Performance Of Microstrip Patch Antenna Using AMC

Abstract
To develop new materials with desirable electro-magnetic properties those are not currently available to microwave engineers. One unifying theme of the materials should be moderately low loss magnetic materials for microwave applications. Specific properties we have investigated are impedance matched materials, tuned enhanced permeability, reactive impedance surfaces, and negative permeability electromagnetic band-gap materials.

1 Introduction
Recent applications in wireless and military communication systems have introduced a great interest in developing low profile antennas that can be integrated with compact systems like cellular phones, personal computer systems and wearable antennas [1]. However, low profile antennas above a perfect electrical conducting surface have a very small gain and bandwidth due to the destructive interference between the antenna and its image. This was the motivation to introduce the idea of using artificial magnetic conductor (AMC) surfaces as supporting structures for such low profile antennas [2]. In this case, the interference between the antenna and its image would be constructive [2] and consequently the antenna gain and bandwidth is increased. AMC surfaces can also be combined with perfect electric conductor (PEC) surfaces to develop TEM waveguide structure [3]. This TEM waveguide structure can be used for spatial power combination in high power mill metric-wave amplifiers.
These applications and others were the motivation to introduce different structures of AMC surfaces.

A simple configuration of such AMC surfaces can be an array of square patches arranged on a square grid above a grounded dielectric slab with electromagnetic band gap (EBG) substrate is shown in Fig. 1. Its side view is shown in Fig. 2. The square grid of this array shown in Fig. 3 is usually much less than the wave length of the operating frequency to avoid the presence of any grating lobes. Thus, the amplitude of the specular reflection coefficient of such structure is always unity. The key point is to design this surface to introduce reflected field in the same phase of the incident field [4]-[5]. In this case, the surface would correspond to a magnetic surface. A main difference between such AMC surface and ideal perfect magnetic conductor surface PMC is that in addition to the specular reflection, the former one includes higher order Floquet modes. Although all these higher order Floquet modes are evanescent modes, they still have a significant effect on the nearby antenna structure in the case of using such structure as a supporting surface for low profile antennas.

Thus, for AMC surface it was found that the optimum phase of the reflection coefficient that introduce the highest gain and the minimum Reflection coefficient in the antenna structure is centered around $\pi/2$ [1]. In this case, the AMC surface was found to have a better performance than the traditional PMC surface. This may be explained due to the interaction of such higher order Floquet modes that are not present in the case of the PMC surface. Thus, depending on the application, it may be required to design AMC with phase reflection coefficient around zero degree as in the case of TEM waveguide or around $\pi/2$ as in the case of low profile antenna. From the analytical point of view, this problem can be solved by using a full wave analysis technique such as method of moment, finite difference time domain or finite element method [1], [4], [6]. However, for design purpose, it may be required to develop a simple approximate technique that can be used to obtain the effects of the different parameters included in the AMC structure.

2 Present Theory and Practices

Zhang et al. [4] introduced a simple approach for solving the AMC structure shown in Fig. 1. Their approach is based on a simple equivalent circuit model for the periodic patch antennas. This circuit consists of capacitive resistive loads connected by transmission line sections. These capacitive resistive loads correspond to the capacitance effects between the patches and the resistance is due to the radiation effects from the edges of these patches. However, the main disadvantage of their model is that it can be used only for normal incidence.

Clavijo et al. [5] introduced another approach for simulating mushroom type AMC surface. Their model is based on approximating the patches as a shunt capacitive load along multilayered transmission line sections.

D. Qu, L. Shafai and A. Foroozesh [8] stated that parametric studies are conducted to maximize their impedance bandwidths and gains. It is found that very wide bandwidths, of around 25%, can be obtained by variation of the original antenna and EBG parameter. Their gains are similarly increased.

2.1 Artificial Magnetic Conductor

The undesired surface waves are a serious problem in microstrip antennas. Surface waves reduce antenna efficiency and gain, limit bandwidth, increase end-fire radiation & cross-polarization levels which limits the applicable frequency range of microstrip antenna. For designing compact microstrip antennas and their integration with microstrip circuits is hindered due to the surface wave loss for
high dielectric constant substrates which is required to achieve these objectives. Important considerations for antenna designers of compact high data rate wireless Communications systems are wideband performance and antenna size reduction. However, in many cases, for the size reduction, the main problem is the reduction of ground plane size, given the limited area available on the platforms. Such reduction means an increase in antenna backward radiation even for larger sizes, a normal conducting metal ground plane allows for surface wave propagation, which also contributes to backward radiation via edge diffraction. Two solutions are there regarding surface wave’s problem OR Microstrip Patch Antenna’s Limitation.

![Simulated design of AMC in HFSS.](image)

**2.2 Measured Dimensions**

**Table: 1 Patch Dimensions**

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Antenna Type</th>
<th>Width</th>
<th>Length</th>
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<tbody>
<tr>
<td>1</td>
<td>Cell</td>
<td>6.25mm</td>
<td>6.25mm</td>
</tr>
<tr>
<td>2</td>
<td>Internal Patch Antenna</td>
<td>42mm</td>
<td>28mm</td>
</tr>
<tr>
<td>3</td>
<td>Total Antenna System</td>
<td>85</td>
<td>85mm</td>
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In this case the substrate is periodically loaded so that the surface wave dispersion diagram presents a forbidden frequency range (stop band or Band gap) about the antenna’s operating frequency. In the below figure 2 AMC antenna is simulated using HFSS Version 11.0. four boundary condition are used to model the above antenna
- Perfect electric boundary for antenna ground
- Dominate mode boundary for excitation
- Absorber boundary condition for radiation space
- Perfect magnetic for multilayer AMC structure

The fabricated patch antenna (Dimensions described in Table 1) shown in figure 2. The antenna model with dimensions described above was sent to the Engineering Workshop for fabrication. The antenna
was fabricated by a milling process using double-sided copper FR4 substrate, so that the ground plane covers the opposite side of substrate. The antenna was simulated with 20 HFSS passes. The measured antenna performance is consistent with the results of simulation in that differences are within simulation and fabrication errors.

![Antenna Diagram]

**Figure 2: Ground side of AMC antenna**

![VSWR Graph]

**Figure 3: Measured VSWR result of AMC**

**Table: 2 Simulated Result of AMC**

<table>
<thead>
<tr>
<th>Center frequency</th>
<th>VSWR</th>
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<td></td>
<td>Simulated</td>
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3. Conclusion
The research presented within this paper has demonstrated some of the advanced applications that electromagnetic band gap materials can be used to improve, such as meta ferrites, increasing operating bandwidth of AMC surfaces, low frequency AMC designs, and integration of AMC surfaces and planar antennas. These concepts were realized by improving upon one or more of the difficulties experienced by typical artificial magnetic conductors such as a narrow bandwidth,
minimum thickness constraints, and near-field interactions causing unwanted problems in the case of AMC antennas.

4. References