

1 Maximum Permissible Exposure

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 x 10 ⁻⁴ <i>f</i> ^{0.5}	3.33 x 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 x 10 ⁻⁴ <i>f</i> ^{0.5}	6.67 x 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

RF General Information						
Frequency Range (MHz)	IEEE Std. 802.11	Ch. Freq. (MHz)	Channel Number	Transmit Chains (N _{TX})	RF Output Power (dBm)	Co-location
5250-5350	a	5260-5320	52-64 [4]	2	23.59	N/A
5250-5350	n(HT20)	5260-5320	52-64 [4]	2	23.65	N/A
5250-5350	n(HT40)	5270-5310	54-62 [2]	2	23.55	N/A
5250-5350	ac(VHT20)	5260-5320	52-64 [4]	2	23.65	N/A
5250-5350	ac(VHT40)	5270-5310	54-62 [2]	2	23.51	N/A
5250-5350	ac(VHT80)	5290	58 [1]	2	15.19	N/A
Note 1: RF output power specifies that Maximum Conducted Output Power. Note 2: RF output power specifies that Maximum Peak Conducted Output Power for ac(VHT80) only. Note 3: 802.11a/n uses a combination of OFDM-BPSK, QPSK, 16QAM, 64QAM modulation. Note 4: 802.11ac uses a combination of OFDM-BPSK, QPSK, 16QAM, 64QAM, 256QAM modulation. Note 5: 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 RF Output Power Result								
Exposure Environment	General Population / Uncontrolled Exposure							
Separation Distance (cm)	20							
Condition	RF Output Power (dBm)							
Modulation Mode	Chain-Port 1	Chain-Port 2	Chain-Port 3	Chain-Port 4	Sum Chain	DG (dBi)	EIRP Power	PD (S) (mW/cm ²)
a	20.48	20.69	---	---	23.59	2.90	26.49	0.089
n(HT20)	20.52	20.75	---	---	23.65	2.90	26.55	0.090
n(HT40)	20.41	20.66	---	---	23.55	2.90	26.45	0.088
ac(VHT20)	20.57	20.72	---	---	23.65	2.90	26.55	0.090
ac(VHT40)	20.36	20.63	---	---	23.51	2.90	26.41	0.087
ac(VHT80)	12.09	12.28	---	---	15.19	2.90	18.09	0.013
Maximum Permissible Exposure Limit (mW/cm ²)								1

RF General Information						
Frequency Range (MHz)	IEEE Std. 802.11	Ch. Freq. (MHz)	Channel Number	Transmit Chains (N _{TX})	RF Output Power (dBm)	Co-location
5470-5725	a	5500-5700	100-140 [8]	2	23.54	N/A
5470-5725	n(HT20)	5500-5700	100-140 [8]	2	23.55	N/A
5470-5725	n(HT40)	5510-5670	102-134 [3]	2	23.52	N/A
5470-5725	ac(VHT20)	5500-5700	100-140 [8]	2	23.50	N/A
5470-5725	ac(VHT40)	5510-5670	102-134 [3]	2	23.54	N/A
5470-5725	ac(VHT80)	5530	106 [1]	2	14.38	N/A
Note 1: RF output power specifies that Maximum Conducted Output Power. Note 2: RF output power specifies that Maximum Peak Conducted Output Power for ac(VHT80) only. Note 3: 802.11a/n uses a combination of OFDM-BPSK, QPSK, 16QAM, 64QAM modulation. Note 4: 802.11ac uses a combination of OFDM-BPSK, QPSK, 16QAM, 64QAM, 256QAM modulation. Note 5: 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 RF Output Power Result								
Exposure Environment	General Population / Uncontrolled Exposure							
Separation Distance (cm)	20							
Condition	RF Output Power (dBm)							
Modulation Mode	Chain-Port 1	Chain-Port 2	Chain-Port 3	Chain-Port 4	Sum Chain	DG (dBi)	EIRP Power	PD (S) (mW/cm ²)
a	20.43	20.63	---	---	23.54	2.90	26.44	0.088
n(HT20)	20.48	20.59	---	---	23.55	2.90	26.45	0.088
n(HT40)	20.35	20.67	---	---	23.52	2.90	26.42	0.087
ac(VHT20)	20.32	20.65	---	---	23.50	2.90	26.40	0.087
ac(VHT40)	20.36	20.68	---	---	23.54	2.90	26.44	0.088
ac(VHT80)	11.06	11.67	---	---	14.38	2.90	17.28	0.011
Maximum Permissible Exposure Limit (mW/cm ²)								1

MPE of Co-location evaluation:

2.4 and 5GHz can transmit at the same time, MPE evaluation is as below formula

$$PD1 / \text{Limit1} + PD2 / \text{Limit 2} + \dots < 1$$

PD = Power density

- 1) $2.4 + 5.3\text{GHz} = 0.118 / 1 + 0.090 / 1 = 0.208 < 1$
- 2) $2.4 + 5.6\text{GHz} = 0.118 / 1 + 0.088 / 1 = 0.206 < 1$

Note: Result of Maximum Permissible Exposure for 2.4 GHz comes from original MPE report FA330625-01