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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^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3–3.0	614	1.63	*(100)	6
3.0–30	1842/f	4.89/f	*(900/f^2)	6
30–300	61.4	0.163	1.0	6
300–1500			f/300	6
1500–100,000			5	6
(B) 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
1500–100,000			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:

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

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

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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 Cellular, 802.11, and Zigbee modules transmitting simultaneously, the worse case MPE calculations are less than 32% of 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[1].

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

Total = GSM850 Power Density + 802.11 Power Density + Zigbee Power Density

Total = 0.1527 mW/cm^2 + 0.0181 mW/cm^2 + 0.0239 mW/cm^2

Total = 0.1947 mW/cm^2

Total = 0.1947 mW/cm^2 * (10,000cm^2 / 1m^2) * (1W / 1000mW)

Total = 1.947 W/m^2

[1] It is not possible for the GSM radio to transmit simultaneously with the GSM1900 radio.

Burst Average Conducted Output Power of Cellular Module

			Burst Average Power (dBm)								
Band	Channel	Frequency (MHz)	GSM	GPRS - 1 Tx Slot	GPRS - 2 Tx Slots	GPRS - 3 Tx Slots	GPRS - 4 Tx Slots	EDGE - 1 Tx Slot	EDGE - 2 Tx Slots	EDGE - 3 Tx Slots	EDGE - 4 Tx Slots
	128	824.2	32.04	32.17	32.11	32.05	31.98	26.1	26.22	26.2	26.14
	190	836.6	31.89	32.04	31.99	31.91	31.85	25.9	26.15	26.1	26.02
GSM 850	251	848.8	31.73	31.88	31.85	31.74	31.69	25.7	25.8	25.9	25.88
	512	1850.2	28.92	29.04	29	28.97	29.01	25.46	25.58	25.5	25.45
	661	1880	28.6	28.8	28.82	28.73	28.78	25.25	25.3	25.2	25.2
GSM 1900	810	1909.8	28.48	28.6	28.6	28.51	28.58	25.06	25.12	25.02	25.02

Time Average Conducted Output Power of Cellular Module (Duty Cycle (10*Log(Tx Slots/8) Included)

			Time Average Power (dBm)								
Band	Channel	Frequency (MHz)	GSM	GPRS - 1 Tx Slot	GPRS - 2 Tx Slots	GPRS - 3 Tx Slots	GPRS - 4 Tx Slots	EDGE - 1 Tx Slot	EDGE - 2 Tx Slots	EDGE - 3 Tx Slots	EDGE - 4 Tx Slots
	128	824.2	23.01	23.14	26.09	27.79	28.97	17.07	20.20	21.94	23.13
	190	836.6	22.86	23.01	25.97	27.65	28.84	16.87	20.13	21.84	23.01
GSM 850	251	848.8	22.70	22.85	25.83	27.48	28.68	16.67	19.78	21.64	22.87
	512	1850.2	19.89	20.01	22.98	24.71	26.00	16.43	19.56	21.24	22.44
	661	1880	19.57	19.77	22.80	24.47	25.77	16.22	19.28	20.94	22.19
GSM 1900	810	1909.8	19.45	19.57	22.58	24.25	25.57	16.03	19.10	20.76	22.01

Test Summary

GSM 850 Band Transmitter:

Frequency	824.2	MHz		
Limit	0.549	mW/cm^2		
Distance	20	cm		
Power	28.97	dBm		
TX Ant Gain	-0.12	dBi		
EIRP	28.85		767.3615	mW
Power Density	**0.1527**	mW/cm^2 at 20cm		
% of MPE Limit	**27.78**			

GSM 1900 Band Transmitter:

Frequency	1850.2	MHz		
Limit	1.000	mW/cm^2		
Distance	20	cm		
Power	26	dBm		
TX Ant Gain	2.09	dBi		
EIRP	28.09		644.1693	mW
Power Density	**0.1282**	mW/cm^2 at 20cm		
% of MPE Limit	**12.82**			

802.11

Frequency	2412	MHz		
Limit	1.000	mW/cm^2		
Distance	20	cm		
Power	17.71	dBm		
TX Ant Gain	1.87	dBi		
EIRP	19.58		90.78205	mW
Power Density	**0.0181**	mW/cm^2 at 20cm		
% of MPE Limit	**1.81**			

Zigbee Transmitter

Frequency	2450	MHz		
Limit	1.000	mW/cm^2		
Distance	20	cm		
Power	18.87	dBm		
TX Ant Gain	1.92	dBi		
EIRP	20.79		119.9499	mW
Power Density	**0.0239**	mW/cm^2 at 20cm		
% of MPE Limit	**2.39**			