From: Michael Robinson [mrobinson@atheros.com]
Sent: Friday, August 30, 2002 9:49 AM
To: Mike Kuo
Subject: Re: Atheros CB22 FCC submission
Hi Mike,

It is clear that Professor Gandhi's average power of 21.3dBm from the 5GHz SAR report is higher than any of the average powers in the DTS/UNII reports. Note that the deltas between peak and average are higher for the "turbo" mode channels. This is due to the fact that the turbo spectrum has a wider 26dB bandwidth, which requires a wider video bandwidth setting on the spectrum analyzer, which in turn causes the peak power measurement to be higher. If you have any questions regarding this data, please let me know. Thanks for all of your help in this matter.

-Mike

Frequency (MHz)	Peak Pwr	Average Pwr
UNII Report		
5180	15.38 dBm	14 dBm
5260	19.51 dBm	18 dBm
5320	14.48 dBm	13.5 dBm
5210	16.29 dBm	14 dBm
5250	16.25 dBm	14 dBm
5290	17.89 dBm	15 dBm
DTS Report		
5745	19.13 dBm	18 dBm
5805	19.70 dBm	18 dBm
5825	19.23 dBm	18 dBm
5760	20.64 dBm	18 dBm
5800	21.99 dBm	18 dBm
2412 (11b)	18.22 dBm	18 dBm
2437 (11b)	17.57 dBm	18 dBm
2462 (11b)	17.47 dBm	18 dBm
2412 (11g)	19.22 dBm	18 dBm
2437 (11g)	19.77 dBm	18 dBm
2462 (11g)	18.86 dBm	18 dBm

September 3, 2002

RESPONSES TO QUESTIONS ON THE SAR COMPLIANCE TESTING OF ATHEROS MODEL AR5BCB-00022 (FCC ID# PPD-AR5BCB-00022) CARDBUS CARD INSERTED INTO A LAPTOP COMPUTER

2. *Supplement C contains information that can be adapted for system verification at frequencies outside of the P1528 0.3-3 GHz frequency range. Target values should be reported and can be established in the system or by numerical modeling. FCC public records include examples of lab-developed target values. If 5-GHz-band dipoles are not available, verification data using 2-4 GHz dipole and body liquid may be accepted in the interim.*

Response:

As given in Appendix A [a] of the SAR Test Report, a half-wave dipole at 1900 MHz ($\lambda/2$ = 78.95 mm) was used for system verification. A dipole at 1900 MHz was used in the absence of dipoles at 2450 MHz or for the frequency band 5.18-5.825 GHz. This dipole of length 76.0 mm and diameter 1.5 mm and h = 39.5 mm is shown in Fig. a. The measured SAR distributions for variable spacings of 10, 15, 20, and 25 mm of the dipole for a flat phantom and spacings of 5, 15, and 25 mm of the dipole for a sphere phantom are given in Figs. 5 and 7 of Appendix A. Also given in the same figures are the SAR values calculated using the FDTD numerical method. The agreement of the measured SAR distributions with those obtained numerically using the FDTD method is very good. Taken from Tables IV and V of Appendix A, the difference between measured and calculated peak 1-g SARs are less than ± 5 percent at 1900 MHz.

3. *Supplement C contains evaluation guidelines for mobile and portable devices, not just handheld cellular telephones. Supplement C Appendix B II 7c states, "description, illustration and SAR distribution plots showing the peak SAR locations with respect to the phantom and the test device."*

Response:

An illustration (top view) showing the peak SAR location with respect to the phantom and the Atheros Model AR5BCB CardBus Card for the laptop computer pressed against the bottom of the planar tissue-simulant phantom is attached here as Fig. b. As stated in Section IV of the SAR Test Report, the highest SARs were measured for the region of the phantom above the PC card. The highest peak 1-g SAR was measured for the region above the radiating antenna as shown in Fig. b. This region was measured with a stepper-motor-controlled step size of 2 mm along the three orthogonal axes to obtain peak 1-g SAR. The SAR distributions measured with a step size of 2 mm have been given in Tables 1-4 (of the SAR Test Report) for frequencies of 5.18, 5.32, 5.745, and 5.825 GHz, respectively.

An illustration showing the peak 1-g SAR location for the End-on placement (with the card edge at 90 and separated from the bottom of the phantom by 2.5 cm) is given in Fig. c. The detailed SAR distributions measured with a step size of 2 mm are given in Tables 5-8 of the SAR Test Report for frequencies of 5.18, 5.32, 5.745, and 5.825 GHz, respectively.

4. *Please submit SAR liquid recipes and mixing details.*

Response:

On page 2 of the SAR Test Report, we give the composition of the tissue-simulant fluid used for present measurements. This composition developed at the University of Utah consists of 68.0% water, 31.0% sugar, and 1% HEC. The measured and pre-weighed amount of water is mixed slowly with the pre-weighed amount of sugar (310 g for each kg of the final fluid) while stirring the water in. The 1% HEC is added into the thick syrupy fluid at the end and mixed in. Because of micro bubbles that result, the fluid is allowed to stand for a period of 3-7 days until it is cleared of the air bubbles and is transparent at that stage.

5. *Please submit SAR liquid parameter test details and data analysis.*

Response:

As given on page 2 of the SAR Test Report, the Hewlett Packard Model HP85070B Dielectric Probe (rated frequency band 200 MHz to 20 GHz) in conjunction with HP Model 8720C Network Analyzer (50 MHz-20 GHz) is used for measurement of the dielectric properties of the tissue-simulant fluid given in item 4. This commercial probe (see Fig. d) is an open-circuited transmission-line (coaxial line) probe described in Section B.1.2 of the Draft IEEE Standard 1528 [b]. The theory of the open-circuited coaxial line method has been described in scientific literature [c, d, e]. We have previously used this method in determining the dielectric properties of tissue-simulant materials at 6 GHz [f]. In this method, the complex reflection coefficient Γ^* measured for the open end of the coaxial line can be used to calculate the complex permittivity ε^* from the following equation [f]

$$\varepsilon^* = \frac{1-\Gamma^*}{j\omega Z_o C_o \left(1+\Gamma^*\right)} - \frac{C_f}{C_o} \qquad (1)$$

where Z_o is the characteristic impedance (50 Ω) for the coaxial line, C_o is the capacitance when the line is in air and C_f is the capacitance that accounts for the fringing fields in the dielectric of the coaxial line.

For the HP85070B Dielectric Probe with diameters of the outer and inner conductors 2b = 3.00 mm and 2a = 0.912 mm, respectively, the following capacitances were obtained using deionized water and methanol as the calibration fluids. The following capacitances were obtained:

$$C_o = 0.022 \text{ pF}$$

$$C_f = 0.005 \text{ pF}$$

Using the network analyzer HP8720C, we measured the reflection coefficient Γ^* for the open end of the coaxial line that was submerged in the tissue-simulant fluid. Using Eq. 1, the complex permittivity of the fluid was measured at a midband frequency of 5.30 GHz. From the imaginary part of the complex permittivity $\text{Im}(\varepsilon^*)$, we can obtain the conductivity σ from the relationship

$$\sigma = \frac{\text{Im}(\varepsilon^*)}{\omega\varepsilon_o} \qquad (2)$$

For the tissue-simulant fluid, we obtain ε_r = 48.5 ± 1.7 and σ = 5.40 ± 0.08 S/m. From the FCC Supplement C, we obtain the desired dielectric properties to simulate the body tissue at the midband frequency of 5.30 GHz to be ε_r = 48.9 and σ = 5.42 S/m. Thus, the measured properties for the body-simulant fluid are close to the desired values.

Additional References

a. Q. Yu, O. P. Gandhi, M. Aronsson, and D. Wu, "An Automated SAR Measurement System for Compliance Testing of Personal Wireless Devices," *IEEE Transactions on Electromagnetic Compatibility*, Vol. 41(3), pp. 234-245, August 1999 (attached as Appendix A of the SAR Compliance Test Report).

b. IEEE Draft Standard P1528, "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communication Devices: Experimental Techniques," Draft CBD1.0, April 4, 2002 (IEEE Standards Coordinating Committee 34).

c. T. W. Athey, M. A. Stuchly, and S. S. Stuchly, "Measurement of Radiofrequency Permittivity of Biological Tissues with an Open-Circuited Coaxial Line - Part I," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-30, pp. 82-86, 1982.

d. M. A. Stuchly, T. W. Athey, G. M. Samaras, and G. E. Taylor, "Measurement of Radiofrequency Permittivity of Biological Tissues with an Open-Circuited Coaxial Line - Part II - Experimental Results," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-30, pp. 87-92, 1982.

e. C. L. Pournaropoulos and D. K. Misra, "The Coaxial Aperture Electromagnetic Sensor and Its Application for Material Characterization," *Measurement Science and Technology*, Vol. 8, pp. 1191-1202, 1997.

f. O. P. Gandhi and J-Y. Chen, "Electromagnetic Absorption in the Human Head from Experimental 6-GHz Handheld Transceivers," *IEEE Transactions on Electromagnetic Compatibility*, Vol. 39(4), pp. 547-558, 1995.

Fig. a. Photograph of the half-wave dipole at 1900 MHz used for system verification.

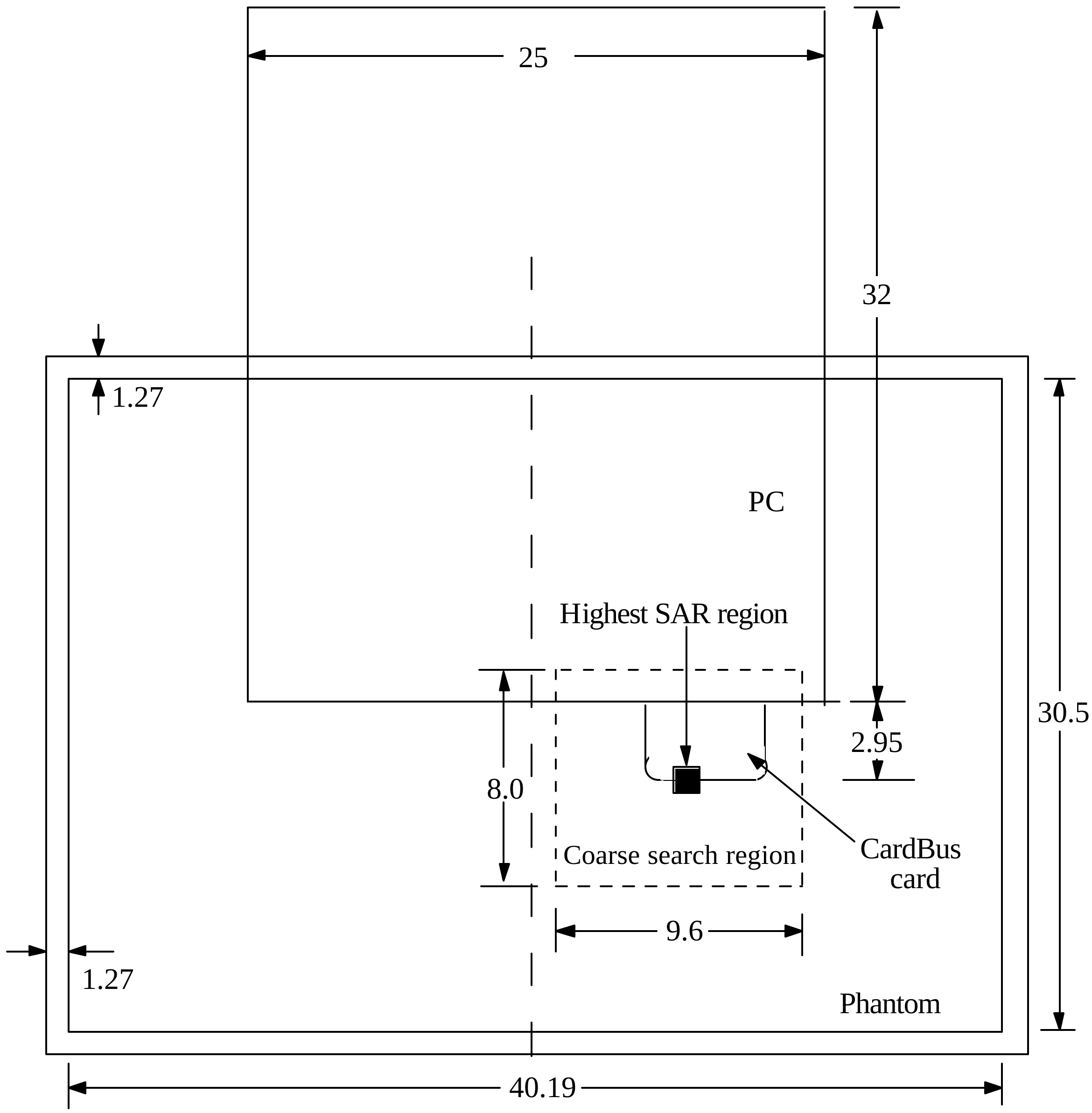

Fig. b. Illustration of the peak SAR location with respect to the phantom and the Atheros Model AR5BCB CardBus Card for the **Above-lap position** (measured SARs for the 1 cm^3 peak SAR region are given in Tables 1-4 of the SAR Test Report). All dimensions are in cm.

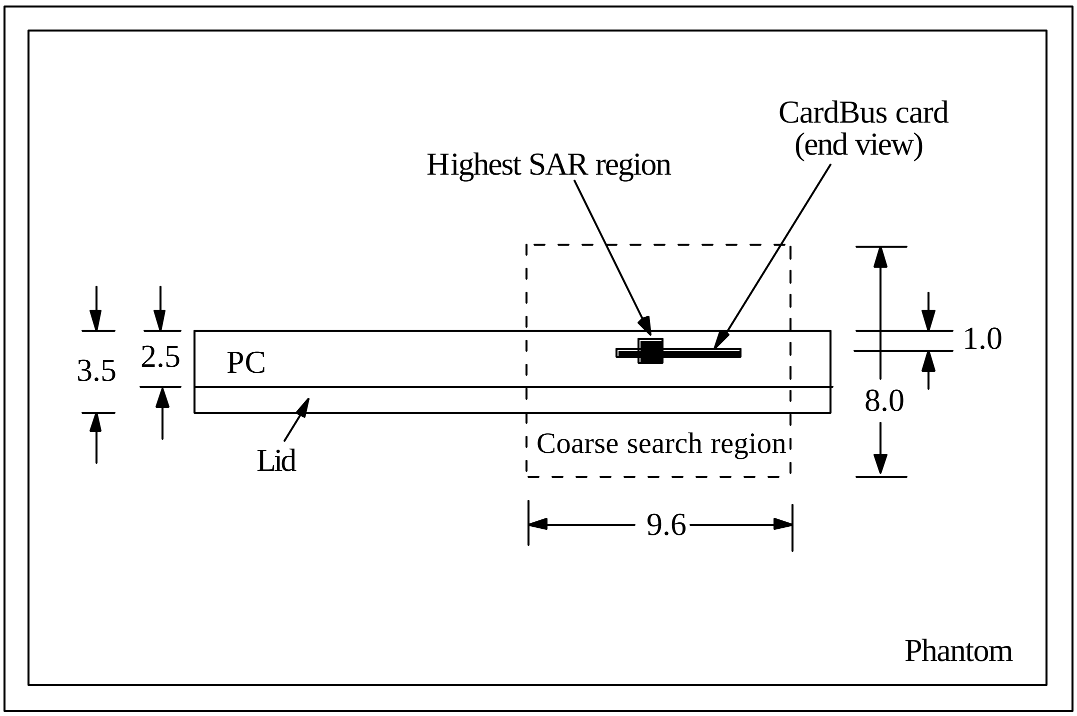

Fig. c. Illustration of the peak SAR location with respect to the phantom and the Atheros Model AR5BCB CardBus Card for the **End-on position** (measured SARs for the 1 cm^3 peak SAR region are given in Tables 5-8 of the SAR Test Report). All dimensions are in cm.

Fig. d. Photograph of the Hewlett Packard Model 85070B Dielectric Probe. This is an open-circuited coaxial line probe.