# 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/ cm²)** | **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 | ($900 / f^2$)* | 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/ cm²)** | **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 | ($180/f^2$)* | 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<br>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/$f$ | 4.9/$f$ | - | 6 |
| 10-30 | 60 | 4.9/$f$ | - | 6 |
| 30-300 | 60 | 0.163 | 10* | 6 |
| 300-1500 | 3.54 $f$ 0.5 | 0.0094 $f$ 0.5 | $f$/30 | 6 |
| 1500-15000 | 137 | 0.364 | 50 | 6 |
| 15000-150000 | 137 | 0.364 | 50 | 616000/$f$ 1.2 |
| 150000-300000 | 0.354 $f$ 0.5 | 9.4 x 10-4 $f$ 0.5 | 3.33 x 10-4 $f$ | 616000/$f$ 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/$f$ | 2.19/$f$ | - | 6 |
| 10-30 | 28 | 2.19/$f$ | - | 6 |
| 30-300 | 28 | 0.073 | 2* | 6 |
| 300-1500 | 1.585 $f^{0.5}$ | 0.0042 $f^{0.5}$ | $f$/150 | 6 |
| 1500-15000 | 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 x $10^{-4}$ $f^{0.5}$ | 6.67 x $10^{-5}$ $f$ | 616000/$f^{1.2}$ |
| Note 1: $f$ is frequency in MHz.<br>Note 2: For the applicable limit, see IC RSS-102 | | | | |

### 1.1.2 MPE Calculation Method

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

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

**E** = Electric field (V/m)
**P** = RF output power (W)
**G** = EUT Antenna numeric gain (numeric)
**d** = Separation distance between radiator and human body (m)

The formula can be changed to

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

### 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.)<br>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/cm²)** |
| 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/cm²)** | | | | | | | 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.)<br>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/cm²)** |
| 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/cm²)** | | | | | | | 1 |
| Note 1: $N_{TX}$ = Number of Transmit Chains<br>Note 2:* Direction gain = 10 log[($10^{1.52/10}$ + $10^{2.15/10)}$/2]=1.85dBi | | | | | | | |

### 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/m²)** |
| 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/cm²)** | | | | | | | 1 |

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