Artificial Magnetic Conductor-backed Dual Band Antenna for Wireless Applications

Manoj M, Remsha M, Shameena V A, Vasudevan K and Mohanan P
CREMA, Department of Electronics, Cochin University of Science and Technology, Cochin-22, Kerala, India

Abstract

A novel compact dual band antenna with Artificial Magnetic Conductor (AMC) backed ground plane is proposed for small form factor gadgets. The antenna is designed to cover two wireless network bands at 2.4 GHz and 5.5 GHz. The antenna has an overall dimension of 20 x 14 x 1.6 mm^3. The AMC structure consists of 4 x 4 first order fractal unit cells that are made up of two concentric square ring slots. The AMC ground plane improves the antenna gain by 2.61 dBi due to the suppression of surface wave.

1. Introduction

Artificial Magnetic Conductor backed antennas have recently received much attention in the wireless communications systems due to their excellent properties like frequency selectivity, bandwidth, polarization and gain. With the rapid development in the designs of wireless communication devices, an enhancement of antenna gain characteristics is becoming more pronounced. Due to the in-phase reflection coefficient similar to a Perfect Magnetic Conductor (PMC), Artificial Magnetic Conductor (AMC) structures are widely employed as antenna ground plane to enhance the antenna performance. AMC structures are created by a periodic arrangement of the unit cell with unique properties in one, two or three dimensions.

Recently, several planar antenna structures for WLAN and WiMAX have been proposed in the literature [1-3]. Tran Minh Tuan et. al. has reported a microstrip line fed F-Shaped dual-band antenna operating at 2.4 GHz and 5.2 GHz frequencies with the size of 50 x 50 x 1.6 mm^3 for WLAN applications [4]. A CPW-fed single band antenna with a central metal patch and two ground plane placed symmetrically with respect to patch having a dimension of 18 x 18 x1.6 mm^3 for WLAN applications is suggested in [5]. A dual-band patch antenna with size 18.8×20×0.76 mm^3 is reported in [6].

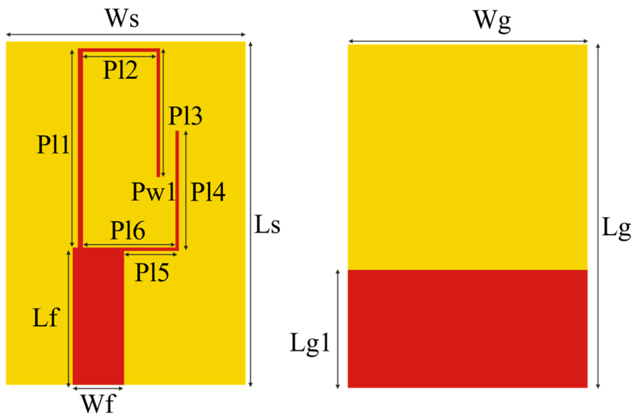
Circular shaped 6x9 fractal AMC structure were designed for enhancing the gain of the order of 4 dBi of a conventional bow-tie antenna [7]. In [8], a combination of perfect electric conductor, perfect magnetic conductor, and their hybrid topologies are used for enhancing the gain and bandwidth of conventional microstrip antennas. The stub loaded 6 x 6 unit cell AMC ground plane is used to enhance the gain up to 1.73 dBi as compared to the conventional patch antenna [9].

However, achieving compact designs with improved gain and bandwidth is a challenging research topic. In this regard the proposed antenna has the advantage of compactness as well as improved gain and bandwidth compared to existing designs.

To synthesize an AMC surface, the unit cell must be selected and should be characterized initially. In this paper, a simple structure for significantly improving the gain and bandwidth, a modified monopole patch antenna is presented. The simulation studies are done using CST Microwave studio and observations are verified using PNA E8362B.

2. Antenna geometry and design

The configuration of the suggested dual-band planar antenna is illustrated in figure 1.



a. Front view b. Back View

Figure 1. Geometry of the Dual band planar antenna.

The dual-band planar antenna is composed of two folded open stub resonators. The compact radiator is fed using a 50Ω microstrip transmission line. The prototype of the antenna with a partial ground is fabricated using the conventional photolithographic process on a substrate of εr= 4.3, tan δ = 0:02 and height h = 1.6mm, with copper trace thickness (t) of 17 µm.

The antenna parameters for the optimum design are tabulated in TABLE I.

TABLE I. Detailed dimensions of the proposed antenna

Parameter	Value (mm)	Parameter	Value (mm)
W_s	14	Pl_4	7
L_s	20	Pl_5	3.2
W_f	3	Pl_6	5.4
L_f	8	Pw_1	.2
Pl_1	11.6	W_g	14
Pl_2	4.3	L_g	20
Pl_3	7.5	Lg_1	14

The lower resonance at 2.4 GHz is obtained by the first folded open stub resonator (long arm).The second resonance at 5.5 GHz is achieved by second folded open stub resonator (short arm). The simulated and measured reflection coefficients (S11) of the antenna are shown in figure 2. From figure 2 it is observed that the proposed antenna is able to operate at two bands 2.35 GHz–2.52 GHz and 5.31 GHz–5.98 GHz, which are suitable for WLAN 2.4/5.8 GHz and WiMAX 2.5/5.5 GHz bands.

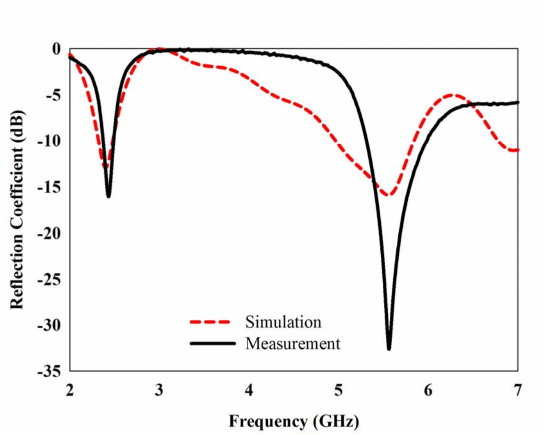
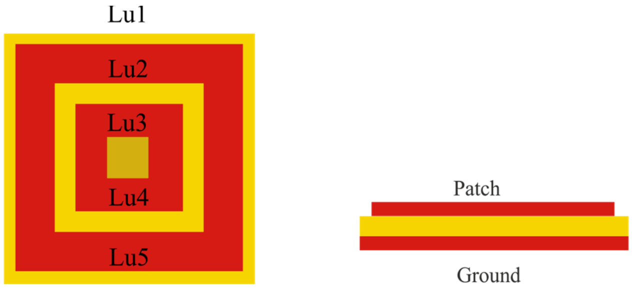


Figure 2. Reflection coefficient of the dual band antenna, as described in figure 1.

3. AMC Ground Plane Design

Figure 3 shows the unit cell of the suggested square slot AMC structure. The overall dimension of the described AMC ground plane is 24.1 x 24.1 x 1.6 mm^3. The AMC structure constitutes of two concentric square ring geometries. It is realized on an FR4 substrate with a thickness of 1.6 mm, with a relative permittivity of ε_r= 4.3 and loss tangent tanδ= 0.02.

The broadband operational bandwidth is achieved by etching out the two concentric square ring slots from AMC ground plane. The proposed AMC unit cell is simulated using periodic boundary setup. The resultant simulated reflection phase, magnitude and the AMC band from an AMC plane are depicted in figure 4.



a. Front view b. Side View

Figure 3. Square slotted unit cell of AMC groud plane.

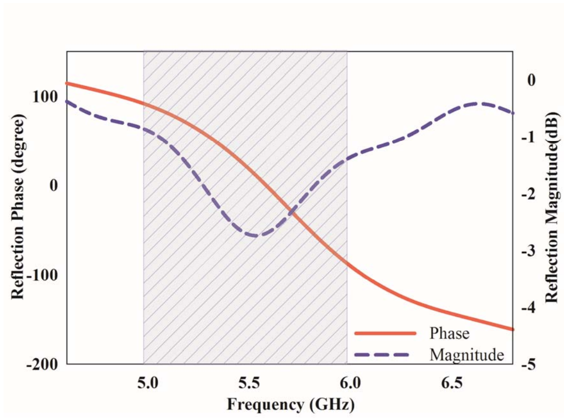


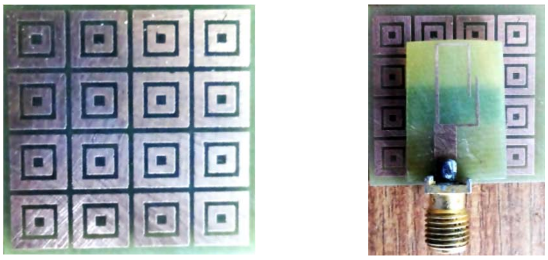
Figure 4. Simulated reflection phase characteristics of AMC ground plane.

4. Antenna with AMC ground plane

The fabricated structure of the modified monopole patch antenna on an AMC ground plane depicted in figure 5. The AMC ground plane consists of 4×4 unit cells with optimum dimensions Lu_1= 6.1 mm, Lu_2= 3.6 mm, Lu_3= 1 mm, Lu_4= 2.6 mm, Lu_5= 5.5 mm.

The antenna ground plane and the AMC ground plane are not connected. The distance between the antenna and AMC ground plane is kept at an optimum distance of 20 mm. As shown in figure 5, the spacing between the antenna and the AMC is maintained using foam.

The frequency range for which the reflection phase is between −90◦ and +90◦ is defined as the AMC bandwidth due to the fact that the reflected wave is not out of phase with the incident wave in this frequency range [10]. According to this definition, it is observed that the reflection phase of the proposed AMC ground plane covers the frequency band of 5 GHz - 6 GHz as shown in Figure 4.



a. AMC ground plane b. AMC backed antenna

Figure 5. Photograph of the fabricated prototypes.

5. Measured Results

The simulated and measured reflection coefficient of the antenna with and without AMC ground plane is compared in Figure 6.

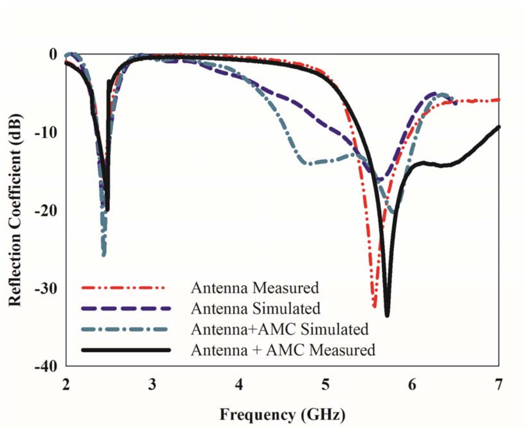


Figure 6. Reflection coefficient of the dual band antenna with and without AMC.

The bandwidth of the antenna for the second resonance is improved by 788 MHz as shown in figure 6. The gain of the antenna is measured using gain comparison method.

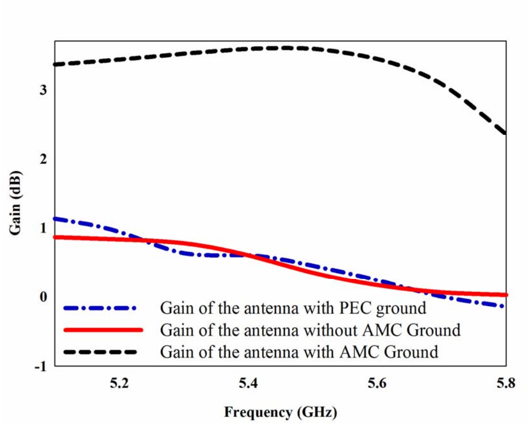


Figure 7. Measured gain of the proposed antenna is compared with PEC ground plane.

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As expected, with the use of square ring slotted AMC, the gain is improved by 2.61 dBi as shown in figure 7. The E-plane and H-plane patterns for 5.5 GHz and 2.4 GHz are depicted in figure 8.

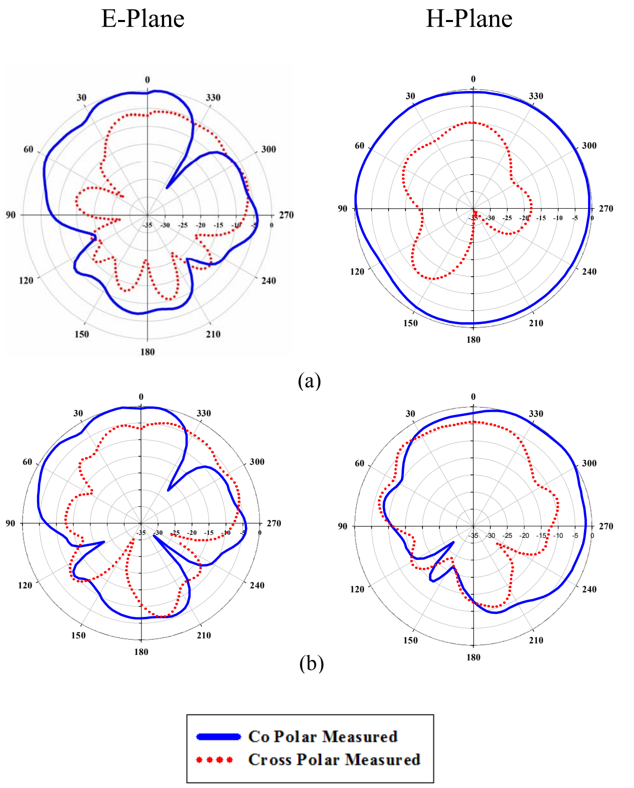

Figure 8. Measured radiation pattern in E-plane and H-plane at (a) 2.4 GHz (b) 5.5 GHz.

6. Acknowledgements

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7. References

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