

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 §2.1091 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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1.2 Maximum Permissible Exposure (MPE) Evaluation (Worst Case)

MPE Prediction (5150~5250MHz)

Average output power at antenna input terminal:	16.54	(dBm)
Average output power at antenna input terminal:	45.08167	(mW)
Duty cycle:	76.02	(%)
Maximum Pav :	34.271086	(mW)
Peak Antenna gain (Maximum):	3.37	(dBi)
Peak Antenna gain (linear):	2.1727012	(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)	0.015	(mW/cm ²)

Measurement Result

The predicted power density level at 20 cm is 0.015 mW/cm².

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

MPE Prediction (5250~5350MHz)

Average output power at antenna input terminal:	16.50	(dBm)
Average output power at antenna input terminal:	44.668359	(mW)
Duty cycle:	76.02	(%)
Maximum Pav :	33.956887	(mW)
Peak Antenna gain (Maximum):	3.23	(dBi)
Peak Antenna gain (linear):	2.1037784	(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)	0.014	(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 5270MHz.

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MPE Prediction (5470~5725MHz)

Average output power at antenna input terminal:	15.58	(dBm)
Average output power at antenna input terminal:	36.140986	(mW)
Duty cycle:	86.46	(%)
Maximum Pav :	31.247497	(mW)
Peak Antenna gain (Maximum):	1.51	(dBi)
Peak Antenna gain (linear):	1.4157938	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	5700	(MHz)
MPE limit for uncontrolled exposure at prediction	1	(mW/cm ²)
Power density at predication frequency at 20 (cm)	0.009	(mW/cm ²)

Measurement Result

The predicted power density level at 20 cm is 0.009 mW/cm².

This is below the uncontrolled exposure limit of 1 mW/cm² at 5700MHz.

MPE Prediction (5725~5850MHz)

Average output power at antenna input terminal:	14.33	(dBm)
Average output power at antenna input terminal:	27.101916	(mW)
Duty cycle:	86.46	(%)
Maximum Pav :	23.432317	(mW)
Peak Antenna gain (Maximum):	0.42	(dBi)
Peak Antenna gain (linear):	1.1015393	(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)	0.005	(mW/cm ²)

Measurement Result

The predicted power density level at 20 cm is 0.005 mW/cm².

This is below the uncontrolled exposure limit of 1 mW/cm² at 5785MHz.

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2 MAXIMUM PERMISSIBLE EXPOSURE (MPE)

2.1 Standard Applicable

According to RSS 102 March 19,2015 issue 5 §2.5.2 RF Exposure Evaluation

RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:

below 20 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1 W (adjusted for tune-up tolerance);

at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $22.48/f^{0.5}W$ (adjusted for tune-up tolerance), where f is in MHz;

at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance);

at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $1.31 \times 10^{-2} f^{0.6834} W$ (adjusted for tune-up tolerance), where f is in MHz;

This is a Mobile device, at which separation distance between the user and the device's antenna is 20cm. Therefore, section 2.5.2 shall be complied with.

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2.2 Maximum Permissible Exposure (MPE) Exemption (Worst Case)

802.11a (5150~5250MHz)

Max. output power including tune-up tolerance:	16.54	(dBm)
Max. output power including tune-up tolerance:	45.08167	(mW)
Antenna gain (Peak):	3.37	(dBi)
Maximum antenna gain:	2.1727012	(numeric)
Frequency	5230	MHz
Limit	4.5551	W
EIRP	0.0979	W

Evaluation Result

The radiated power is $16.54 + 3.37 = 19.91$ dBm(EIRP) = 97.949 mW = 0.097949 W that is less than or equal to 4.555 W. Hence, following section 2.5.2 of RSS102 issue 5, RF exposure evaluation is no longer required.

802.11a (5250~5350MHz)

Max. output power including tune-up tolerance:	16.5	(dBm)
Max. output power including tune-up tolerance:	44.668359	(mW)
Antenna gain (Peak):	3.23	(dBi)
Maximum antenna gain:	2.1037784	(numeric)
Frequency	5270	MHz
Limit	4.5789	W
EIRP	0.0940	W

Evaluation Result

The radiated power is $16.5 + 3.23 = 19.73$ dBm(EIRP) = 93.972 mW = 0.093972 W that is less than or equal to 4.579 W. Hence, following section 2.5.2 of RSS102 issue 5, RF exposure evaluation is no longer required.

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802.11a (5470~5725MHz)

Max. output power including tune-up tolerance:	15.58	(dBm)
Max. output power including tune-up tolerance:	36.140986	(mW)
Antenna gain (Peak):	1.51	(dBi)
Maximum antenna gain:	1.4157938	(numeric)
Frequency	5700	MHz
Limit	4.8310	W
EIRP	0.0512	W

Evaluation Result

The radiated power is $15.58 + 1.51 = 17.09$ dBm(EIRP) = 51.168 mW = 0.051168 W that is less than or equal to 4.831 W. Hence, following section 2.5.2 of RSS102 issue 5, RF exposure evaluation is no longer required.

802.11a (5725~5850MHz)

Max. output power including tune-up tolerance:	14.33	(dBm)
Max. output power including tune-up tolerance:	27.101916	(mW)
Antenna gain (Peak):	0.42	(dBi)
Maximum antenna gain:	1.1015393	(numeric)
Frequency	5785	MHz
Limit	4.8801	W
EIRP	0.0299	W

Evaluation Result

The radiated power is $14.33 + 0.42 = 14.75$ dBm(EIRP) = 29.854 mW = 0.029854 W that is less than or equal to 4.88 W. Hence, following section 2.5.2 of RSS102 issue 5, RF exposure evaluation is no longer required.

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3 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 .

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

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)	IC Power Density @20cm (W/m ²)	IC MPE Limit (W/m ²)
BT-BR	2441	7.18	1.48	77	0.00113	1	0.01126	5.410
WLAN 5G	5230	16.54	3.37	76.02	0.01482	1	0.14821	9.107

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)
0.00113	1	0.00113	0.01482	1	0.01482	0.01595	1

BT-BR (W/cm ²)	ISED MPE limit (W/cm ²)	BT-BR / MPE limit	WLAN 5G (W/cm ²)	ISED MPE limit (W/cm ²)	WLAN 5G / MPE limit	BT+ WLAN 5G	ISED Limit (W/cm ²)
0.01126	5.410	0.00208	0.14821	9.107	0.01627	0.01836	1

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