APPENDIX D – Maximum Permissible Exposure

RF Exposure Limit

According to FCC 1.1310: The criteria listed in the following table shall be used to evaluate the Environmental of human exposure to radio frequency (RF) radiation as specified in 1.1307(b)

Limits for Maximum Permissible Exposure (MPE)

Frequency Range(MHz)	Electric Field Strength(V/m)	Magnetic Field Strength(A/m)	Power Density (mW/cm^2)	Averaging Time (Minutes)
(A) Limits for occupational / Contral Exposure				
30 - 300	61.4	0.163	1	6
300 - 1500	…	…	F/300	6
1500 - 100000	…	…	5	6
(B) Limits for General Population / Uncontrolled Exposure				
30 - 300	27.5	0.073	0.2	30
300 - 1500	…	…	F/1500	30
1500 - 100000	…	…	1	30

F = Frequency (MHz)

Fries formula

Fries transmission formula : $Pd = (Pout * G) / (4 * \pi * r^2)$

$r = \sqrt{((Pout * G) / 4 * \pi * Pd)}$

Where

Pd = Power density in ㎽/㎠

Pout = Output power to antenna in ㎽

G = Gain of antenna in linear scale

π= 3.1416

r = Distance between observation point center of the radiator in cm

Pd is the limit of MPE, 1 ㎽/㎠. If we know the Maximum Gain of the antenna and the total power input to the antenna, through the calculation, we will know the Maximum distance r where the MPE limit is reached and Power density at prediction frequency.

For 2.4 GHz band

Maximum peak output power at antenna input terminal:	20.50	(dBm)
Maximum peak output power at antenna input terminal:	112.20	(mW)
Antenna gain(typical):	5.85	(dBi)
Maximum antenna gain:	3.85	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	2437	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	1	(mW/cm^2)

Maximum allowable antenna gain:	15.50	(dBi)
Maximum Distance:	5.86	(cm)

Power density at prediction frequency : ***0.09*** ***(mW/cm^2)***

Test result: PASS

Note(s)

The MPE was calculated with maximum permitted output level add to positive power tolerance. According to the operational description submitted by manufacturer, maximum permitted output power is 18 dBm and positive tolerance is 2.5 dB for 2.4 GHz band.

According to the KDB 662911 D01 v01r02, the directional gain of the correlated signal for the output power is as in the following table.

Frequency Band (GHz)	Antenna G1 (dBi)	Antenna G2 (dBi)	[1)]Directional gain for CCD mode (dBi)	[2)]Directional gain for correlated signal (dBi)
2.4	2.85	2.82	2.85	5.85

[1)] Directional gain for CCD mode (correlated signal) = G_{ANT} + 0 dB for N_{ANT} = 2

[2)] Directional gain for the correlated signal with unequal antenna gains, with equal transmit powers = 10 log[($10^{G1/20}$+$10^{G2/20}$)^2/N_{ANT}] dBi for N_{ANT} = 2

The maximum directional gain is 5.85 dBi.

For 5 GHz band

Maximum peak output power at antenna input terminal:	20.50	(dBm)
Maximum peak output power at antenna input terminal:	112.20	(mW)
Antenna gain(typical):	6.98	(dBi)
Maximum antenna gain:	4.99	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5785	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	1	(mW/cm^2)

Maximum allowable antenna gain:	15.50	(dBi)
Maximum Distance:	6.67	(cm)

Power density at prediction frequency : 0.11 (mW/cm^2)

Test result: PASS

Note(s)

The MPE was calculated with maximum permitted output level add to positive power tolerance. According to the operational description submitted by manufacturer, maximum permitted output power is 18 dBm and positive tolerance is 2.5 dB for the 5 GHz band.

According to the KDB 662911 D01 v01r02, the directional gain of the correlated signal for the output power is as in the following table.

Frequency Band (GHz)	Antenna G1 (dBi)	Antenna G2 (dBi)	[1)]Directional gain for CCD mode (dBi)	[2)]Directional gain for correlated signal (dBi)
5.7	4.42	3.50	4.42	6.98

[1)] Directional gain for CCD mode (correlated signal) = G_{ANT} + 0 dB for N_{ANT} = 2

[2)] Directional gain for the correlated signal with unequal antenna gains, with equal transmit powers = 10 log[($10^{G1/20}$+$10^{G2/20}$)^2/N_{ANT}] dBi for N_{ANT} = 2

The maximum directional gain is 6.98 dBi.

For Band I

Maximum peak output power at antenna input terminal:	14.50	(dBm)
Maximum peak output power at antenna input terminal:	28.18	(mW)
Antenna gain(typical):	6.80	(dBi)
Maximum antenna gain:	4.79	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5180	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	1	(mW/cm^2)

Maximum allowable antenna gain:	8.50	(dBi)
Maximum Distance:	3.28	(cm)

Power density at prediction frequency : ***0.03*** ***(mW/cm^2)***

Test result: PASS

Note(s)

The MPE was calculated with maximum permitted output level add to positive power tolerance. According to the operational description submitted by manufacturer, maximum permitted output power is 12 dBm and positive tolerance is 2.5 dB for the Band I.

According to the KDB 662911 D01 v01r02, the directional gain of the correlated signal for the output power is as in the following table.

Frequency Band	Antenna G1 (dBi)	Antenna G2 (dBi)	1)Directional gain for CCD mode (dBi)	2)Directional gain for correlated signal (dBi)
Band I	3.79	3.79	3.79	6.80

1) Directional gain for CCD mode (correlated signal) = G_{ANT} + 0 dB for N_{ANT} = 2

2) Directional gain for the correlated signal with equal antenna gains, with equal transmit powers = G_{ANT} + 10 log(N_{ANT}) dBi for G_{ANT} = 3.79 and N_{ANT} = 2

The maximum directional gain is 6.80 dBi.

For Band II

Maximum peak output power at antenna input terminal:	20.50	(dBm)
Maximum peak output power at antenna input terminal:	112.20	(mW)
Antenna gain(typical):	6.80	(dBi)
Maximum antenna gain:	4.79	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5260	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	1	(mW/cm^2)

Maximum allowable antenna gain:	9.50	(dBi)
Maximum Distance:	6.54	(cm)

Power density at prediction frequency : ***0.11*** ***(mW/cm^2)***

Test result: PASS

Note(s)

The MPE was calculated with maximum permitted output level add to positive power tolerance.

According to the operational description submitted by manufacturer, maximum permitted output power is 18 dBm and positive tolerance is 2.5 dB for the Band II.

According to the KDB 662911 D01 v01r02, the directional gain of the correlated signal for the output power is as in the following table.

Frequency Band	Antenna G1 (dBi)	Antenna G2 (dBi)	[1)]Directional gain for CCD mode (dBi)	[2)]Directional gain for correlated signal (dBi)
Band II	3.79	3.79	3.79	6.80

[1)] Directional gain for CCD mode (correlated signal) = G_{ANT} + 0 dB for N_{ANT} = 2

[2)] Directional gain for the correlated signal with equal antenna gains, with equal transmit powers = G_{ANT} + 10 log(N_{ANT}) dBi for G_{ANT} = 3.79 and N_{ANT} = 2

The maximum directional gain is 6.80 dBi.

For Band III

Maximum peak output power at antenna input terminal:	20.50	(dBm)
Maximum peak output power at antenna input terminal:	112.20	(mW)
Antenna gain(typical):	6.98	(dBi)
Maximum antenna gain:	4.99	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5580	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	1	(mW/cm^2)

Maximum allowable antenna gain:	9.50	(dBi)
Maximum Distance:	6.67	(cm)

Power density at prediction frequency : ***0.11*** ***(mW/cm^2)***

Test result: PASS

Note(s)

The MPE was calculated with maximum permitted output level add to positive power tolerance.

According to the operational description submitted by manufacturer, maximum permitted output power is 18 dBm and positive tolerance is 2.5 dB for the Band III.

According to the KDB 662911 D01 v01r02, the directional gain of the correlated signal for the output power is as in the following table.

Frequency Band	Antenna G1 (dBi)	Antenna G2 (dBi)	1)Directional gain for CCD mode (dBi)	2)Directional gain for correlated signal (dBi)
Band III	4.42	3.50	4.42	6.98

1) Directional gain for CCD mode (correlated signal) = G_{ANT} + 0 dB for N_{ANT} = 2

2) Directional gain for the correlated signal with unequal antenna gains, with equal transmit powers = 10 log[$(10^{G1/20}+10^{G2/20})^2/N_{ANT}$] dBi for N_{ANT} = 2

The maximum directional gain is 6.98 dBi.