MPE Evaluation for AirCard 771S Wireless Hot Spot

June 27, 2013

Revision 1, May 2013	Initial Version
Revision 2, June 2013	Added LTE B41 TDD duty cycle information

1. Introduction

In this application we also seek approval for the AirCard 771S wireless hotspot to operate as a mobile device using external antennas. The MPE report demonstrates compliance with FCC CFR 47 §2.1091 in usage of external antenna under mobile exposure conditions.

2. RF Exposure Limits and Equations

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.

FCC RULES:

According to FCC CFR 47 §1.310, the criteria listed in the 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)

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. MPE Assessment

The power density calculations for individual transmitters per wireless technology at a separation distance of 20cm are shown in the following table. For frequency dependent limits, the lowest transmitter frequency was used to represent the most stringent limit in this analysis (eg. 824MHz = 0.55mW/cm^2). The calculations are based on the highest conducted power to represent the worst-case scenario.

Operating Mode	TX Freq (MHz)	Max Time-Avg Cond Power (dBm)	Max Time-Avg Cond Power (W)	Max Ant Gain (dBi)	Duty Cycle	Power Density @20 cm (mW/cm^2)	FCC MPE Limit (mW/cm^2)	Power Density to MPE Limit Ratio
GSM850 1UL	824	33	2.00	5	0.125	0.16	0.55	0.29
GSM850 2UL	824	30.5	1.12	5	0.250	0.18	0.55	0.32
GSM850 3UL	824	28.5	0.71	5	0.375	0.17	0.55	0.30
GSM850 4UL	824	27.5	0.56	5	0.500	0.18	0.55	0.32
GSM850 1UL	1850	30	1.00	3	0.125	0.05	1.00	0.05
GSM850 2UL	1850	30	1.00	3	0.250	0.10	1.00	0.10
GSM850 3UL	1850	28.5	0.71	3	0.375	0.11	1.00	0.11
GSM850 4UL	1850	27.5	0.56	3	0.500	0.11	1.00	0.11
WCDMA 850	824	23.5	0.22	5	1.000	0.14	0.55	0.26
WCDMA 850	1850	23.5	0.22	3	1.000	0.09	1.00	0.09

CDMA BC 0	824	23.5	0.22	5	1.000	0.14	0.55	0.26
CDMA BC 1	1850	23.5	0.22	3	1.000	0.09	1.00	0.09
CDMA BC 10	816	23.5	0.22	5	1.000	0.14	0.54	0.26
LTE Band 25	1850	23.5	0.22	3	1.000	0.09	1.00	0.09
LTE Band 26	814	23.5	0.22	5	1.000	0.14	0.54	0.26
LTE Band 41	2496	23.5	0.22	5	0.600	0.08	1.00	0.08
WLAN 2.4 GHz	2400	12	0.02	2.3	1.000	0.01	1.00	0.01

The sum of the highest power density to MPE limit ratio of WWAN and WLAN transmitters is as follows:

$$0.18/0.55 + 0.01/1 = 0.33 < 1$$

3.1 LTE TDD Duty Cycle

The duty cycle of the testing for LTE TDD Band 41 used the worst-case Configuration 0, which is 60% transmit duty cycle. This is verified by using the test settings in the call box to control the device under test. The duty cycle is controlled by the call box, and the device under test follows these settings. The call box uses the 3GPP settings as per below:

3GPP Table 4.2-1: Configuration of special subframe (lengths of DwPTS/GP/UpPTS).

Special subframe configuration	Normal cyclic prefix in downlink			Extended cyclic prefix in downlink			EUT Support Special subframe	Worst case UpPTS
	DwPTS	UpPTS		DwPTS	UpPTS			
		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink		
0	6592×Ts	2192×Ts	2560×Ts	7680×Ts	2192×Ts	2560×Ts	☐	☐
1	19760×Ts			20480×Ts			☐	☐
2	21952×Ts			23040×Ts			☐	☐
3	24144×Ts			25600×Ts			■	☐
4	26336×Ts			7680×Ts	4384×Ts	5120×Ts	■	☐
5	6592×Ts	4384×Ts	5120×Ts	20480×Ts			☐	☐
6	19760×Ts			23040×Ts			☐	☐
7	21952×Ts			12800×Ts			■	■
8	24144×Ts			-	-	-	☐	☐
9	13168×Ts			-	-	-	☐	☐

Table 4.2.2: Uplink-downlink configuration.

Uplink-downlink configuration	Downlink-to-Uplink Switch-point periodicity	Subframe number									
		0	1	2	3	4	5	6	7	8	9
0	5ms	D	S	U	U	U	D	S	U	U	U
1	5ms	D	S	U	U	D	D	S	U	U	D
2	5ms	D	S	U	D	D	D	S	U	D	D
3	10ms	D	S	U	U	U	D	D	D	D	D
4	10ms	D	S	U	U	D	D	D	D	D	D
5	10ms	D	S	U	D	D	D	D	D	D	D
6	5ms	D	S	U	U	U	D	S	U	U	D

Conclusion

Based on the analysis above, the AC771S wireless hotspot complies with the FCC RF exposure requirements in mobile exposure condition using external antennas, provided the maximum antenna gains do not exceed the limits listed in the table below.

Transmitter Frequency Band (MHz)	**Max External Antenna Gain (dBi)**
824 - 849	**5**
1850 - 1915	**3**
814-849	**5**
2496 - 2690	**5**