MPE Evaluation for HL7800 Radio Module

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1. Introduction

In this application we seek modular approval for the HL7800 radio module for use in standalone and collocated simultaneous transmission under mobile and fixed configurations. This Maximum Permissive Exposure (MPE) report demonstrates compliance analysis for HL7800 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	$3.142f^{0.3417}$	$0.008335f^{0.3417}$	$0.02619f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/f^{1.2}$
150000-300000	$0.158f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-5} f$	$616000/f^{1.2}$

Note: f is frequency in MHz.
*Based on nerve stimulation (NS).
** Based on specific absorption rate (SAR).

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 :

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

where

S = Power density (mW/cm^2)
EIRP = Equivalent Isotropic Radiated Power (mW)
D = Separation distance (cm)

3. Stand-Alone Transmission

When HL7800 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 calculations to present a worse-case analysis. 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)	Source-Based Time-Averaged Max EIRP (dBm)	IC Exemption Limit (EIRP) (dBm)	EIRP/ERP Limits
LTE Band 2	1850	1910	24	0.25	6	30	33.50	2 W EIRP
LTE Band 4	1710	1755	24	0.25	6	30	33.27	1 W EIRP
LTE Band 5	824	849	24	0.25	6	30	31.10	6.3 W ERP
LTE Band 12	699	716	24	0.25	6	30	30.61	3 W ERP
LTE Band 13	777	787	24	0.25	6	30	30.93	3 W ERP
LTE Band 14	788	798	24	0.25	6	30	30.97	3 W ERP
LTE Band 17	704	716	24	0.25	6	30	30.63	3 W ERP
LTE Band 25	704	716	24	0.25	6	30	33.50	3 W ERP
LTE Band 26	1710	1780	24	0.25	6	30	31.06	3 W ERP
LTE Band 66	1710	1780	24	0.25	6	30	33.27	3 W ERP

Table 2: WP7610 Stand-Alone Transmission

4. Collocated Transmission

When HL7800 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:

$$\sum MPE\ Ratio = Max\ (WP7610\ MPE\ ratio) + Max\ (WLAN\ MPE\ ratio) + BT\ MPE\ Ratio + Max\ (WiGig\ MPE\ ratio)$$
$$= 0.545+0.372+0.015+0.063=0.995 < 1.0$$

Operating Mode	TX Freq Range (MHz)		Max Time-Avg Cond Power (dBm)	Max Time-Avg Cond Power (W)	Max Ant Gain (dBi)	Source-Based Time-Averaged Max EIRP	Power Density @20 cm (W/m^2)	IC MPE Limit (W/m2)	IC PwrDensity MPE Ratio
LTE Band 2	1850	1910	24	0.25	6	30	1.99	4.48	0.444
LTE Band 4	1710	1755	24	0.25	6	30	1.99	4.24	0.469
LTE Band 5	824	849	24	0.25	4	28	1.26	2.58	0.487
LTE Band 12	699	716	24	0.25	4	28	1.26	2.30	**0.545**
LTE Band 13	777	787	24	0.25	4	28	1.26	2.47	0.507
LTE Band 14	788	798	24	0.25	3	27	1.00	2.50	0.399
LTE Band 17	704	716	24	0.25	3	27	1.00	2.31	0.431
LTE Band 25	704	716	24	0.25	6	30	1.99	4.48	0.444
LTE Band 26	1710	1780	24	0.25	3	27	1.00	2.55	0.390
LTE Band 66	1710	1780	24	0.25	6	30	1.99	4.24	0.469
WLAN 2.4 GHz	2400	2500				30	1.99	5.35	**0.372**
WLAN 5 GHz	5150	5850				30	1.99	9.01	0.221
BT	2400	2500				16	0.08	5.35	**0.015**
WiGig	58320	62640				25	0.63	10.00	**0.063**

Table 3: HL7800 Collocated Transmission

5. Conclusion

The analysis presented in this report concludes that the HL7800 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)		Max Time-Avg Cond Power (dBm)	Antenna Gain Limits(dBi)		EIRP Limits (dBm)
					Standalone	Collocated	
HL7800	LTE Band 2	1850	1910	24	6	6	30
HL7800	LTE Band 4	1710	1755	24	6	6	30
HL7800	LTE Band 5	824	849	24.5	6	4	30
HL7800	LTE Band 12	699	716	24	6	4	30
HL7800	LTE Band 13	777	787	24	6	4	30
HL7800	LTE Band 14	788	798	24.5	6	3	30
HL7800	LTE Band 17	704	716	24	6	3	30
HL7800	LTE Band 25	1850	1915	24	6	6	30
HL7800	LTE Band 26	814	849	24	6	3	30
HL7800	LTE Band 66	1710	1780	24	6	6	30
Collocated Radio Transmitters	WLAN 2.4 GHz	2400	2500				30
	WLAN 5 GHz	5150	5850				30
	BT	2400	2500				16
	WiGig	58320	62640				25

Table 4: HL7800 RF Exposure Conditions