



MPE Evaluation for WP7700 Radio Module

May 31, 2018

1. Introduction

In this application we seek modular approval for the WP7700 radio module for use in standalone and collocated simultaneous transmission under mobile and fixed configurations. This Maximum Permissible Exposure (MPE) report demonstrates compliance analysis for WP7700 radio module with FCC CFR 47 §2.1091 and IC RSS-102 for standalone and collocated transmission in the exposure conditions where a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons. The MPE analysis is limited for US / Canada bands only.

The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure.

2. RF Exposure Limits and Equations

FCC Limits:

According to FCC OET Bulletin 65 Supplement C, the criteria listed in Table 1 shall be used to evaluate the environmental impact of human exposure to radio frequency (RF) radiation as specified in §1.1307.

(B) Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm ²)	Averaging Time E ² , H ² or S (minutes)
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

Table 1 : Limits for Maximum Permissible Exposure (MPE)

IC Limits:

IC has adopted the RF field strength limits established in Health Canada's RF exposure guideline. The limits are shown in Table 2 below per RSS-102.

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m ²)	Reference Period (minutes)
0.003-10 ²¹	83	90	-	Instantaneous*
0.1-10	-	0.73/ f	-	6**
1.1-10	87/ f ^{0.5}	-	-	6**
10-20	27.46	0.0728	2	6
20-48	58.07/ f ^{0.25}	0.1540/ f ^{0.25}	8.944/ f ^{0.5}	6
48-300	22.06	0.05852	1.291	6
300-6000	3.142 f ^{0.3417}	0.008335 f ^{0.3417}	0.02619f ^{0.6834}	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	616000/ f ^{1.2}
150000-300000	0.158 f ^{0.5}	4.21 x 10 ⁻⁴ f ^{0.5}	6.67 x 10 ⁻⁵ f	616000/ f ^{1.2}
<p>Note: f is frequency in MHz. *Based on nerve stimulation (NS). ** Based on specific absorption rate (SAR).</p>				

Table 2 : RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)

In the frequency range of 300-6000 MHz, the IC limits are more stringent than the FCC limits. The MPE evaluation in this report will be based on the IC limits, so the deduced output power and antenna gain limits will guarantee compliance with both FCC and IC requirements.

EQUATIONS:

EIRP (dBm) = Conducted Power (dBm) + Antenna Gain (dBi)

Power density is given by :

$$S = \text{EIRP} / (4 \pi * D^2)$$

where

S = Power density (mW/cm²)

EIRP = Equivalent Isotropic Radiated Power (mW)

D = Separation distance (cm)

3. WP7700 Product Specifications

WP7700 will transmit on only one band and mode of operation at any one time. Table 3 lists the supported frequency bands in Canada/USA and the maximum power in each of those bands.

Technology	Band	UL Freq. (MHz)	Max Power (dBm)
LTE CAT-M1/NB1	2	1850 – 1910	24
	4	1710 – 1755	24
	5	824 – 849	24
	12	699 – 716	24
	13	777 – 787	24
	17	704 – 716	24
	26	814 – 849	24

Table 3: WP7700 Frequency Bands and Output Power

4. Stand-Alone Transmission

When WP7700 module transmits as a stand-alone mobile device, the source-based time-averaged EIRP is calculated by summing up conducted power and antenna gain. A 100% duty cycle is used for the calculations in LTE mode to present a worse-case analysis. The actual duty cycle is much smaller. The antenna gains are chosen so that the resulted radiated power levels are within the limits specified by the FCC rules and IC Radio Standards Specifications (RSS). The IC exemption limits for routine RF exposure evaluation are calculated using the lowest frequency of the operating band presenting the most stringent limits.

As shown in Table 2 below, the resulted EIRP are always below the IC exemption limits for all the operating modes.

Operating Mode	TX Freq Range (MHz)		Max Time-Avg Cond Power (dBm)	Max Time-Avg Cond Power (W)	Max Ant Gain (dBi)	Duty Cycle	Source-Based Time-Averaged Max EIRP	IC Exemption Limit (EIRP)	ERP/EIRP Limits
LTE Band 2	1850	1910	24	0.25	9	100%	33.00	33.50	2 W EIRP
LTE Band 4	1710	1755	24	0.25	6	100%	30.00	33.27	1 W EIRP
LTE Band 5	824	849	24	0.25	7	100%	31.00	31.10	7 W ERP
LTE Band 12	699	716	24	0.25	6	100%	30.00	30.61	3 W ERP
LTE Band 13	777	787	24	0.25	6	100%	30.00	30.93	3 W ERP
LTE Band 17	704	716	24	0.25	6	100%	30.00	30.63	3 W ERP

LTE Band 26	814	849	24	0.25	6	100%	30.00	31.06	7 W ERP
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Table 2: WP7700 Stand-Alone Transmission

5. Collocated Transmission

When WP7700 module co-transmits with radio transmitter(s) as a mobile device, per KDB 447498 D01, 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 the calculated/estimated, numerically modeled or measured field strengths or power density, is ≤ 1.0 .

The evaluation here considers a WiMAX or WLAN transmitter, and a Bluetooth transmitter as collocated transmitters. Their radiated output power levels are listed in Table 3 below. The MPE ratio is defined by the ratio of power density to MPE limit. The sum of the MPE ratios is calculated as follows:

$$\begin{aligned} \sum \text{MPE Ratio} &= \text{Max (WP7700 MPE ratio)} + \text{Max (WLAN/WiMax MPE ratio)} + \text{BT MPE Ratio} \\ &= 0.864 + 0.121 + 0.012 = 0.997 < 1.0 \end{aligned}$$

Operating Mode	TX Freq Range (MHz)		Max Time-Avg Cond Power (dBm)	Max Time-Avg Cond Power (W)	Max Ant Gain (dBi)	Duty Cycle	Source-Based Time-Averaged Max EIRP	Power Density @20 cm (W/m ²)	IC MPE Limit (W/m ²)	IC Power Density MPE Ratio
LTE Band 2	1850	1910	24	0.25	8	100%	32.00	3.15	4.48	0.704
LTE Band 4	1710	1755	24	0.25	6	100%	30.00	1.99	4.24	0.469
LTE Band 5	824	849	24	0.25	6	100%	30.00	1.99	2.58	0.772
LTE Band 12	699	716	24	0.25	6	100%	30.00	1.99	2.30	0.864
LTE Band 13	777	787	24	0.25	6	100%	30.00	1.99	2.47	0.804
LTE Band 17	704	716	24	0.25	6	100%	30.00	1.99	2.31	0.860
LTE Band 26	814	849	24	0.25	6	100%	30.00	1.99	2.55	0.779
WLAN 2.4 GHz	2400	2500				100%	25	0.63	5.35	0.118
WLAN 5 GHz	5150	5850				100%	27	1.00	9.01	0.111
WiMAX	2300	2400				100%	25	0.63	5.19	0.121
	2500	2700				100%	25	0.63	5.50	0.114
	3300	3800				100%	25	0.63	6.65	0.095
Bluetooth	2400	2500				100%	15	0.06	5.35	0.012

Table 3: WP7700 Collocated Transmission

6. Conclusion

The analysis presented in this report concludes that the WP7700 radio module, when transmitting either in standalone or simultaneously with other co-located radio transmitters within a host device, is compliant with the FCC/IC RF exposure requirements in mobile exposure condition, provided the conducted power and antenna gain do not exceed the limits in Table 4 for each given frequency band and operating mode.

	Operating Mode	TX Freq Range (MHz)		Antenna Gain Limits (dBi)		EIRP Limits of Collocated Radio Transmitters (dBm)
				Stand-Alone	Collocated	
WP7700	LTE Band 2	1850	1910	9	8	X
	LTE Band 4	1710	1755	6	6	
	LTE Band 5	824	849	7	6	
	LTE Band 12	699	716	6	6	
	LTE Band 13	777	787	6	6	
	LTE Band 17	704	716	6	6	
	LTE Band 26	814	849	7	6	
Collocated Radio Transmitters	WLAN 2.4 GHz	2400	2500	X	X	25
	WLAN 5 GHz	5150	5850			27
	WiMAX	2300	2400			25
		2500	2700			25
		3300	3800			25
	Bluetooth	2400	2500			15

Table 4: WP7700 RF Exposure Conditions