

Mutual Coupling Reduction Using Electromagnetic Band Gap Structures in Wideband High Gain Antenna for L Band Applications

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Abstract: In this paper, simple techniques are been proposed and investigated successfully to overcome the basic limitations of gain, bandwidth for a microstrip antenna and mutual coupling for a microstrip antenna array. A meandered E shape patch antenna with a air cavity is proposed to enhance gain and bandwidth. To reduce mutual coupling an Electromagnetic band gap structure has been proposed. Coax feed has been used for excitation. The meandered patch provides band width enhancement and the air cavity along with a thick aluminum ground plane combindly provided gain enhancement. E shaped patch has been formed by considering a basic rectangular patch and by etching slots at the edge of the patch. The simulated results show a bandwidth of 89MHz ranging from 1.30GHz to 1.39GHz with a maximum gain of 8.37dB at the operating frequency of 1.35GHz. The antenna has been designed over a RT Duroid 5880 substrate with a dielectric constant of 2.2 and thickness of 62mil. Antenna Design and simulation studies are carried out in Ansys HFSS software.

Keywords: Air cavity, Coax feed, Meandered patch.

I. INTRODUCTION

Microstrip patch antennas are most significant with their unique abilities of low profile and ease of fabrication. Though microstrip antennas are widely been used they are having some limitations in terms of gain and bandwidth [1]. Microstrip antennas have low gain and band width due to which they are not been used for specific applications. To overcome these limitations many

techniques and design considerations are been proposed by researchers and are been successfully implemented. One of the techniques for gain enhancement is to use a substrate with low dielectric constant and to enhance the bandwidth thickness of the substrate is to be increased [2]. But there are limitations for these methods also, with increase in the substrate after a significant height the bandwidth will again decrease and also the long probe length will increase inductance on the antenna and it will reduce the impedance bandwidth [3]. And the material cost increases with reduction in the dielectric constant.

To overcome these limitations here we proposed a meandered E shape patch antenna with a air cavity. Air is having a dielectric constant of one and is having no material losses. So air cavity is been placed between the substrate and the ground plane so that the effective dielectric constant of substrate and air cavity will be very low and is useful for the gain enhancement [4]. This will also help in bandwidth enhancement as the height between the patch and the ground plane is high will give high bandwidth. By using air cavity we can also minimize the inductance effect of the long probe length and by having a meandered radiating patch the inductance effect of the probe will be cancelled. For the fabrication purpose the air cavity can be filled with a non radiating foam which will not affect the radiation characteristics of the antenna and will provide additional physical strength to the antenna [5].

With the advancement of technologies and requirement of device array size reduction is necessary and the best way to achieve size reduction is placing array elements very close to each other. However, this change in inter-element separation and relative orientation arises the mutual coupling, which in hand causes undesirable effects on characteristics.

The proposal of this work is to reduce the mutual coupling in patch antenna array. The proposed structure has EBG structure printed on the substrate. The proposed periodic structures help to reduce mutual coupling.

II. ANTENNA DESIGN

The geometry of the proposed antenna is shown in Fig. 1, the antenna consists of a aluminum ground plane, RT Duroid 5880 substrate, a meandered rectangular patch in the shape E shape and a air cavity in between the substrate and the ground plane. Coax feed is provided for excitation of the patch antenna. The air cavity is 12mm in height and the aluminum ground plane is 1mm in height. The substrate is having a thickness of 62mil. For fabrication purpose the air cavity can be filled with non radiating foam materials like ROHACELL which do not affect the radiation characteristics of the antenna and will provide additional physical strength to the antenna.

The ground plane and the substrate are having a length and width of 145mm×145mm. The rectangular patch is having a dimension of 88.75mm×110mm and the slots dimensions are 52mm×7mm, four slots of equal dimensions are etched on the antenna edge which are placed at equal distance from each other. The feed is provided near to the opposite edge of the slotted edge. The patch is placed at the center of the substrate.

The air cavity provides the high gain and bandwidth enhancement for the antenna and the meandered slot helps in improving the bandwidth of the antenna.

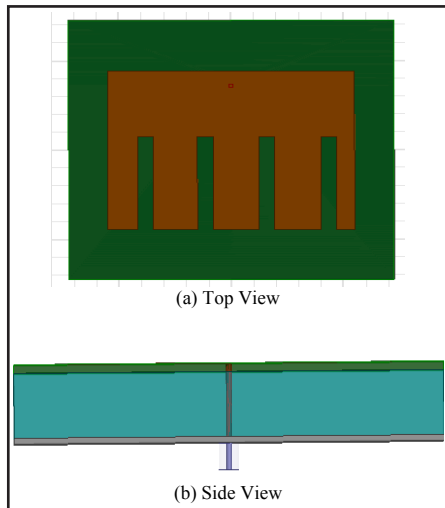


Fig. 1: Proposed Patch Antenna

III. RESULTS AND ANALYSIS

Fig. 2 depicts the simulated S11 characteristics of the proposed antenna. A return loss of -15.47dB is observed at the operating frequency of 1.35GHz. A 10dB bandwidth of 89 MHz which is 6.7% of bandwidth and it is ranging from 1.30GHz to 1.39GHz. Observed a VSWR value of 1.4 at 1.35GHz as shown in Fig. 3. The obtained results depicts that the impedance matching of the antenna with the coax feed is close to 50Ω.

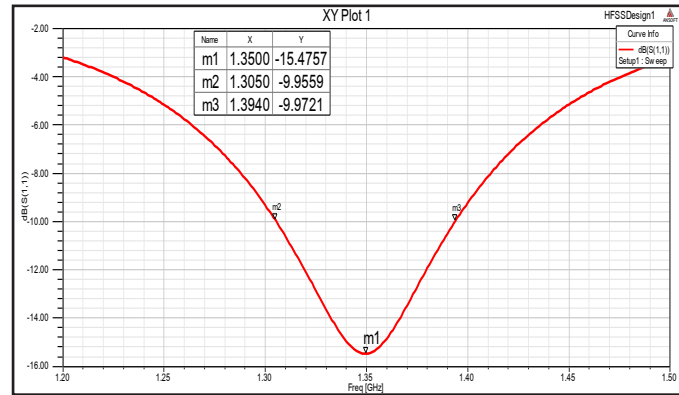


Fig. 2: Return Loss

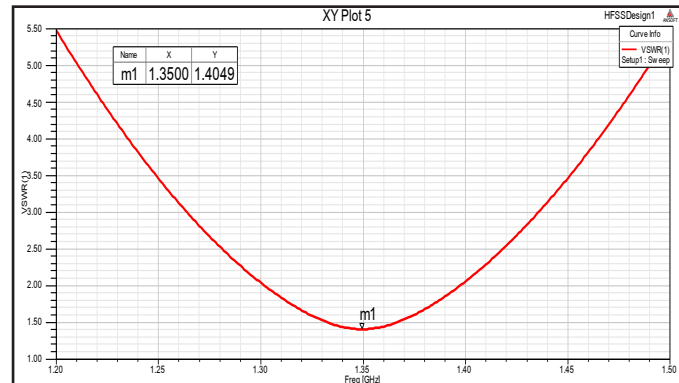
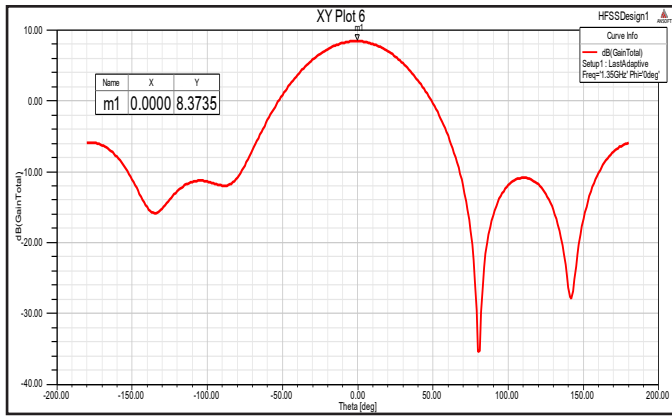
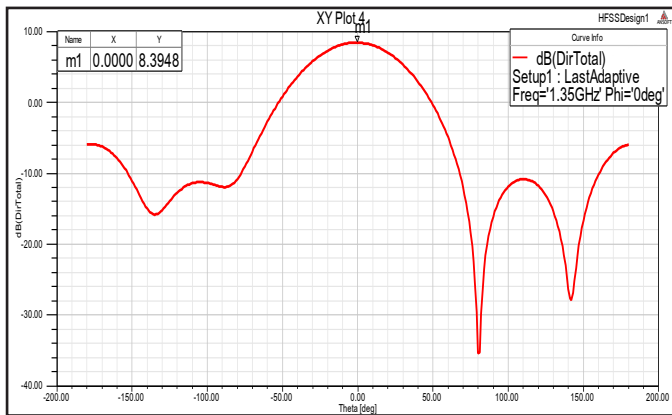


Fig. 3: VSWR

A air cavity is introduced in between the ground and the substrate which improves the gain of the antenna. The Air cavity height is adjusted such that the antenna radiates at the required operating frequency with a maximum achievable gain. The simulated gain and directivity plots of the proposed antenna are presented in Fig. 4 below. The gain observed at the frequency of 1.35GHz is 8.37dB and directivity observed is 8.39dB.



(a) Gain



(b) Directivity

Fig. 4: Gain and Directivity at 1.35GHz

The current distribution in the meandered patch at the operating frequency of 1.35GHz is shown in the Fig. 5, it can be clearly observed that the slotted edges are radiating mostly at the operating frequency.

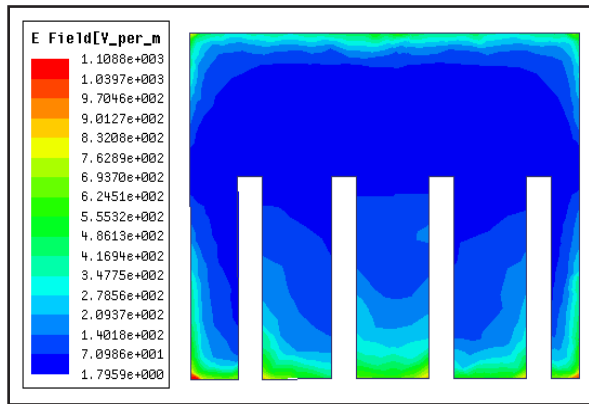


Fig. 5: Current Distribution at 1.35GHz

Fig. 6 below the radiation patterns of the proposed antenna at 1.35GHz for both Elevation plane and Azimuthal plane. Half

power beamwidth of 63° and 67° are observed for the Elevation and Azimuthal planes respectively at 1.35GHz. Notable, radiation patterns obtained for the proposed patch antenna are broadside when compared to the radiation properties of the normal microstrip patch antenna[6]-[8].

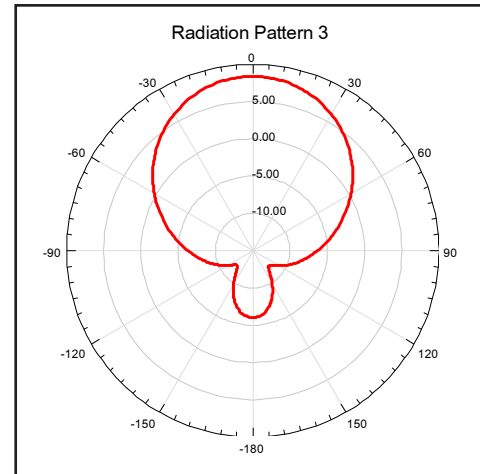
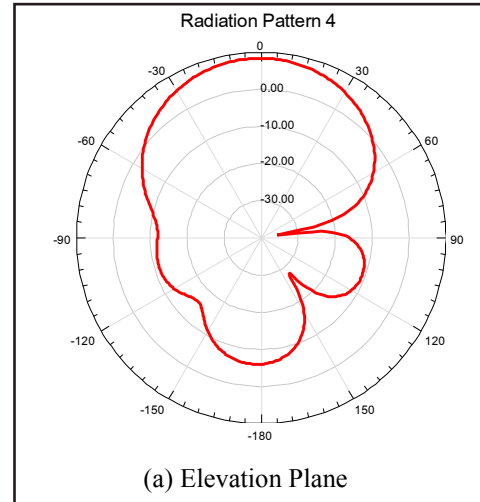


Fig. 6: Radiation Patterns of Proposed Antenna at 1.35GHz

Fig. 7 below shows the antenna array structure of the proposed antenna.

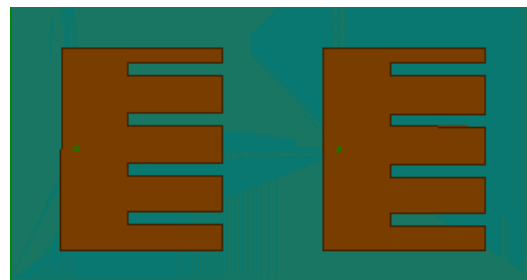


Fig. 7: Proposed Patch Antenna Array

Fig. 8 below shows the mutual coupling plot of the antenna array.

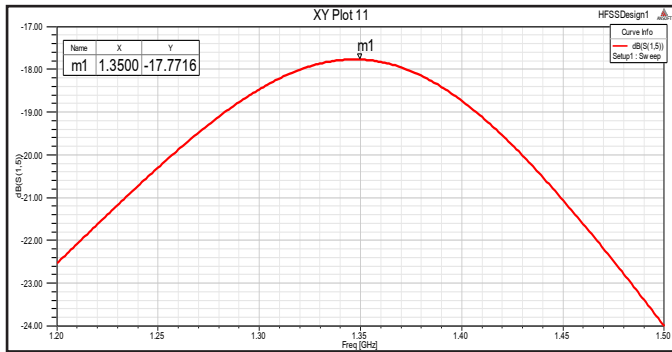


Fig. 8: Mutual Coupling of the Antenna Array

Characteristics of EBG structure to suppress surface wave at frequencies of band gap region [9-10]. Fig. 9 shows the proposed configuration's basic unit cell of the EBG structure used. The proposed structure has interesting behavior in L-band. The parameters of the EBG structure are designed to accommodate the resonant frequency of 1.35GHz. The center square is having a side length 0.325mm the two strip lines passing through the center square are of 1.65mm*0.115mm. The four squares in the four quadrants are having a side length of 0.425mm.

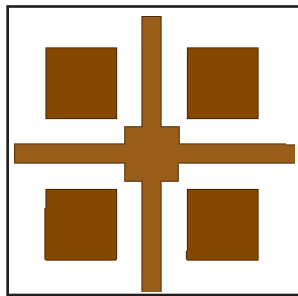


Fig. 9: Unit Cell of EBG Structure

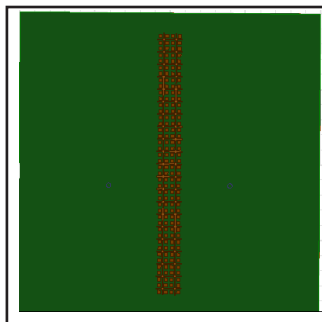


Fig. 10: Schematic of the Proposed EBG Structure

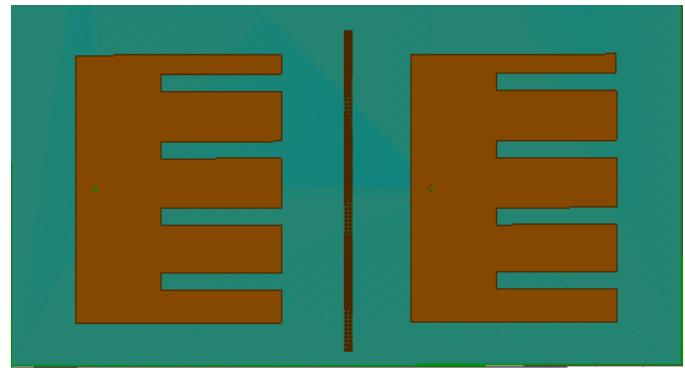


Fig. 11: Schematic of the Proposed Antenna Array with EBG

Fig. 12 below shows the mutual coupling plot of the antenna array integrated with the proposed EBG structure. Here we can observe that by integrating the proposed EBG structure to the antenna array the mutual coupling of the antenna array has reduced by -20dB i.e. from -17.77dB to -38.54dB.

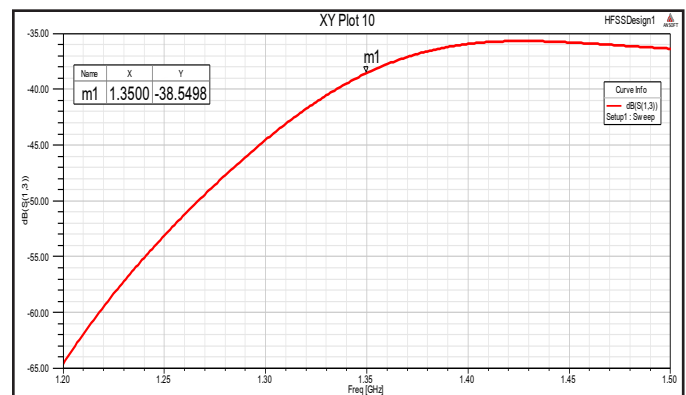


Fig. 12: Mutual Coupling of the Antenna Array with EBG

IV. CONCLUSION

In this paper, simple techniques are been proposed and investigated successfully to overcome the basic limitations of gain, bandwidth and mutual coupling for a microstrip antenna. A coax fed meandered E shape patch antenna with a air cavity is presented and a two element array is considered for mutual coupling analysis. The meandered patch provides band width enhancement and the air cavity along with a thick aluminum ground plane combindly provided gain enhancement. The proposed EBG structure has demonstrated that the mutual coupling can be reduced in a considerable range by integrating the EBG in antenna array. The simulated results show a bandwidth of 89MHz ranging from 1.30GHz to 1.39GHz with a maximum gain of 8.37dB at the operating frequency of 1.35GHz with a

mutual coupling reduction of -20dB. The proposed antenna have a compact dimension of 145mm×145mm×14.5mm and is best suitable for the L band applications.

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