
# MPE Evaluation for AR7582-1 Wireless Module

**January 24, 2018**

# 1. Introduction

In this application we seek modular approval for the AR7582-1 radio module. This Maximum Permissive Exposure (MPE) report demonstrates compliance analysis for AR7582 radio module with FCC CFR 47 §2.1091 and IC RSS-102 for operation in mobile exposure conditions. 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.

Any collocated transmitter must have a valid FCC ID with the collocated parameters defined in this MPE report. A separation distance of 20cm or more shall be maintained between the end user and each collocated transmitting antenna.

## 2. RF Exposure Limits and Equations

### FCC RULES:

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.

Table 1: Limits for Maximum Permissible Exposure (MPE)

**(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

### IC RULES:

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) |
|---|---|---|---|---|
| $0.003\text{-}10^{21}$ | 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:**

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. AR7582-1 Product Specs

AR7582-1 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) | DL Freq. (MHz) | Max Power |
|---|---|---|---|---|
| LTE | B2 | 1850 – 1910 | 1930 – 1990 | 25.7 dBm |
| | B4 | 1710 – 1755 | 2110 – 2155 | 25.7 dBm |
| | B5 | 824 – 849 | 869 – 894 | 25.7 dBm |
| | B12 | 699 – 716 | 729 – 746 | 25.7 dBm |
| | B13 | 777 – 787 | 746 – 756 | 25.7 dBm |
| | B17 | 704 – 716 | 734 – 746 | 25.7 dBm |
| WCDMA/HSDPA/HSUPA | B2 | 1850 – 1910 | 1930 – 1990 | 25.7 dBm |
| | B4 | 1710-1755 | 2110 - 2155 | 25.7 dBm |
| | B5 | 829 – 849 | 864 – 894 | 25.7 dBm |
| GSM | G850 | 829 – 849 | 864 – 894 | 35 dBm |
| | G1900 | 1850 – 1910 | 1930 – 1990 | 32 dBm |
| EDGE | G850 | 829 – 849 | 864 – 894 | 30 dBm |
| | G1900 | 1850 – 1910 | 1930 – 1990 | 29 dBm |

Table 3: AR7582-1 Frequency Bands and Output Power

AR7582-1 supports multislot Class 12 GPRS and Class 12 EGPRS with power backoff for GMSK modulation at 3 and 4 times slots, as specified in Table 4.

| | | | | | Power Backoff (dB) | | | |
|---|---|---|---|---|---|---|---|---|
| Power Class | Mode | Band | Coding Scheme | Modulation | Time Slot1 | Time Slot2 | Time Slot3 | Time Slot4 |
| 12 | EGPRS | GSM850 | MCS1 - MCS4 | GMSK | 0 | 2 | 4 | 5 |
| | | GSM850 | MCS5 - MCS9 | 8PSK | 0 | 0 | 0 | 0 |
| | | GSM1900 | MCS1 - MCS4 | GMSK | 0 | 2 | 4 | 5 |
| | | GSM1900 | MCS5 - MCS9 | 8PSK | 0 | 0 | 0 | 0 |

Table 4: AR7582-1 Power Backoff

## 4. Stand-Alone Transmission

When AR7582-1 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 5 below, the resulted EIRP are always below the IC exemption limits for all the operating modes.

| | Technology | Frequency (MHz) | Maximum Conducted Power (dBm) | Maximum Conducted Power (W) | Maximum Antenna Gain (dBi) | Duty Cycle | Average EIRP (dBm) | Power Density @ 20cm (W/m^2) | IC Exemption Limit (EIRP) (dBm) | ERP/ EIRP Limits |
|---|---|---|---|---|---|---|---|---|---|---|
| AR7582-1 module(Standalone) | G850-GMSK (2TS) | 824 - 849 | 33 | 1.995 | 4.0 | 25% | 30.99 | 2.50 | 31.10 | 7W ERP |
| | G850-GMSK (3TS) | 824 - 849 | 31 | 1.259 | 4.0 | 38% | 30.79 | 2.39 | 31.10 | 7W ERP |
| | G850-GMSK (4TS) | 824 - 849 | 30 | 1.000 | 4.0 | 50% | 30.99 | 2.50 | 31.10 | 7W ERP |
| | G850-8PSK (2TS) | 824 - 849 | 30 | 1.000 | 4.0 | 25% | 27.98 | 1.25 | 31.10 | 7W ERP |
| | G850-8PSK (3TS) | 824 - 849 | 30 | 1.000 | 4.0 | 38% | 29.80 | 1.90 | 31.10 | 2W EIRP |
| | G850-8PSK (4TS) | 824 - 849 | 30 | 1.000 | 4.0 | 50% | 30.99 | 2.50 | 31.10 | 2W EIRP |
| | G1900-GMSK (4TS) | 1850 - 1910 | 27 | 0.501 | 5.0 | 50% | 28.99 | 1.58 | 33.50 | 2W EIRP |
| | G1900-8PSK (4TS) | 1850 - 1910 | 29 | 0.794 | 5.0 | 50% | 30.99 | 2.50 | 33.50 | 2W EIRP |
| | WCDMA B II | 1850 - 1910 | 25.7 | 0.372 | 5.0 | 100% | 30.70 | 2.34 | 33.50 | 2W EIRP |
| | WCDMA B IV | 1710 - 1755 | 25.7 | 0.372 | 4.0 | 100% | 29.7 | 1.86 | 33.27 | 1W EIRP |
| | WCDMA B V | 824 - 849 | 25.7 | 0.372 | 4.0 | 100% | 29.70 | 1.86 | 31.10 | 7W ERP |
| | LTE B2 | 1850 – 1910 | 25.7 | 0.331 | 5.0 | 100% | 30.7 | 2.34 | 33.50 | 2W EIRP |
| | LTE B4 | 1710 – 1755 | 25.7 | 0.331 | 4.0 | 100% | 29.7 | 1.86 | 33.27 | 1W EIRP |
| | LTE B5 | 824 – 849 | 25.7 | 0.331 | 4.0 | 100% | 29.7 | 1.86 | 31.10 | 7W ERP |
| | LTE B12 | 699 – 716 | 25.7 | 0.331 | 4.0 | 100% | 29.7 | 1.86 | 30.61 | 3W ERP |
| | LTE B13 | 777 – 787 | 25.7 | 0.331 | 4.0 | 100% | 29.7 | 1.86 | 30.93 | 7W ERP |
| | LTE B17 | 704 – 716 | 25.7 | 0.331 | 4.0 | 100% | 29.7 | 1.86 | 30.64 | 7W ERP |

Table 5: AR7582-1 Standalone Transmission

## 4. Collocated Transmission

When AR7582 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 6 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:

$\Sigma MPE\ Ratio$ = Max (AR7582 MPE ratio) + Max (WLAN/WiMax MPE ratio) + BT MPE Ratio
$= 0.769+0.192+0.037=0.998 < 1.0$

| | Technology | Frequency (MHz) | Maximum Conducted Power (dBm) | Maximum Conducted Power (W) | Maximum Antenna Gain (dBi) | Duty Cycle | Average EIRP (dBm) | Power Density @ 20cm (W/m^2) | IC MPE Limit (W/m^2) | IC PwrDensity MPE Ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| AR7582-1 module (Collocated) | G850-GMSK(2TS) | 824 - 849 | 33 | 2.00 | 3.0 | 25% | 30.99 | 1.98 | 2.58 | 0.767 |
| | G850-GMSK(3TS) | 824 - 849 | 31 | 1.58 | 3.0 | 38% | 30.79 | 1.90 | 2.58 | 0.736 |
| | G850-GMSK(4TS) | 824 - 849 | 30 | 1.26 | 3.0 | 50% | 30.99 | 1.98 | 2.58 | 0.769 |
| | G850-8PSK(2TS) | 824 - 849 | 30 | 0.63 | 3.0 | 25% | 27.98 | 0.99 | 2.58 | 0.385 |
| | G850-8PSK(3TS) | 824 - 849 | 30 | 0.63 | 3.0 | 38% | 29.80 | 1.51 | 2.58 | 0.585 |
| | G850-8PSK(4TS) | 824 - 849 | 30 | 0.63 | 3.0 | 50% | 30.99 | 1.98 | 2.58 | 0.769 |
| | G1900-GMSK(4TS) | 1850 - 1910 | 27 | 0.63 | 5.0 | 50% | 28.99 | 1.58 | 4.48 | 0.352 |
| | G1900-8PSK(4TS) | 1850 - 1910 | 29 | 0.50 | 5.0 | 50% | 30.99 | 2.50 | 4.48 | 0.558 |
| | WCDMA Band II | 1850 - 1910 | 25.7 | 0.25 | 5.0 | 100% | 30.70 | 2.34 | 4.48 | 0.522 |
| | WCDMA Band IV | 1710 - 1755 | 25.7 | 0.372 | 4.0 | 100% | 29.7 | 1.86 | 4.24 | 0.438 |
| | WCDMA Band V | 824 - 849 | 25.7 | 0.372 | 3.0 | 100% | 29.70 | 1.47 | 2.58 | 0.572 |
| | LTE B2 | 1850 – 1910 | 25.7 | 0.331 | 5.0 | 100% | 30.2 | 2.34 | 4.48 | 0.522 |
| | LTE B4 | 1710 – 1755 | 25.7 | 0.331 | 4.0 | 100% | 29.2 | 1.86 | 4.24 | 0.438 |
| | LTE B5 | 824 – 849 | 25.7 | 0.331 | 3.0 | 100% | 29.2 | 1.47 | 2.58 | 0.572 |
| | LTE B12 | 699 – 716 | 25.7 | 0.331 | 3.0 | 100% | 29.2 | 1.47 | 2.30 | 0.641 |
| | LTE B13 | 777 – 787 | 25.7 | 0.331 | 3.0 | 100% | 29.2 | 1.47 | 2.47 | 0.597 |
| | LTE B17 | 704 – 716 | 25.7 | 0.331 | 3.0 | 100% | 29.2 | 1.47 | 2.31 | 0.638 |
| Other Collocated Transmitters | WLAN | 2400 -2500 | | | | 100% | 27.00 | 1.00 | 5.35 | 0.187 |
| | WLAN | 5150 -5850 | | | | 100% | 27.00 | 1.00 | 9.01 | 0.111 |
| | WiMax | 2300 -2400 | | | | 100% | 27.00 | 1.00 | 5.19 | 0.192 |
| | WiMax | 2500 -2700 | | | | 100% | 27.00 | 1.00 | 5.50 | 0.181 |
| | WiMax | 3300 -3800 | | | | 100% | 27.00 | 1.00 | 6.65 | 0.150 |
| | BT | 2400 -2500 | | | | 100% | 20.00 | 0.20 | 5.35 | 0.037 |

Table 6: AR7582-1 Collocated Transmission

## 5. Conclusion

The analysis presented in this report concludes that the AR7582-1 radio module, when transmitting either in standalone or simultaneously with other co-located radio transmitters within a host device, is compliant with the 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.

| | Technology | | Frequency (MHz) | Maximum Antenna Gain (dBi) | | EIRP Limits (dbm) |
|---|---|---|---|---|---|---|
| | | | | Standalone | Collocated | |
| AR7582-1 | GPRS/EDGE 850 | | 824-849 | 4 | 3 | |
| | GPRS/EDGE 1900 | | 1850-1910 | 5 | 5 | |
| | UMTS 850 | | 824-849 | 4 | 3 | |
| | UMTS 1700 | | 1710-1755 | 4 | 4 | |
| | UMTS 1900 | | 1850-1910 | 5 | 5 | |
| | LTE B2 | | 1850 – 1910 | 5 | 5 | |
| | LTE B4 | | 1710 – 1755 | 4 | 4 | |
| | LTE B5 | | 824 – 849 | 4 | 3 | |
| | LTE B12 | | 699 – 716 | 4 | 3 | |
| | LTE B13 | | 777 – 787 | 4 | 3 | |
| | LTE B17 | | 704 – 716 | 4 | 3 | |
| Collocated Transmitters | WLAN | | 2400 -2500 | | | 27 |
| | WLAN | | 5150 -5850 | | | 27 |
| | | WiMAX | 2300 -2400 | | | 27 |
| | | WiMAX | 2500 -2700 | | | 27 |
| | | WiMAX | 3300 -3800 | | | 27 |
| | BT | BT | 2400 -2500 | | | 20 |

Table 7: AR7582-1 RF Exposure Conditions