

## MPE Calculation

§ 1.1310: The criteria listed in table 1 shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in §1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of §2.1093 of this chapter.

### Part 1.1310 Limits for Maximum Permissible Exposure (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm <sup>2</sup> )	Averaging time (minutes)
<b>(A) Limits for Occupational/Controlled Exposures</b>				
0.3–3.0 .....	614	1.63	*(100)	6
3.0–30 .....	1842/f	4.89/f	*(900/f <sup>2</sup> )	6
30–300 .....	61.4	0.163	1.0	6
300–1500 .....			f/300	6
1500–100,000 .....			5	6
<b>(B) Limits for General Population/Uncontrolled Exposure</b>				
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
1500–100,000 .....			1.0	30

f = frequency in MHz

\* = Plane-wave equivalent power density

NOTE 1 TO TABLE 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2 TO TABLE 1: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

### 1.1 Test Procedure

An MPE evaluation for was performed in order to show that the device was compliant with §2.1091. The maximum power density was calculated for each transmitter at a separation distance of 20cm.

For each transmitter the maximum RF exposure at a 20 cm distance using the formula:

$$ConductedPower_{mW} = 10^{ConductedPower(dBm)/10}$$

$$PowerDensity = \frac{ConductedPower_{mW} \times Ant.Gain}{4\pi \times (20_{cm})^2}$$



## 1.2 Results:

The device contains Cellular, Zigbee, and 802.11 transmitters which can transmit simultaneously. The following calculations show that the total power density from each transmitter at 20cm is less than the limit for general population / un-controlled exposure. With the worst case Cellular, 802.11, and Zigbee modules transmitting simultaneously, the MPE calculations are less than the applicable limit. The device meets the RF exposure limit at a 20cm separation distance as required by part 2.1091 of the FCC rules with all modules transmitting simultaneously<sup>1</sup>.

The total sum of the ratio of the power densities to the corresponding limit for all radios capable of transmitting simultaneously was computed as follows:

Total = (GSM850 Power Density / Limit GSM850) + (802.11 Power Density / Limit 802.11) + (Zigbee Power Density / Limit Zigbee)

**Total = 0.77 + 0.02 + 0.03 = 0.82**

Compliance is shown by the sum of the ratio of the power densities for all radios that can transmit simultaneously being less than 1.

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<sup>1</sup> The cellular radio is only capable of transmitting in one mode at a time.



**Individual Radio Test Results:**

**GSM 850 Band Transmitter:**

Frequency	824.2	MHz	
Limit	0.549	mW/cm <sup>2</sup>	
Distance	20	cm	
Maximum Scaled Power	35	dBm	
TX Ant Gain	4.28	dBi	
EIRP	39.28		8472.274 mW
Source Based Duty Cycle (2/8 Timeslots)	0.25		
Source Based Output Power	2118.06854	mW	
Power Density MPE / Limit Ratio	<b>0.4214</b>	mW/cm <sup>2</sup> at 20cm	<b>0.77</b>

**GSM 1900 Band Transmitter:**

Frequency	1850.2	MHz	
Limit	1.000	mW/cm <sup>2</sup>	
Distance	20	cm	
Maximum Scaled Power	32	dBm	
TX Ant Gain	3	dBi	
EIRP	35		3162.278 mW
Source Based Duty Cycle (2/8 Timeslots)	0.25		
Source Based Output Power	790.569415	mW	
Power Density MPE / Limit Ratio	<b>0.1573</b>	mW/cm <sup>2</sup> at 20cm	<b>0.16</b>



**WCDMA Band V Transmitter:**

Frequency	826.4	MHz	
Limit	0.551	mW/cm <sup>2</sup>	
Distance	20	cm	
Maximum Scaled Power	25	dBm	
TX Ant Gain	4.28	dBi	
EIRP	29.28		847.2274 mW
Power Density	<b>0.1686</b>	mW/cm <sup>2</sup> at 20cm	
MPE / Limit Ratio	<b>0.31</b>		

**WCDMA Band II Transmitter**

Frequency	1852.4	MHz	
Limit	1.000	mW/cm <sup>2</sup>	
Distance	20	cm	
Maximum Scaled Power	25	dBm	
TX Ant Gain	3	dBi	
EIRP	28		630.9573 mW
Power Density	<b>0.1255</b>	mW/cm <sup>2</sup> at 20cm	
MPE / Limit Ratio	<b>0.13</b>		



**802.11**

Frequency	2412	MHz	
Limit	1.000	mW/cm <sup>2</sup>	
Distance	20	cm	
Power	17.74	dBm	
TX Ant Gain	2.04	dBi	
EIRP	19.78		95.06048 mW
Power Density	<b>0.0189</b>	mW/cm <sup>2</sup> at 20cm	
MPE / Limit Ratio	<b>0.02</b>		

**Zigbee Transmitter**

Frequency	2450	MHz	
Limit	1.000	mW/cm <sup>2</sup>	
Distance	20	cm	
Power	18.87	dBm	
TX Ant Gain	2.41	dBi	
EIRP	21.28		134.2765 mW
Power Density	<b>0.0267</b>	mW/cm <sup>2</sup> at 20cm	
MPE / Limit Ratio	<b>0.03</b>		

