SAR COMPLIANCE TESTING OF ATHEROS COMMUNICATIONS MODEL AR5BCB-00013 CARDBUS CARD INSERTED INTO A LAPTOP COMPUTER

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I. Introduction

The U.S. Federal Communications Commission (FCC) has adopted limits of human exposure to RF emissions from mobile and portable devices that are regulated by the FCC [1]. The FCC has also issued Supplement C (Edition 97-01) to OET Bulletin 65 [2] and a more recent version of the same [3] defining both the measurement and the computational procedures that should be followed for evaluating compliance of mobile and portable devices with FCC limits for human exposure to radiofrequency emissions.

We have used the measurement procedure for SAR compliance testing of the Atheros Communications CardBus card (FCC ID: PPD-AR5BCB-00013) inserted into a laptop computer. A photograph of the unit with the CardBus card inserted into the laptop computer is given in Fig. 1. A picture of the Model AR5BCB-00013 CardBus card placed on the laptop is given in Fig. 2. The Atheros Model AR5BCB-00013 CardBus card operates with a transmit power to up to 21 dBm (126 mW).

Since the wireless PC may possibly be placed on a user's lap where the RF antennas would be the closest to the body, a planar phantom model was used for SAR measurements.

II. Experimental Measurements of SAR Distribution

The testing of the SAR distribution for the Atheros Communications Model AR5BCB-00013 CardBus Card inserted into a laptop computer was done with a planar rectangular box phantom shown in Fig. 3. This box phantom of external dimensions 30 × 50 cm is filled with a tissue-simulant fluid up to a depth of 15.5 cm. To maintain flatness of the phantom, the rectangular box is made of acrylic ($\varepsilon_r = 2.56$) of thickness 6.35 mm. The tissue-simulant fluid uses a composition developed at the University of Utah which consists of 68.0% water, 31.0% sugar and 1% HEC. For this composition, we have measured the dielectric properties using a Hewlett Packard (HP) Model 85070B Dielectric Probe in conjunction with HP Model 8720C Network Analyzer (50 MHz-20 GHz). The measured dielectric properties at the mid band frequency of 5.30 GHz are as follows: $\varepsilon_r = 48.5 \pm 1.7$ and $\sigma = 5.40 \pm 0.08$ S/m. From the FCC Supplement C [3], we obtain the desired dielectric properties to simulate the body tissue at 5.30 GHz to be $\varepsilon_r = 48.9$ and $\sigma = 5.42$ S/m. Thus, the measured properties for the body-simulant fluid are close to the desired values.

III. Calibration of the E-Field Probe

As in some previously reported SAR measurements at 6 GHz [4], we have calibrated the Narda Model 8021 Miniature Broadband Electric Field Probe of tip diameter 4 mm (0.4 to 10 GHz) using a rectangular waveguide WR 159 that was filled with this body-simulant fluid at 5.30 GHz. By comparing the electric fields expected in the tissue from the analytical expressions of the waveguide theory, we obtain a calibration factor of 2.98 (mW/kg)/μV. This is considerably larger than calibration factors of 0.39 and 0.565 (mW/kg)/μV previously reported for the same probe at 835 MHz and 1900 MHz, respectively [5]. This is to be expected since the sensitivity of the diodes used for the Narda Model 8021 Miniature Broadband Electric Field Probe of tip diameter 4 mm is likely to diminish with frequency.

IV. The Measured SAR Distributions

The SAR distribution was determined using the automated SAR measurement system developed at the University of Utah [4]. As described in [4], this SAR measurement system has been validated using a number of wireless telephones at 835 and 1900 MHz, respectively.

The highest SAR region for each of the frequencies (5.26 and 5.32 GHz) was identified in the first instance by using a coarser sampling with a step size of 8.0 mm over three overlapping areas for a total scan area of 8.0 × 9.6 cm. After identifying the region of the highest SAR, the SAR distribution was measured with a resolution of 2 mm in order to obtain the peak 1 cm^3 or 1-g SAR. As given in [5], the SAR measurements are performed at 4, 6, 8, 10, 12 mm height from the bottom surface of the body-simulant fluid. The SARs thus measured were extrapolated to obtain values at 1, 3, 5, 7 and 9 mm height and used to obtain 1-g SARs. The estimated error in determination of peak 1-g SAR is within ± 20% as compared to the values obtained using numerical procedures [5].

The SAR distributions were measured for transmit frequencies of 5.26 and 5.32 GHz and are given in Tables 1 and 2. The peak 1-g SARs at 5.26 and 5.32 GHz are 0.402 and 0.331 W/kg, respectively. For the measurements in Tables 1 and 2, the separation between the Atheros Model AR5BCB-00013 CardBus card and the bottom of the experimental phantom is on the order of 1 cm and yet the peak 1-g SAR is only 0.331-0.402 W/kg. The end-on SAR value (for a bystander), where the spacing is larger and may be on the order of 2.5 cm or more, is likely to be smaller and was, therefore, not measured.

V. Comparison of the Data With FCC 96-326 Guidelines

According to the FCC 96-326 Guidelines [1], the peak SAR for any 1-g of tissue should not exceed 1.6 W/kg. For the maximum radiated power condition of 21 dBm (126 mW), the Atheros Communications Model AR5BCB-00013 CardBus card has been measured to give peak 1-g SARs of 0.331-0.402 W/kg which are considerably smaller than 1.6 W/kg.

REFERENCES

1. Federal Communications Commission, "Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation," FCC 96-326, August 1, 1996.

2. K. Chan, R. F. Cleveland, Jr., and D. L. Means, "Evaluating Compliance With FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields," Supplement C (Edition 97-01) to OET Bulletin 65, December, 1997. Available from Office of Engineering and Technology, Federal Communications Commission, Washington D.C., 20554.

3. Federal Communications Commission "Supplement C Edition 01-01 to OET Bulletin 65 Edition 97-01" June 2001.

4. 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.

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Table 1. The SARs measured for the Atheros Model AR5BCB-00013 CardBus Card (nominal power of 21 dBm) inserted into a laptop computer at 5.26 GHz

1-g SAR = 0.402 W/kg

a. At depth of 1 mm

0.770	0.799	0.769	0.803	0.812
0.787	0.845	0.838	0.848	0.836
0.847	0.875	0.881	0.868	0.870
0.825	0.856	0.903	0.876	0.855
0.823	0.859	0.874	0.881	0.866

b. At depth of 3 mm

0.507	0.531	0.512	0.536	0.538
0.526	0.561	0.562	0.570	0.562
0.563	0.576	0.585	0.578	0.578
0.556	0.574	0.599	0.582	0.571
0.542	0.578	0.586	0.590	0.582

c. At depth of 5 mm

0.302	0.320	0.309	0.326	0.325
0.322	0.339	0.345	0.351	0.346
0.341	0.343	0.353	0.351	0.350
0.344	0.353	0.361	0.352	0.348
0.322	0.357	0.360	0.363	0.359

d. At depth of 7 mm

0.154	0.167	0.161	0.174	0.170
0.173	0.179	0.187	0.190	0.189
0.181	0.176	0.187	0.187	0.186
0.189	0.193	0.191	0.185	0.186
0.164	0.195	0.196	0.200	0.197

e. At depth of 9 mm

0.063	0.071	0.067	0.079	0.076
0.080	0.083	0.088	0.089	0.091
0.083	0.076	0.086	0.087	0.086
0.090	0.092	0.088	0.082	0.085
0.068	0.093	0.093	0.099	0.096

Table 2. The SARs measured for the Atheros Model AR5BCB-00013 CardBus Card (nominal power of 21 dBm) inserted into a laptop computer at 5.32 GHz

1-g SAR = 0.331 W/kg

a. At depth of 1 mm

0.687	0.695	0.676	0.678	0.695
0.702	0.703	0.705	0.722	0.685
0.689	0.709	0.691	0.703	0.669
0.684	0.682	0.688	0.695	0.682
0.672	0.671	0.686	0.667	0.654

b. At depth of 3 mm

0.465	0.461	0.459	0.456	0.464
0.467	0.469	0.471	0.482	0.461
0.460	0.472	0.462	0.467	0.442
0.461	0.460	0.459	0.465	0.454
0.444	0.447	0.457	0.447	0.441

c. At depth of 5 mm

0.289	0.279	0.287	0.281	0.283
0.283	0.286	0.288	0.294	0.286
0.280	0.287	0.282	0.282	0.264
0.286	0.286	0.280	0.285	0.275
0.266	0.272	0.278	0.276	0.275

d. At depth of 7 mm

0.160	0.150	0.161	0.154	0.153
0.150	0.154	0.157	0.157	0.157
0.149	0.154	0.151	0.148	0.135
0.160	0.161	0.152	0.156	0.146
0.139	0.144	0.149	0.153	0.155

e. At depth of 9 mm

0.077	0.072	0.081	0.074	0.073
0.067	0.072	0.077	0.072	0.076
0.067	0.071	0.069	0.066	0.056
0.081	0.084	0.074	0.077	0.067
0.062	0.065	0.070	0.078	0.082

Fig. 1. Photograph of the Atheros Communications Model AR5BCB-00013 CardBus card inserted into a laptop computer.

Fig. 2. A picture of the Model AR5BCB-00013 CardBus card placed on the laptop computer.

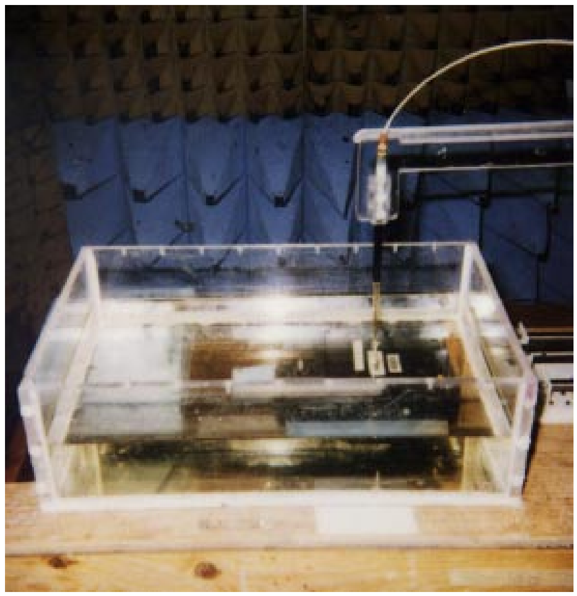

Fig. 3. Photograph of the Atheros Communications Model AR5BCB-00013 CardBus card inserted into a laptop computer with its bottom pressed against the bottom of the planar tissue-simulant phantom.