

## 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 <sup>2</sup> )	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 <sup>2</sup> )	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

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## 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=  $G+(10 \log N)=5+4.77=9.77\text{dBm}$

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/cm <sup>2</sup> )
Power density at predication frequency at 20 (cm)	0.031	(mW/cm <sup>2</sup> )
<b>Measurement Result</b>		
The predicted power density level at 20 cm is 0.031 mW/cm <sup>2</sup> .		
This is below the uncontrolled exposure limit of 1 mW/cm <sup>2</sup> at 5240MHz.		

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## MPE Prediction (802.11a 5250~5350)

MIMO gain=  $G+(10 \log N)= 5+4.77= 9.77\text{dBm}$

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/cm <sup>2</sup> )
Power density at predication frequency at 20 (cm)	0.086	(mW/cm <sup>2</sup> )
<b>Measurement Result</b>		
The predicted power density level at 20 cm is 0.086 mW/cm <sup>2</sup> .		
This is below the uncontrolled exposure limit of 1 mW/cm <sup>2</sup> at 5300MHz.		

## MPE Prediction (802.11a 5470~5725)

MIMO gain=  $G+(10 \log N)= 5+4.77= 9.77\text{dBm}$

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/cm <sup>2</sup> )
Power density at predication frequency at 20 (cm)	0.136	(mW/cm <sup>2</sup> )
<b>Measurement Result</b>		
The predicted power density level at 20 cm is 0.136 mW/cm <sup>2</sup> .		
This is below the uncontrolled exposure limit of 1 mW/cm <sup>2</sup> at 5700MHz.		

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## MPE Prediction (802.11a 5725~5850)

MIMO gain=  $G+(10 \log N)= 5+4.77= 9.77\text{dBm}$

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.

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## 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	<b>12.69</b>	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	<b>12.25</b>	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	<b>15.78</b>	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	<b>21.26</b>	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=  $G+(10 \log N)= 5+4.77= 9.77\text{dBm}$

Max. output power including tune-up tolerancel:	<b>12.69</b>	(dBm)
Max. output power including tune-up tolerancel:	18.578045	(mW)
Duty cycle:	<b>90.77</b>	(%)
Maximum Pav :	16.863291	(mW)
Peak Antenna gain (Maximum):	<b>9.77</b>	(dBi)
Peak Antenna gain (linear):	9.4841846	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	<b>5180</b>	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm <sup>2</sup> )
Power density at predication frequency at 20 (cm)	0.032	(mW/cm <sup>2</sup> )
<b>Measurement Result</b>		
The predicted power density level at 20 cm is 0.032 mW/cm <sup>2</sup> .		
This is below the uncontrolled exposure limit of 1 mW/cm <sup>2</sup> at 5180MHz.		

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## MPE Prediction (802.11n\_HT20 5250~5350)

MIMO gain=  $G+(10 \log N)= 5+4.77= 9.77\text{dBm}$

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/cm <sup>2</sup> )
Power density at predication frequency at 20 (cm)	0.029	(mW/cm <sup>2</sup> )

### Measurement Result

The predicted power density level at 20 cm is 0.029 mW/cm<sup>2</sup>.

This is below the uncontrolled exposure limit of 1 mW/cm<sup>2</sup> at 5260MHz.

## MPE Prediction (802.11n\_HT20 5470~5725)

MIMO gain=  $G+(10 \log N)= 5+4.77= 9.77\text{dBm}$

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/cm <sup>2</sup> )
Power density at predication frequency at 20 (cm)	0.065	(mW/cm <sup>2</sup> )

### Measurement Result

The predicted power density level at 20 cm is 0.065 mW/cm<sup>2</sup>.

This is below the uncontrolled exposure limit of 1 mW/cm<sup>2</sup> at 5700MHz.

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## MPE Prediction (802.11n\_HT20 5725~5850)

MIMO gain=  $G+(10 \log N)= 5+4.77= 9.77\text{dBm}$

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.

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## 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	<b>12.29</b>	16.929	20.21	PASS
54	5270	8.9	8.53	8.03	<b>13.27</b>	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	<b>16.26</b>	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	<b>19.77</b>	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	<b>12.27</b>	16.868	20.21	PASS
54	5270	8.88	8.57	7.93	<b>13.25</b>	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	<b>16.28</b>	42.457	20.21 or 11+10log(B) = 27.31	PASS
151	5755	15.12	15.26	14.53	<b>19.75</b>	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=  $G+(10 \log N)=5+4.77=9.77\text{dBm}$

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

### Measurement Result

The predicted power density level at 20 cm is 0.027 mW/cm<sup>2</sup>.

This is below the uncontrolled exposure limit of 1 mW/cm<sup>2</sup> at 5230MHz.

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## MPE Prediction (802.11n\_HT40 5250~5350)

MIMO gain=  $G+(10 \log N)= 5+4.77= 9.77\text{dBm}$

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/cm <sup>2</sup> )
Power density at predication frequency at 20 (cm)	0.034	(mW/cm <sup>2</sup> )

### Measurement Result

The predicted power density level at 20 cm is 0.034 mW/cm<sup>2</sup>.

This is below the uncontrolled exposure limit of 1 mW/cm<sup>2</sup> at 5270MHz.

## MPE Prediction (802.11ac\_VHT40 5470~5725)

MIMO gain=  $G+(10 \log N)= 5+4.77= 9.77\text{dBm}$

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/cm <sup>2</sup> )
Power density at predication frequency at 20 (cm)	0.067	(mW/cm <sup>2</sup> )

### Measurement Result

The predicted power density level at 20 cm is 0.067 mW/cm<sup>2</sup>.

This is below the uncontrolled exposure limit of 1 mW/cm<sup>2</sup> at 5670MHz.

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## MPE Prediction (802.11n\_HT40 5725~5850)

MIMO gain=  $G+(10 \log N)=5+4.77=9.77\text{dBm}$

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/cm <sup>2</sup> )
Power density at predication frequency at 20 (cm)	0.150	(mW/cm <sup>2</sup> )

### Measurement Result

The predicted power density level at 20 cm is 0.15 mW/cm<sup>2</sup>.

This is below the uncontrolled exposure limit of 1 mW/cm<sup>2</sup> at 5795MHz.

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## 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=  $G+(10 \log N)= 5+4.77= 9.77\text{dBm}$

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/cm <sup>2</sup> )
Power density at predication frequency at 20 (cm)	0.018	(mW/cm <sup>2</sup> )
<b>Measurement Result</b>		
The predicted power density level at 20 cm is 0.018 mW/cm <sup>2</sup> .		
This is below the uncontrolled exposure limit of 1 mW/cm <sup>2</sup> at 5210MHz.		

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## MPE Prediction (802.11ac\_VHT80 5250~5350)

MIMO gain=  $G+(10 \log N)= 5+4.77= 9.77\text{dBm}$

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/cm <sup>2</sup> )
Power density at predication frequency at 20 (cm)	0.016	(mW/cm <sup>2</sup> )
<b>Measurement Result</b>		
The predicted power density level at 20 cm is 0.016 mW/cm <sup>2</sup> .		
This is below the uncontrolled exposure limit of 1 mW/cm <sup>2</sup> at 5290MHz.		

## MPE Prediction (802.11ac\_VHT80 5470~5725)

MIMO gain=  $G+(10 \log N)= 5+4.77= 9.77\text{dBm}$

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/cm <sup>2</sup> )
Power density at predication frequency at 20 (cm)	0.016	(mW/cm <sup>2</sup> )
<b>Measurement Result</b>		
The predicted power density level at 20 cm is 0.016 mW/cm <sup>2</sup> .		
This is below the uncontrolled exposure limit of 1 mW/cm <sup>2</sup> at 5530MHz.		

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## MPE Prediction (802.11ac\_VHT80 5725~5850)

MIMO gain=  $G+(10 \log N)= 5+4.77= 9.77\text{dBm}$

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/cm <sup>2</sup> )
Power density at predication frequency at 20 (cm)	0.014	(mW/cm <sup>2</sup> )

### Measurement Result

The predicted power density level at 20 cm is 0.014 mW/cm<sup>2</sup>.

This is below the uncontrolled exposure limit of 1 mW/cm<sup>2</sup> at 5775MHz.

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