



MPE Evaluation for AR7592-1 Wireless Module

December 17, 2019

1. Introduction

In this application we seek modular approval for the AR7592-1 radio module. This Maximum Permissible Exposure (MPE) report demonstrates compliance analysis for AR7592-1 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)
0.003-10 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}
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:

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

where S = Power density (mW/cm²)

EIRP = Equivalent Isotropic Radiated Power (mW)

D = Separation distance (cm)

3. AR7592-1 Product Specs

AR7592-1 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	25.2 dBm
	B4	1710 – 1755	2110 – 2155	25.2 dBm
	B5	824 – 849	869 – 894	25.2 dBm
	B12	699 – 716	729 – 746	25.2 dBm
	B13	777 – 787	746 – 756	25.2 dBm
	B17	704 – 716	734 – 746	25.2 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: AR7592-1 Frequency Bands and Output Power

AR7592-1 supports multislots 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 Class	Mode	Band	Coding Scheme	Modulation	Power Backoff (dB)			
					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: AR7592-1 Power Backoff

4. Stand-Alone Transmission

When AR7592-1 module transmits as a stand-alone mobile device, the source-based time-averaged EIRP is calculated by summing up conducted power and antenna gain. 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
AR7592 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	25.2	0.331	5.0	100%	30.2	2.08	33.50	2W EIRP
	LTE B4	1710 – 1755	25.2	0.331	4.0	100%	29.2	1.65	33.27	1W EIRP
	LTE B5	824 – 849	25.2	0.331	4.0	100%	29.2	1.65	31.10	7W ERP
	LTE B12	699 – 716	25.2	0.331	4.0	100%	29.2	1.65	30.61	3W ERP
	LTE B13	777 – 787	25.2	0.331	4.0	100%	29.2	1.65	30.93	7W ERP
	LTE B17	704 – 716	25.2	0.331	4.0	100%	29.2	1.65	30.64	7W ERP

Table 5: AR7592-1 Standalone Transmission

4. Collocated Transmission

When AR7592-1 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:

$$\begin{aligned} \Sigma MPE \text{ Ratio} &= \text{Max (AR7592-1 MPE ratio)} + \text{Max (WLAN/WiMax MPE ratio)} + \text{BT MPE Ratio} \\ &= 0.769 + 0.192 + 0.037 = 0.998 < 1.0 \end{aligned}$$

	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
AR7592 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	25.2	0.331	5.0	100%	30.2	2.08	4.48	0.465
	LTE B4	1710 - 1755	25.2	0.331	4.0	100%	29.2	1.65	4.24	0.390
	LTE B5	824 - 849	25.2	0.331	3.0	100%	29.2	1.31	2.58	0.509
	LTE B12	699 - 716	25.2	0.331	3.0	100%	29.2	1.31	2.30	0.571
	LTE B13	777 - 787	25.2	0.331	3.0	100%	29.2	1.31	2.47	0.532
	LTE B17	704 - 716	25.2	0.331	3.0	100%	29.2	1.31	2.31	0.569
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: AR7592-1 Collocated Transmission

5. Conclusion

The analysis presented in this report concludes that the AR7592-1 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	
AR7592	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: AR7592-1 RF Exposure Conditions