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A MIMO Antenna for Wireless Communications with EBG Structure

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Abstract: This paper described the design of MIMO antenna array with EBG structure to improve return loss, directivity and gain at 5.85GHz frequency which has application in wireless communication. 5.85 GHz frequency basically used in sending information into home through internet, video and computer communication Design of antenna restricted to MIMO patch on which EBG structure has been applied. EBG assisted antenna designs, which have improved performance of some of the traditional antennas, have been applied in many real-life applications. Some EBG antennas are designed for GPS applications. Radio frequency identifications (RFID) is a rapidly developing technology for automatic target identifications. Zeland IE3D Software is used as an effective tool for 3D electromagnetic simulation of high frequency components. Probe feeding has been used in this paper because of easy to apply. The objective of this paper is to design 2 element MIMO patch antenna array with EBG structure and compare the performance parameter such as gain, directivity etc with MIMO patch without EBG structure.

KeyWords: IE3D software, EBG structure, MIMO Microstrip antenna

I. Introduction

Now a day's communication system changes into wireless ubiquity which means that every person wants to reach whatever he wants ,whenever he wants , wherever he wants and for this much we have broad frequency spectrum ranging from 88MHz TO 6GHz.The WiMAX (Worldwide Interoperability for Microwave Access) system [1] is becoming increasingly popular to allow broadband wireless internet access for private and business users. WiMAX is based on the IEEE 802.16 family of standards [2]. The first system implementations, based on the 802.l6-2004 specifications intended for fixed wireless access, are already being tested and even used. Antenna play paramount role in present developing communication system. Microstrip antenna is generally used for research work due to light weight and patch can be of any shape. Patch is generally made of material such as copper or gold. Here for research work is based on MIMO patch. After the rectangular patch the next most popular configuration is the circular patch. In radar and satellite communication, it is necessary to design antennas with very high directive characteristics to meet the demand of long distance communication and the most common configuration to satisfy this demand is the array form of the Microstrip antenna. The arrangement of the array may be such that the radiation from the element adds up to give a radiation maximum in particular direction, minimum in others, or otherwise as desired [4]. For the same reasons, electromagnetic band gap (EBG) structures and their applications in antennas have become a new research direction in the antenna community due to following advantages

•Ultra wideband (greater than 80%) relative Bandwidth.
•Compatibility with existing circuit-board technology.
•Excellent insertion loss and impedance matching characteristics.
• Negligible crosstalk and radiation.

II. Materials And Methods

Here Microstrip antenna has been used due to its light weight, thin size and patch can be of any shape. MIMO patch Microstrip antenna has been selected for investigation. MIMO patch is etched on dielectric substrate i.e. FR4 substrate which thickness is 1.6mm and dielectric constant is 4.4. FR4 in comparison has a higher dielectric constant which results in a smaller patch size.

A. For Rectangular Patch

The calculation of length and width are using the equations.
Calculation of the width (W):- The width of the Microstrip patch antenna is given by

$$w = \frac{1}{2f_r\sqrt{\mu_o\varepsilon_o}} \times \sqrt{\frac{2}{\varepsilon_r + 1}}$$

Calculation of Effective dielectric constant (ε_{reff}):-
Effective dielectric constant is calculated

$$E_{reff} = \frac{E_r + 1}{2} + \frac{E_r - 1}{2\sqrt{1 + 12\frac{h}{w}}}$$

Substituting ε_r=4.7 and h=1.6mm We can get ε_{reff}
Calculation of the effective length (L):- The effective length is given as:-

$$L = \frac{1}{2f_r\sqrt{\varepsilon_{eff}}\sqrt{\varepsilon_0\mu_0}} - 2\Delta L$$

Calculation of length extension (ΔL):- The length extension is given by:- $\Delta L = 0.412h\frac{\varepsilon_{re} + 0.3\left(\frac{W}{h}\right) + 0.246}{\varepsilon_{re} - 0.258\left(\frac{W}{h}\right) + 0.813}$

B. Ebg Structure

Generally speaking, electromagnetic band gap structures are defined as artificial periodic (or sometimes non-periodic) objects that prevent/assist the propagation of electromagnetic waves in a specified band of frequency for all incident angles and all polarization states.

When the EBG is formed by periodically spaced circular hole the ripple and suppression of holes depend on the cell factor d and filling factor r/d, which is defined as ratio of radius of circular hole and cell spacing. In order to get a optimum performance in the rejection band the filling factor in the range of .24 to .3

Probe feed selected at location (x, y). Then with these dimensions along with probe feed antenna simulated on Zeland IE3D Software. When simulation is completed then antenna parameters presented [9][10].

III. Design of MIMO Antenna Array

The MIMO Array antenna is designed by IE3D Software. The design layout of 2-input MIMO Microstrip patch with and without EBG structure antenna array are illustrated in Figure Figures for 5.85 GHz frequency .

A. For MIMO Array antenna

We used the same values of height of the dielectric substrate (h) and the same dielectric material at the design frequency so we used the same dimension of single patch antenna.

- Width of the patch W_1 = 5mm,$W_{2=}$3mm
- Effective Dielectric Constant ε_{eff} of the patch = 4.4
- Actual length of the patch, L = 15.1884 mm.
- The value of the W1 = 4.8125 mm.
- Input impedance of the patch W2 = 1.4079mm

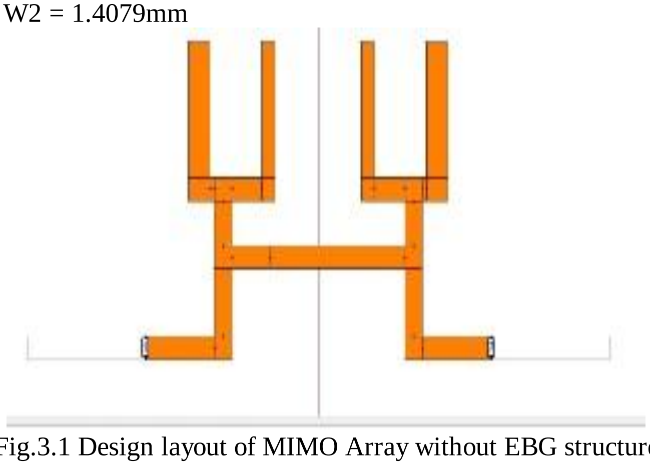

Fig.3.1 Design layout of MIMO Array without EBG structure

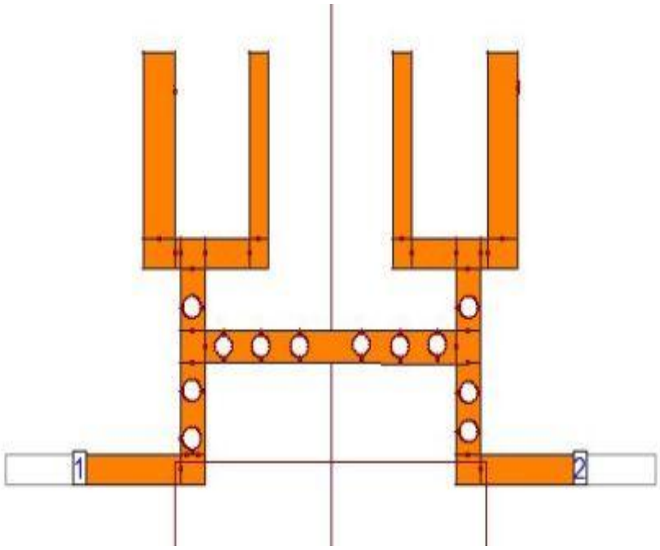

Fig. 3.2 Design layout of MIMO Array with EBG structure

IV. RESULTS

The MIMO Array antenna is designed Zeland IE3D Software. The design layout of 2-patches rectangular Microstrip patch antenna array with and without EBG structure are illustrated in Figures.. various results such as return loss, antenna gain, directivity , VSWR, efficiency are calculated and are presented in this section

Table: Comparison of MIMO Array

Antenna Type	Return Loss (dB)	Directivity (dB)	Gain	RF (GHz)	Eff.
MIMO Array Without EBG	-7.8	8.26	6.6	5.2	91
MIMO Array With EBG	-19	8.5	6.5	5.45	90

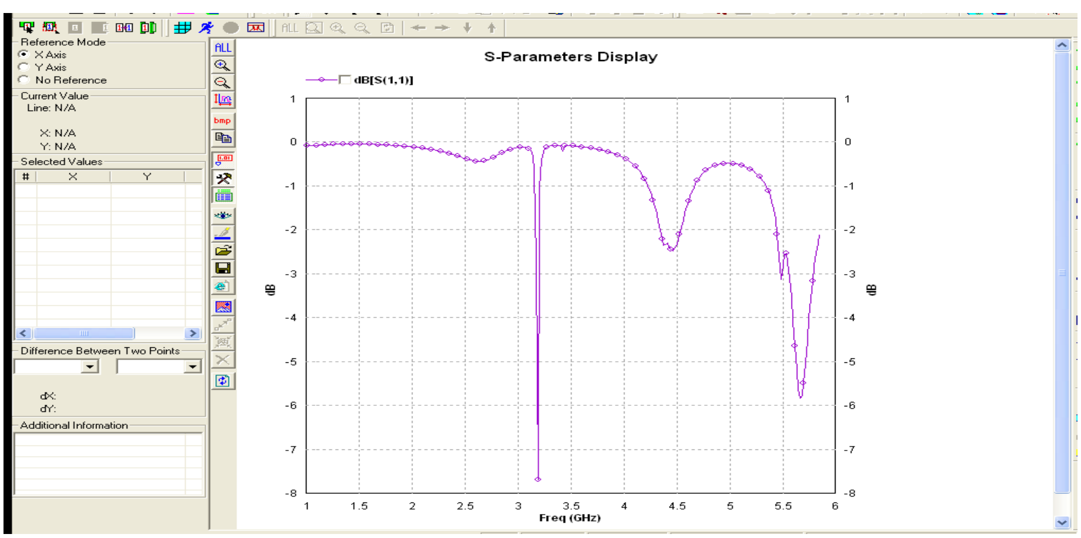

Fig. 4.1- Return loss in MIMO Array without EBG structure

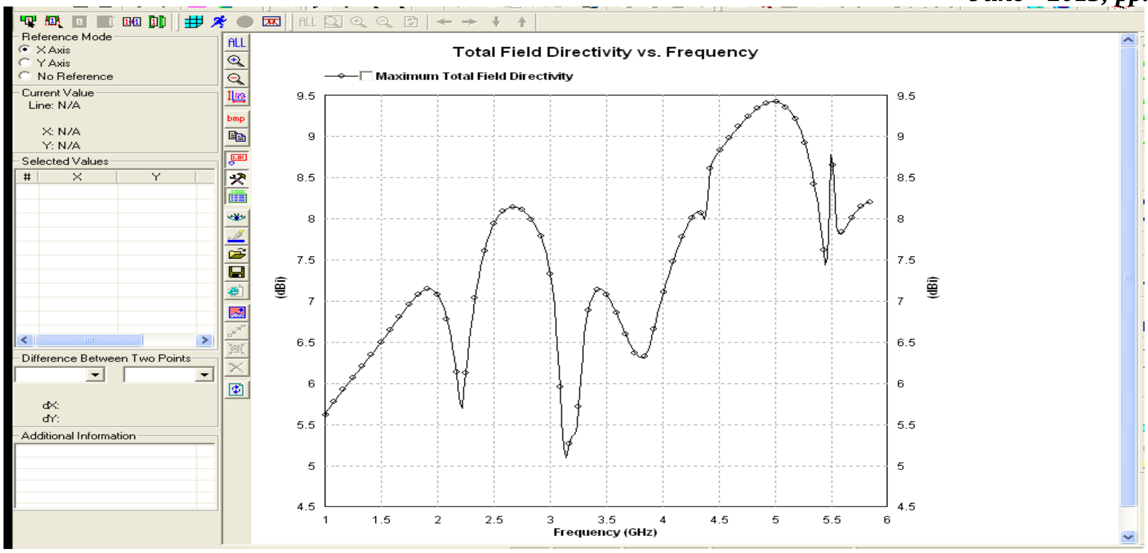

Fig-4.2. Directivity in MIMO Array without EBG structure

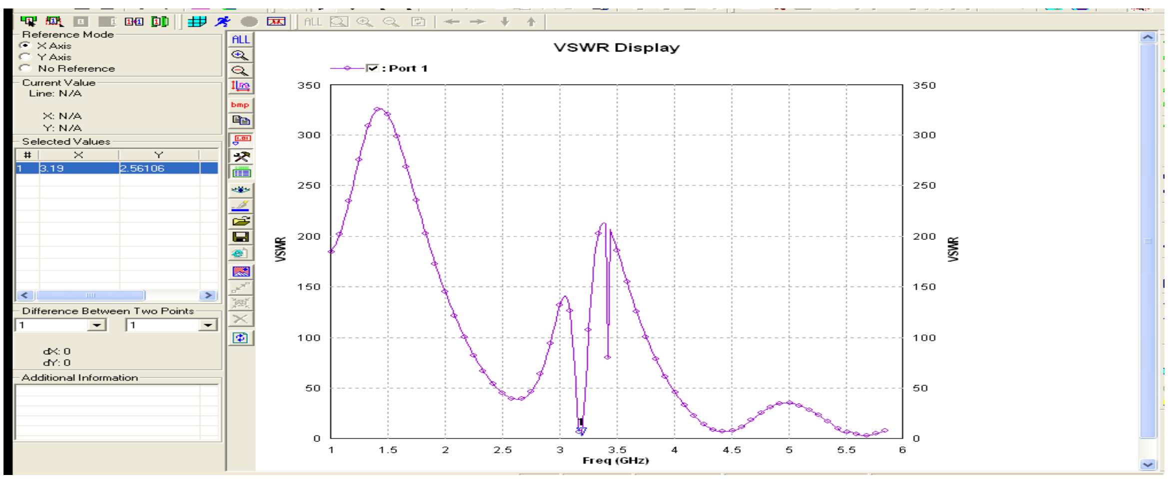

Fig-4.3. VSWR in MIMO Array without EBG structure

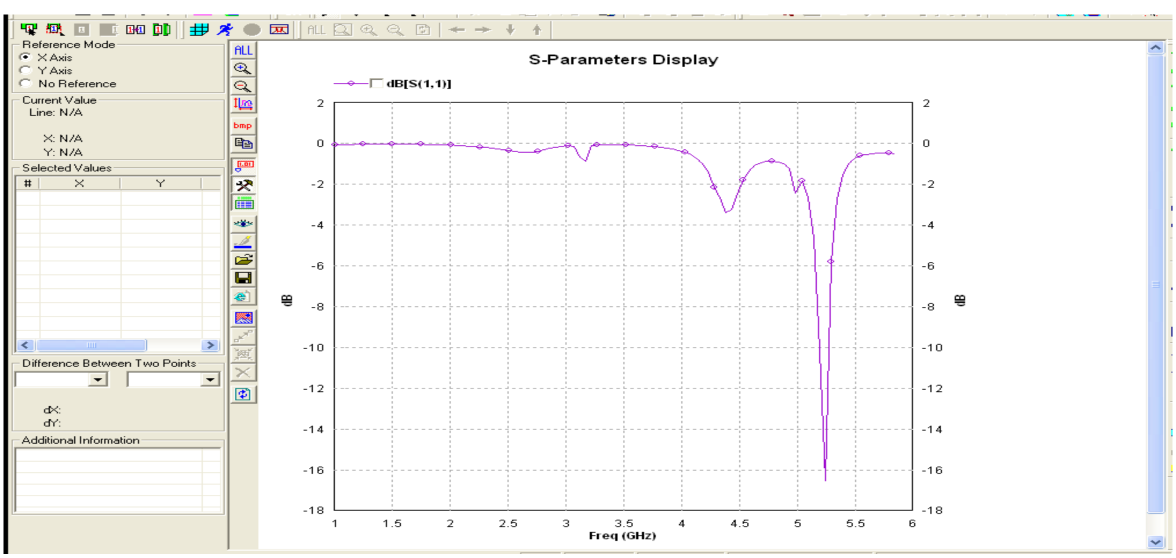

Fig. 4.4- Return loss in MIMO Array with EBG structure

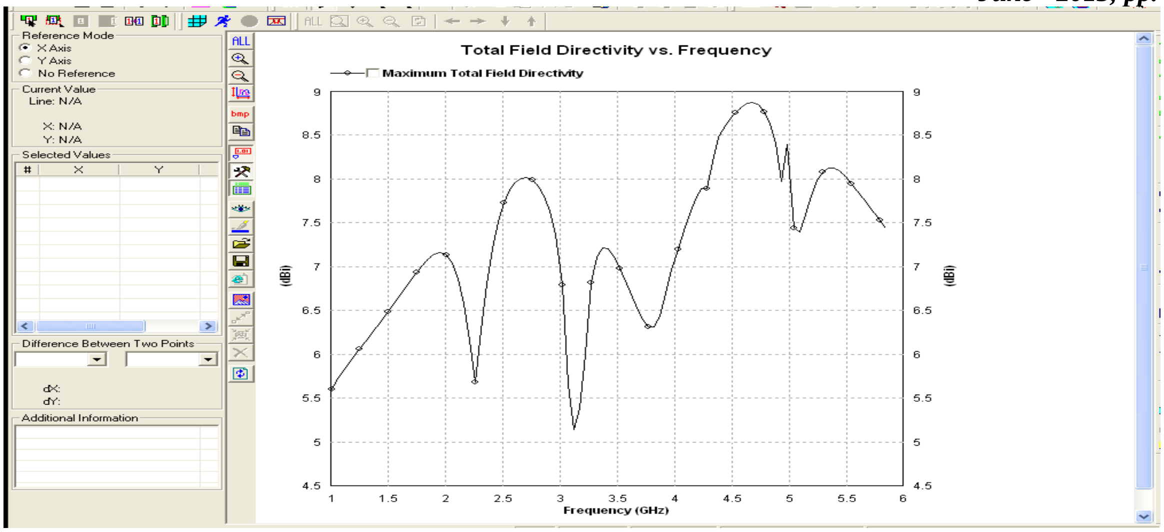

Fig. 4.5. Directivity in MIMO Array with EBG structure

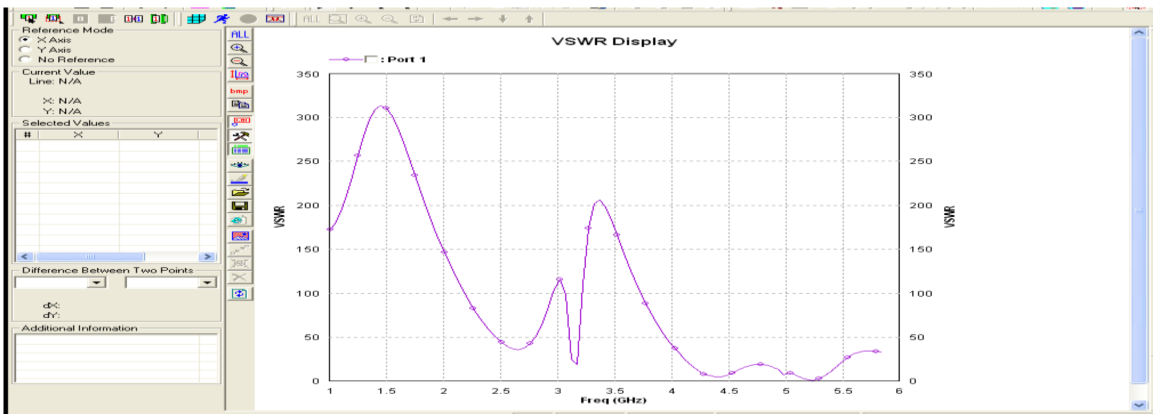

Fig. 4.6. VSWR in MIMO Array with EBG structure

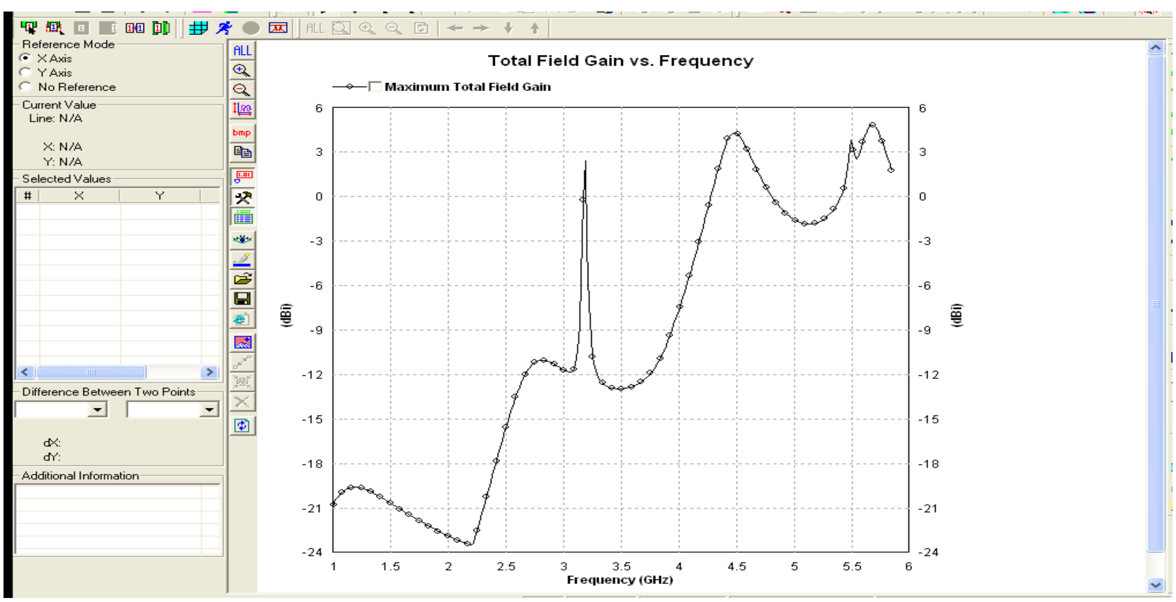

Fig-4.7. Gain in MIMO Array without EBG structure

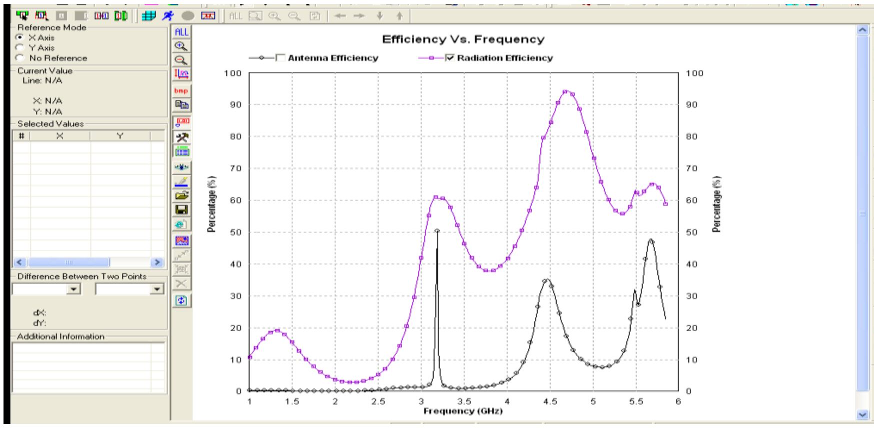

Fig-4.8. Efficiency in MIMO Array without EBG structure

From the Table 1, the performance of Microstrip two element antenna array with EBG structure is better than Microstrip antenna without EBG structure. From table it is clear that return loss has been increased in patch antenna array from -7.8 to -19Db when EBG structure applied . Directivity has been also improved after applying EBG structure in antenna from and from 8.26 to 8.5. Gain has been increased in antenna from 4.7 to 5.4. This result shows that while using Ebg structure on the mimo antenna various factors such as return loss,directivity,vswr,efficiency and gain has increased and antenna performance is seen to be enhanced in case of EBG structure. Thus the use of EBG has resulted in many advantages for various applications in the frequency range 3GHZ to 6 GHZ, this range has wide applications in wireless communications such as WIMAX. The EBG technique is now a days emerging as a powerfull technique to enhance the performance of radiating elements , EBG are implemented in the range 2GHZ to 20 GHZ.

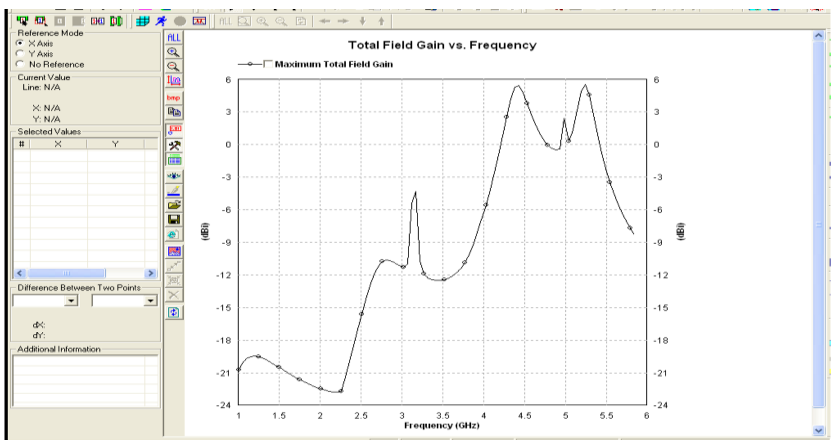

Fig. 4.9. Gain in MIMO Array with EBG structure

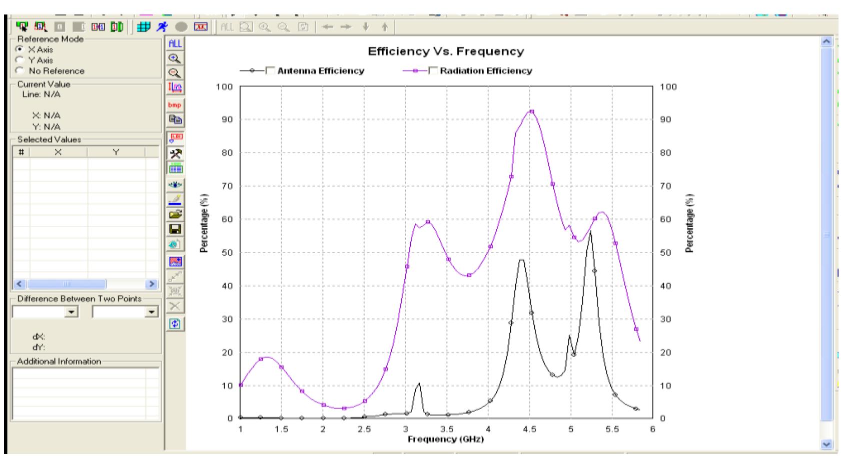

Fig. 4.10. Efficiency in MIMO Array with EBG structure

V. CONCLUSIONS

A two element Microstrip antenna wit EBG structure has been designed. Antenna play very important role in modern wireless communication system. Good design of antenna can improve performance of system. Return loss shows impedance matching and best return loss in greater than -10dB which is achieved in proposed antenna after applying EBG structure and good impedance matching also shows that available power to be absorbed and radiated by the antenna without reflections back down the line. Many factors must be considered such as operating frequencies, bandwidth requirements of the antenna system, and directivity, all of which affect its efficiency. A MIMO Microstrip patch antenna has been successfully designed at the frequency of 5.85GHz. It can be concluded from the above results, while designing, a proper feed network and impedance matching are very important parameters in Microstrip patch antenna design. Further work can be done using EBG structure on metamaterial. In the field of electromagnetic wave engineering the recent interest is on metamaterial technology, and application of EBG (Electromagnetic Band Gap) structure utilizing this technology to noise suppression and interference control is under consideration.

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