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 2.4GHz 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: Chain 0: PIFA antenna,

Chain 1: PCB antenna.

Antenna Gain: Chain 0: -1.72 dBi gain (2400 ~ 2500 MHz)

Chain 1: -1.66 dBi gain (2400 ~ 2500 MHz)

Note2. The TX chains are correlated and the antenna gain is unequal among the chains.

The directional gain = $10 \log[(10^{G1/20} + 10^{G2/20} + \ldots + 10^{GN/20})^2 / NANT]$ dBi

$= 10 \log[(10^{-1.72/20} + 10^{-1.66/20})^2 / 2]$

= 1.32dBi

The nominal SISO conducted output Average power specified: 802.11b: 16 dBm (Tolerance: +/-1.5dB)

802.11g: 14 dBm (Tolerance: +/-1.5dB)

802.11n: 12 dBm (Tolerance: +/-1.5dB)

The nominal MIMO conducted output Average power specified: 802.11n: 15 dBm (Tolerance: +/-1.5dB)

The maximum conducted output Average power for the EUT is 15.32 dBm in the frequency 2.412GHz 802.11n (HT20) mode which is within the production variation.

The maximum EIRP= 15+ 1.5+ (1.32) =17.82dBm=60.53mW

The worst case is power density at prediction frequency at 20cm: **0.012 (mw/cm^2)**

MPE limit for general population exposure at prediction frequency: 1 (mw/cm^2)

0.012 (mw/cm^2) < 1 (mw/cm^2)

Result: Pass

1.3.2 Result for operational 5.2GHz Band

For WiFi function, operating at 5180-5240MHz for 802.11a /n-HT20, 4 channels with 20MHz channel spacing and 5190-5230MHz for 802.11n-HT40, 2 channels with 40MHz channel spacing.

Modulation Type: BPSK, QPSK, 16QAM, 64QAM for OFDM. CCK, DQPSK, DBPSK for DSSS.
Antenna Type: Chain 0: PIFA antenna,
Chain 1: PCB antenna.
Antenna Gain: Chain 0: -1.21 dBi gain (5180 ~ 5240 MHz)
Chain 1: -0.94 dBi gain (5180 ~ 5240 MHz)
The TX chains are correlated and the antenna gain is unequal among the chains.
The directional gain = $10 \log[(10^{G1/20} + 10^{G2/20} + \ldots + 10^{GN/20})^2 / NANT]$
$= 10\log[(10^{-1.21/10} + 10^{-0.94/10})^2 / 2]$
$=1.94$dBi

The nominal conducted output Average power specified: 802.11a: 11 dBm (Tolerance: +/-1.5dB)
802.11n: 10 dBm (Tolerance: +/-1.5dB)
So the nominal MIMO conducted output Average power specified: 802.11n: 13 dBm (Tolerance: +/-1.5dB)

The maximum conducted output Average power for the EUT is 9.49 dBm in the frequency 5180 GHz 802.11n(HT20) mode which is within the production variation.

The maximum EIRP= 13+ 1.5+1.94 =16.44dBm=44.06mW

The worst case is power density at prediction frequency at 20cm: **0.009 (mw/cm^2)**
MPE limit for general population exposure at prediction frequency: 1 (mw/cm^2)

0.009 (mw/cm^2) < 1 (mw/cm^2)

Result: Pass

1.3.3 Result for operational 5.8GHz Band

For WiFi function, operating at 5745-5825MHz for 802.11a /n-HT20, 5 channels with 20MHz channel spacing and 5755-5795MHz for 802.11n-HT40, 2 channels with 40MHz channel spacing.

Modulation Type: BPSK, QPSK, 16QAM, 64QAM for OFDM. CCK, DQPSK, DBPSK for DSSS.
Antenna Type: Chain 0: PIFA antenna,
Chain 1: PCB antenna.
Antenna Gain: Chain 0: 4.46 dBi gain (5745 ~ 5825 MHz)
Chain 1: 2.82 dBi gain (5745 ~ 5825 MHz)
The TX chains are correlated and the antenna gain is unequal among the chains.
The directional gain = $10 \log[(10^{G1/20} + 10^{G2/20} + \ldots + 10^{GN/20})^2 / NANT]$
$= 10\log[(10^{4.46/10} + 10^{2.82/10})^2 / 2]$
$=6.69$dBi

The nominal conducted output Average power specified: 802.11a: 11 dBm (Tolerance: +/-1.5dB)
802.11n: 10 dBm (Tolerance: +/-1.5dB)

So the nominal MIMO conducted output Average power specified: 802.11n: 13 dBm (Tolerance: +/-1.5dB)

The maximum conducted output Average power for the EUT is 11.67 dBm in the frequency 5180 GHz 802.11n(HT20) mode which is within the production variation.

The maximum EIRP= 13+ 1.5+6.69 =21.19dBm=131.52mW

The worst case is power density at prediction frequency at 20cm: **0.026 (mw/cm^2)**
MPE limit for general population exposure at prediction frequency: 1 (mw/cm^2)

0.026 (mw/cm^2) < 1 (mw/cm^2)

Result: Pass

