

1. MAXIMUM PERMISSIBLE EXPOSURE (MPE)

1.1 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

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1.2 Maximum Permissible Exposure (MPE) Evaluation (Worst Case)

1M BR mode (Average):

CH	Freq. (MHz)	Avg. Output Power (dBm)	Output Power (mW)	Limit (mW)
0	2402	6.06	4.036	125
39	2441	6.23	4.198	125
78	2480	4.85	3.055	125

MPE Prediction (BT-BR)

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

Max. output power including tune-up tolerancel:	6.23	(dBm)
Max. output power including tune-up tolerancel:	4.1975898	(mW)
Duty cycle:	77	(%)
Maximum Pav :	3.2321442	(mW)
Peak Antenna gain (Maximum):	0.8	(dBi)
Peak Antenna gain (linear):	1.2022644	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	2441	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm ²)
Power density at predication frequency at 20 (cm)	0.001	(mW/cm ²)

Measurement Result

The predicted power density level at 20 cm is 0.001 mW/cm².

This is below the uncontrolled exposure limit of 1 mW/cm² at 2441MHz.

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BLE mode:

CH	Frequency (MHz)	Peak Power Output (dBm)	Required Limit
0	2402	3.92	1 Watt = 30 dBm
19	2440	4.48	1 Watt = 30 dBm
39	2480	3.43	1 Watt = 30 dBm

BLE mode:

CH	Frequency (MHz)	Avg. Output Power (dBm)	Required Limit
0	2402	3.04	1 Watt = 30 dBm
19	2440	3.75	1 Watt = 30 dBm
39	2480	2.45	1 Watt = 30 dBm

*Note: Measured by power meter, cable loss as 10.7 dB that offsets on the power meter

*Note: Measured by power meter, **as Duty cycle factor that offsets on the power meter in Peak.**

MPE Prediction (BLE)

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

Max. output power including tune-up tolerancel:	3.75	(dBm)
Max. output power including tune-up tolerancel:	2.3713737	(mW)
Duty cycle:	85.46	(%)
Maximum Pav :	2.026576	(mW)
Peak Antenna gain (Maximum):	0.8	(dBi)
Peak Antenna gain (linear):	1.2022644	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	2440	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm ²)
Power density at predication frequency at 20 (cm)	0.000	(mW/cm ²)

Measurement Result

The predicted power density level at 20 cm is 0 mW/cm².

This is below the uncontrolled exposure limit of 1 mW/cm² at 2440MHz.

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802.11b Main						
CH	Frequency (MHz)	Data Rate	Peak Output Power (dBm)	Peak Output Power (mW)	Limit	RESULT
1	2412	1	18.57	71.94	1 Watt = 30.00 dBm	PASS
6	2437	1	19.10	81.28	1 Watt = 30.00 dBm	PASS
11	2462	1	19.47	88.51	1 Watt = 30.00 dBm	PASS
802.11b Main						
CH	Frequency (MHz)	Data Rate	Avg. Output Power (dBm)	Avg. Output Power (mW)	Limit	RESULT
1	2412	1	15.67	36.90	1 Watt = 30.00 dBm	PASS
6	2437	1	16.22	41.88	1 Watt = 30.00 dBm	PASS
11	2462	1	16.5	44.67	1 Watt = 30.00 dBm	PASS

MPE Prediction (802.11b 2412~2462)

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

Max. output power including tune-up tolerancel:	16.50	(dBm)
Max. output power including tune-up tolerancel:	44.668359	(mW)
Duty cycle:	99.54	(%)
Maximum Pav :	44.462885	(mW)
Peak Antenna gain (Maximum):	0.8	(dBi)
Peak Antenna gain (linear):	1.2022644	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	2462	(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/cm².

This is below the uncontrolled exposure limit of 1 mW/cm² at 2462MHz.

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802.11a Main

CH	Frequency (MHz)	Data Rate	TOTAL POWER (dBm)	TOTAL POWER (mW)	REQUIRED LIMIT (dBm)	RESULT
36	5180	MCS0	13.64	23.121	23.98	PASS
44	5220	MCS0	15.36	34.356	23.98	PASS
48	5240	MCS0	15.41	34.754	23.98	PASS
52	5260	MCS0	15.13	32.584	23.98 or 11+10log(B) = 23.22	PASS
60	5300	MCS0	15.20	33.113	23.98 or 11+10log(B) = 23.21	PASS
64	5320	MCS0	15.06	32.063	23.98 or 11+10log(B) = 23.22	PASS
100	5500	MCS0	15.17	32.885	23.98 or 11+10log(B) = 23.22	PASS
116	5580	MCS0	16.25	42.170	23.98 or 11+10log(B) = 23.24	PASS
140	5700	MCS0	15.32	34.041	23.98 or 11+10log(B) = 23.22	PASS
149	5745	MCS0	13.52	22.491	30	PASS
157	5785	MCS0	13.35	21.627	30	PASS
165	5825	MCS0	13.11	20.464	30	PASS

MPE Prediction (WLAN-802.11 a)

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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5150~5250MHz

Max. output power including tune-up tolerancel:	15.41	(dBm)
Max. output power including tune-up tolerancel:	34.753616	(mW)
Duty cycle:	99.52	(%)
Maximum Pav :	34.586799	(mW)
Peak Antenna gain (Maximum):	-0.2	(dBi)
Peak Antenna gain (linear):	0.9549926	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5240	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm ²)
Power density at predication frequency at 20 (cm)	0.007	(mW/cm ²)
Measurement Result		
The predicted power density level at 20 cm is 0.007 mW/cm ² .		
This is below the uncontrolled exposure limit of 1 mW/cm ² at 5240MHz.		

5250~5350MHz

Max. output power including tune-up tolerancel:	15.20	(dBm)
Max. output power including tune-up tolerancel:	33.113112	(mW)
Duty cycle:	99.14	(%)
Maximum Pav :	32.828339	(mW)
Peak Antenna gain (Maximum):	2	(dBi)
Peak Antenna gain (linear):	1.5848932	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5300	(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/cm ² .		
This is below the uncontrolled exposure limit of 1 mW/cm ² at 5300MHz.		

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5470~5725MHz

Max. output power including tune-up tolerancel:	16.25	(dBm)
Max. output power including tune-up tolerancel:	42.16965	(mW)
Duty cycle:	98.54	(%)
Maximum Pav :	41.553973	(mW)
Peak Antenna gain (Maximum):	-0.6	(dBi)
Peak Antenna gain (linear):	0.8709636	(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)	0.007	(mW/cm ²)
Measurement Result		
The predicted power density level at 20 cm is 0.007 mW/cm ² .		
This is below the uncontrolled exposure limit of 1 mW/cm ² at 5580MHz.		

5725~5850MHz

Max. output power including tune-up tolerancel:	13.52	(dBm)
Max. output power including tune-up tolerancel:	22.490546	(mW)
Duty cycle:	97.14	(%)
Maximum Pav :	21.847316	(mW)
Peak Antenna gain (Maximum):	0.3	(dBi)
Peak Antenna gain (linear):	1.0715193	(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)	0.005	(mW/cm ²)
Measurement Result		
The predicted power density level at 20 cm is 0.005 mW/cm ² .		
This is below the uncontrolled exposure limit of 1 mW/cm ² at 5745MHz.		

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2. 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/IC 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 .

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

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

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Table 1 : Collocated MPE Calculation (Worse 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	2441	6.23	0.8	77	0.00773	1
WLAN 5G	5580	16.25	-0.6	98.54	0.07204	1

Scenario 1:

BT-BR+WLAN 5G

BT-BR (mW/cm ²)	FCC MPE limit (mW/cm ²)	BT-BR / MPE limit	WLAN 5G (mW/cm ²)	FCC MPE limit (mW/cm ²)	WLAN 5G / MPE limit	BT+ WLAN 5G	FCC Limit (mW/cm ²)
0.00077	1	0.00077	0.00720	1	0.00720	0.00798	1

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