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Improving the Performance of Edge-Fed Monopole Antenna Using Artificial Magnetic Conductors

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***Abstract*—A wideband edge-fed monopole antenna with artificial magnetic conductor (AMC) as ground plane is proposed. AMC ground plane instead of conventional PEC plane is used to improve the antenna gain and bandwidth. The proposed AMC structure which uses a 1 mm air gap results in increasing the bandwidth to about 18.25% with nearly 4% improvement compared to the AMC structure without air gap. Using air gap and reducing AMC substrate height is a suitable method for decreasing weight, especially in lower frequencies. In the case of using air gap a 1-mm-thick AMC substrate can be used that improves bandwidth to 23.91% at the expense of only 1dB reduction of the gain which is a desired result.**

***Index Terms*—artificial magnetic conductor (AMC), monopole antenna, edge-fed antenna, unit cell, air gap.**

I. Introduction

Nowadays planar antennas are one of the most popular commercial antennas, especially in mobile and wireless communications. This popularity is a result of the numerous advantages of these antennas such as low weight, small profile, compatibility with different kinds of surfaces, simplicity in fabricating and matching with modern printed circuits [1]. Unfortunately these antennas have also some disadvantages such as low power, low gain, narrow bandwidth and existence of surface waves which may reduce the efficiency [2].

Using a PEC ground plane as a reflector is one way for improving performance of these antennas. Using this solution can increase the gain and directivity of the antenna; however it seriously reduces the bandwidth [3]. One technique for enhancing the bandwidth is to increase the substrate height. But this results more weight, surface waves and also a wider feed line which may increase the unwanted spurious radiations. Another method is to use artificial magnetic conductors (AMC), which provides the capability of reducing back-radiation, increasing gain, and broadening the bandwidth when they are employed as the antenna ground plane. It should be noted that all these properties can be achieved when the structure reflection phase lies in the interval of [-90˚,+90˚], especially near 0 ˚ for the working frequency band [4]. This phase-shift band is defined as the AMC in-phase frequency band.

In this paper, first a wideband monopole antenna is designed then an AMC structure is used to enhance the performance of the antenna.

II. Analysis and Design of the Single Monopole Antenna

The top and back views of the edge-fed monopole antenna are shown in Fig. 1. This antenna consists of a rectangular patch with a feed line which is inserted into patch with the size of s_i= 0.05 mm. The patch is etched on a 1-mm-thick dielectric substrate of Arlon Diclad 880 material ($\varepsilon_r = 2.2$, $\tan\delta = 0.001$) with the dimensions of 35.6×35.6 mm². The feeding ground plane length (L_f) is selected as the same as the microstrip feed line length. The width of feed line is w_f = 0.89 mm which is chosen for achieving a 100-Ω microstrip line.

The optimization and full-wave simulation of the structure is performed by CST MWS 2014. The input reflection coefficient of the antenna is depicted in Fig. 2. It is observed that the antenna has the bandwidth (SWR < 2) of 55% from 5.7 to 10 GHz, with maximum gain of 5.34 dB at 8.9 GHz.

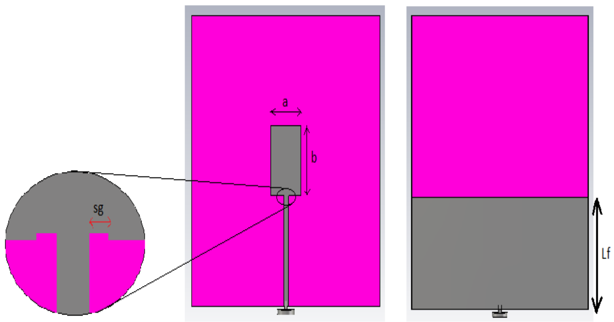


Fig. 1. Configuration of the printed monopole antenna. (a = 5.64, b = 8.5, s_g = 0.52 and L_f = 13.6, all in mm).

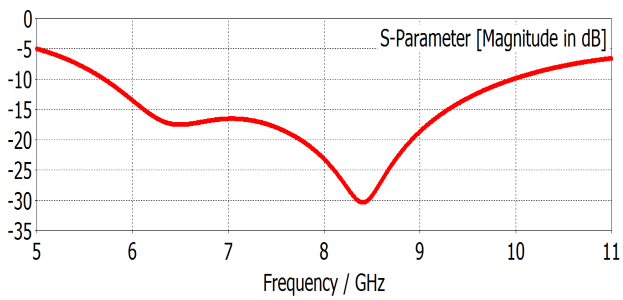
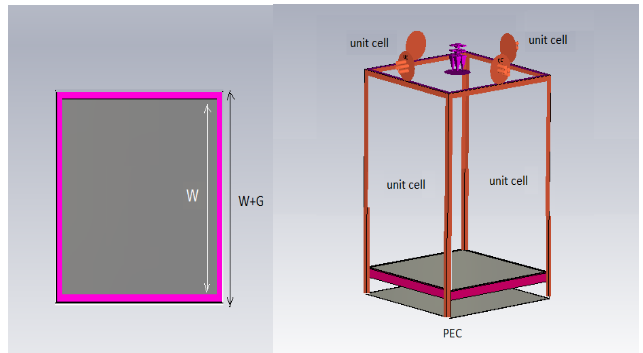


Fig. 2. Reflection coefficient of the printed monopole antenna.



(a) (b)

Fig. 3. (a) The geometry of the AMC unit-cell. (b) Unit-cell boundary conditions in CST. (W = 8 mm and G = 0.4 mm)

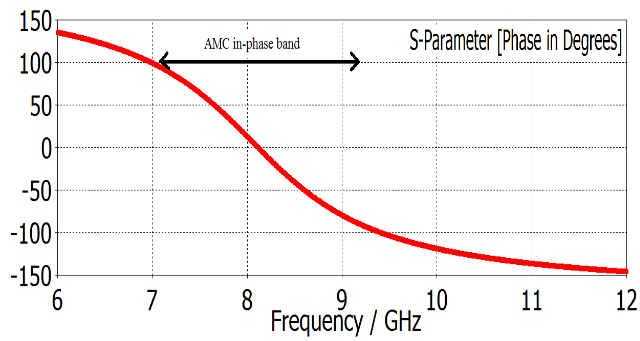


Fig. 4. The proposed unit cell's reflection phase

III. Design and Simulation of Unit-Cell

In order to improve the gain of the antenna, we can use a PEC plane as reflector behind the antenna. In this case, the gain is increased but the bandwidth is considerably reduced. Another technique is to use an AMC ground plane instead of the PEC one.

The proposed AMC unit-cell is shown in Fig. 3. It consists of a metal square plate on top, a 0.5-mm-thick dielectric substrate and a square ground plane in the bottom. There is a 1-mm air gap between the substrate and the ground plane. Existence of this air gap results in achieving a wider AMC in-phase frequency band with better performance [5]-[6]-[7].

The proposed AMC unit-cell is simulated using CST MWS 2014 in frequency domain with boundary conditions shown in Fig. 3(b). The reflection phase versus frequency is depicted in Fig. 4. It is observed that the AMC in-phase frequency band is 7.15-9.19 GHz. It is expected that using the AMC structure result in the improvement of the antenna performance.

IV. Monopole Antenna With AMC Structure

Here, a 3×4 array of AMC unit-cells is used as the antenna ground plane. The ground plane below the feed line is raised to the same height as the AMC top plates, as shown in Fig. 5, to achieve better bandwidth, lower cross-polarization and increasing the forward-to-back radiation ratio [8].

The Gain and bandwidth of the antenna on AMC ground plane with and without air gap are compared in Figs. 6 and 7. In the case of using air gap the AMC substrate height is 0.5 mm but in absence of the air gap, increases to 1 mm. The results are summerized in Table 1.

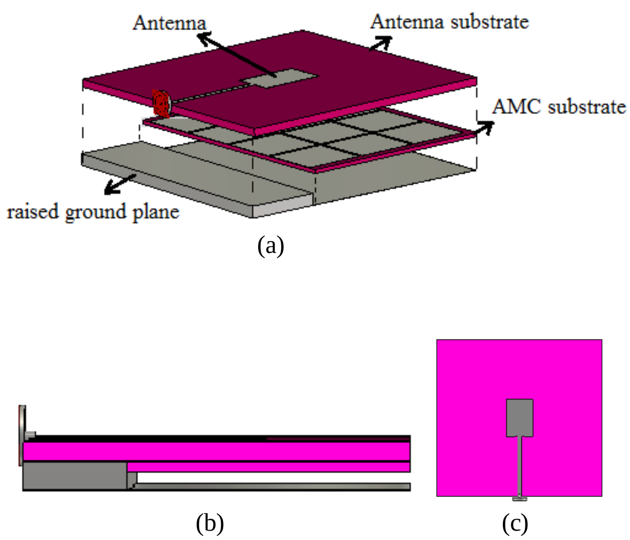


Fig. 5. Topology of the proposed structure. (a) 3-D configuration. (b) side view. (c) top view.

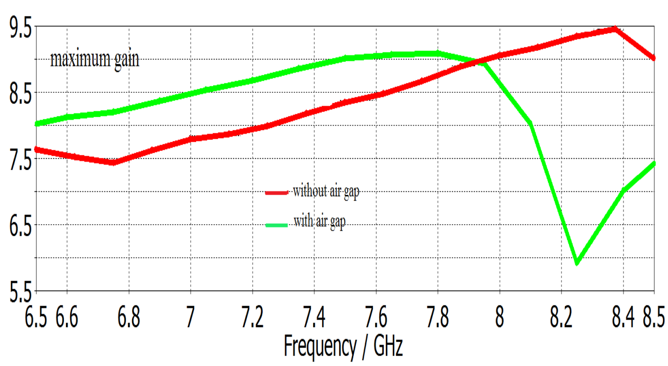


Fig. 6. Maximum gain of antenna on AMC ground plane with and without air gap.

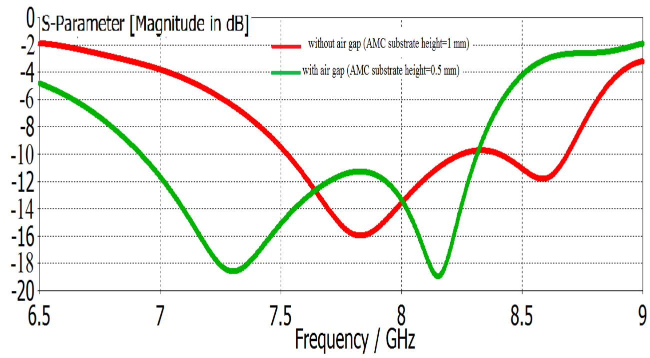


Fig. 7. Simulated reflection cofficient of antenna on AMC ground plane with and without air gap.

TABLE I.
Comparision between performances of antenna on AMC ground plane with and without air gap.

section	Relative bandwidth	Maximum gain
Antenna over AMC without air gap	14.43% (7.52-8.69 GHz)	9.51 dB
Antenna over AMC with air gap	18.25% (6.92-8.31 GHz)	9.1 dB

As shown in Fig. 8, if both of air gap and the 1-mm-thick AMC substrate are used, the -10dB bandwidth of the antenna is improved to 23.91% covering 6-7.63 GHz, while its maximum gain is 8.5 dB at 7 GHz. In this case, 9.48% improvement in bandwidth is achieved but the antenna's gain decreases to about 1 dB.

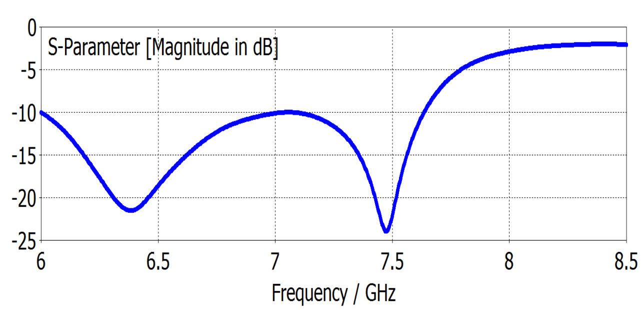


Fig. 8. Simulated reflection cofficient of the structure using air gap and 1-mm-thick AMC substrate together.

V. CONCLUSION

An AMC structure was proposed to enhance the gain of an edge-fed planar monopole antenna without considerable reduction of its bandwidth. The initial edge-fed monopole antenna has a bandwidth of about 55% with a gain of 5.34 dB. Using the proposed AMC structure as the ground plane of antenna, increased its bandwidth to about 18.25% with nearly 4% improvement compared to the previous structure. Using air gap and reducing AMC substrate height is an appropriate technique for decreasing weight, especially in low frequencies. With using both 1-mm-thick AMC substrate and the air gap, the bandwidth was increased to 23.91%. However, in this case there was a 1-dB reduction in the gain of the antenna.

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