15. MAXIMUM PERMISSIBLE EXPOSURE (MPE)

15.1 Standard Applicable

According to §1.1307(b)(1), systems operating under the provisions of this section shall be operated in a manner that ensure that the public is not exposed to radio frequency energy level in excess of the Commission's guideline.

This is a Mobile device, the MPE is required.

According to §1.1310 and §2.1093 RF exposure is calculated.

Limits for Maximum Permissive Exposure (MPE)

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)	Averaging Time (minute)
Limits for General Population/Uncontrolled Exposure				
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
1500-15000	/	/	1.0	30

F = frequency in MHz

* = Plane-wave equipment power density

Prediction of MPE limit at a given distance

Equation from page 18 of OET Bulletin 65, Edition 97-01

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

Where: S = Power density

P = Power input to antenna

G = Power gain of the antenna in the direction of interest relative to an isotropic radiator

R = Distance to the center of radiation of the antenna

802.11a Max. output power

802.11a_MIMO

CH	Frequency (MHz)	AVERAGE POWER (dBm)			TOTAL POWER (dBm)	TOTAL POWER (mW)	REQUIRED LIMIT (dBm)	RESULT
		CHAIN 0	CHAIN 1	CHAIN 2				
36	5180	7.63	7.68	7.37	12.33	17.113	20.21	PASS
44	5220	7.83	7.93	7.04	12.39	17.334	20.21	PASS
48	5240	8.01	7.62	7.21	**12.40**	17.365	20.21	PASS
52	5260	12.63	11.99	11.11	16.73	47.048	20.21 or 11+10log(B) = 24.21	PASS
60	5300	12.67	11.59	11.61	**16.76**	47.402	20.21 or 11+10log(B) = 24.17	PASS
64	5320	12.13	11.75	11.72	16.64	46.152	20.21 or 11+10log(B) = 24.09	PASS
100	5500	14.52	13.97	12.99	18.64	73.167	20.21 or 11+10log(B) = 24.24	PASS
116	5580	14.12	13.96	13.3	18.58	72.091	20.21 or 11+10log(B) = 24.25	PASS
140	5700	14.36	14.02	13.51	**18.75**	74.963	20.21 or 11+10log(B) = 24.19	PASS
149	5745	14.7	14.93	14.06	19.35	86.098	26.23	PASS
157	5785	16.38	16.44	15.1	20.79	119.866	26.23	PASS
165	5825	16.34	16.37	15.25	**20.79**	119.900	26.23	PASS

MPE Prediction (802.11a 5150~5250)

MIMO gain= G+(10 logN)= 5+4.77= 9.77dBm

Max. output power including tune-up tolerancel:	12.40	(dBm)
Max. output power including tune-up tolerancel:	17.378008	(mW)
Duty cycle:	95.74	(%)
Maximum Pav :	16.637705	(mW)
Peak Antenna gain (Maximum):	9.77	(dBi)
Peak Antenna gain (linear):	9.4841846	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5240	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm2)
Power density at predication frequency at 20 (cm)	0.031	(mW/cm^2)

Measurement Result

The predicted power density level at 20 cm is 0.031 mW/cm2.

This is below the uncontrolled exposure limit of 1 mW/cm2 at 5240MHz.

MPE Prediction (802.11a 5250~5350)

MIMO gain= G+(10 logN)= 5+4.77= 9.77dBm

Max. output power including tune-up tolerancel:	16.76	(dBm)
Max. output power including tune-up tolerancel:	47.424199	(mW)
Duty cycle:	95.74	(%)
Maximum Pav :	45.403928	(mW)
Peak Antenna gain (Maximum):	9.77	(dBi)
Peak Antenna gain (linear):	9.4841846	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5300	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm2)
Power density at predication frequency at 20 (cm)	0.086	(mW/cm^2)

Measurement Result
The predicted power density level at 20 cm is 0.086 mW/cm2.
This is below the uncontrolled exposure limit of 1 mW/cm2 at 5300MHz.

MPE Prediction (802.11a 5470~5725)

MIMO gain= G+(10 logN)= 5+4.77= 9.77dBm

Max. output power including tune-up tolerancel:	18.75	(dBm)
Max. output power including tune-up tolerancel:	74.989421	(mW)
Duty cycle:	95.74	(%)
Maximum Pav :	71.794872	(mW)
Peak Antenna gain (Maximum):	9.77	(dBi)
Peak Antenna gain (linear):	9.4841846	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5700	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm2)
Power density at predication frequency at 20 (cm)	0.136	(mW/cm^2)

Measurement Result
The predicted power density level at 20 cm is 0.136 mW/cm2.
This is below the uncontrolled exposure limit of 1 mW/cm2 at 5700MHz.

MPE Prediction (802.11a 5725~5850)

MIMO gain= G+(10 logN)= 5+4.77= 9.77dBm

Max. output power including tune-up tolerancel:	20.79	(dBm)
Max. output power including tune-up tolerancel:	119.94993	(mW)
Duty cycle:	95.74	(%)
Maximum Pav :	114.84006	(mW)
Peak Antenna gain (Maximum):	9.77	(dBi)
Peak Antenna gain (linear):	9.4841846	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5825	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm2)
Power density at predication frequency at 20 (cm)	0.217	(mW/cm^2)

Measurement Result

The predicted power density level at 20 cm is 0.217 mW/cm2.

This is below the uncontrolled exposure limit of 1 mW/cm2 at 5825MHz.

802.11n_HT20M Max. output power

802.11n_HT20_MIMO

CH	Frequency (MHz)	AVERAGE POWER (dBm)			TOTAL POWER (dBm)	TOTAL POWER (mW)	REQUIRED LIMIT (dBm)	RESULT
		CHAIN 0	CHAIN 1	CHAIN 2				
36	5180	8.2	7.9	7.63	**12.69**	18.567	20.21	PASS
44	5220	7.89	8.12	7.4	12.58	18.134	20.21	PASS
48	5240	8.17	7.74	7.43	12.56	18.038	20.21	PASS
52	5260	7.85	7.54	6.99	**12.25**	16.771	20.21 or 11+10log(B) = 24.29	PASS
60	5300	7.72	7.02	7.1	12.06	16.079	20.21 or 11+10log(B) = 24.23	PASS
64	5320	7.31	6.73	7.33	11.90	15.500	20.21 or 11+10log(B) = 24.39	PASS
100	5500	11.3	10.99	10.49	15.71	37.244	20.21 or 11+10log(B) = 24.17	PASS
116	5580	11.23	10.73	10.83	15.71	37.210	20.21 or 11+10log(B) = 24.33	PASS
140	5700	10.98	11.09	10.95	**15.78**	37.829	20.21 or 11+10log(B) = 24.22	PASS
149	5745	14.87	15.11	14.22	19.52	89.548	26.23	PASS
157	5785	16.78	16.93	15.65	**21.26**	133.689	26.23	PASS
165	5825	16.41	16.61	15.37	20.93	124.001	26.23	PASS

MPE Prediction (802.11n_HT20 5150~5250)

MIMO gain= G+(10 logN)= 5+4.77= 9.77dBm

Max. output power including tune-up tolerancel:	12.69	(dBm)
Max. output power including tune-up tolerancel:	18.578045	(mW)
Duty cycle:	90.77	(%)
Maximum Pav :	16.863291	(mW)
Peak Antenna gain (Maximum):	9.77	(dBi)
Peak Antenna gain (linear):	9.4841846	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5180	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm2)
Power density at predication frequency at 20 (cm)	0.032	(mW/cm^2)

Measurement Result

The predicted power density level at 20 cm is 0.032 mW/cm2.

This is below the uncontrolled exposure limit of 1 mW/cm2 at 5180MHz.

MPE Prediction (802.11n_HT20 5250~5350)

MIMO gain= G+(10 logN)= 5+4.77= 9.77dBm

Max. output power including tune-up tolerancel:	12.25	(dBm)
Max. output power including tune-up tolerancel:	16.78804	(mW)
Duty cycle:	90.77	(%)
Maximum Pav :	15.238504	(mW)
Peak Antenna gain (Maximum):	9.77	(dBi)
Peak Antenna gain (linear):	9.4841846	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5260	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm2)
Power density at predication frequency at 20 (cm)	0.029	(mW/cm^2)

Measurement Result

The predicted power density level at 20 cm is 0.029 mW/cm2.
This is below the uncontrolled exposure limit of 1 mW/cm2 at 5260MHz.

MPE Prediction (802.11n_HT20 5470~5725)

MIMO gain= G+(10 logN)= 5+4.77= 9.77dBm

Max. output power including tune-up tolerancel:	15.78	(dBm)
Max. output power including tune-up tolerancel:	37.844258	(mW)
Duty cycle:	90.77	(%)
Maximum Pav :	34.351233	(mW)
Peak Antenna gain (Maximum):	9.77	(dBi)
Peak Antenna gain (linear):	9.4841846	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5700	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm2)
Power density at predication frequency at 20 (cm)	0.065	(mW/cm^2)

Measurement Result

The predicted power density level at 20 cm is 0.065 mW/cm2.
This is below the uncontrolled exposure limit of 1 mW/cm2 at 5700MHz.

MPE Prediction (802.11n_HT20 5725~5850)

MIMO gain= G+(10 logN)= 5+4.77= 9.77dBm

Max. output power including tune-up tolerancel:	21.26	(dBm)
Max. output power including tune-up tolerancel:	133.65955	(mW)
Duty cycle:	90.77	(%)
Maximum Pav :	121.32278	(mW)
Peak Antenna gain (Maximum):	9.77	(dBi)
Peak Antenna gain (linear):	9.4841846	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5785	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm2)
Power density at predication frequency at 20 (cm)	0.229	(mW/cm^2)

Measurement Result

The predicted power density level at 20 cm is 0.229 mW/cm2.
This is below the uncontrolled exposure limit of 1 mW/cm2 at 5785MHz.

802.11n_HT40M Max. output power

802.11n_HT40_MIMO

CH	Frequency (MHz)	AVERAGE POWER (dBm)			TOTAL POWER (dBm)	TOTAL POWER (mW)	REQUIRED LIMIT (dBm)	RESULT
		CHAIN 0	CHAIN 1	CHAIN 2				
38	5190	7.53	7.63	7.02	12.17	16.492	20.21	PASS
46	5230	7.68	7.78	7.05	**12.29**	16.929	20.21	PASS
54	5270	8.9	8.53	8.03	**13.27**	21.244	20.21 or 11+10log(B) = 27.28	PASS
62	5310	8.58	7.94	8.17	13.01	19.996	20.21 or 11+10log(B) = 27.35	PASS
102	5510	11.76	11.22	10.92	16.09	40.600	20.21 or 11+10log(B) = 27.34	PASS
110	5550	11.35	11.04	11.05	15.92	39.087	20.21 or 11+10log(B) = 27.21	PASS
134	5670	11.7	11.47	11.3	**16.26**	42.309	20.21 or 11+10log(B) = 27.31	PASS
151	5755	12.4	12.31	11.74	16.93	49.328	26.23	PASS
159	5795	15.29	15.36	14.25	**19.77**	94.770	26.23	PASS

802.11ac_VHT40M Max. output power

802.11ac_VHT40_MIMO

CH	Frequency (MHz)	AVERAGE POWER (dBm)			TOTAL POWER (dBm)	TOTAL POWER (mW)	REQUIRED LIMIT (dBm)	RESULT
		CHAIN 0	CHAIN 1	CHAIN 2				
38	5190	7.5	7.55	6.75	12.05	16.043	20.21	PASS
46	5230	7.72	7.78	6.95	**12.27**	16.868	20.21	PASS
54	5270	8.88	8.57	7.93	**13.25**	21.130	20.21 or 11+10log(B) = 27.28	PASS
62	5310	8.51	7.86	8.1	12.94	19.662	20.21 or 11+10log(B) = 27.35	PASS
102	5510	11.65	11.13	10.87	16.00	39.812	20.21 or 11+10log(B) = 27.34	PASS
110	5550	11.35	11.07	10.97	15.90	38.942	20.21 or 11+10log(B) = 27.21	PASS
134	5670	11.75	11.52	11.24	**16.28**	42.457	20.21 or 11+10log(B) = 27.31	PASS
151	5755	15.12	15.26	14.53	**19.75**	94.462	26.23	PASS
159	5795	15.3	15.33	14.22	19.75	94.428	26.23	PASS

MPE Prediction (802.11n_HT40 5150~5250)

MIMO gain= G+(10 logN)= 5+4.77= 9.77dBm

Max. output power including tune-up tolerancel:	12.29	(dBm)
Max. output power including tune-up tolerancel:	16.943378	(mW)
Duty cycle:	83.83	(%)
Maximum Pav :	14.203634	(mW)
Peak Antenna gain (Maximum):	9.77	(dBi)
Peak Antenna gain (linear):	9.4841846	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5230	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm2)
Power density at predication frequency at 20 (cm)	0.027	(mW/cm^2)

Measurement Result

The predicted power density level at 20 cm is 0.027 mW/cm2.

This is below the uncontrolled exposure limit of 1 mW/cm2 at 5230MHz.

MPE Prediction (802.11n_HT40 5250~5350)

MIMO gain= G+(10 logN)= 5+4.77= 9.77dBm

Average output power at antenna input terminal:	13.27	(dBm)
Average output power at antenna input terminal:	21.232445	(mW)
Duty cycle:	83.83	(%)
Maximum Pav :	17.799158	(mW)
Peak Antenna gain (Maximum):	9.77	(dBi)
Peak Antenna gain (linear):	9.4841846	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5270	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm2)
Power density at predication frequency at 20 (cm)	0.034	(mW/cm^2)

Measurement Result
The predicted power density level at 20 cm is 0.034 mW/cm2.
This is below the uncontrolled exposure limit of 1 mW/cm2 at 5270MHz.

MPE Prediction (802.11ac_VHT40 5470~5725)

MIMO gain= G+(10 logN)= 5+4.77= 9.77dBm

Average output power at antenna input terminal:	16.28	(dBm)
Average output power at antenna input terminal:	42.461956	(mW)
Duty cycle:	83.83	(%)
Maximum Pav :	35.595858	(mW)
Peak Antenna gain (Maximum):	9.77	(dBi)
Peak Antenna gain (linear):	9.4841846	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5670	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm2)
Power density at predication frequency at 20 (cm)	0.067	(mW/cm^2)

Measurement Result
The predicted power density level at 20 cm is 0.067 mW/cm2.
This is below the uncontrolled exposure limit of 1 mW/cm2 at 5670MHz.

MPE Prediction (802.11n_HT40 5725~5850)

MIMO gain= G+(10 logN)= 5+4.77= 9.77dBm

Average output power at antenna input terminal:	19.77	(dBm)
Average output power at antenna input terminal:	94.841846	(mW)
Duty cycle:	83.83	(%)
Maximum Pav :	79.50592	(mW)
Peak Antenna gain (Maximum):	9.77	(dBi)
Peak Antenna gain (linear):	9.4841846	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5795	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm2)
Power density at predication frequency at 20 (cm)	0.150	(mW/cm^2)

Measurement Result

The predicted power density level at 20 cm is 0.15 mW/cm2.

This is below the uncontrolled exposure limit of 1 mW/cm2 at 5795MHz.

802.11ac VHT80M Max. output power

802.11ac_VHT80_MIMO

CH	Frequency (MHz)	AVERAGE POWER (dBm)			TOTAL POWER (dBm)	TOTAL POWER (mW)	REQUIRED LIMIT (dBm)			RESULT
		CHAIN 0	CHAIN 1	CHAIN 2						
42	5210	8.45	8.01	7.07	12.65	18.416	20.21			PASS
58	5290	7.57	7.49	7.05	12.15	16.395	20.21	or 11+10log(B) =	30.42	PASS
106	5530	7.64	7.01	7.16	12.05	16.031	20.21	or 11+10log(B) =	30.44	PASS
122	5610	7.33	6.87	6.51	11.69	14.749	20.21	or 11+11log(B) =	30.38	PASS
155	5775	6.81	6.92	6.41	11.49	14.093	26.23			PASS

MPE Prediction (802.11ac_VHT80 5150~5250)

MIMO gain= G+(10 logN)= 5+4.77= 9.77dBm

Average output power at antenna input terminal:	12.65	(dBm)
Average output power at antenna input terminal:	18.40772	(mW)
Duty cycle:	51.45	(%)
Maximum Pav :	9.4707719	(mW)
Peak Antenna gain (Maximum):	9.77	(dBi)
Peak Antenna gain (linear):	9.4841846	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5210	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm2)
Power density at predication frequency at 20 (cm)	0.018	(mW/cm^2)

Measurement Result
The predicted power density level at 20 cm is 0.018 mW/cm2.
This is below the uncontrolled exposure limit of 1 mW/cm2 at 5210MHz.

MPE Prediction (802.11ac_VHT80 5250~5350)

MIMO gain= G+(10 logN)= 5+4.77= 9.77dBm

Average output power at antenna input terminal:	12.15	(dBm)
Average output power at antenna input terminal:	16.405898	(mW)
Duty cycle:	51.45	(%)
Maximum Pav :	8.4408344	(mW)
Peak Antenna gain (Maximum):	9.77	(dBi)
Peak Antenna gain (linear):	9.4841846	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5290	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm2)
Power density at predication frequency at 20 (cm)	0.016	(mW/cm^2)

Measurement Result
The predicted power density level at 20 cm is 0.016 mW/cm2.
This is below the uncontrolled exposure limit of 1 mW/cm2 at 5290MHz.

MPE Prediction (802.11ac_VHT80 5470~5725)

MIMO gain= G+(10 logN)= 5+4.77= 9.77dBm

Average output power at antenna input terminal:	12.05	(dBm)
Average output power at antenna input terminal:	16.032454	(mW)
Duty cycle:	51.45	(%)
Maximum Pav :	8.2486975	(mW)
Peak Antenna gain (Maximum):	9.77	(dBi)
Peak Antenna gain (linear):	9.4841846	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5530	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm2)
Power density at predication frequency at 20 (cm)	0.016	(mW/cm^2)

Measurement Result
The predicted power density level at 20 cm is 0.016 mW/cm2.
This is below the uncontrolled exposure limit of 1 mW/cm2 at 5530MHz.

MPE Prediction (802.11ac_VHT80 5725~5850)

MIMO gain= G+(10 logN)= 5+4.77= 9.77dBm

Average output power at antenna input terminal:	11.49	(dBm)
Average output power at antenna input terminal:	14.092888	(mW)
Duty cycle:	51.45	(%)
Maximum Pav :	7.2507909	(mW)
Peak Antenna gain (Maximum):	9.77	(dBi)
Peak Antenna gain (linear):	9.4841846	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5775	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm2)
Power density at predication frequency at 20 (cm)	0.014	(mW/cm^2)

Measurement Result

The predicted power density level at 20 cm is 0.014 mW/cm2.

This is below the uncontrolled exposure limit of 1 mW/cm2 at 5775MHz.