that operating 2.4GHz and 5GHz.) Note 2: RF output power specifies that Maximum Conducted (Average) Output Power.					

Worst Maximum RF Output Power Result								
Exposure Environment		General Population / Uncontrolled Exposure						
Separation Distance (cm)		20						
Power Level	1	RF Output Power (dBm)						
Modulation Mode	N <sub>TX</sub>	Chain-Port 1	Chain-Port 2	Chain-Port 3	Sum Chain	Gain (dBi)	EIRP Power	PD (S) (mW/cm <sup>2</sup> )
a	1	23.71	-	-	23.71	2.58	26.29	0.08467
n(HT20)	3	21.53	23.31	20.64	26.74	7.35	34.09	0.51069
n(HT40)	3	22.17	23.64	21.27	27.24	7.35	34.59	0.57295
ac(VHT20)	3	21.55	23.39	20.62	26.78	7.35	34.13	0.51514
ac(VHT40)	3	22.24	23.66	21.33	27.29	7.35	34.64	0.57902
ac(VHT80)	3	12.11	13.91	11.49	17.40	7.35	24.75	0.05941
Maximum Permissible Exposure Limit (mW/cm <sup>2</sup> )								1
Note 1: N <sub>TX</sub> = Number of Transmit Chains								

<b>Worst Maximum RF Output Power Result</b>								
<b>Exposure Environment</b>		General Population / Uncontrolled Exposure						
<b>Separation Distance (cm)</b>		20						
<b>Condition</b>		<b>RF Output Power (dBm)</b>						
<b>Modulation Mode</b>	<b>N<sub>TX</sub></b>	<b>Chain-Port 1</b>	<b>Chain-Port 2</b>	<b>Chain-Port 3</b>	<b>Sum Chain</b>	<b>DG (dBi)</b>	<b>EIRP Power</b>	<b>PD (S) (mW/cm<sup>2</sup>)</b>
n (HT20)	3	18.71	17.58	19.45	23.42	7.17	30.59	0.22785
ac(VHT40)	3	22.24	23.66	21.33	27.29	7.35	34.64	0.57902
<b>Co-location Total</b>								0.80687
<b>Maximum Permissible Exposure Limit (mW/cm<sup>2</sup>)</b>								1
Note 1: N <sub>TX</sub> = Number of Transmit Chains								