Review Paper on Microstrip Antenna Integrated with TVS-EBG Structure to Reduce Mutual Coupling

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Abstract— In this paper, we are presenting review on several electromagnetic bandgap structures to reduce the mutual coupling of a microstrip patch antenna array. If two microstrip antenna patches are near to each other then they interchange the energy. This interchange of energy is known as "mutual coupling," and due to this mutual coupling the analysis and design of an antenna becomes complicated [1]. The TVS-EBG structure consists of two lines of Two via Slots which is inserted to reduce mutual coupling between closely spaced patches of a 2 x 1 patch array antenna. As reported in [2], due to the insertion of TVS-EBG structure the equivalent value of capacitance and inductance getting increased. The structure has single ground plane and it is consequently low cost and simple to fabricate.

Keywords: Electromagnetic Bandgap, Mutual Coupling, Two-Via Slot, Antenna Array

I. INTRODUCTION

In microstrip antenna array structures the mutual coupling depends on the dielectric constant (ε_r) of substrate, thickness (h) of substrate and the distance between two patches. In microstrip antenna array, strong mutual coupling affects the performances of an antenna in terms of Side Lobe Level (SLL), change in beam shape, input impedance mismatch, grating lobes and scan blindness [2]. If the values of dielectric constant and substrate thickness are high then the mutual coupling will be large and therefore it must be suppressed. There are various methods to supress the mutual coupling but from experimental results shown in [3], it is observed that by inserting electromagnetic band gap structure between two patches, the lowest mutual coupling is reported. EBG structures are defined as artificial periodic objects that prevent the propagation of Electro-Magnetic waves in a specified band of frequency for all incident angles and all polarization states [4].

The TVS-EBG structure consists of two via per EBG cell as shown in fig 1. If we compare this TVS-EBG structure with conventional mushroom type EBG structure (CM-EBG) then it is observed that in CM-EBG structure the area of the EBG patch is not utilize efficiently to get compactness. But proposed TVS-EBG structure as shown in Fig. 1 uses this unutilized EBG patch area as well as provides compactness and reduction in mutual coupling.

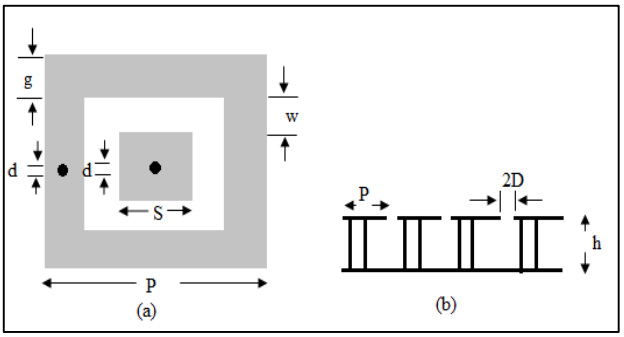

Fig. 1: Two via Slot type Electromagnetic Band Gap (TVS-EBG) structure (a) top view (b) side view.

II. LITERATURE SURVEY

Literature survey provides the idea about several EBG structures to reduce mutual coupling effect.

A. Simple EBG Structure:

Ankit Arora and Niraj Kumar presented EBG structured microstrip antenna as shown in fig. 2. This paper proposed an EBG structure for reducing the mutual coupling in microstrip patch array antenna for X band region application and successfully reduced the mutual coupling by 4 dB. [5].

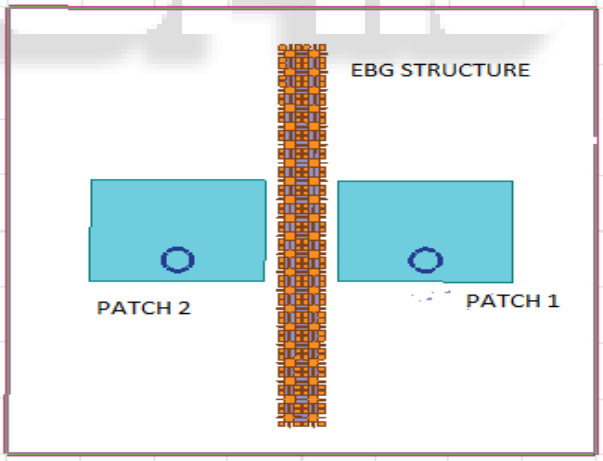

Fig. 2: EBG structured 2x1 microstrip antanna.

B. Conventional Mushroom Electromagnetic Band Gap (CM-EBG) structure:

Fan Yang investigated Conventional Mushroom Electromagnetic Band Gap (CM-EBG) structure in patch antenna array for reduction of mutual coupling effects. Fan yang observed that the E-plane coupled microstrip antenna array on a thick and high permittivity substrate has a strong mutual coupling. Therefore, an EBG structure is inserted between array elements to reduce the mutual coupling. This EBG structure is analysed by both the FDTD simulations and experimental results. Fan yang noticed 8 dB mutual coupling reduction [3].

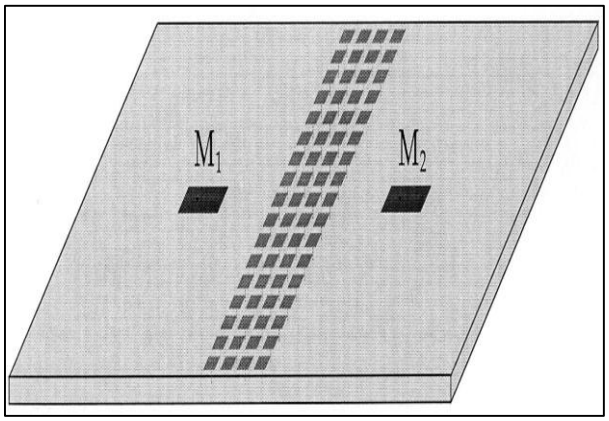

Fig. 3: Microstrip antennas separated by the mushroom-like EBG structure (CM-EBG)

C. Elongated Mushroom Electromagnetic Band Gap (EM-EBG) Structure:

Martin Coulombe et al. investigated a compact Elongated Mushroom Electromagnetic Band Gap (EM-EBG) structure for mutual coupling reduction and to enhance the performance of patch antenna array. The EM-EBG utilizes the vertical dimension of the substrate and it is assumed to be electrically thick which improves capacitance per unit cell. The author rescaled EBG to the initial design frequency to reduce the unit cell size which allows fitting a larger number of unit cells between the antenna array elements in order to provide stronger mutual coupling reduction. By EM-EBG structure around 13.1 dB reduction in mutual coupling achieved. [6].

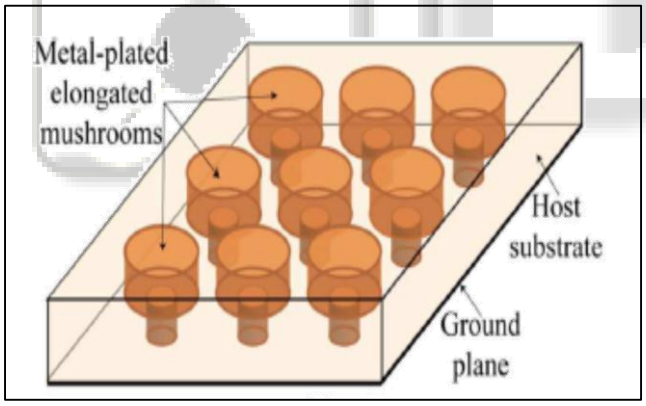

Fig. 4: Elongated Mushroom Electromagnetic Band Gap (EM-EBG) structure

D. Two-via Hammer Spanner-Type Polarization-Dependent Electromagnetic Bandgap (TVHS-PDEBG) Structure:

Pramod P. Bhavarthe, Surendra S. Rathod and Kuraparthi T. V. Reddy presented, Two-via Hammer Spanner-Type Polarization-Dependent Electromagnetic Bandgap Structure (TVHS-PDEBG) as shown in fig.5. TVHS-PDEBG is simulated in Ansoft high-frequency structure simulator. In that a 35.48% and 16.66% reduction in the centre frequency of the lower bandgap is noticed. [7].

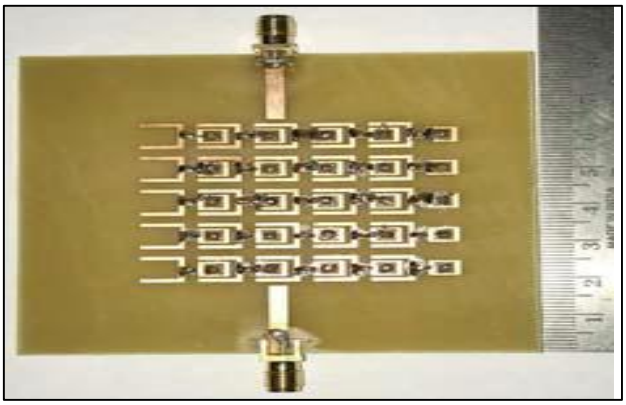

Fig. 5: TVHS-PDEBG structures

E. A Compact Two Via Slot-Type Electromagnetic Bandgap Structure:

Pramod P. Bhavarthe et al. [8] presented novel two via slot-type electromagnetic bandgap (TVS-EBG). Design and analysis of the proposed structure is done by using the LC analytical model. Simulated and experimental compared with CLV-EBG structured antenna and it is found that size reduction of 35.29% is obtained in TVS-EBG structured antenna.

F. Mutual Coupling Reduction in Patch Antenna Using Electromagnetic Band Gap (EBG) Structure for IoT Application

Pramod P. Bhavarthe et al. [2] designed compact patch array for Internet-of-things (IoT) application. A Two via Slot Type Electromagnetic Band-Gap (TVS-EBG) structure is used for mutual coupling reduction in patch antenna. Researchers used HFSS Simulator to Design and simulate proposed structure. The TVS-EBG structure has been designed using FR4 substrate having dielectric constant (ε_r) = 4.4 and thickness (h) = 1.60 mm. Experimental results show that 7.1 dB reduction of mutual coupling is obtained in patch array by inserting two columns of TVS-EBG structure between two patch antennas.

III. Conclusion

Electromagnetic bandgap (EBG) structures have gained more popularity due to the growing interest in improving antenna's performance such as increasing the antenna gain, reducing mutual coupling between microstrip antenna arrays. This paper presents several EBG structures to reduce the mutual coupling in 2x1 patch antenna array. Amongst that TVS-EBG structure is simple and also improves antenna performance.

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