731 Enterprise Drive
Lexington, KY 40510

Telephone: 859-226-1000
Facsimile: 859-226-1040
www.intertek-etlsemko.com

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 LTE and Bluetooth 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 LTE and Bluetooth radios 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[1].

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 = (LTE Power Density / Limit LTE) + (Bluetooth Power Density / Limit Bluetooth)

Total = 0.2482 + 0.0045 = 0.2527

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

[1] The cellular radio is only capable of transmitting in one mode at a time (Cell band or PCS band).

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Individual Radio Test Results:

LTE Band 4	Value	Unit	Comments
Frequency	824.2	MHz	
Distance	20	cm	
Maximum Scaled Power	23.5	dBm	Measured conducted power
TX Antenna Gain	4.86	dBi	Peak gain from datasheet
Source Based Duty Cycle	100	%	Percent of time transmitter is active
EIRP	**28.36**	**dBm**	Maximum Scaled Power x Antenna Gain
Source Based Output Power	**28.4**	**dBm**	EIRP x Duty Cycle
Power Density @ Distance	**0.1364**	**mW/cm^2**	(Source Based Output Power, mW) / (4π x (distance, cm)^2)
FCC Limit	**0.5495**	**mW/cm^2**	.0007 x f^1
Ratio of Power Density to Limit	**0.2482**		Power Density / FCC Limit
Maximum Permissible Antenna Gain	**10.91**	**dBi**	((Limit, mW/cm^2) x 4π x (distance, cm)^2) / ((Maximum Scaled Power, mW) x Source Based Duty Cycle)

LTE Band 13	Value	Unit	Comments
Frequency	787	MHz	
Distance	20	cm	
Maximum Scaled Power	23.5	dBm	Measured conducted power
TX Antenna Gain	4.07	dBi	Peak gain from datasheet
Source Based Duty Cycle	100	%	Percent of time transmitter is active
EIRP	**27.57**	**dBm**	Maximum Scaled Power x Antenna Gain
Source Based Output Power	**27.6**	**dBm**	EIRP x Duty Cycle
Power Density @ Distance	**0.1137**	**mW/cm^2**	(Source Based Output Power, mW) / (4π x (distance, cm)^2)
FCC Limit	**0.5247**	**mW/cm^2**	.0007 x f^1
Ratio of Power Density to Limit	**0.2167**		Power Density / FCC Limit
Maximum Permissible Antenna Gain	**10.71**	**dBi**	((Limit, mW/cm^2) x 4π x (distance, cm)^2) / ((Maximum Scaled Power, mW) x Source Based Duty Cycle)

Bluetooth	Value	Unit	Comments
Frequency	2402	MHz	
Distance	20	cm	
Maximum Scaled Power	12	dBm	Measured conducted power
TX Antenna Gain	1.5	dBi	Peak gain from operational description
Source Based Duty Cycle	100	%	Percent of time transmitter is active
EIRP	**13.5**	**dBm**	Maximum Scaled Power x Antenna Gain
Source Based Output Power	**13.5**	**dBm**	EIRP x Duty Cycle
Power Density @ Distance	**0.0045**	**mW/cm^2**	(Source Based Output Power, mW) / (4π x (distance, cm)^2)
FCC Limit	**1.0000**	**mW/cm^2**	1. x f^0
Ratio of Power Density to Limit	**0.0045**		Power Density / FCC Limit
Maximum Permissible Antenna Gain	**25.01**	**dBi**	((Limit, mW/cm^2) x 4π x (distance, cm)^2) / ((Maximum Scaled Power, mW) x Source Based Duty Cycle)