8. APPENDIX I
RADIO FREQUENCY EXPOSURE

LIMIT

According to §15.247(i), systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines. See § 1.1307(b)(1) of this chapter.

EUT Specification

EUT	Computer
Frequency band (Operating)	☒ WLAN: 2.412GHz ~ 2.462GHz ☐ WLAN: 5.745GHz ~ 5.825GHz ☐ Others: Bluetooth: 2.402GHz ~ 2.480GHz
Device category	☐ Portable (<20cm separation) ☒ Mobile (>20cm separation) ☐ Others
Exposure classification	☐ Occupational/Controlled exposure (S = 5mW/cm2) ☒ General Population/Uncontrolled exposure (S=1mW/cm2)

Antenna diversity	☒ Single antenna
	☐ Multiple antennas
	    ☐ Tx diversity
	    ☐ Rx diversity
	    ☐ Tx/Rx diversity

Max. output power	IEEE 802.11b mode: 19.57 dBm (90.57mW) IEEE 802.11g mode: 24.02 dBm (252.34mW) IEEE 802.11n HT 20 MHz mode: 25.10 dBm (323.59mW) IEEE 802.11n HT 40 MHz mode: 21.35 dBm (136.45mW)
Antenna gain (Max)	IEEE 802.11b/g/n mode: 1.99 dBi (Numeric gain: 1.58) MIMO:$10*\log(((10^{(1.99 \text{ dBi}/20)}+10^{(1.99 \text{ dBi}/20)})^2)/2) = 5.00$ dBi (Numeric gain: 3.16)
Evaluation applied	☒ MPE Evaluation* ☐ SAR Evaluation ☐ N/A
Remark: *The maximum output power is <u>25.10dBm (323.59mW)</u> at <u>2442MHz</u> (with <u>3.16 numeric antenna gain</u>.)*	

TEST RESULTS

No non-compliance noted.

Calculation

Given $E = \dfrac{\sqrt{30 \times P \times G}}{d}$ & $S = \dfrac{E^2}{3770}$

Where   E = Field strength in Volts / meter

P = Power in Watts

G = Numeric antenna gain

d = Distance in meters

S = Power density in milliwatts / square centimeter

Combining equations and re-arranging the terms to express the distance as a function of the remaining variables yields:

$$S = \frac{30 \times P \times G}{3770 d^2}$$

Changing to units of mW and cm, using:

P (mW) = P (W) / 1000 and

d (cm) = d(m) / 100

Yields

$$S = \frac{30 \times (P/1000) \times G}{3770 \times (d/100)^2} = 0.0796 \times \frac{P \times G}{d^2} \quad \textbf{Equation 1}$$

Where   d = Distance in cm

P = Power in mW

G = Numeric antenna gain

S = Power density in mW / cm²

Maximum Permissible Exposure

Substituting the MPE safe distance using d = 20 cm into Equation 1:

Yields

$$S = 0.000199 \times P \times G$$

Where   P = Power in mW

G = Numeric antenna gain

S = Power density in mW / cm²

IEEE 802.11b mode:

EUT output power = 90.57 mW

Numeric Antenna gain = 1.58

→ *Power density =0.028477 mW / cm2*

IEEE 802.11g mode:

EUT output power = 252.34 mW

Numeric Antenna gain = 1.58

→ *Power density = 0.079341 mW / cm2*

IEEE 802.11n HT 20 MHz mode:

EUT output power = 323.59 mW

Numeric Antenna gain = 3.16

→ *Power density = 0.203486 mW / cm2*

IEEE 802.11n HT 40 MHz mode:

EUT output power = 136.45mW

Numeric Antenna gain = 3.16

→ *Power density = 0.085805 mW / cm2*

(For mobile or fixed location transmitters, the maximum power density is 1.0 mW/cm^2 even if the calculation indicates that the power density would be larger.)

EUT	Computer
Frequency band (Operating)	☐ WLAN: 2.412GHz ~ 2.462GHz ☒ WLAN: 5.725GHz ~ 5.850GHz ☐ Others: Bluetooth: 2.402GHz ~ 2.480GHz
Device category	☐ Portable (<20cm separation) ☒ Mobile (>20cm separation) ☐ Others
Exposure classification	☐ Occupational/Controlled exposure (S = 5mW/cm2) ☒ General Population/Uncontrolled exposure (S=1mW/cm2)

Antenna diversity	☐ Single antenna
	☒ Multiple antennas
	   ☐ Tx diversity
	   ☐ Rx diversity
	   ☒ Tx/Rx diversity

Max. output power	IEEE 802.11a mode: 22.09 dBm (161.80mW) IEEE 802.11n HT 20 MHz mode: 24.81 dBm (302.69mW) IEEE 802.11n HT 40 MHz mode: 23.72 dBm (235.50mW)
Antenna gain (Max)	IEEE 802.11a/n mode: 0.39 dBi (Numeric gain: 1.09) MIMO: $10*\log(((10^{(0.39\ dBi/20)}+10^{(0.39\ dBi/20)})^2)/2) = 3.40$ dB (Numeric gain: 2.18)
Evaluation applied	☒ MPE Evaluation* ☐ SAR Evaluation ☐ N/A

Remark:
The maximum output power is 24.81 dBm (302.69mW) at 5825MHz (with 2.18 numeric antenna gain.)

TEST RESULTS

No non-compliance noted.

Calculation

Given $E = \dfrac{\sqrt{30 \times P \times G}}{d}$ & $S = \dfrac{E^2}{3770}$

       Where   *E = Field strength in Volts / meter*
                   P = Power in Watts
                   G = Numeric antenna gain
                   d = Distance in meters
                   S = Power density in milliwatts / square centimeter

Combining equations and re-arranging the terms to express the distance as a function of the remaining variables yields:

$$S = \frac{30 \times P \times G}{3770 d^2}$$

Changing to units of mW and cm, using:

       P (mW) = P (W) / 1000 and

       d (cm) = d(m) / 100

Yields

$$S = \frac{30 \times (P/1000) \times G}{3770 \times (d/100)^2} = 0.0796 \times \frac{P \times G}{d^2} \quad \textbf{\textit{Equation 1}}$$

       Where   *d = Distance in cm*
                  P = Power in mW
                  G = Numeric antenna gain
                  S = Power density in mW / cm^2

Maximum Permissible Exposure

Substituting the MPE safe distance using d = 20 cm into Equation 1:

Yields

     $S = 0.000199 \times P \times G$

Where   *P = Power in mW*
               G = Numeric antenna gain
               S = Power density in mW / cm^2

IEEE 802.11a mode:

EUT output power = 161.80 mW

Numeric Antenna gain = 1.09

→ *Power density = 0.035096 mW / cm2*

IEEE 802.11n HT 20 MHz mode:

EUT output power = 302.69 mW

Numeric Antenna gain = 2.18

→ *Power density = 0.131313 mW / cm2*

IEEE 802.11n HT 40 MHz mode:

EUT output power = 235.50mW

Numeric Antenna gain = 2.18

→ *Power density = 0.102165 mW / cm2*

(For mobile or fixed location transmitters, the maximum power density is 1.0 mW/cm^2 even if the calculation indicates that the power density would be larger.)