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Comparative Isolation Techniques of 1x2 MIMO Antenna for 5G

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ABSTRACT *: In this paper a simple mender line EBG with slotted ground planer 1x2 rectangle patch multi-band antenna is designed and simulated. Presently the communication system provides the ultra wideband internet services. This is possible due to higher data rates and improved spectral efficiency of the communication system. The higher data rates and improved spectral efficiency are achieved by the use of MIMO antenna. MIMO antenna provide a significant increase in data rate and range of link without more bandwidth and power. The main design challenge in MIMO antenna is to attain high isolation between the antenna elements. This paper reviews various decoupling techniques to improve the mutual coupling between the antenna elements.*

KEYWORDS: Triple band; MIMO Antenna; Decoupling Techniques; Isolation; Parasitic Element; Return Loss.; EBG; DGS.

I. INTRODUCTION

Numerous MIMO antenna is reported in the literature for various applications: A tri-band antenna is presented in [1], [2] for mobile phone applications. The authors utilize a T-shaped field cancellation line without effect on the performance of the regular phone antenna is applied to up grate the isolation for the MIMO antenna, and high isolation is reached within the wide operation band. Meta material-based multiple inputs multiple outputs (MIMO) antennas are presented in [3-5]. Some of these antennas use a ring resonator based meta material. A wideband MIMO antenna is reported in [6] use bent slits in the antennas and place a metal strip between antennas to achieve the good isolation.Because of the developing need portable remote devices needs to arrange quicker access, brighter and greater resolution screens, and supplementary connectivity with smaller size [7]. The extent of devices can be lessened by utilizing reduced size components. The receiving antenna is one of the imperative parts that should be examined for size miniaturization and another execution improvement of the transmitting and receiving devices. In 5G wireless systems, not one but rather two antennas are necessary each with particular necessities: Bandwidth, Mutual Coupling, structure, and cost. Wideband antennas are one of the components of the wide-band communication systems. Different methods have been executed to acquire a wideband response of antennas as Fractal Microstrip antenna [8], Aperture coupled antennas [9], slotted antennas [10] and [11], Psi-shaped antennas [12], meta material antennas [13-14] and modified ground plane antenna [15-16].

II. MIMO ANTENNA GEOMETRY AND ANALYSIS

A Meander line is placed between the two antennas and strong rejection characteristic are observed for the designed multiband frequency range. A meander line behaves like a parallel resonance circuit and the resonance frequency can be calculated by the formula given in equation 1.1 to 1.4.

$$f_{res} = 1/(2\pi\sqrt{L_t C_t}) \quad 1.1$$

$$L = \frac{\mu_0}{2\pi}[l \ln(2l/(w+t)) + l/2 + 0.2235\,(w+t)] \quad 1.2$$

$$C_u = (\varepsilon_0 S)/d \quad 1.3$$

$$C_{end} = 8\varepsilon_0 \pi a \quad 1.4$$

Where L: length of Meander line arm
w: Width of Meander line arm
t: Thickness of copper plate
s: Total surface area
a: Radius of Meander line
The capacitance Ct, is the sum of two types of capacitance, Cu and Cg calculated by equation 1.3 and 1.4. The capacitance Ct is per unit length. To calculate the total capacitance Ct is multiplied by the total length of the line.

The configuration of Meander line and 1x2 antennas with meander line EBG is presented in fig.1 and fig. 2. The simulation results of the 1x2 antenna with meander line EBG is shown in figure 3 to figure 7.

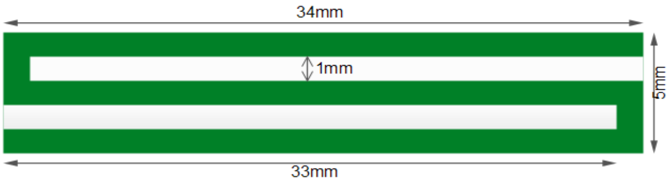

Fig. 1. 1x2 Patch with Meander Line EBG

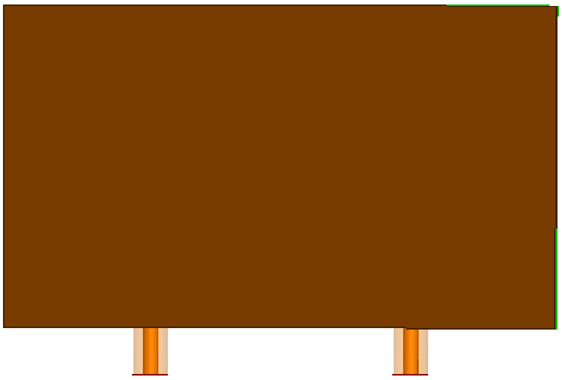

Fig. 2. Ground with Meander Line EBG

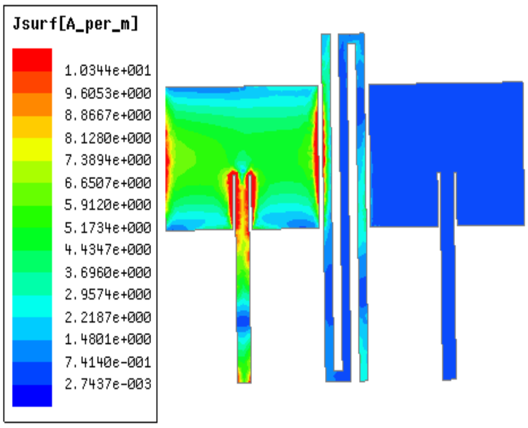

Fig. 3. Comparative return losses of 1x2 antennas

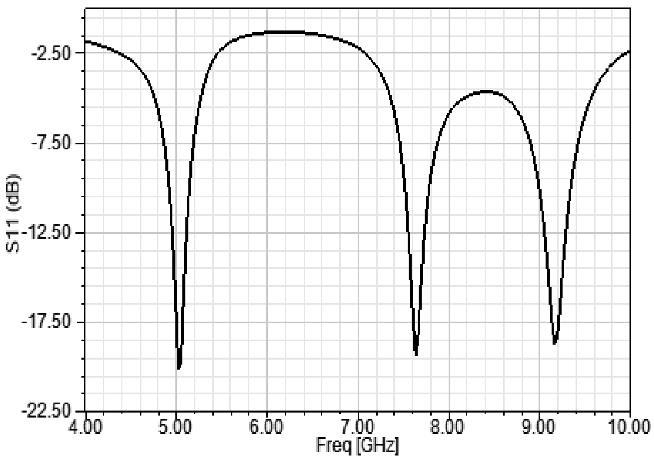

Fig. 4. Comparative return losses of 1x2 antennas

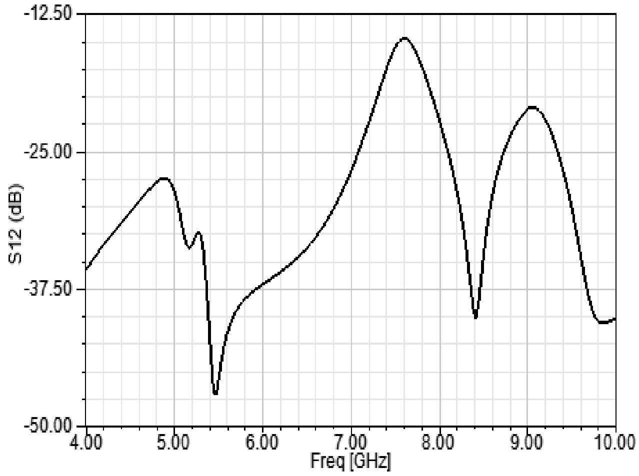

Fig. 5. Comparative mutual coupling of 1x2 antennas

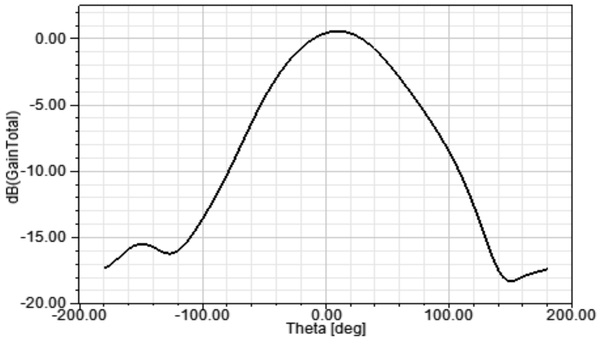

Fig. 6. Comparative Gain of 1x2 antennas

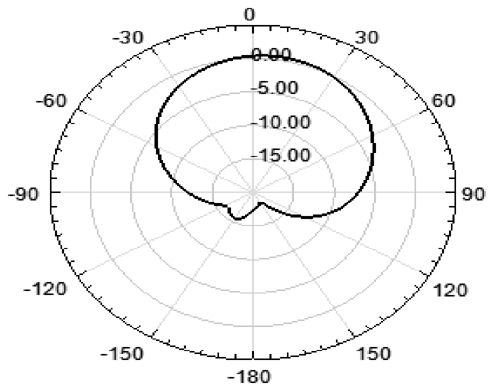

Fig. 7. a. Comparative Radiation patterns of 1x2 antennas

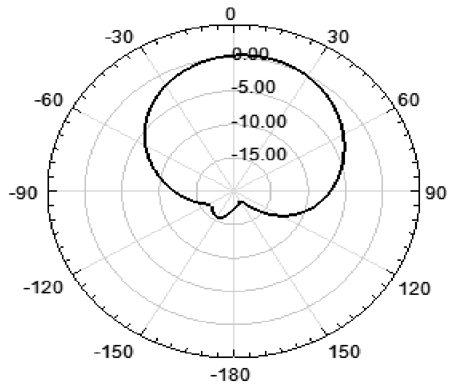

Fig. 7. b. Comparative Radiation patterns of 1x2 antennas

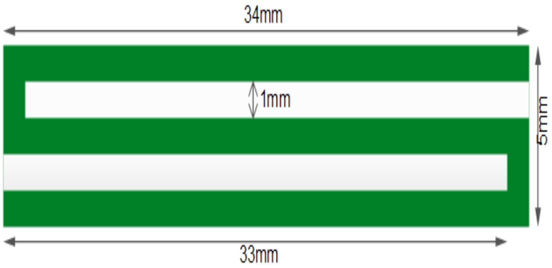

Fig. 8. Novel planar ladder shaped coplanar EBG

The proposed ladder shaped collinear EBG suppressed the second resonance band .The radiation pattern of the MIMO antenna is not significantly affected due to the implementation of different EBG structure and can be observed in Figure 7a. and Figure 7b.

Mimo Antenna With A Planar Meander Line Ebg With Slotted Ground Structure : To overcome the issue of degradation of gain and Meander Line with Slotted Ground are proposed in this paper and satisfactory results are obtained. The placement of the proposed Electronic Band-gap Structures does not significantly affect the overall gain of the rectangular patch antenna and maintain good isolation and return loss between antennas.
In this section, 1x2 antennas are designed with meander line EBG and mutual coupling is further enhanced by incorporating the separate ground plane for both the antenna. The ground plane of two antennas is separated by a rectangular microstrip line as shown in fig.10. The border of each ground plane and the microstrip line forms a capacitive structure and hence suppress the surface waves. This results in the mutual coupling from one antenna to another. The configuration of the antenna and simulation results is shown in fig. 11 to 15.

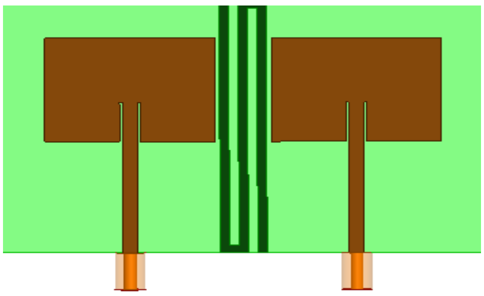

Fig. 9. 1x2 antenna with planer ladder shaped coplanar EBG

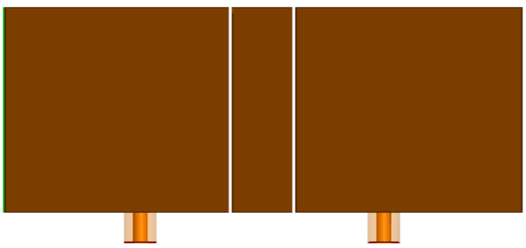

Fig. 10. 1x2 antenna with planer ladder shaped coplanar EBG

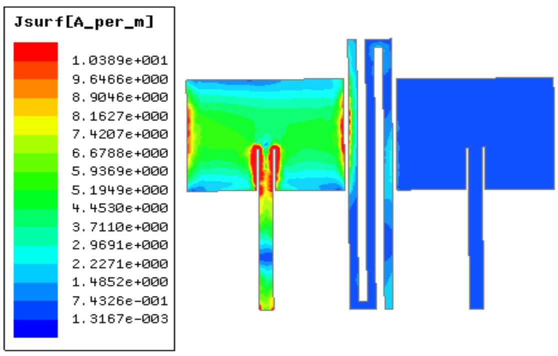

Fig. 11. Comparative return losses of 1x2 antennas

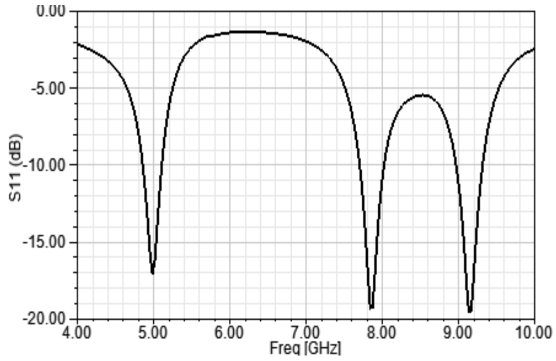

Fig. 12. Comparative return losses of 1x2 antennas

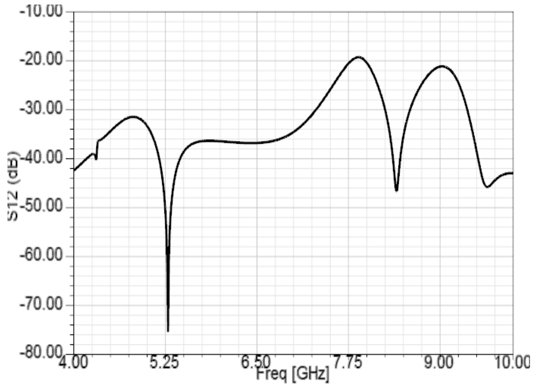

Fig. 13. Comparative mutual coupling of 1x2 antennas

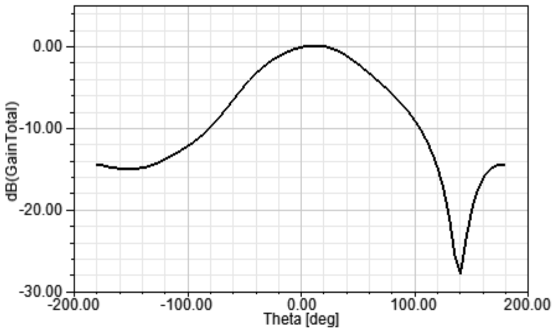

Fig. 14. Comparative Gain of 1x2 antennas

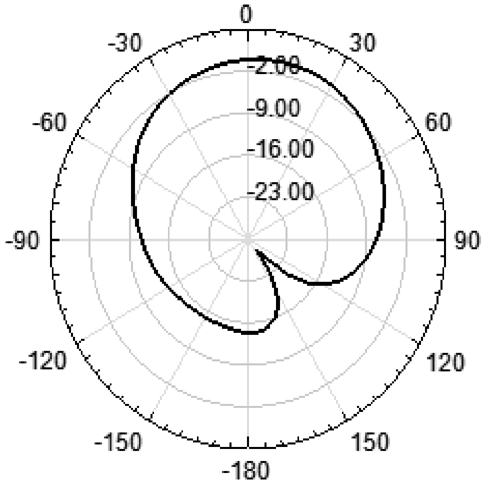

Fig. 15. a. Comparative Radiation patterns of 1x2 antennas

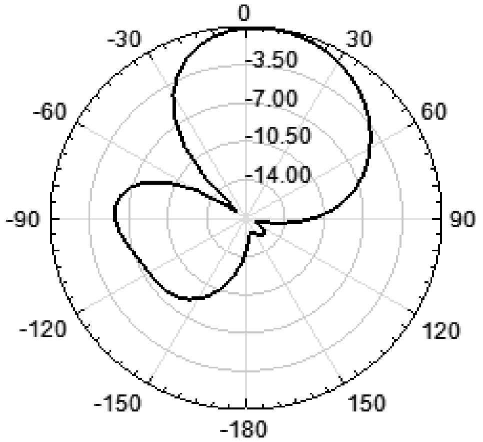

Fig. 15. b. Comparative Radiation patterns of 1x2 antennas

III. CONCLUSION

Mutual Coupling between antennas is investigated and EBG structure is incorporated between 1x2 antennas. A novel ladder shaped coplanar EBG is proposed for mutual coupling reduction. The proposed work intends to achieve low Mutual coupling without a reduction in gain of antennas. This research work has attempted to explore the design challenges of MIMO antenna and its possible solutions. A single element for triple band (5, 7 and 9 GHz) is designed. Using this single element, a 1x2 MIMO antenna EBG is placed between the antennas and simulated results are observed. The proposed EBG has good return loss and mutual coupling in all three bands in comparison with the literature survey done. A prototype of a single element, 1x2 MIMO antennas without slotted ground and 1x2 antennas with proposed slotted ground EBG is fabricated and tested on VNA. Good agreement is found in measured and simulated results which validate the design. A comparative results of 1x2 antennas with meander and slotted ground is shown in Table1.

TABLE I. COMPARATIVE RESULTS OF 1X2 ANTENNAS WITH EBG STRUCTURE

Structure	Return Loss (dB)			Mutual Coupling (dB)		
	Band-1	Band-2	Band-3	Band-1	Band-2	Band-3
Meander	-29	-26	-16.5	-32	-18.4	-22.5
Slotted Ground	-19.5	-21	-19.5	-35	-25	-21.5

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