

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 ²)	Averaging Time E ² , H ² or S (minutes)
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842 / f	4.89 / f	(900 / f)*	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 ²)	Averaging Time E ² , H ² or S (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	(180/f)*	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/m²)	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> ^{0.5}	0.0094 <i>f</i> ^{0.5}	<i>f</i> /30	6
1500-15000	137	0.364	50	6
15000-150000	137	0.364	50	616000/ <i>f</i> ^{1.2}
150000-300000	0.354 <i>f</i> ^{0.5}	9.4 × 10 ⁻⁴ <i>f</i> ^{0.5}	3.33 × 10 ⁻⁴ <i>f</i>	616000/ <i>f</i> ^{1.2}
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/m²)	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> ^{0.5}	0.0042 <i>f</i> ^{0.5}	<i>f</i> /150	6
1500-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	616000/ <i>f</i> ^{1.2}
150000-300000	0.158 <i>f</i> ^{0.5}	4.21 × 10 ⁻⁴ <i>f</i> ^{0.5}	6.67 × 10 ⁻⁵ <i>f</i>	616000/ <i>f</i> ^{1.2}
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
11B-20M	1	1	N/A	23.34	N/A
11G-20M	1	1	N/A	20.14	N/A
n (HT-20)	2	2	Uncorrelated	22.77	N/A
n (HT-40)	2	2	Uncorrelated	18.25	N/A
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							
Condition		RF Output Power (dBm)							
Modulation Mode	N _{TX}	Chain-Port 1	Chain-Port 2	-	-	Sum Chain	DG (dBi)	EIRP Power	PD (S) (mW/cm ²)
11B-20M	1		23.28	-	-	23.34	0.67	24.01	0.05012
11G-20M	1		19.64	-	-	20.14	0.67	20.81	0.02398
11N-HT-20	2	18.65	18.80	-	-	22.77	0.21	22.98	0.03950
11N-HT-40	2	13.43	13.40	-	-	18.25	0.21	18.47	0.01397
Maximum Permissible Exposure Limit (mW/cm ²)									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 _{TX})	Number of Receive Chains (N _{RX})	Correlation Signals with Multiple N _{TX}	RF Output Power (dBm)	Co-location
11A5.8G-20M	1	1	Correlated	20.87	N/A
11N5.8G- HT20	2	2	Uncorrelated	21.22	N/A
11N5.8G- HT40	2	2	Uncorrelated	23.00	N/A
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							
Condition		RF Output Power (dBm)							
Modulation Mode	N _{TX}	Chain-Port 1	Chain-Port 2	-	-	Sum Chain	DG (dBi)	EIRP Power	PD (S) (mW/cm ²)
11A5.8G-20M	1		20.35-	-	-	20.87	2.15	23.02	0.03983
11N5.8G- HT20	2	17.29	17.17	-	-	21.22	1.85*	23.06	0.04028
11N5.8G- HT40	2	18.05	18.19	-	-	23.00	1.85*	24.85	0.06074
Maximum Permissible Exposure Limit (mW/cm ²)									1
Note 1: N _{TX} = Number of Transmit Chains									
Note 2:* Direction gain = $10 \log[(10^{1.52/10} + 10^{2.15/10})/2]=1.85\text{dBi}$									

1.1.5 Result of Maximum Permissible Exposure-(5.2G~5.6G)

RF General Information					
Modulation Mode	Ch. Freq. (MHz)	Channel Number	Transmit Chains (N _{TX})	RF Output Power (dBm)	Co-location
11A5.2G-20M	5180-5240	36-48 [4]	1	14.79	N/A
11A5.3G-20M	5260-5320	52-64 [4]	1	20.37	
11A5.6G-20M	5500-5700	100-140 [8]	1	20.87	
11N5.2G-HT-20	5180-5240	36-48 [4]	2	14.53	N/A
11N5.3G-HT-20	5260-5320	52-64 [4]	2	21.59	
11N5.6G-HT-20	5500-5700	100-140 [8]	2	21.26	
11N5.2G-HT-40	5190-5230	38-46 [2]	2	16.60	N/A
11N5.3G-HT-40	5270-5310	54-62 [2]	2	22.65	
11N5.6G-HT-40	5510-5670	102-134 [3]	2	22.41	
Note 1: RF output power specifies that Maximum Conducted (Average) Output Power.					
Note 2: 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.)					

Worst Maximum Permissible Exposure Result									
Exposure Environment		General Population / Uncontrolled Exposure							
Separation Distance (cm)		20							
Condition		RF Output Power (dBm)							
Modulation Mode	N _{TX}	Chain-Port 1	Chain-Port 2	-	-	Sum Chain	DG (dBi)	EIRP Power	PD (S) (W/m ²)
11A5.2G-20M	1		14.79	-	-	14.79	2.15	16.94	0.00982
11A5.3G-20M	1		20.37	-	-	20.37	2.15	22.52	0.03550
11A5.6G-20M	1		20.87	-	-	20.87	2.15	23.02	0.03983
11N5.2G-20M	2	11.47	11.57	-	-	14.53	1.85*	16.37	0.00863
11N5.3G-20M	2	18.45	18.71	-	-	21.59	1.85*	23.43	0.04387
11N5.6G-20M	2	18.33	18.18	-	-	21.26	1.85*	23.11	0.04070
11N5.2G-40M	2	13.7	13.48	-	-	16.60	1.85*	18.45	0.01392
11N5.3G-40M	2	19.74	19.54	-	-	22.65	1.85*	24.50	0.05605
11N5.6G-40M	2	19.51	19.28	-	-	22.41	1.85*	24.25	0.05298
Maximum Permissible Exposure Limit (mW/cm ²)									1

Note 1* : Direction gain = $10 \log[(10^{1.52}/10 + 10^{2.15}/10)/2] = 1.85\text{dBi}$