



# MPE Evaluation for HL7800 Radio Module

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May 20, 2020

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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 Permissible 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 <sup>2</sup> ) | Averaging Time  E  <sup>2</sup> ,  H  <sup>2</sup> or S (minutes) |
|-----------------------|-----------------------------------|-----------------------------------|---|---|
| 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

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 <sup>2</sup> ) | Reference Period (minutes) |
|---|---------------------------|--|-----------------------------------|----------------------------|
| 0.003-10 <sup>21</sup>  | 83                        | 90                                       | -                                 | Instantaneous*             |
| 0.1-10  | -                         | 0.73/ f                                  | -                                 | 6**                        |
| 1.1-10  | 87/ f <sup>0.5</sup>      | -  | -                                 | 6**                        |
| 10-20   | 27.46                     | 0.0728                                   | 2                                 | 6                          |
| 20-48   | 58.07/ f <sup>0.25</sup>  | 0.1540/ f <sup>0.25</sup>                | 8.944/ f <sup>0.5</sup>           | 6                          |
| 48-300  | 22.06                     | 0.05852                                  | 1.291                             | 6                          |
| 300-6000  | 3.142 f <sup>0.3417</sup> | 0.008335 f <sup>0.3417</sup>             | 0.02619f <sup>0.6834</sup>        | 6                          |
| 6000-15000  | 61.4                      | 0.163                                    | 10                                | 6                          |
| 15000-150000  | 61.4                      | 0.163                                    | 10                                | 616000/ f <sup>1.2</sup>   |
| 150000-300000   | 0.158 f <sup>0.5</sup>    | 4.21 x 10 <sup>-4</sup> f <sup>0.5</sup> | 6.67 x 10 <sup>-5</sup> f         | 616000/ f <sup>1.2</sup>   |
| <p>Note: f is frequency in MHz.<br/>           *Based on nerve stimulation (NS).<br/>           ** 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/cm<sup>2</sup>)

EIRP = Equivalent Isotropic Radiated Power (mW)

D = Separation distance (cm)

### 3. HL7800 Product Specifications

HL7800 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.

| Operating Mode | Operating Mode | TX Freq Range (MHz) |      | Max Time-Avg Cond Power (dBm) |
|----------------|----------------|---------------------|------|-------------------------------|
| LTE CAT-M1/NB1 | LTE Band 2     | 1850                | 1910 | 24.5                          |
|                | LTE Band 4     | 1710                | 1755 | 24.5                          |
|                | LTE Band 5     | 824                 | 849  | 24.5                          |
|                | LTE Band 12    | 699                 | 716  | 24.5                          |
|                | LTE Band 13    | 777                 | 787  | 24.5                          |
|                | LTE Band 25    | 1850                | 1915 | 24.5                          |
|                | LTE Band 26    | 814                 | 849  | 24.5                          |
|                | LTE Band 66    | 1710                | 1780 | 24.5                          |

Table 3: HL7800 Frequency Bands and Output Power

## 4. 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 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 (dBm) | IC Exemption Limit (EIRP) (dBm) | EIRP/ERP Limits |
|----------------|---------------------|------|-------------------------------|-----------------------------|--------------------|------------|---|---------------------------------|-----------------|
|                |                     |      |                               |                             |                    |            |   |                                 |                 |
| LTE Band 2     | 1850                | 1910 | 24.5                          | 8                           | 0.28               | 100%       | 32.5                                      | 33.50                           | 2 W EIRP        |
| LTE Band 4     | 1710                | 1755 | 24.5                          | 6                           | 0.28               | 100%       | 30.5                                      | 33.27                           | 1 W EIRP        |
| LTE Band 5     | 824                 | 849  | 24.5                          | 6                           | 0.28               | 100%       | 30.5                                      | 31.10                           | 7 W ERP         |
| LTE Band 12    | 699                 | 716  | 24.5                          | 6                           | 0.28               | 100%       | 30.5                                      | 30.61                           | 3 W ERP         |
| LTE Band 13    | 777                 | 787  | 24.5                          | 6                           | 0.28               | 100%       | 30.5                                      | 30.93                           | 3 W ERP         |
| LTE Band 25    | 1850                | 1915 | 24.5                          | 6                           | 0.28               | 100%       | 30.5                                      | 33.50                           | 3 W ERP         |
| LTE Band 26    | 814                 | 849  | 24.5                          | 6                           | 0.28               | 100%       | 30.5                                      | 31.06                           | 7 W ERP         |
| LTE Band 66    | 1710                | 1780 | 24.5                          | 6                           | 0.28               | 100%       | 30.5                                      | 33.27                           | 1 W ERP         |

Table 2: HL7800 Stand-Alone Transmission

## 5. 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  $\leq 1.0$ .

The evaluation here considers a WLAN transmitter, a Bluetooth transmitter and a WiGig 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:

$$\begin{aligned} \sum MPE \text{ Ratio} &= \text{Max (HL7800 MPE ratio)} + \text{Max (WLAN MPE ratio)} + \text{BT MPE Ratio} \\ &\quad + \text{Max (WiGig MPE ratio)} \\ &= 0.551+0.372+0.011+0.063=0.998 < 1.0 \end{aligned}$$

| 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 <sup>2</sup> ) | IC MPE Limit (W/m <sup>2</sup> ) | IC PwrDensity MPE Ratio |
|----------------|---------------------|-------|-------------------------------|-----------------------------|--------------------|------------|-------------------------------------|--|----------------------------------|-------------------------|
|                |                     |       |                               |                             |                    |            |                                     |  |                                  |                         |
| LTE Band 2     | 1850                | 1910  | 24.5                          | 0.28                        | 6                  | 100%       | 30.5                                | 2.23                                     | 4.48                             | 0.499                   |
| LTE Band 4     | 1710                | 1755  | 24.5                          | 0.28                        | 6                  | 100%       | 30.5                                | 2.23                                     | 4.24                             | 0.526                   |
| LTE Band 5     | 824                 | 849   | 24.5                          | 0.28                        | 4                  | 100%       | 28.5                                | 1.41                                     | 2.58                             | 0.547                   |
| LTE Band 12    | 699                 | 716   | 24.5                          | 0.28                        | 3                  | 100%       | 27.5                                | 1.12                                     | 2.30                             | 0.486                   |
| LTE Band 13    | 777                 | 787   | 24.5                          | 0.28                        | 3                  | 100%       | 27.5                                | 1.12                                     | 2.47                             | 0.452                   |
| LTE Band 25    | 1850                | 1915  | 24.5                          | 0.28                        | 6                  | 100%       | 30.5                                | 2.23                                     | 4.48                             | 0.499                   |
| LTE Band 26    | 814                 | 849   | 24.5                          | 0.28                        | 4                  | 100%       | 28.5                                | 1.41                                     | 2.55                             | <b>0.551</b>            |
| LTE Band 66    | 1710                | 1780  | 24.5                          | 0.28                        | 6                  | 100%       | 30.5                                | 2.23                                     | 4.24                             | 0.526                   |
| WLAN 2.4 GHz   | 2400                | 2500  |                               |                             |                    |            | 30                                  | 1.99                                     | 5.35                             | <b>0.372</b>            |
| WLAN 5 GHz     | 5150                | 5850  |                               |                             |                    |            | 30                                  | 1.99                                     | 9.01                             | 0.221                   |
| BT             | 2400                | 2500  |                               |                             |                    |            | 15                                  | 0.06                                     | 5.35                             | <b>0.011</b>            |
| WiGig          | 58320               | 62640 |                               |                             |                    |            | 25                                  | 0.63                                     | 10                               | <b>0.063</b>            |

Table 3: HL7800 Collocated Transmission



## 6. 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  | 24.5                          | 8                        | 6          | X                 |
|                               | LTE Band 4     | 1710                | 1755  | 24.5                          | 6                        | 6          |                   |
|                               | LTE Band 5     | 824                 | 849   | 24.5                          | 6                        | 4          |                   |
|                               | LTE Band 12    | 699                 | 716   | 24.5                          | 6                        | 3          |                   |
|                               | LTE Band 13    | 777                 | 787   | 24.5                          | 6                        | 3          |                   |
|                               | LTE Band 25    | 1850                | 1915  | 24.5                          | 6                        | 6          |                   |
|                               | LTE Band 26    | 814                 | 849   | 24.5                          | 6                        | 4          |                   |
|                               | LTE Band 66    | 1710                | 1780  | 24.5                          | 6                        | 6          |                   |
| Collocated Radio Transmitters | WLAN 2.4 GHz   | 2400                | 2500  |                               | X                        | X          | 30                |
|                               | WLAN 5 GHz     | 5150                | 5850  |                               |                          |            | 30                |
|                               | BT             | 2400                | 2500  |                               |                          |            | 15                |
|                               | WiGig          | 58320               | 62640 |                               |                          |            | 25                |

Table 4: HL7800 RF Exposure Conditions