A Miniaturized Wearable High Gain and Wideband Inkjet-Printed AMC Antenna

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***Abstract*—A highly directive AMC-based wearable antenna which exhibits a wide 1 GHz impedance bandwidth and a gain of over 6 dBi which covers the 802.11 Wifi band is demonstrated for the first time while maintaining a small electrical size. The antenna is inkjet printed on paper substrate making it low-cost and bio-friendly. The performance of the antenna is studied in air and on a body phantom to demonstrate the high performance of the antenna whether in air or on a lossy body.**

I. Introduction

The proliferation of on-body sensing and communication platforms requires antennas which are designed to be immune to the lossy effects of the body while maintaining a low-cost and bio-friendly nature. Inkjet printing of antennas on paper substrate can help meet the low-cost and eco-friendly requirements of on-body antennas. To isolate the fields of the antenna from the body, a ground-plane based antenna such as a patch must be used. However, ground-plane based antennas have high field concentrations in the substrate, and when lossy organic substrates such as paper are used, the high loss tangent degrades the efficiency of the antenna [1]. The bandwidth also suffers on the majority of ground plane backed antennas which typically achieve a bandwidth of 5% or less due to the substrate being a fraction of a wavelength thick [2].

One technique which is used to overcome the narrow bandwidth and low-gain of on-body antennas is to replace the ground plane with an artificial magnetic conductor (AMC). An artificial magnetic conductor has the unique property of reflecting an incident wave at 0° instead of 180° like a PEC ground. This allows for constructive interference when an antenna is placed on top of the AMC, and, by tailoring the bandwidth of the AMC surface, extremely wideband and high gain radiating properties can be obtained [3].

Current wearable AMC-based antennas have extended the fractional bandwidth to approximately 10% [4], however this is too low to cover the entire 802.11 5 GHz Wifi band which ranges from 5 - 6 GHz. This work demonstrates an improved version of the AMC-backed monopole which extends the bandwidth of the antenna to cover the entire 5 GHz Wifi band while maintaining a high gain of approximately 7 dBi. The antenna has applications in on-body sensing, location tracking, and many others.

II. Antenna Design and Fabrication

The proposed AMC-backed monopole is shown in Fig. 1. The antenna comprises of a microstrip monopole, and a ground backed frequency selective surface (FSS) which acts as the AMC. The first step in design is to tailor the AMC surface to operate with a near 0° reflection phase over the desired band which in this case is 5 - 6 GHz.

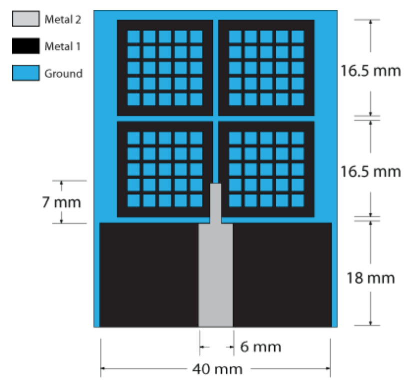

Fig. 1. Layout of the AMC-backed monopole

A waffle-like unit cell is used in this work as it has been demonstrated to be an inherently wideband structure which exhibits lower loss on lossy substrates such as paper due to a weak resonance [3]. The waffle-like unit cell is simulated as an infinitely repeated array in the CST floquet mode solver to extract the reflection phase of the surface which is shown in Fig. 2. It can be seen that the infinite surface demonstrates AMC properties at approximately 5 GHz with a wide +/- 90° bandwidth. The AMC frequency is designed to be lower than the middle of the 5 - 6 GHz band in the simulation as the finite four element AMC used in the antenna design will have a higher AMC frequency due to decreased edge loading.

After designing the surface, the entire antenna is optimized in the CST time domain solver to meet a 1 GHz bandwidth around 5.5 GHz with a peak gain of 7 dBi. The resulting antenna shown in in Fig. 1 is 40 x 50 mm in size which is approximately 0.6 x 0.8λ, and .04λ thick. This is 45% smaller than previous AMC-backed monopoles operating at the same frequency [3], [4].

To fabricate the antenna, a Dimatix DMP-2800 materials printer is used along with Cabot CCI-300 silver nanoparticle ink. The three metal layers (top monopole, middle AMC, and ground) are printed onto a commercially available photo paper using the silver nanoparticle ink and then cured in an oven

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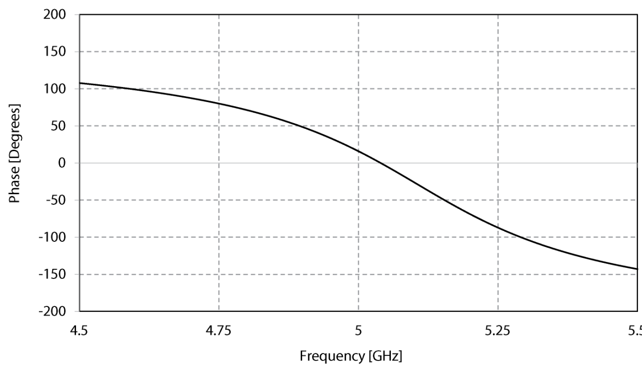


Fig. 2. Phase response of the infinite AMC surface

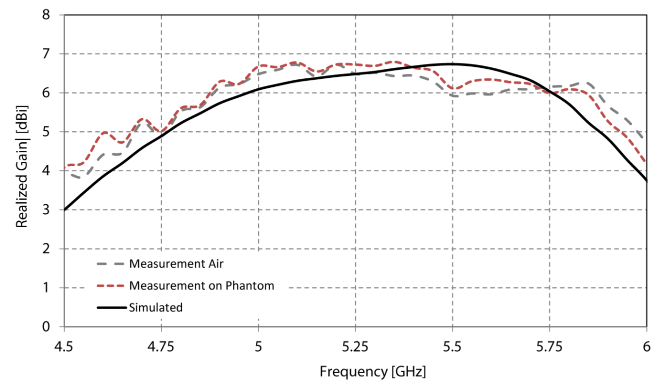


Fig. 4. Simulated and measured realized gain of the antenna in air and on a body phantom

at 150° C for one hour. The three layers are aligned using printed alignment marks and then glued together with a thin adhesive layer. An SMA connector is then mounted using C&W conductive silver epoxy.

A. Results

The S-parameters of the antenna are measured on a Rhode and Schwartz ZVA-8 VNA and compared with the simulation in Fig. 3. The impedance bandwidth of the simulation and measurement are in good agreement having a 1 GHz bandwidth centered at 5.5 GHz.

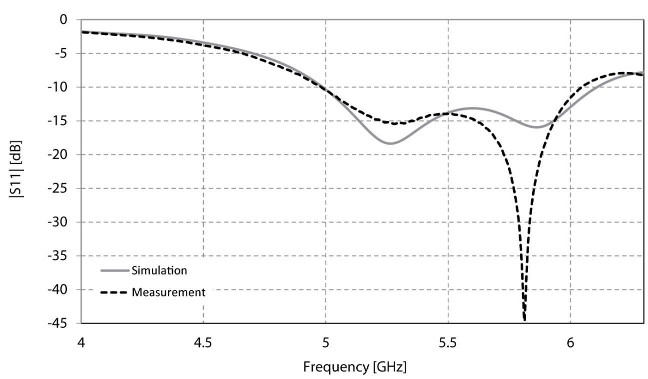
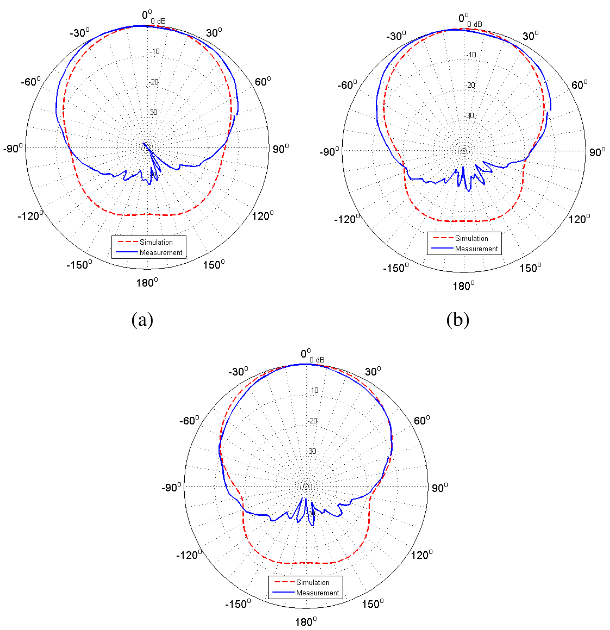


Fig. 3. Measured S-parameters of the AMC-backed monopole



(a) (b) (c)

Fig. 5. Simulation and measurement radiation patterns on a body phantom at (a) 5 GHz, (b) 5.5 GHz, and (c) 6 GHz

The radiation pattern and gain are then measured on a body phantom and in air at a Satimo far-field chamber. The gain versus frequency plot in Fig. 4 shows that the antenna maintains a high gain of over 6 dBi for the entire Wifi band with a peak gain of 7 dBi. The radiation patterns in Fig. 5 show the H-Plane over the frequency range and confirm that the pattern is a stable broadside beam over the entire operational bandwidth. It can be noted that the on-body and in-air performance of the antenna is nearly identical.

III. Conclusions

A wearable AMC-backed monopole has been demonstrated for the 5 GHz 802.11 Wifi band which exhibits a wide 1 GHz impedance bandwidth and a gain of over 6 dBi. The antenna is studied in air and on a body phantom which confirms nearly identical performance in both cases and no degredation in radiation pattern or gain when mounted on a lossy surface.

References

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