

FCC MAXIMUM PERMISSIBLE EXPOSURE (MPE)

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

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Maximum Permissible Exposure (MPE) Evaluation

802.11a Max. output power

802.11a_Main

CH	Frequency (MHz)	Data Rate	TOTAL POWER (dBm)	TOTAL POWER (mW)	REQUIRED LIMIT (dBm)	RESULT
36	5180	MCS0	14.44	27.797	23.98	PASS
44	5220	MCS0	14.37	27.353	23.98	PASS
48	5240	MCS0	14.24	26.546	23.98	PASS
52	5260	MCS0	14.16	26.062	23.98 or $11+10\log(B) = 23.98$	PASS
60	5300	MCS0	14.44	27.797	23.98 or $11+10\log(B) = 24.02$	PASS
64	5320	MCS0	14.47	27.990	23.98 or $11+10\log(B) = 24.04$	PASS
100	5500	MCS0	14.49	28.119	23.98 or $11+10\log(B) = 24.13$	PASS
116	5580	MCS0	14.49	28.119	23.98 or $11+10\log(B) = 24.17$	PASS
140	5700	MCS0	14.46	27.925	23.98 or $11+10\log(B) = 24.08$	PASS
149	5745	MCS0	14.49	28.119	30	PASS
157	5785	MCS0	14.48	28.054	30	PASS
165	5825	MCS0	14.22	26.424	30	PASS

MPE Prediction (802.11a 5150~5250)

Average output power at antenna input terminal:	14.44	(dBm)
Average output power at antenna input terminal:	27.797133	(mW)
Duty cycle:	100	(%)
Maximum Pav :	27.797133	(mW)
Peak Antenna gain (Maximum):	3.01	(dBi)
Peak Antenna gain (linear):	1.9998619	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5180	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm ²)
Power density at predication frequency at 20 (cm)	0.011	(mW/cm ²)
Measurement Result		
The predicted power density level at 20 cm is 0.011 mW/cm ² .		
This is below the uncontrolled exposure limit of 1 mW/cm ² at 5180MHz.		

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MPE Prediction (802.11a 5250~5350)

Average output power at antenna input terminal:	14.47	(dBm)
Average output power at antenna input terminal:	27.989813	(mW)
Duty cycle:	100	(%)
Maximum Pav :	27.989813	(mW)
Peak Antenna gain (Maximum):	3.01	(dBi)
Peak Antenna gain (linear):	1.9998619	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5320	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm ²)
Power density at predication frequency at 20 (cm)	0.011	(mW/cm ²)
Measurement Result		
The predicted power density level at 20 cm is 0.011 mW/cm ² .		
This is below the uncontrolled exposure limit of 1 mW/cm ² at 5320MHz.		

MPE Prediction (802.11a 5470~5725)

Average output power at antenna input terminal:	14.49	(dBm)
Average output power at antenna input terminal:	28.119008	(mW)
Duty cycle:	100	(%)
Maximum Pav :	28.119008	(mW)
Peak Antenna gain (Maximum):	4.11	(dBi)
Peak Antenna gain (linear):	2.5763212	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5500	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm ²)
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/cm ² .		
This is below the uncontrolled exposure limit of 1 mW/cm ² at 5500MHz.		

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MPE Prediction (802.11a 5725~5850)

Average output power at antenna input terminal:	14.49	(dBm)
Average output power at antenna input terminal:	28.119008	(mW)
Duty cycle:	100	(%)
Maximum Pav :	28.119008	(mW)
Peak Antenna gain (Maximum):	2.66	(dBi)
Peak Antenna gain (linear):	1.8450154	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5745	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm ²)
Power density at predication frequency at 20 (cm)	0.010	(mW/cm ²)

Measurement Result

The predicted power density level at 20 cm is 0.01 mW/cm².

This is below the uncontrolled exposure limit of 1 mW/cm² at 5745MHz.

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802.11n_HT20M Max. output power

802.11n_HT20_MIMO

CH	Frequency (MHz)	Data Rate	AVERAGE POWER (dBm)		TOTAL POWER (dBm)	TOTAL POWER (mW)	REQUIRED LIMIT (dBm)	RESULT
			CH 0	CH 1				
36	5180	MCS8	11.72	11.21	14.48	28.072	23.96	PASS
44	5220	MCS8	11.69	11.11	14.42	27.669	23.96	PASS
48	5240	MCS8	11.65	11.07	14.38	27.416	23.96	PASS
52	5260	MCS8	11.68	11.27	14.49	28.120	23.96 or 11+10log(B) 24.05	PASS
60	5300	MCS8	11.67	11.24	14.47	27.994	23.96 or 11+10log(B) 23.96	PASS
64	5320	MCS8	11.66	11.3	14.49	28.145	23.96 or 11+10log(B) 24.02	PASS
100	5500	MCS8	11.68	11.11	14.41	27.635	22.86 or 11+10log(B) 24.10	PASS
116	5580	MCS8	11.76	11.11	14.46	27.909	22.86 or 11+10log(B) 24.04	PASS
140	5700	MCS8	11.88	10.74	14.36	27.275	22.86 or 11+10log(B) 24.00	PASS
149	5745	MCS8	11.98	10.67	14.38	27.444	30	PASS
157	5785	MCS8	11.84	11.02	14.46	27.923	30	PASS
165	5825	MCS8	11.73	10.57	14.20	26.296	30	PASS

MPE Prediction (802.11n_HT20 5150~5250)

MIMO gain= G+(10 logN)= 3.01+3.01=6.025dBm

Max. output power including tune-up tolerancel:	14.48	(dBm)
Max. output power including tune-up tolerancel:	28.05433638	(mW)
Duty cycle:	100	(%)
Maximum Pav :	28.05433638	(mW)
Peak Antenna gain (Maximum):	6.02	(dBi)
Peak Antenna gain (linear):	3.999447498	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5180	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm ²)
Power density at predication frequency at 20 (cm)	0.022	(mW/cm ²)

Measurement Result

The predicted power density level at 20 cm is 0.022 mW/cm².

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

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MPE Prediction (802.11n_HT20 5250~5350)

MIMO gain= $G+(10 \log N)= 3.01+3.01= 6.02\text{dBm}$

Max. output power including tune-up tolerancel:	14.49	(dBm)
Max. output power including tune-up tolerancel:	28.119008	(mW)
Duty cycle:	100	(%)
Maximum Pav :	28.119008	(mW)
Peak Antenna gain (Maximum):	6.02	(dBi)
Peak Antenna gain (linear):	3.9994475	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5320	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm ²)
Power density at predication frequency at 20 (cm)	0.022	(mW/cm ²)

Measurement Result

The predicted power density level at 20 cm is 0.022 mW/cm².
This is below the uncontrolled exposure limit of 1 mW/cm² at 5320MHz.

MPE Prediction (802.11n_HT20 5470~5725)

MIMO gain= $G+(10 \log N)= 4.11+3.01= 7.12\text{dBm}$

Max. output power including tune-up tolerancel:	14.46	(dBm)
Max. output power including tune-up tolerancel:	27.925438	(mW)
Duty cycle:	100	(%)
Maximum Pav :	27.925438	(mW)
Peak Antenna gain (Maximum):	7.12	(dBi)
Peak Antenna gain (linear):	5.1522864	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5580	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm ²)
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 5580MHz.

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MPE Prediction (802.11n_HT20 5725~5850)

MIMO gain= $G+(10 \log N)= 2.66+3.01= 5.67\text{dBm}$

Max. output power including tune-up tolerancel:	14.46	(dBm)
Max. output power including tune-up tolerancel:	27.925438	(mW)
Duty cycle:	100	(%)
Maximum Pav :	27.925438	(mW)
Peak Antenna gain (Maximum):	5.67	(dBi)
Peak Antenna gain (linear):	3.689776	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5785	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm ²)
Power density at predication frequency at 20 (cm)	0.021	(mW/cm ²)

Measurement Result

The predicted power density level at 20 cm is 0.021 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)	Data Rate	AVERAGE POWER (dBm)		TOTAL POWER (dBm)	TOTAL POWER (mW)	REQUIRED LIMIT (dBm)	RESULT
			CH 0	CH 1				
38	5190	MCS8	11.46	11.33	14.41	27.579	23.96	PASS
46	5230	MCS8	11.89	10.87	14.42	27.671	23.96	PASS
54	5270	MCS8	11.68	11.28	14.49	28.151	23.96 or 11+10log(B) 27.03	PASS
62	5310	MCS8	11.61	11.22	14.43	27.731	23.96 or 11+10log(B) 27.04	PASS
102	5510	MCS8	11.81	11.12	14.49	28.112	22.86 or 11+10log(B) 27.04	PASS
110	5550	MCS8	11.72	11.11	14.44	27.772	22.86 or 11+10log(B) 27.09	PASS
134	5670	MCS8	11.79	11.14	14.49	28.102	22.86 or 11+10log(B) 27.05	PASS
151	5755	MCS8	11.73	11.13	14.45	27.865	30	PASS
159	5795	MCS8	11.77	10.75	14.30	26.916	30	PASS

MPE Prediction (802.11n_HT40 5150~5250)

MIMO gain= $G+(10 \log N)= 3.01+3.01= 6.02\text{dBm}$

Average output power at antenna input terminal:	14.42	(dBm)
Average output power at antenna input terminal:	27.669416	(mW)
Duty cycle:	100	(%)
Maximum Pav :	27.669416	(mW)
Peak Antenna gain (Maximum):	6.02	(dBi)
Peak Antenna gain (linear):	3.9994475	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5230	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm ²)
Power density at predication frequency at 20 (cm)	0.022	(mW/cm ²)

Measurement Result

The predicted power density level at 20 cm is 0.022 mW/cm².

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

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MPE Prediction (802.11n_HT40 5250~5350)

MIMO gain= $G+(10 \log N)= 3.01+3.01= 6.02\text{dBm}$

Average output power at antenna input terminal:	14.49	(dBm)
Average output power at antenna input terminal:	28.119008	(mW)
Duty cycle:	100	(%)
Maximum Pav :	28.119008	(mW)
Peak Antenna gain (Maximum):	6.02	(dBi)
Peak Antenna gain (linear):	3.9994475	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5270	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm ²)
Power density at predication frequency at 20 (cm)	0.022	(mW/cm ²)
Measurement Result		
The predicted power density level at 20 cm is 0.022 mW/cm ² .		
This is below the uncontrolled exposure limit of 1 mW/cm ² at 5270MHz.		

MPE Prediction (802.11n_HT40 5470~5725)

MIMO gain= $G+(10 \log N)= 4.11+3.01= 7.12\text{dBm}$

Average output power at antenna input terminal:	14.49	(dBm)
Average output power at antenna input terminal:	28.119008	(mW)
Duty cycle:	100	(%)
Maximum Pav :	28.119008	(mW)
Peak Antenna gain (Maximum):	7.12	(dBi)
Peak Antenna gain (linear):	5.1522864	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5510	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm ²)
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 5510MHz.

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MPE Prediction (802.11n_HT40 5725~5850)

MIMO gain= $G+(10 \log N)= 2.66+3.01= 5.67\text{dBm}$

Average output power at antenna input terminal:	14.45	(dBm)
Average output power at antenna input terminal:	27.861212	(mW)
Duty cycle:	100	(%)
Maximum Pav :	27.861212	(mW)
Peak Antenna gain (Maximum):	5.67	(dBi)
Peak Antenna gain (linear):	3.689776	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5755	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm ²)
Power density at predication frequency at 20 (cm)	0.020	(mW/cm ²)

Measurement Result

The predicted power density level at 20 cm is 0.02 mW/cm².

This is below the uncontrolled exposure limit of 1 mW/cm² at 5755MHz.

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802.11ac VHT80M Max. output power

802.11ac_VHT80_MIMO

CH	Frequency (MHz)	Data Rate	AVERAGE POWER (dBm)		TOTAL POWER (dBm)	TOTAL POWER (mW)	REQUIRED LIMIT (dBm)		RESULT
			CH 0	CH 1					
42	5210	MCS8	11.1	11.3	14.21	26.372	23.96		PASS
58	5290	MCS8	11.28	11.18	14.24	26.550	23.96	or 11+10log(B) 30.08	PASS
106	5530	MCS8	11.75	10.27	14.08	25.604	22.86	or 11+10log(B) 30.05	PASS
122	5610	MCS8	11.11	11.23	14.18	26.186	22.86	or 11+10log(B) 30.07	PASS
155	5775	MCS8	11.26	10.89	14.09	25.640	30		PASS

MPE Prediction (802.11ac_VHT80 5150~5250)

MIMO gain= $G+(10 \log N)= 3.01+3.01= 6.02\text{dBm}$

Average output power at antenna input terminal:	14.21	(dBm)
Average output power at antenna input terminal:	26.363314	(mW)
Duty cycle:	100	(%)
Maximum Pav :	26.363314	(mW)
Peak Antenna gain (Maximum):	6.02	(dBi)
Peak Antenna gain (linear):	3.9994475	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5210	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm ²)
Power density at predication frequency at 20 (cm)	0.021	(mW/cm ²)
Measurement Result		
The predicted power density level at 20 cm is 0.021 mW/cm ² .		
This is below the uncontrolled exposure limit of 1 mW/cm ² at 5210MHz.		

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MPE Prediction (802.11ac_VHT80 5250~5350)

MIMO gain= $G+(10 \log N)= 3.01+3.01= 6.02\text{dBm}$

Average output power at antenna input terminal:	14.24	(dBm)
Average output power at antenna input terminal:	26.546056	(mW)
Duty cycle:	100	(%)
Maximum Pav :	26.546056	(mW)
Peak Antenna gain (Maximum):	6.02	(dBi)
Peak Antenna gain (linear):	3.9994475	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5290	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm ²)
Power density at predication frequency at 20 (cm)	0.021	(mW/cm ²)
Measurement Result		
The predicted power density level at 20 cm is 0.021 mW/cm ² .		
This is below the uncontrolled exposure limit of 1 mW/cm ² at 5290MHz.		

MPE Prediction (802.11ac_VHT80 5470~5725)

MIMO gain= $G+(10 \log N)= 4.11+3.01= 7.12\text{dBm}$

Average output power at antenna input terminal:	14.18	(dBm)
Average output power at antenna input terminal:	26.18183	(mW)
Duty cycle:	100	(%)
Maximum Pav :	26.18183	(mW)
Peak Antenna gain (Maximum):	7.12	(dBi)
Peak Antenna gain (linear):	5.1522864	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5610	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm ²)
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/cm ² .		
This is below the uncontrolled exposure limit of 1 mW/cm ² at 5610MHz.		

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MPE Prediction (802.11ac_VHT80 5725~5850)

MIMO gain= $G+(10 \log N)= 2.66+3.01= 5.67\text{dBm}$

Average output power at antenna input terminal:	14.09	(dBm)
Average output power at antenna input terminal:	25.64484	(mW)
Duty cycle:	100	(%)
Maximum Pav :	25.64484	(mW)
Peak Antenna gain (Maximum):	5.67	(dBi)
Peak Antenna gain (linear):	3.689776	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5775	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm ²)
Power density at predication frequency at 20 (cm)	0.019	(mW/cm ²)

Measurement Result

The predicted power density level at 20 cm is 0.019 mW/cm².

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

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Collocated MPE Analysis:

The modem may transmit simultaneously with other collocated radio transmitters within a host device, provided the following conditions are met:

- Each collocated radio transmitter has been certified by FCC for mobile application (that will be met since SQNS module will have its own FCC ID and host device will have its own FCC ID)
- At least 20 cm separation distance between the antennas of the collocated transmitters and the user's body must be maintained at all times (host installation should taking care of that)

The output power and antenna gain in a collocated configuration must not exceed the limits and configurations stipulated in the following table 1. The power density calculations for the individual transmitters per wireless technology at an exposure minimum separation distance of 20cm.

Exclusion of test condition:

Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneous transmitting antennas incorporated in a host device, based on calculated or measured field strengths or power density, is ≤ 1.0 .

$$MPE\ ratio1 + MPE\ ratio2 + MPE\ ratio3 \leq 1.0$$

The spreadsheet as FCC deduces, and releases is employed to conduct the measurement:

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Table 1: Collocated MPE Calculation (Worst-case table)

Technology	Frequency (MHz)	Max Conducted Power (dBm)	Max Gain (dBi)	Duty Cycle	FCC Power Density @20cm (mW/cm ²)	FCC MPE Limit (mW/cm ²)
BT (BR)	2480	1.28	3.11	0.58	0.000	1.000
WLAN (802.11n 20)	2452	16.46	6.37	1	0.038	1.000
UNII (802.11 n 20)	5320	14.49	6.02	1	0.022	1.000

Scenario 1:

BT +WLAN +UNII

BT (mW/c m ²)	FCC MPE Limit (mW/c m ²)	(BT) / MPE Result	WLAN (mW/c m ²)	FCC MPE Limit (mW/c m ²)	(WLAN) / MPE Result	UNII (mW/c m ²)	FCC MPE Limit (mW/c m ²)	(UNII) / MPE Result	(BT +WLAN +UNII)	FCC Limit (mW/c m ²)
0.000	1.000	0	0.038	1.000	0.038	0.022	1.000	0.022	0.06	1.000

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