Wideband Diamond Dipole Antenna with Broadside Radiation Characteristics

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***Abstract*—This paper presents a low profile wideband diamond dipole antenna backed with an Artificial Magnetic Conductor. The paper addresses the problem of drop in the broadside gain due to the split in the radiation pattern at some particular frequencies within the operation bandwidth. A solution is proposed by using a hybrid Artificial Magnetic Conductor that can effectively cancel this effect. The resulting antenna is characterized by an overall thickness of 6.8 mm which corresponds to a tenth of wavelength at the lowest operating frequency.**

***Index Terms*—Wideband diamond dipole antenna, Artificial Magnetic Conductor, directive antenna.**

I. INTRODUCTION

A printed diamond dipole is an interesting antenna because of its wide operating bandwidth. When coupled with a ground plane, the gain of the antenna is mainly improved in the broadside direction. The problem with classical ground planes made of electrical conductors like copper is that they need to be placed at a distance of a quarter wavelength in order to promote constructive interference in the broadside direction. A magnetic conductor is a solution to this problem because it does not cause a phase reversal of the incident electric field, thereby allowing the antenna to be placed very close to the ground plane. An Artificial Magnetic Conductor (AMC) has been traditionally designed using the Sievenpiper like periodic printed surfaces [1]. The dipoles in proximity of AMC have been previously studied in various works. In [2], the radiation pattern splits close to the resonant frequency of the AMC. This is corrected by changing the periodicity of the patches. In [3], it is observed that radiation pattern splits in higher frequencies in the bandwidth. For applications that require visibility in the broadside direction of the antenna, appearance of nulls and split radiation pattern inhibit the functioning of the device. This paper presents a UWB antenna design scheme, which tackles the problem of splitting of radiation pattern by using a hybrid AMC.

II. DESIGN

The antenna structure comprises of the diamond dipole backed with an artificial magnetic conductor. The antenna is printed on CuClad Substrate of thickness h = 1.58 mm, dielectric constant, ε_r = 2.5 and loss tangent, $tan\ \delta$ = 0.0018. The dimensions of the antenna as shown in Fig. 1 are L = 9 mm, S = 0.3 mm, a = 1.5 mm, b = 3 mm. The antenna will be fed in the gap S.

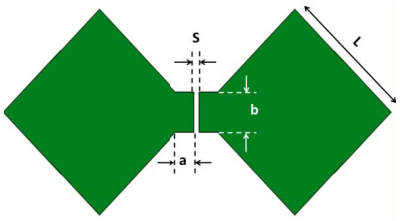


Fig. 1. Diamond Dipole.

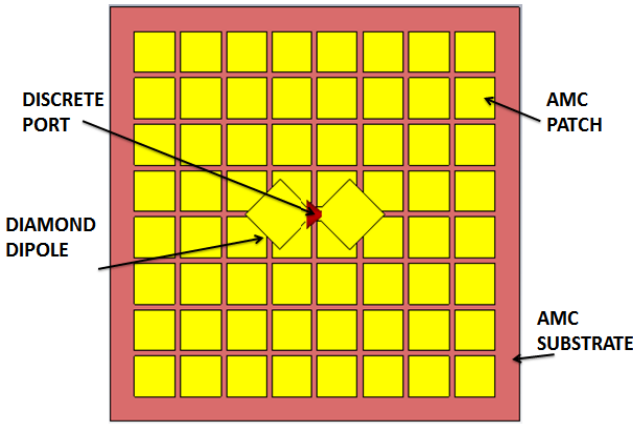


Fig. 2. Antenna with Classical AMC Reflector.

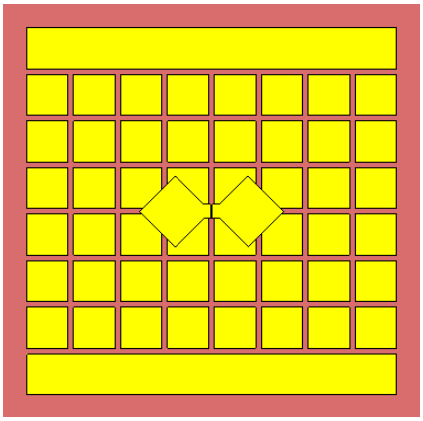


Fig. 3. Antenna with the Hybrid AMC Reflector.

The dimensions of the unit cell in the AMC are w = 7.4 mm, g = 1 mm, where w is the length of the square patch and g is the distance between two consecutive patches. It is noticed that there is no via in the structure. The substrate used for AMC is FR4 Epoxy (h = 3.2 mm, ε_r = 4.1, $tan\ \delta$ = 0.02). The above dimensions allow a zero reflection frequency at f_0 = 5 GHz. At this frequency, the patches behave as a magnetic conductor. As the number of unit cells of AMC increases, the bandwidth of the antenna increases. The size of the AMC is thus a compromise between optimum bandwidth and size. As shown in Fig. 2, an 8 x 8 cells configuration of the AMC designed using unit cell as defined above is used in this case. The size of FR4 substrate is 75 mm x 75 mm. The size of the antenna substrate is also taken identical to that of AMC substrate. The AMC is placed at a distance of 2 mm from the antenna. The overall thickness of the antenna is then 6.78 mm.

III. Results and Discussion

The antenna has been simulated using CST Microwave Studio (Transient solver). The antenna is fed by a discrete input port into the gap S. The bandwidth in which the patch array behaves as a magnetic conductor is 1.61 GHz (4.23 - 5.84 GHz) around the zero reflection phase frequency.

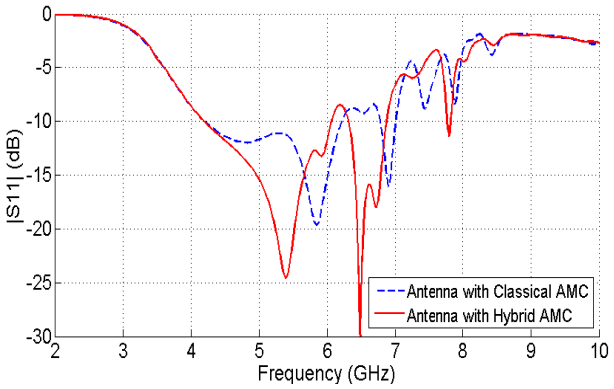


Fig. 4. Magnitude of reflection coefficient versus frequency.

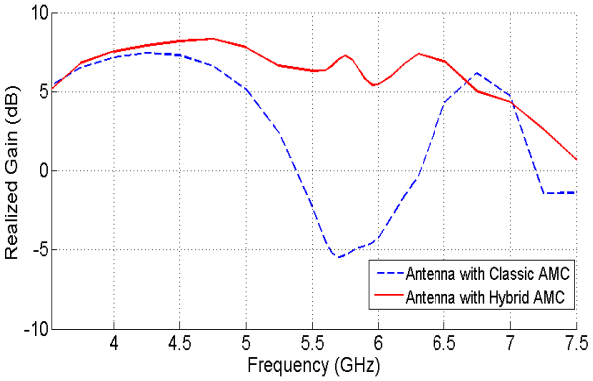


Fig. 5. Realized gain in broadside direction versus frequency.

As seen in Fig. 4, the blue trace gives the magnitude of the reflection coefficient for diamond dipole backed with a classical AMC reflector. The impedance bandwidth defined by |S11| < - 10 dB is 2 GHz (4.2 - 6.2 GHz) with a second band between 6.8 and 7 GHz. On observing the radiation patterns on various frequencies in the bandwidth, it is seen that the main radiation lobe splits up around 5.7 GHz. This is shown in Fig. 5 in blue trace by plotting the realized gain of the antenna in broadside direction. The maximum gain in the impedance bandwidth is observed to be 7.4 dB.

Using the technique detailed in [4], it is found that the currents which lead to destructive interference in broadside radiation are located in the last two rows of patches in the AMC. In order to change the distribution of these currents, a metallic strip as shown in Fig. 3 replaces the two rows respectively. Thus, the AMC reflector is now comprised of magnetic and electrical conductor and is called a hybrid reflector. When the antenna is coupled to the hybrid AMC, the impedance bandwidth of the new device is observed to be 1.8 GHz (4.2 - 6 GHz) with a second band between 6.3 and 6.9 GHz, as seen plotted in red trace in Fig 4. When taking in consideration both bands, bandwidth has been marginally improved. Fig. 4 also shows that changing the AMC pattern does not have an adverse effect on the input impedance of the antenna. The introduction of metallic strip changes the distribution of the currents on AMC in order to cancel the destructive contribution in the broadside radiation direction. This restores the radiation in broadside direction as seen in red trace in Fig. 5. This antenna thus has a broadside radiation pattern in its entire impedance bandwidth. The maximum gain of the antenna is 8.3 dB.

IV. Conclusion

In this paper, a wideband antenna with a hybrid reflector is discussed. The problem of split radiation patterns for dipoles placed over AMC is investigated and the problem was resolved by cancelling the contribution of destructive currents found on the magnetic reflector. The resulting antenna is characterized by an overall thickness of a tenth of wavelength at the lowest operating frequency. This antenna offers a larger impedance bandwidth and ensures a broadside radiation pattern over its whole bandwidth.

V. Acknowledgement

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