



Reduction of Mutual Coupling and Gain Improvement Using Step Electromagnetic Band-Gap (EBG) Structure

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Abstract: Propagating surface waves in array microstrip patch antennas causes some problems such as mutual coupling and scan blindness. Electromagnetic band-gap (EBG) structures are the form of periodic structures that in a certain frequency band suppress propagating surface waves. A new EBG structure terminated as step EBG structure is introduced in this paper. Primarily, the frequency band-gap of mushroom-like EBG is exhibited graphically. Afterward its application between two microstrip patch antennas is explained. Then the step EBG structure is compared with traditional structure. A computer model is developed, applying HFSS software. The satisfactory results of the mentioned model also are shown as monograph.

Keywords : mutual coupling , EBG , mushroom-like

I. INTRODUCTION

There are different ways to reduce mutual coupling such as : removed substrate between antennas , cavity back microstrip antennas and the EBG structure between antennas. In fig 1 the mutual coupling between antennas are compared in different methods [1]. As seen the reduction in EBG case is about 6dB lower than the other methods.

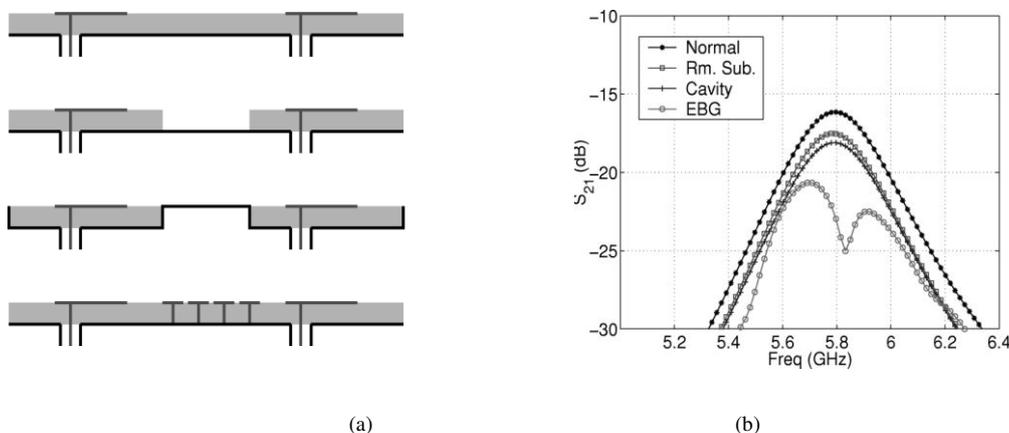


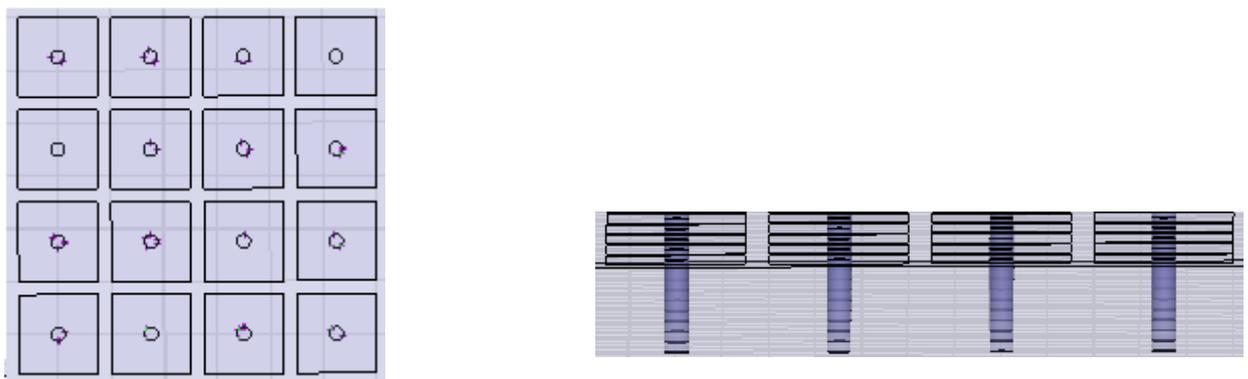
Fig 1-comparison between different methods to reduce mutual coupling a)the structures b)S₂₁

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The EBG structure has been suggested in [2] based on the photonic band-gap (PBG) phenomena in optics. Different forms of EBG structures are determined in [2],[3], but mushroom-like EBG structure is focused in this paper (fig 2). In the frequency band-gap the mushroom-like EBG structure suppresses propagating surface waves



(a)(b)

Fig 2- mushroom-like EBG structure a)Top view b)side view

Depending on the size and gaps between patches in EBG, the height and permittivity of the substrate the frequency band-gap can be changed. Suppression of propagating wave results in increasing the antenna gain and reducing the mutual coupling in arrays [4-7].

In comparison with the propagating fields of an infinitesimal dipole source together and without the EBG structure Prof. Rahmatsamii simulated and explored the effect of surface wave suppression. He applied the finite difference time domain (FDTD) method. For this purpose also he identified a frequency stop band for the field propagation (fig3). The author simulated the propagating near field inside and outside of the band-gap by HFSS (fig 4). To reduce mutual coupling between arrays, the patches resonance frequency should be in the stop band of the EBG structure. The characteristic of the band-gap are formulated in [1].

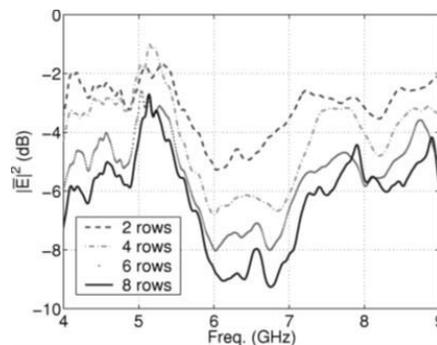


Fig 3-frequency stop band of EBG structure

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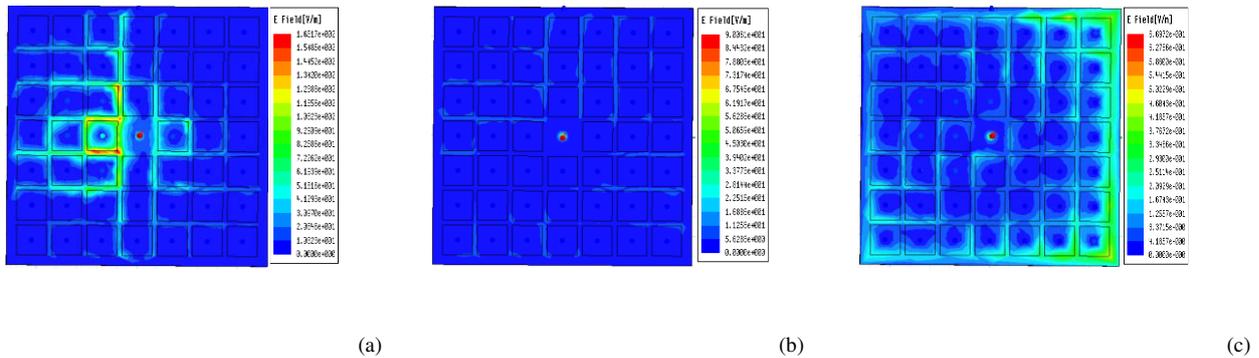


Fig 4-propagating near field of the infinitesimal dipole on EBG structure a)f=5GHz outside the band-gap b)f=6GHz inside the band-gap c)f=8GHz outside the band-gap

II. REDUCTION of MUTUAL COUPLING by STEP EBG STRUCTURE

This investigation results in increasing the height of the substrate under the EBG structure and reducing the distance between two patches. The height of the substrate under the patches is 2mm while, the height of the EBG structure increase to 3mm so, 5dB increase in antenna gain and 4dB reduction in mutual coupling is seen (fig 5).

More satisfaction results are obtained although the distance between two patches 15.8 cm reduces.

The resonance frequency of two antennas is around 6GHz that is in the stop band of the EBG structure. The patches are 4 in 7 mm , the height of the substrate under the patches is 2mm and dielectric constant is 10.2 . The size of the EBG patches is 3in3mm however, the gaps between them are 0.5mm. The radius of the vias is 0.259 mm.

The equivalent circuit of the EBG structure based on lumped element is shown (fig 6). The main idea is to increase the height of the EBG structure that results to increase the parallel impedance and finally increase the characteristic impedance in Γ formulation [8].

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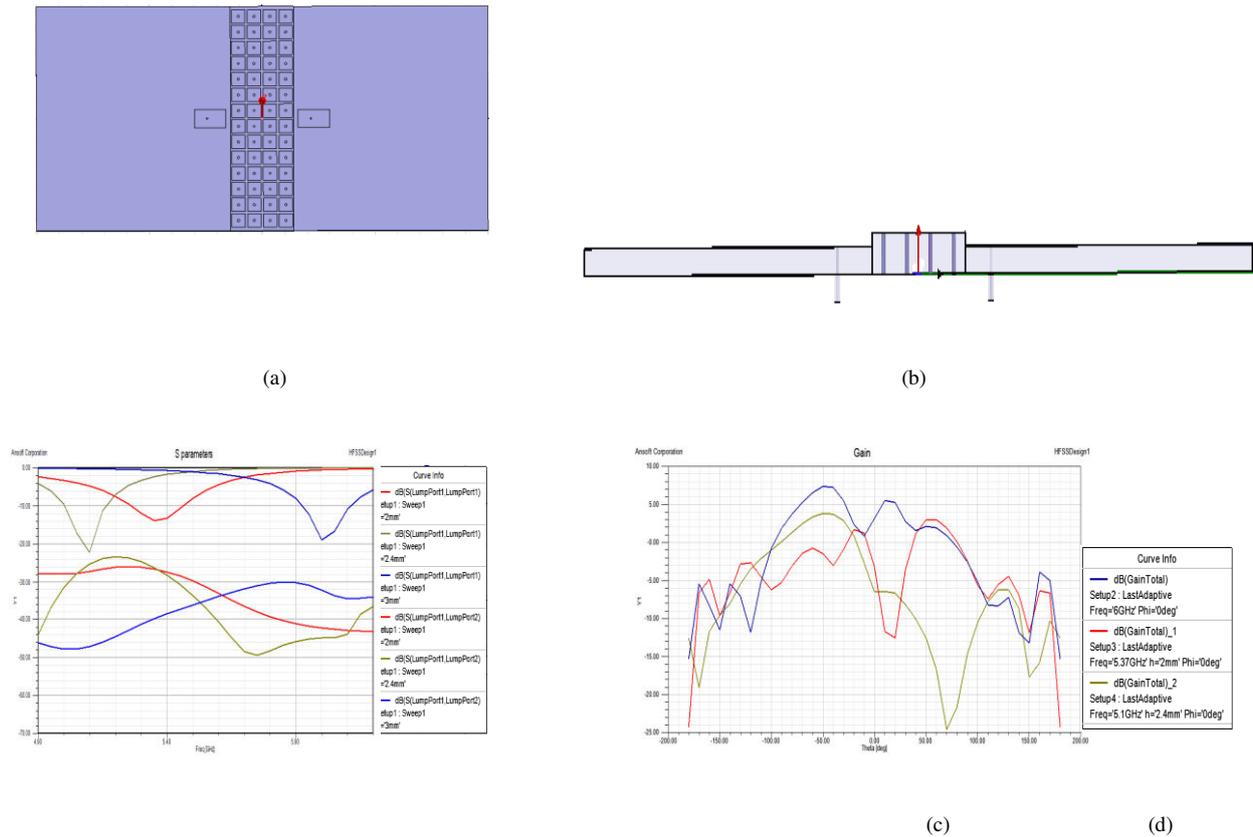


Fig 5- step EBG structure a)the geometry of top view b)the geometry of side view c) S_{21} d)gain

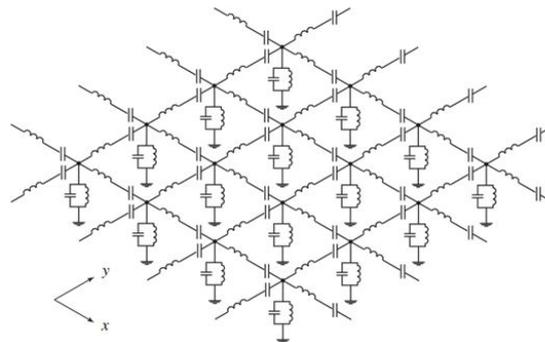


Fig 6- the equivalent circuit of EBG structure based on lumped element



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III. CONCLUSION

EBG structures are inserted between arrays to reduce mutual coupling. Increasing the height of the EBG structure with constant height of the substrate under the antenna patches the structure changes to step EBG structure, that results to reduction the S_{11} and S_{12} and increasing the antenna gain.

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