Abstract: A dual band 802.11a/b antenna system fabricated on two separate artificial magnetic conductor (AMC) substrates is described. This low profile antenna, which is 3.4 mm in thickness and 12 mm in width, is mounted onto the metal housing above a laptop screen. In each band, the antenna system has a peak gain at the horizon of at least 2 dBi and has –5 dBi or greater gain over 80% of the horizon azimuth angles.

I. Introduction

Most current high-end laptops come standard with 802.11b (2.4-2.48 GHz) antennas and radios for wireless networking. In addition to 802.11b, future laptops will be equipped for the 802.11a (5.15-5.35 GHz) wireless protocol. 802.11 mobile antennas should be efficient and ideally offer omnidirectional coverage since the location of the basestation is often unknown. The dual band 802.11a/b antenna described in this work is designed to be low profile (< 4 mm) and narrow (<12 mm) in order to fit above a laptop screen. There are two distinct advantages for mounting 802.11 antennas above the screen: (1) excellent coverage since this is the highest location on the laptop and; (2) less detuning since the antennas are away from the user’s hands and body. Also, antennas that mount exterior to the metal housing are better isolated and shielded from the noise and electromagnetic interference (EMI) from the computer electronics. In this case the radio is less susceptible to desensing.

II. AMC Antenna Design

An AMC is a high impedance surface that has a zero degree reflection phase relative to a perfect electric conductor (PEC) at one frequency [1]. Printed antennas can be built using this low-profile surface that may be as thin as $\lambda/50$. The antenna system described here utilizes two separate AMC antennas that are fed through a microstrip diplexer and are narrower (0.1$\lambda$ to 0.2$\lambda$) than typical AMC antennas. The stackup of the antenna system is shown in Figure 1. A top view of the printed diplexer and printed monopole feedlines is shown in Figure 2. The printed superstrate is 0.75 mm thick FR4 that has a local ground plane beneath the diplexer circuit. Vias connect the ground plane of each AMC to the “top” copper patches seen beneath the FR4 in Figure 2. One row of these copper patches on each AMC is soldered to the microstrip ground plane.

The 2.4 GHz antenna element was fabricated on a section of AMC that had a 1.7 GHz zero degree reflection phase as a large panel (25 x 41 cm). The 5.2 GHz monopole feedline is above an AMC that, as a large panel, resonated at 3.6 GHz.
Thus, when the AMCs are truncated severely in width in order to make antennas, the frequency of antenna resonance may be much higher than the AMC resonance (frequency of zero degree reflection phase).

The diplexer circuit is formed by placing open circuited microstrip stubs in parallel with each antenna. An open circuit stub that is 90° in electrical length at 5.2 GHz is placed in parallel with the 2.4 GHz antenna, and another open circuited stub that is 90° in electrical length at 2.4 GHz is in parallel with the 5.2 GHz antenna. Additional microstrip lines connecting the antennas to the common feedpoint cause each branch to have a high impedance at the appropriate band (2.4 GHz or 5.2 GHz). All performance data shown here was measured with a 300 mm coaxial cable [2] connected to the antenna/diplexer system.

III. Results

The return loss and efficiency data of the AMC antenna system of Figure 3 are plotted in Figure 4. The efficiency includes mismatch losses and was measured in a Satimo spherical near field range that also produced the pattern data shown in Figure 5. In the 802.11b band (2.4-2.48 GHz), the antenna system has a minimum return loss of –8 dB, 58% peak efficiency, 40% minimum efficiency, and peak gain at the horizon of 2dBi. In the 802.11a band (5.15-5.35 GHz), the minimum return loss is –12 dB, the peak efficiency is 58%, the minimum efficiency is 45%, and the peak gain at the horizon is 3 dBi. A very useful tool for calculating link margins is the cumulative gain plot, which can be used to determine percentage of azimuth angles for which the gain exceeds a given value. An example of the cumulative gain plot is shown in Figure 5d for the antenna of this paper. One sees that for 80% of the azimuth angles in the plane of the horizon, the total gain is greater than –4 dBi at 2.44 GHz and greater than –5 dBi at 5.2 GHz.

IV. Conclusions

We have demonstrated a low-profile AMC-based 802.11a/b antenna concept for use in laptops above the screen. The AMC antenna may be attached directly to a metal surface making it easily integrated into laptop designs and less susceptible to the adverse effects of EMI from on-board electronics. The 802.11 antenna of this paper is 3.4 mm in total thickness, making it a very low profile antenna. The antenna has dimensions of 97 mm x 12mm x 3.4 mm and a weight of 8 grams. Total efficiency of the antenna system is greater than 40% over both 802.11a/b bands including losses in the 300 mm cable and integrated diplexer that are approximately 1 dB at 2.4 GHz and 2 dB at 5.2 GHz. Cumulative gain plots show that over 80% of the azimuth angles at the horizon, the total gain is –5 dBi or better.

V. Acknowledgement

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VI. References


Figure 1. Profile view of the 802.11a/b antenna stackup.

Figure 2. Top view of prototype 802.11a/b AMC antenna.

Figure 3. Photograph of 802.11a/b AMC antenna mounted on a surrogate laptop made of aluminum.
Figure 4. Return loss and total efficiency of 802.11a/b AMC antenna system. (a) 802.11b band 2.4 – 2.48 GHz, (b) 802.11a band 5.15 – 5.35 GHz.

Figure 5. Pattern data of 802.11a/b antenna system. (a) 2D color map pattern at 2.44 GHz, (b) 2D color map pattern at 5.2 GHz, (c) azimuth pattern at 2.44 GHz at horizon, (d) cumulative total gain patterns at horizon for 2.44 GHz and 5.2 GHz.