# 1. MAXIMUM PERMISSIBLE EXPOSURE (MPE)

## 1.1 Standard Applicable

According to § 1.1307(b)(1), system operating under the provisions of this section shall be operating in a manner that the public is not exposed to radio frequency energy level in excess limit for maximum permissible exposure.

(a) 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 Times $\|E\|^2$, $\|H\|^2$ 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 |
| 1500-100000 | / | / | 5 | 6 |

(b) 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 Times $\|E\|^2$, $\|H\|^2$ 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 |
| 1500-100000 | / | / | 1 | 30 |

Note: f = frequency in MHz: * = Plane-wave equivalents power density

## 1.2 MPE Calculation Method

$S = PG/4\pi R^2 = EIRP/4\pi R^2$

S = power density (in appropriate units, e.g., $mw/cm^2$)

P = power input to the antenna (in appropriate units, e.g., mw)

G = power gain of the antenna in the direction of interest relative to an isotropic radiator, the power gain factor is normally numeric gain.

R = distance to the center of radiation of the antenna (in appropriate units, e.g., cm)

## 1.3 MPE Calculation Result

### 1.3.1 Result for operational ISM Band

For WiFi function, operating at 2412-2462MHz for 802.11b/g/n-HT20, 11 channels with 5MHz channel spacing and 2422-2452MHz for 802.11n-HT40, 9 channels with 5MHz channel spacing.

Modulation Type: BPSK, QPSK, 16QAM, 64QAM for OFDM. CCK, DQPSK, DBPSK for DSSS.
Antenna Type: sucker antenna
Antenna Gain: 2.0dBi
The nominal conducted output power specified: 20dBm (Tolerance: +/-1dB)

The maximum conducted output power for the EUT is 19.79 dBm in the frequency 2.462GHz 802.11n-HT20 mode which is within the production variation.

In MIMO, Ant1+Ant2 Directional gain = GANT + 10 log(N) dBi = 2 + 10 log(2) = 5dBi

The maximum EIRP= 20+1+2+5=28dBm=630.9573mW
The source-based time averaged maximum radiated power = 630.9573mW x Duty Cycle = 630.9573mW

The worst case is power density at prediction frequency at 20cm: **0.1255 (mw/cm$^2$)**
MPE limit for general population exposure at prediction frequency: 1 (mw/cm$^2$)

0.1255 (mw/cm$^2$) < 1 (mw/cm$^2$)

Result: Pass

### 1.3.2 Result for lower operational Band: LTE Band 5 and LTE Band 17, GSM850 and WCDMA Band 5

| Operating Mode | Frequency on channel (MHz) | Declared maximum conducted output power (dBm) | Max. positive tolerance according manufacturer (dBm) | Antenna Gain (dBm) | Calculated maximum EIRP (declared + Tune-up + antenna Gain) (dBm) | Duty cycle (%) | Declared maximum EIRP (W) | Equivalent EIRP (maximum EIRP x duty cycle) (mW) | MPE Limit (mw/cm$^2$) | MPE-Value (mw/cm$^2$) | Margin to limit: (mw/cm$^2$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GSM/GPRS (Peak) | 824.2 | 33 | 0.5 | 2.15 | 35.65 | 50 | 3.673 | 1836 | 0.5495 | 0.3653 | 0.1842 |
| | 837 | 33 | 0.5 | 2.15 | 35.65 | | 3.673 | 1836 | 0.5580 | 0.3653 | 0.1927 |
| | 848.8 | 33 | 0.5 | 2.15 | 35.65 | | 3.673 | 1836 | 0.5659 | 0.3653 | 0.2006 |
| GSM/GPRS (Avg.Burst Power) | 824.2 | 33 | 0.5 | 2.15 | 35.65 | 50 | 3.673 | 1836 | 0.5495 | 0.3653 | 0.1842 |
| | 837 | 33 | 0.5 | 2.15 | 35.65 | | 3.673 | 1836 | 0.5580 | 0.3653 | 0.1927 |
| | 848.8 | 33 | 0.5 | 2.15 | 35.65 | | 3.673 | 1836 | 0.5659 | 0.3653 | 0.2006 |
| EDGE (Peak) | 824.2 | 27 | 0.5 | 2.15 | 29.65 | 50 | 0.923 | 461 | 0.5495 | 0.0918 | 0.4577 |
| | 837 | 27 | 0.5 | 2.15 | 29.65 | | 0.923 | 461 | 0.5580 | 0.0918 | 0.4662 |
| | 848.8 | 27 | 0.5 | 2.15 | 29.65 | | 0.923 | 461 | 0.5659 | 0.0918 | 0.4741 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| EDGE (Avg.Burst Power) | 824.2 | 27 | 0.5 | 2.15 | 29.65 | 50 | 0.923 | 461 | 0.5495 | 0.0918 | 0.4577 |
| | 837 | 27 | 0.5 | 2.15 | 29.65 | | 0.923 | 461 | 0.5580 | 0.0918 | 0.4662 |
| | 848.8 | 27 | 0.5 | 2.15 | 29.65 | | 0.923 | 461 | 0.5659 | 0.0918 | 0.4741 |
| WCDMA FDD Band 5 (RMS-Value) | 826.4 | 24 | 0.5 | 2.15 | 26.65 | 100 | 0.462 | 462 | 0.5509 | 0.0920 | 0.4589 |
| | 836.4 | 24 | 0.5 | 2.15 | 26.65 | | 0.462 | 462 | 0.5576 | 0.0920 | 0.4656 |
| | 846.6 | 24 | 0.5 | 2.15 | 26.65 | | 0.462 | 462 | 0.5644 | 0.0920 | 0.4724 |
| LTE Band 17 (QPSK,#RB=1,RMS-Value) | 706.5 | 23 | 0.5 | 2.15 | 25.65 | 100 | 0.367 | 367 | 0.4710 | 0.0731 | 0.3979 |
| | 710 | 23 | 0.5 | 2.15 | 25.65 | | 0.367 | 367 | 0.4733 | 0.0731 | 0.4002 |
| | 713.5 | 23 | 0.5 | 2.15 | 25.65 | | 0.367 | 367 | 0.4757 | 0.0731 | 0.4026 |
| LTE Band 17 (16QAM,#RB=1,RMS-Value) | 706.5 | 22 | 0.5 | 2.15 | 24.65 | 100 | 0.292 | 292 | 0.4710 | 0.0580 | 0.4130 |
| | 710 | 22 | 0.5 | 2.15 | 24.65 | | 0.292 | 292 | 0.4733 | 0.0580 | 0.4153 |
| | 713.5 | 22 | 0.5 | 2.15 | 24.65 | | 0.292 | 292 | 0.4757 | 0.0580 | 0.4177 |
| LTE Band 5 (QPSK,#RB=1,RMS-Value) | 824.7 | 23 | 0.5 | 2.15 | 25.65 | 100 | 0.367 | 367 | 0.5498 | 0.0731 | 0.4767 |
| | 836.5 | 23 | 0.5 | 2.15 | 25.65 | | 0.367 | 367 | 0.5577 | 0.0731 | 0.4846 |
| | 836.5 | 23 | 0.5 | 2.15 | 25.65 | | 0.367 | 367 | 0.5655 | 0.0731 | 0.4924 |
| LTE Band 5 (16QAM,#RB=1,RMS-Value) | 824.7 | 22 | 0.5 | 2.15 | 24.65 | 100 | 0.292 | 292 | 0.5498 | 0.0580 | 0.4918 |
| | 836.5 | 22 | 0.5 | 2.15 | 24.65 | | 0.292 | 292 | 0.5577 | 0.0580 | 0.4997 |
| | 836.5 | 22 | 0.5 | 2.15 | 24.65 | | 0.292 | 292 | 0.5655 | 0.0580 | 0.5075 |
| LTE Band 13 (QPSK,#RB=1,RMS-Value) | 779.5 | 23 | 0.5 | 2.15 | 25.65 | 100 | 0.367 | 367 | 0.5197 | 0.0731 | 0.4466 |
| | 782 | 23 | 0.5 | 2.15 | 25.65 | | 0.367 | 367 | 0.5213 | 0.0731 | 0.4482 |
| | 784.5 | 23 | 0.5 | 2.15 | 25.65 | | 0.367 | 367 | 0.5230 | 0.0731 | 0.4499 |
| LTE Band 13 (16QAM,#RB=1,RMS-Value) | 779.5 | 22 | 0.5 | 2.15 | 24.65 | 100 | 0.292 | 292 | 0.5197 | 0.0580 | 0.4617 |
| | 782 | 22 | 0.5 | 2.15 | 24.65 | | 0.292 | 292 | 0.5213 | 0.0580 | 0.4633 |
| | 784.5 | 22 | 0.5 | 2.15 | 24.65 | | 0.292 | 292 | 0.5230 | 0.0580 | 0.4650 |

Result: Pass

### 1.3.3 Result for upper operational Band: LTE Band 4 and WCDMA Band 4

| Operating Mode | Frequency on channel (MHz) | Declared maximum conducted output power (dBm) | Max. positive tolerance according manufacturer (dBm) | Antenna Gain (dBm) | Calculated maximum EIRP (declared + Tune-up + antenna Gain) (dBm) | Duty cycle (%) | Declared maximum EIRP (W) | Equivalent EIRP (maximum EIRP x duty cycle) (mW) | MPE Limit ($mw/cm^2$) | MPE-Value ($mw/cm^2$) | Margin to limit: ($mw/cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| WCDMA FDD Band 4 (RMS-Value) | 1712.4 | 24 | 0.5 | 2.15 | 26.65 | 100 | 0.462 | 462 | 1.0000 | 0.0920 | 0.9080 |
| | 1740.0 | 24 | 0.5 | 2.15 | 26.65 | | 0.462 | 462 | 1.0000 | 0.0920 | 0.9080 |
| | 1752.6 | 24 | 0.5 | 2.15 | 26.65 | | 0.462 | 462 | 1.0000 | 0.0920 | 0.9080 |
| LTE Band 4 (QPSK,#RB=1,RMS-Value) | 1710.7 | 23 | 0.5 | 2.15 | 25.65 | 100 | 0.367 | 367 | 1.0000 | 0.0731 | 0.9269 |
| | 1732.5 | 23 | 0.5 | 2.15 | 25.65 | | 0.367 | 367 | 1.0000 | 0.0731 | 0.9269 |
| | 1754.3 | 23 | 0.5 | 2.15 | 25.65 | | 0.367 | 367 | 1.0000 | 0.0731 | 0.9269 |
| LTE Band 4 (16QAM,#RB=1,RMS- Value) | 1710.7 | 22 | 0.5 | 2.15 | 24.65 | 100 | 0.292 | 292 | 1.0000 | 0.0580 | 0.9420 |
| | 1732.5 | 22 | 0.5 | 2.15 | 24.65 | | 0.292 | 292 | 1.0000 | 0.0580 | 0.9420 |
| | 1754.3 | 22 | 0.5 | 2.15 | 24.65 | | 0.292 | 292 | 1.0000 | 0.0580 | 0.9420 |

Result: Pass

## 1.3.4 Result for upper operational Band: GSM 1900 LTE Band 2 and WCDMA Band 2

| Operating Mode | Frequency on channel (MHz) | Declared maximum conducted output power (dBm) | Max. positive tolerance according manufacturer (dBm) | Antenna Gain (dBm) | Calculated maximum EIRP (declared + Tune-up + antenna Gain) (dBm) | Duty cycle (%) | Declared maximum EIRP (W) | Equivalent EIRP (maximum EIRP x duty cycle) (mW) | MPE Limit ($mw/cm^2$) | MPE-Value ($mw/cm^2$) | Margin to limit: ($mw/cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GSM/GPRS (Peak) | 824.2 | 33 | 0.5 | 2.15 | 32.65 | 50 | 1.841 | 920 | 1.0 | 0.1831 | 0.8169 |
| | 837 | 33 | 0.5 | 2.15 | 32.65 | | 1.841 | 920 | 1.0 | 0.1831 | 0.8169 |
| | 848.8 | 33 | 0.5 | 2.15 | 32.65 | | 1.841 | 920 | 1.0 | 0.1831 | 0.8169 |
| GSM/GPRS (Avg.Burst Power) | 824.2 | 33 | 0.5 | 2.15 | 32.65 | 50 | 1.841 | 920 | 1.0 | 0.1831 | 0.8169 |
| | 837 | 33 | 0.5 | 2.15 | 32.65 | | 1.841 | 920 | 1.0 | 0.1831 | 0.8169 |
| | 848.8 | 33 | 0.5 | 2.15 | 32.65 | | 1.841 | 920 | 1.0 | 0.1831 | 0.8169 |
| EDGE (Peak) | 824.2 | 27 | 0.5 | 2.15 | 28.65 | 50 | 0.733 | 366 | 1.0 | 0.0729 | 0.9271 |
| | 837 | 27 | 0.5 | 2.15 | 28.65 | | 0.733 | 366 | 1.0 | 0.0729 | 0.9271 |
| | 848.8 | 27 | 0.5 | 2.15 | 28.65 | | 0.733 | 366 | 1.0 | 0.0729 | 0.9271 |
| EDGE (Avg.Burst Power) | 824.2 | 27 | 0.5 | 2.15 | 28.65 | 50 | 0.733 | 366 | 1.0 | 0.0729 | 0.9271 |
| | 837 | 27 | 0.5 | 2.15 | 28.65 | | 0.733 | 366 | 1.0 | 0.0729 | 0.9271 |
| | 848.8 | 27 | 0.5 | 2.15 | 28.65 | | 0.733 | 366 | 1.0 | 0.0729 | 0.9271 |
| WCDMA FDD Band 4 (RMS-Value) | 1712.4 | 24 | 0.5 | 2.15 | 26.65 | 100 | 0.462 | 462 | 1.0 | 0.0920 | 0.9080 |
| | 1740.0 | 24 | 0.5 | 2.15 | 26.65 | | 0.462 | 462 | 1.0 | 0.0920 | 0.9080 |
| | 1752.6 | 24 | 0.5 | 2.15 | 26.65 | | 0.462 | 462 | 1.0 | 0.0920 | 0.9080 |
| LTE Band 4 (QPSK,#RB=1,RMS-Value) | 1710.7 | 23 | 0.5 | 2.15 | 25.65 | 100 | 0.367 | 367 | 1.0 | 0.0731 | 0.9269 |
| | 1732.5 | 23 | 0.5 | 2.15 | 25.65 | | 0.367 | 367 | 1.0 | 0.0731 | 0.9269 |
| | 1754.3 | 23 | 0.5 | 2.15 | 25.65 | | 0.367 | 367 | 1.0 | 0.0731 | 0.9269 |
| LTE Band 4 (16QAM,#RB=1,RMS- Value) | 1710.7 | 22 | 0.5 | 2.15 | 24.65 | 100 | 0.292 | 292 | 1.0 | 0.0580 | 0.9420 |
| | 1732.5 | 22 | 0.5 | 2.15 | 24.65 | | 0.292 | 292 | 1.0 | 0.0580 | 0.9420 |
| | 1754.3 | 22 | 0.5 | 2.15 | 24.65 | | 0.292 | 292 | 1.0 | 0.0580 | 0.9420 |

Result: Pass

### 1.3.5 Simultaneous Multi-band Transmission MPE Analysis

**List of Mode for Simultaneous Multi-band Transmission**

| No. | Configurations | Hotspot SAR |
|---|---|---|
| **1** | **GSM + WLAN** | Yes |
| **2** | **WCDMA + WLAN** | Yes |
| **3** | **LTE + WLAN** | Yes |

**Remark:** GSM and WCDMA and LTE share the same antenna, and cannot transmit simultaneously.

LTE Band 5 and LTE Band 17, GSM850 and WCDMA Band 5 minimum margin to limit: 0.1842mw/$cm^2$;
LTE Band 4 and WCDMA Band 4 minimum margin to limit: 0.9080mw/$cm^2$;
GSM 1900 LTE Band 2 and WCDMA Band 2 minimum margin to limit: 0.8169mw/$cm^2$;
ISM Band maximum MPE: 0.1255mw/$cm^{2`}$;

MPE ratio=(0.1255mw/$cm^2$)/1+(0.3653 mw/$cm^2$)/(0.5495 mw/$cm^2$)=0.7903＜1.0
Result: Pass