Maximum Permissible Exposure (MPE) Estimation for B200

1 Introduction

HUAWEI B200 Wireless Gateway is subscriber equipment in the UMTS/GSM system, also supports wireless Internet accessing function, routing function, and network address translation (NAT) function. The WCDMA frequency is Band I and V. The GSM/GPRS/EDGE frequency band includes 850M, EGSM900, DCS1800 and PCS1900, the WLAN frequency is 2.4G. B200 implements such functions as RF signal receiving/transmitting, HSDPA/ WCDMA and EDGE/GPRS/GSM protocol processing, data service ,etc. Externally it provides USB interface (to connect to the laptop etc.), USIM card interface, RJ11 interface (to connect to fixed telephone), RJ45 interface (to connect to pc).

2 Limits and Guidelines on Exposure to Electromagnetic Fields

According to the FCC Part 2.1091(which reference the part1.1310), we know: mobile device (transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitters radiating structure(s) and the body of the user or nearby persons). And the Cellular radiotelephone service and PCS services are subject to routine environmental evaluation for RF exposure prior to equipment authorization or use if they operate at frequencies of 1.5 GHz or below and their effective radiated power (ERP) is 1.5 watts or more, or if they operate at frequencies above 1.5 GHz and their ERP is 3 watts or more.

Uncontrolled limits are used for general public. General population/uncontrolled exposure apply in situations is which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure. The exposure levels can be expressed in terms of power density, electric field strength, or magnetic field strength, as averaged over 30 minutes for the general public and 6 minutes for trained personnel. The exposure criterion is frequency dependent, and a chart covering the range from 3 kHz to 100 GHz can be found in NCRP No.86 (references IEEE C95.1-1999). Below are the limits.

Limits for Occupational/Controlled Exposure			
Frequency Range (MHz)	**Electric Field Strength (E) (V/m)**	**Magnetic Field Strength (H) (A/m)**	**Power Density (S) (mW/cm^2)**
0.3-3.0 **3.0-30** **30-300** **300-1500** **15,00-100,000**	**614** **1842/f** **61.4** **--** **--**	**16.3/f** **16.3/f** **0.163** **--** **--**	**(100)*** **($900/f^2$)*** **1.0** **f/300** **5**

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)**
0.3-1.34 **1.34-30.0** **30-300** **300-1500** **15,00-100,000**	**614** **824/f** **27.5** **--** **--**	**1.63** **2.19/f** **0.073** **--** **--**	**(100)*** **($180/f^2$)*** **0.2** **f/1500** **1**

Power density S [mW/cm2] for controlled area at 850 MHz ， (TX: 824MHz – 849MHz)

$$S = \frac{f(MHz)}{300} = \frac{824}{300} = 2.75 \ \text{mW/cm}^2$$

Power density S [mW/cm2] for uncontrolled area at 850 MHz

$$S = \frac{f(MHz)}{1500} = \frac{824}{1500} = 0.55 \ \text{mW/cm}^2$$

Power density S [mW/cm2] for uncontrolled area at 1900/2400 MHz

S=1 mW/cm^2

Reference levels are provided for exposure assessment to determine whether the basic restrictions on exposure of humans to electromagnetic fields are exceeded. The basic restrictions on exposure to electromagnetic fields are based directly on established health effects and biological considerations.

3 Location of EUT

The source of the radiation is mounted on terminal; generally the direction of the antenna position is uprightness tabletop. The highest level of emission would be expected in close vicinity of the antenna and in line of sight to the antenna.

4 Prediction of the Exposure to Electromagnetic Fields

Calculations can be made on a site by site basis to ensure the power density is below the limits given above, or guidelines can be done beforehand to ensure the minimum distances from the antenna is maintained through the site planning. The calculations are based on FCC OET 65 Appendix B.

4.1 Calculation of the Safe Distance

Below method describes a theoretical approach to calculate possible exposure to electromagnetic radiation around a base station transceiver antenna. Precise statements are basically only possible either with measurements or complex calculations considering the complexity of the environment (e.g. soil conditions, near buildings and other obstacles) which causes reflections, scattering of electromagnetic fields.

The maximum output power (given in EIRP) of a base station is usually limited by license conditions of the network operator.

A rough estimation of the expected exposure in power flux density on a given point can be made with the following equation. The calculations are based on FCC OET 65 Appendix B.

$$S = \frac{P(W) * G_{numeric}}{4 * r^2(m) * \pi}$$

Whereas:

P = Maximum output power in W of the site

G numeric = Numeric gain of the antenna relative to isotropic antenna

R = distance between the antenna and the point of exposure in meters

4.2 Technical Description B200

Technical Specification:

Cellular Band

ERP:	33.17dBm for GSM850MHz	22.81dBm for WCDMA850MHz
Transmitter frequency band	GSM850	WCDMA850
Frequency range:	850M： Uplink:824 M~849M； Downlink:869 M~894M	850M： Uplink:824 M~849M； Downlink:869 M~894M

PCS Band

EIRP:	31.93 dBm for GSM1900MHz	
Transmitter frequency band	GSM1900	
Frequency range:	1900M： Uplink:1850 M~1910M； Downlink:1930M~1990M	

For Wlan, the max conducted output power is 16.56dBm, and it's antenna's max gain is 1.0dBi, so we can get the max EIRP 17.56dBm.

EIRP:	57.02mW (17.56 dBm) for WLAN
Transmitter frequency band	2400~2483.5MHz

4.3 Estimation of compliance boundary for indoor antenna

1) Cellular Band:

GSM850

For the final determination of the compliance boundary the model for far-field calculation is used since this overestimates the field strength in the near-field region. Thus the calculated compliance boundary should be rather more conservative and on the safe side.

For EUT the following compliance boundary is calculated:

One time slot ERP: 33.17dBm

EIRP: **3404.1mW (35.32dBm)**

Compliance boundary

For GSM 850MHz band:

When r=20cm and GSM only use one timeslot, so

$$S = \frac{P(W) * G_{numeric}}{8 * 4 * r^2(m) * \pi}$$

$$S = \frac{3404.1}{8 * 4 * 20^2 * \pi} = 0.085 \text{ mW/cm}^2 < 0.55 \text{ mW/cm}^2$$

For GPRS and EDGE, the transmitter support multi-timeslot, but the conducted ERP will decrease 2dB when add one uplink timeslot, so we can get the following conclusion:
The power(dB) decrease 2dB, the power(W) should be divide by 1.58($10^{2/10}$)

Uplink timeslot	Output Power(W)	duty cycle
1	P	0.125
2	P/1.58	0.25
3	P/2.51	0.375
4	P/4	0.5

Note: we assume the output power of GPRS which with one uplink is P(W)

For two timeslot（which duty cycle is 0.25）:

$$S_{two\ timeslot} = \frac{P/1.58 * G}{8 * r^2 * \pi} * 2 = S_{one\ timeslot} * 2/1.58 = 1.27\ S_{one\ timeslot}$$

For three timeslot（which duty cycle is 0.375）:

$$S_{three\ timeslot} = \frac{P/2.51 * G}{8 * r^2 * \pi} * 3 = S_{one\ timeslot} * 3/2.51 = 1.2\ S_{one\ timeslot}$$

For four timeslot（which duty cycle is 0.5）:

$$S_{two\ timeslot} = \frac{P/4 * G}{8 * r^2 * \pi} * 4 = S_{one\ timeslot} * 4/4 = S_{one\ timeslot}$$

The two timeslot's S is the biggest. And it is same in EDGE.

$S_{max} = 1.27\ S_{one\ timeslot} = 0.11$ mW/cm^2 < 0.55 mW/cm^2

Because the EDGE's output power is smaller than the GRPS's output power, so here the calculation is abbreviated.

WCDMA850
For EUT the following compliance boundary is calculated:

ERP: 22.81dBm

EIRP: **313.4mW（24.96dBm）**

$$S = \frac{313.4}{4 * 20^2 * \pi} =$$ **0.063 mW/cm^2**< 0.55 **mW/cm^2**

Because the HSDPA's output power is smaller than the WCDMA's output power, so here the calculation is abbreviated.

2) PCS Band

GSM1900

For EUT the following compliance boundary is calculated:

EIRP for one time slot: **1559.6mW（31.93dBm）**

$$S = \frac{1261.9}{8 * 4 * 20^2 * \pi} = 0.031 \text{ mW/cm}^2$$

S_{max}=1.27 $S_{one\ timeslot}$ =0.039mW/cm^2< 1 mW/cm^2

3) WLAN

For EUT the following compliance boundary is calculated:

EIRP : **57.02mW (17.56 dBm)**

$$S = \frac{57.02}{4 * 20^2 * \pi} = 0.012 \text{ mW/cm}^2$$

Modulation	MPE Limit (mW/cm^2)	Con Output Power (mW)	Duty cycle (%)	Max Anna Gain (dBi)	EIRP (dBm)	Pd at 20cm (mW/cm2)	% of limit
824.2 – 848.8 MHz Band							
GPRS (2 time slot)	0.55	1807.2	0.25	2.75	35.32	0.11	**20.0%**
WCDMA	0.55	166.4	1	2.75	24.96	0.063	11.5%
1805.2-1909.8 MHz Band							
GPRS (2 time slot)	1	877.0	0.25	2.5	31.93	0.039	3.9%
2412~2462MHz							
802.11b	1	45.3	1	1.0	17.56	0.012	**1.2%**

The maximum power spectral density 20cm from the antenna relative to the limit is the highlighted row and the power density is 20.0% of the limit.

When the two devices are co-located the total power density 20cm from both antennas, expressed as a ratio of the allowable RF exposure, is the sum of the individual percentages of the limits for each module. The sum is **21.2%**. As this value is below 100% of the limit the two devices may be collocated and used in applications with a separation distance of at least 20cm from persons.

The S at the position which is 20cm far from the EUT is smaller than the uncontrolled exposure limit line. So the EUT also complies with the Limits for Occupational/Controlled Exposure.

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