A Decoupling Technique for Improving Isolation in MIMO Antenna

Vilas Mapare¹ and Dr. G. G. Sarate ²

¹ Sant Gadge Baba Amravati University, Amravati, Maharashtra, India
mapare.vilas@gmail.com
² Government Polytechnic, Amravati, Maharashtra, India
ggsanshu@gmail.com

Abstract

In this paper the mutual coupling of 1x2 rectangular patches Triple-band antenna is investigated and possible solutions are discussed. The higher data rates and improved spectral efficiency are achieved by the use of MIMO antennas. MIMO antennas offer a significant increase in data throughput and link range without additional bandwidth and transmitter power. So Multiple Input Multiple Input antennas are the new research area for the communication engineers.

The proposed EBG has reasonable mutual coupling reduction and radiation performance compared to EBGs proposed in literature. The limitations of U-shaped and Mushroom Type EBG are found and overcome by proposing a novel Filled Ladder Shaped EBG structure.

Keywords — MIMO Antennas, Triple Band, Rectangular Microstrip Antenna, Electronic Bandgap, Parasitic Resonators, Multi Band MIMO Antenna, Mutual Coupling, Correlation Coefficient.

1. INTRODUCTION

In the future, wireless communications will require higher data rate for various mobile services. In compact devices such as smartphones wireless modems, there is the requirement of small antennas. This requirement is satisfied by the microstrip antenna. A microstrip antenna consists of a metallic patch which is mounted on a dielectric material. The other side of the dielectric material is also a metallic layer with larger dimension. In MIMO antennas, two or more patches are placed at the common ground plane and dielectric material.

Due to the emerging need mobile wireless devices has to provide faster access, brighter and higher resolution screens, additional connectivity all with compact size [1]. The technique of improving the channel capacity with increasing the number of antennas at the transmitter and receiver was first predicted by Foschini in [2]. When multiple antennas are brought at closer spacing, the basic aim of MIMO antenna design is to minimize the correlation between the multiple signals [3]. Higher mutual coupling may result in higher correlation coefficients which affects the transmission capacity of MIMO systems [4]. In addition to increasing the distance between adjacent antenna elements, various methods have been proposed to enhance isolation among the elements [4-6].

2. MINIATURIZATION AND MUTUAL COUPLING REDUCTION

In general two theoretical solutions are available for the mutual coupling reduction in MIMO antennas: by field cancellation and using Electronic Bandgap Structure. Many EBG structures are proposed for different application as interface minimization within multilayer PCB, bandwidth and gain enhancement of patch antenna, mutual coupling reduction etcetera. The EBG structures affect the gain of the antennas. In EBG based MIMO antennas, an EBG structure is placed between two antennas. In literature gain analysis is not done for EBG based MIMO antenna, which is required for the selection of an EBG structure.

A rectangular patch antenna is chosen as basic configuration
for MIMO antenna design. The mutual coupling analysis of MIMO antenna is done and effect of different EBG structures on the performance on MIMO antennas are investigated. Ladder shaped EBG structure is proposed and results are compared.

When identical antennas are coupled to the same mode, they experience mutual coupling so that power introduced into one antenna is partially coupled to the opposite antenna’s source resistance, and is subsequently lost.

There have been numerous approaches to solving this dilemma, including various chassis modifications combined with antenna placement, but these can be difficult for industrial designers to accommodate. Several recently developed antenna design methods reduce mutual coupling through the use of a single-structure antenna that optimally excites different radiation modes. The method reduces mutual coupling between the antenna’s two feed points, resulting in a minimum antenna pattern envelope correlation coefficient (APECC) while providing improved efficiency and equal gain balance between feed points. Operator requirements for APECC can also be difficult to achieve and to measure in real devices. Correlation measurements can vary significantly depending on how the testing is done, being influenced by cable connections, device positioning, and the channel direction of arrival (DOA) probabilistic weighting. Test methods for determining the overall MIMO performance due to the combined effects of the antenna pattern, APECC, and channel model are current topics in 3GPP, since MIMO system performance depends on both the antenna configuration and the channel model for the specific usage environment. Furthermore, these effects change with the phone usage model due to perturbations of the antenna near field radiation and proximity detuning.

### 2.1 Mutual Coupling Analysis Of MIMO Antennas:

If antennas are placed closer, they suffer from mutual coupling thus results in poor radiation efficiency. In this section, a MIMO antenna (1x2 Configuration) is designed using the basic configuration. Two elements are placed on the common substrate and a common ground plane. The configuration of the 1x2 antenna is illustrated in Fig. 2.1 and results are depicted in Fig.s 2.3 to 2.6.

![Fig. 2.1 Configuration of 1x2 antennas](image1)

2.2 Design of MIMO Antenna Using U-Shaped EBG Structure:

In literature numerous solutions have been proposed for mutual coupling reduction in MIMO antennas. One of the prominent methods is incorporating EBG between two antennas. Different type of EBG is also proposed in literature. In this section, a U-shaped EBG is incorporated between the antennas and results are compared with the MIMO antenna without EBG. Configuration of 1x2 antennas with EBG is depicted in Fig. 2.2. The comparative results are presented in Fig.s 2.3 to 2.6.

![Fig. 2.2 Configuration of 1x2 antennas with U-shaped EBG](image2)
The return loss and radiation pattern of the antennas are depicted in Fig. 2.3 and Fig. 2.5. We can see that the return loss and radiation pattern of the antennas are slightly affected. U-shaped EBG Leeds in poor impedance matching for the same feeding point. We need to modify the feeding point to achieve better impedance matching. The mutual coupling of the antennas is depicted in Fig. 2.4. Due to implementation of the EBG the mutual coupling for lower frequency band (4.97 GHz) is reduced from -14 dB to -31 dB. For 9 GHz band the reduction in mutual coupling is also significant, 3.8 dB. The mutual coupling of the middle band, 7.6 GHz band is not affected.

The adverse effect of the U-shaped EBG can be seen in Fig. 2.6. Due to implementation of EBG the gain of the antenna is

---

**Fig. 2.3** Return losses of 1x2 antennas with and without EBG

**Fig. 2.4** Mutual Coupling of 1x2 antennas with and without EBG

**Fig. 2.5** Radiation patterns of 1x2 antennas with and without EBG

**Fig. 2.6** Gain of 1x2 antennas with and without EBG
reduced which is not acceptable. So there is need of some gain enhancement technique or some another EBG structure can be used.

3. MIMO ANTENNA WITH A NOVEL PLANER EBG STRUCTURE:

In this section a novel ladder shaped planner EBG structure is presented. The proposed EBG supports all three bands and meet the gain requirement of the antenna. The ladder structure introduces the inductive effect and the patches inside the ladder structure combine introduce the capacitive effect. The structure of the novel EBG structure and 1x2 antenna with novel EBG structure is presented in Fig.s 3.1 and 3.2. The results of the proposed method are investigated using HFSS 13 and results are compared with the conventional, U-shaped EBG and Mushroom type EBG antennas. The comparative results are presented in Fig.s 3.4 to 3.7.

![Fig. 3.1 Unit cell of ladder shaped EBG](image)

![Fig. 3.2 Novel planer ladder shaped coplanar EBG](image)

![Fig. 3.3 1x2 antenna with planer ladder shaped coplanar EBG](image)
The U-shaped EBG proposed in literature is investigated in the earlier section. The U-shaped EBG degrade the gain of the MIMO antenna and Mushroom type EBG eliminate the second band this can be observed in Fig. 3.4 and 3.6 respectively. The proposed ladder shaped collinear EBG meet the reasonable return loss, mutual coupling and gain. The radiation pattern of the MIMO antennas is not significantly affected due to implementation of different EBG structure and can be observed in Fig. 3.7.

4. CONCLUSION

Mutual Coupling between antennas is investigated and EBG structure are 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.

REFERENCES