



MPE Evaluation for EM7655 Radio Module

December 5, 2012

1. Introduction

In this application we seek for modular approval to the EM7655 wireless modem for use in standalone and collocated simultaneous transmission under mobile configuration. This Maximum Permissible Exposure (MPE) report demonstrates compliance analysis for EM7655 wireless modem with FCC CFR 47 §2.1091 and IC RSS-102 for standalone and collocated transmission 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 documenting equivalent or degraded RF characteristics 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 WWAN, WiMAX or WLAN, and Bluetooth transmitting antenna.

Portable user conditions or additional collocated transmitters not allowed based on this RF exposure analysis require a Class II permissive change and updated RF exposure report.

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.

(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 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)	Averaging Time (minutes)
0.003-1	280	2.19	-	6
1-10	280/f	2.19/f	-	6
10-30	28	2.19/f	-	6
30-300	28	0.073	2*	6
300-1500	1.585 f ^{0.5}	0.0042 f ^{0.5}	f/150	6
1500-15000	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.

* Power density limit is applicable at frequencies greater than 100 MHz.

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

EQUATIONS:

Power density is given by :

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

where

S = Power density (mW/cm²)

EIRP = Equivalent Isotropic Radiated Power (mW)

D = Separation distance (cm)

3. Product Declarations

The EM7655 wireless modem can be installed for use in any mobile host as long as the antenna gain of the host antenna does not exceed the gain listed in table 2.

This MPE analysis is applicable to any collocated transmitters with transmit power:

- less than or equal to 29.0dBm for WLAN/WiMAX; and
- less than or equal to 15.0dBm for BT.

Specific FCC IDs for those devices are not necessary or identified in this analysis providing they are classified as mobile transmitters. A 100% duty cycle is used for calculations to present a worse-case analysis when applicable.

Mode	Equipment Category	Max Transmitter Duty Cycle	Transmitter Range (MHz)	Maximum Conducted Power		Max Antenna Gain (dBi)	
				(dBm)	(W)	Standalone	Collocated
GPRS	Class 10	25%	824-849	33.0	2.00	6.5	3.0
			1850-1910	30.0	1.00	3.0	3.0
EDGE	Class 10	25%	824-849	28.0	0.63	6.5	3.0
			1850-1910	27.0	0.50	3.0	3.0
	Class 11	37.50%	824-849	26.2	0.42	6.5	3.0
			1850-1910	25.2	0.33	3.0	3.0
	Class 12	50%	824-849	25.0	0.32	6.5	3.0
			1850-1910	24.0	0.25	3.0	3.0
CDMA	EvDo	100%	824-849	25.0	0.32	6.5	3.0
			1850-1910	25.0	0.32	3.0	3.0
			816.0 – 823.975	25.0	0.32	6.5	3.0
UMTS	HSDPA HSUPA	100%	824 - 849	24.0	0.25	6.5	3.0
			1710-1755	24.0	0.25	6.0	6.0
			1850 - 1910	24.0	0.25	3.0	3.0
LTE	Band 17 Band 13 Band 5 Band 4 Band 2 Band 25	100%	704 - 716	24.0	0.25	9.0	6.0
			777 - 787	24.0	0.25	9.0	6.0
			824 - 849	24.0	0.25	6.5	3.0
			1710 - 1755	24.0	0.25	6.0	6.0
			1850 - 1910	24.0	0.25	3.0	3.0
			1850 - 1915	24.0	0.25	3.0	3.0

Table 2: EM7655 Standalone and Collocated Transmission Declarations

4. MPE Calculations

The WWAN MPE calculations are based on conservative conducted transmit power exceeding those listed in the FCC ID N7NEM7655 and IC number 2417C-EM7655 filing. The higher transmit power levels are used to present a worst case assessment.

The WiMAX, WLAN, and BT transmit power and antenna gain parameters represent a maximum transmit power for a given frequency band.

Integration of either a WiMAX or WLAN, and BT module that exceeds the parameters requires a new FCC authorization or permissive change application. A maximum antenna gain of 5 dBi for WLAN/WiMAX/BT has been assumed for all collocated antennas.

Table 3, 4, and 5 summarize transmitter parameters associated with this analysis.

4.1. Individual Transmitter Calculations

4.1.1. Maximum Output Power

The maximum power calculations for EM7655 per wireless technology are shown in Table 3

	Technology	Frequency (MHz)	Maximum Conducted Power (dBm)	Maximum Conducted Power (W)	Maximum Antenna Gain (dBi)	Duty Cycle	Max EIRP (dBm)	Max EIRP (W)	Max ERP (dBm)	Max ERP (W)	Max output power limit
EM7655 module (Standalone)	GPRS 2 UL	824-849	33.0	2.00	6.5	0.250	39.500	8.913	37.360	5.445	7 W ERP
	EDGE 2 UL	824-849	28.0	0.63	6.5	0.250	34.500	2.818	32.360	1.722	7 W ERP
	EDGE 3 UL	824-849	26.2	0.42	6.5	0.375	32.700	1.862	30.560	1.138	7 W ERP
	EDGE 4UL	824-849	25.0	0.32	6.5	0.500	31.500	1.413	29.360	0.863	7 W ERP
	GPRS 2 UL	1850-1910	30.0	1.00	3.0	0.250	33.000	1.995	30.860	1.219	2 W EIRP
	EDGE 2 UL	1850-1910	27.0	0.50	3.0	0.250	30.000	1.000	27.860	0.611	2 W EIRP
	EDGE 3 UL	1850-1910	25.2	0.33	3.0	0.375	28.200	0.661	26.060	0.404	2 W EIRP
	EDGE 4UL	1850-1910	24.0	0.25	3.0	0.500	27.000	0.501	24.860	0.306	2 W EIRP
	CDMA BC0	824-849	25.0	0.32	6.5	1.000	31.500	1.413	29.360	0.863	7 W ERP
	CDMA BC1	1850-1910	25.0	0.32	3.0	1.000	28.000	0.631	25.860	0.385	2 W EIRP
	CDMA BC10	816.0-823.975	25.0	0.32	6.5	1.000	31.500	1.413	29.360	0.863	7 W ERP
	UMTS	824 - 849	24.0	0.25	6.5	1.000	30.500	1.122	28.360	0.685	7 W ERP
	UMTS	1710-1755	24.0	0.25	6.0	1.000	30.000	1.000	27.860	0.611	1 W EIRP
	UMTS	1850 - 1910	24.0	0.25	3.0	1.000	27.000	0.501	24.860	0.306	2 W EIRP
	LTE	704 - 716	24.0	0.25	9.0	1.000	33.000	1.995	30.860	1.219	3 W ERP
	LTE	777 - 787	24.0	0.25	9.0	1.000	33.000	1.995	30.860	1.219	3 W ERP
	LTE	824 - 849	24.0	0.25	6.5	1.000	30.500	1.122	28.360	0.685	7 W ERP
	LTE	1710 - 1755	24.0	0.25	6.0	1.000	30.000	1.000	27.860	0.611	1 W EIRP
	LTE	1850– 1910	24.0	0.25	3.0	1.000	27.000	0.501	24.860	0.306	2 W EIRP
	LTE	1850- 1915	24.0	0.25	3.0	1.000	27.000	0.501	24.860	0.306	2 W EIRP

Table 3: EM7655 Maximum Output Power Calculation

4.1.2. Standalone Power Density

The power density calculations for the individual transmitters per wireless technology at an exposure minimum separation distance of 20cm are shown in Table 4.

For frequency dependent limit, the lowest transmitter frequency was used to represent the lowest MPE limit in this analysis (eg. 824MHz = 0.549mW/cm²)

	Technology	Frequency (MHz)	Maximum Conducted Power (dBm)	Maximum Conducted Power (W)	Maximum Antenna Gain (dBi)	Duty Cycle	Average EIRP (dBm)	Average EIRP (mW)	Power Density @ 20cm (mW/cm ²)	FCC MPE Limit (mW/cm ²)
EM7655 Module (Standalone)	GPRS 2 UL	824-849	33.0	2.00	6.5	0.250	33.48	2228.127	0.443	0.549
	EDGE 2 UL	824-849	28.0	0.63	6.5	0.250	28.48	704.596	0.140	0.549
	EDGE 3 UL	824-849	26.2	0.42	6.5	0.375	28.44	698.283	0.139	0.549
	EDGE 4UL	824-849	25.0	0.32	6.5	0.500	28.49	706.269	0.141	0.549
	GPRS 2 UL	1850-1910	30.0	1.00	3.0	0.250	26.98	498.816	0.099	1.000
	EDGE 2 UL	1850-1910	27.0	0.50	3.0	0.250	23.98	250.000	0.050	1.000
	EDGE 3 UL	1850-1910	25.2	0.33	3.0	0.375	23.94	247.760	0.049	1.000
	EDGE 4UL	1850-1910	24.0	0.25	3.0	0.500	23.99	250.594	0.050	1.000
	CDMA BC0	824-849	25.0	0.3	6.5	1.000	31.50	1412.538	0.281	0.549
	CDMA BC1	1850-1910	25.0	0.3	3.0	1.000	28.00	630.957	0.126	1.000
	CDMA BC10	816.0-823.975	25.0	0.3	6.5	1.000	31.50	1412.538	0.281	0.544
	UMTS	824 - 849	24.0	0.251	6.5	1.000	30.50	1122.018	0.223	0.549
	UMTS	1710-1755	24.0	0.251	6.0	1.000	30.00	1000.000	0.199	1.000
	UMTS	1850 - 1910	24.0	0.251	3.0	1.000	27.00	501.187	0.100	1.000
	LTE	704 - 716	24.0	0.3	9.0	1.000	33.00	1995.262	0.397	0.469
	LTE	777 - 787	24.0	0.3	9.0	1.000	33.00	1995.262	0.397	0.518
	LTE	824 - 849	24.0	0.3	6.5	1.000	30.50	1122.018	0.223	0.549
	LTE	1710 - 1755	24.0	0.3	6.0	1.000	30.00	1000.000	0.199	1.000
	LTE	1850 - 1910	24.0	0.3	3.0	1.000	27.00	501.187	0.100	1.000
	LTE	1850 - 1915	24.0	0.3	3.0	1.000	27.00	501.187	0.100	1.000

Table 4: EM7655 Standalone MPE Calculation

4.2. Collocated MPE Calculation

The WiMAX, WLAN, and BT power levels listed represent the worse-case scenario for corresponding frequency ranges given.

	Technology	Frequency (MHz)	Maximum Conducted Power (dBm)	Maximum Conducted Power (W)	Maximum Antenna Gain (dBi)	Duty Cycle	Average EIRP (dBm)	Average EIRP (mW)	Power Density @ 20cm (mW/cm ²)	FCC MPE Limit (mW/cm ²)
EM7655 Module (Collocated)	GPRS 2 UL	824-849	33.0	2.00	3.0	0.250	29.98	995.268	0.198	0.549
	EDGE 2 UL	824-849	28.0	0.63	3.0	0.250	24.98	314.731	0.063	0.549
	EDGE 3 UL	824-849	26.2	0.42	3.0	0.375	24.94	311.911	0.062	0.549
	EDGE 4UL	824-849	25.0	0.32	3.0	0.500	24.99	315.479	0.063	0.549
	GPRS 2 UL	1850-1910	30.0	1.00	3.0	0.250	26.98	498.816	0.099	1.000
	EDGE 2 UL	1850-1910	27.0	0.50	3.0	0.250	23.98	250.000	0.050	1.000
	EDGE 3 UL	1850-1910	25.2	0.33	3.0	0.375	23.94	247.760	0.049	1.000
	EDGE 4UL	1850-1910	24.0	0.25	3.0	0.500	23.99	250.594	0.050	1.000
	CDMA BC0	824-849	25.0	0.3	3.0	1.000	28.00	630.957	0.126	0.549
	CDMA BC1	1850-1910	25.0	0.3	3.0	1.000	28.00	630.957	0.126	1.000
	CDMA BC10	816.0-823.975	25.0	0.3	3.0	1.000	28.00	630.957	0.126	0.544
	UMTS	824 - 849	24.0	0.251	3.0	1.000	27.00	501.187	0.100	0.549
	UMTS	1710-1755	24.0	0.251	6.0	1.000	30.00	1000.000	0.199	1.000
	UMTS	1850 - 1910	24.0	0.251	3.0	1.000	27.00	501.187	0.100	1.000
	LTE	704 - 716	24.0	0.3	6.0	1.000	30.00	1000.000	0.199	0.469
	LTE	777 - 787	24.0	0.3	6.0	1.000	30.00	1000.000	0.199	0.518
	LTE	824 - 849	24.0	0.3	3.0	1.000	27.00	501.187	0.100	0.549
	LTE	1710 - 1755	24.0	0.3	6.0	1.000	30.00	1000.000	0.199	1.000
	LTE	1850 - 1910	24.0	0.3	3.0	1.000	27.00	501.187	0.100	1.000
	LTE	1850 - 1915	24.0	0.3	3.0	1.000	27.00	501.187	0.100	1.000
Other Collocated Transmitters	WLAN	2400 - 2500	29.0	0.794	5.0	1.000	34.00	2511.886	0.500	1.000
	WLAN	5150 - 5850	29.0	0.794	5.0	1.000	34.00	2511.886	0.500	1.000
	WiMax	2300 - 2400	29.0	0.794	5.0	1.000	34.00	2511.886	0.500	1.000
	WiMax	2500 - 2700	29.0	0.794	5.0	1.000	34.00	2511.886	0.500	1.000
	WiMax	3300 - 3800	29.0	0.794	5.0	1.000	34.00	2511.886	0.500	1.000
	BT	2400 - 2500	15.0	0.032	5.0	1.000	20.00	100.000	0.020	1.000

Table 5: EM7655 Collocated MPE Calculation

Per OET Bulletin 65, when RF sources have difference frequencies, the fraction of the FCC power density limit shall be determined and the sum of all fractional components shall be less than 1.

WLAN/WiMAX Band (GHz)	WLAN/WiMAX Pd (mW/cm ²)	BT Pd (mW/cm ²)	WLAN/WiMAX + BT Pd (mW/cm ²)	Limit
2.3 - 2.4	0.500	0.020	0.520	1.000
2.4 - 2.5				
2.5 - 2.7				
3.3 - 3.8				
5.15 - 5.85				

Table 6: (WLAN or WiMAX) + BT Collocated MPE Calculation

WLAN / WiMAX Band (GHz)	WLAN / WiMAX + BT Pd (mW/cm ²)	FCC MPE Limit (mW/cm ²)	(WLAN / WiMAX + BT Pd) / (MPE Limit)	850 MHz WWAN Pd (mW/cm ²)	FCC MPE Limit (mW/cm ²)	(WWAN 850 MHz) / MPE Limit	(850 MHz WWAN + WLAN / WiMAX + BT fraction)	Limit	Pass/Fail
2.3 - 2.4	0.520	1.000	0.520	0.198	0.549	0.360	0.880	1.000	Pass
2.4 - 2.5									
2.5 - 2.7									
3.3 - 3.8									
5.15 - 5.85									

Table 7: WWAN 850MHz + WLAN / WiMAX + BT Collocated MPE Calculation

WLAN / WiMAX Band (GHz)	WLAN / WiMAX + BT Pd (mW/cm ²)	FCC MPE Limit (mW/cm ²)	(WLAN / WiMAX + BT Pd) / (MPE Limit)	1900 MHz WWAN Pd (mW/cm ²)	FCC MPE Limit (mW/cm ²)	(WWAN 1900 MHz) / MPE Limit)	(1900 MHz WWAN + WLAN / WiMAX + BT fraction)	Limit	Pass/Fail
2.3 - 2.4	0.520	1.000	0.520	0.126	1.000	0.126	0.645	1.000	Pass
2.4 - 2.5									
2.5 - 2.7									
3.3 - 3.8									
5.15 - 5.85									

Table 8: WWAN 1900MHz + WLAN / WiMAX + BT Collocated MPE Calculation

WLAN / WiMAX Band (GHz)	WLAN / WiMAX + BT Pd (mW/cm ²)	FCC MPE Limit (mW/cm ²)	(WLAN / WiMAX + BT Pd) / (MPE Limit)	700 MHz WWAN Pd (mW/cm ²)	FCC MPE Limit (mW/cm ²)	(WWAN 700 MHz) / MPE Limit)	(700 MHz WWAN + WLAN / WiMAX + BT fraction)	Limit	Pass/Fail
2.3 - 2.4	0.520	1.000	0.520	0.199	0.469	0.424	0.944	1.000	Pass
2.4 - 2.5									
2.5 - 2.7									
3.3 - 3.8									
5.15 - 5.85									

Table 9: WWAN 700MHz + WLAN / WiMAX + BT Collocated MPE Calculation

WLAN / WiMAX Band (GHz)	WLAN / WiMAX + BT Pd (mW/cm^2)	FCC MPE Limit (mW/cm^2)	(WLAN / WiMAX + BT Pd) / (MPE Limit)	1700 MHz WWAN Pd (mW/cm^2)	FCC MPE Limit (mW/cm^2)	(WWAN 1700 MHz) / MPE Limit)	(1700 MHz WWAN + WLAN / WiMAX + BT fraction)	Limit	Pass/Fail
2.3 - 2.4	0.520	1.000	0.520	0.199	1.000	0.199	0.719	1.000	Pass
2.4 - 2.5									
2.5 - 2.7									
3.3 - 3.8									
5.15 - 5.85									

Table 10: WWAN 1700MHz + WLAN / WiMAX + BT Collocated MPE Calculation

5. Conclusion

Based on FCC OET Bulletin 65 Supplement C and 47 CFR §2.1091, the analysis concludes that the EM7655 wireless modem, 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 11 for each given frequency band per wireless technology.

Device	Technology		Frequency (MHz)	Maximum Conducted Power (dBm)	Maximum Antenna Gain (dBi)	
					Standalone	Collocated
EM7655	GPRS		824 - 849	33.0	6.5	3.0
			1850 – 1910	30.0	3.0	3.0
	EDGE		824 – 849	28.0	6.5	3.0
			1850 - 1910	27.0	3.0	3.0
	CDMA		824-849	25.0	6.5	3.0
			1850 - 1910	25.0	3.0	3.0
			816.0 – 823.975	25.0	6.5	3.0
	UMTS		824 - 849	24.0	6.5	3.0
			1710 – 1755	24.0	6.0	6.0
			1850 - 1910	24.0	3.0	3.0
	LTE		704 - 716	24.0	9.0	6.0
			777 – 787	24.0	9.0	6.0
			824 – 849	24.0	6.5	3.0
			1710 – 1755	24.0	6.0	6.0
			1850 – 1910	24.0	3.0	3.0
			1850 - 1915	24.0	3.0	3.0
Collocated Transmitters	WLAN		2400 - 2500	29.0		5.0
	WLAN		5150 - 5850	29.0		5.0
		WiMAX	2300 - 2400	29		5.0
		WiMAX	2500 - 2700	29		5.0
		WiMAX	3300 - 3800	29		5.0
	BT	BT	2400 - 2500	15		5.0

Table 11: Summary of Maximum Conducted Power and Antenna Gain