Simulation of 2.4GHz Microstrip patch Antenna using EBG Structure

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Abstract - *A microstrip patch antenna is low profile antenna mounted over a high impedance electromagnetic bandgap (EBG) substrate is proposed. In this paper, Microstrip patch antenna with rectangular EBG structure is proposed and studied. The proposed antenna has compact structure with a total size of 29.44x38.036mm². The designed antenna resonates at multiple frequencies with improved return loss, bandwidth and gain. The resonant frequency of the antenna 2.35GHz and 2.33GHz without and with EBG and improved return loss of -17.61dB and -18.30dB. With rectangular EBG the antenna gives improved gain of 2.14 dB. The Proposed antenna is simulated by using the method of moment based commercial software (IE3D) and simulated results are in good with practical antenna characteristics.*

Key Words: EBG, Microstrip patch antenna, Return loss, Gain, bandwidth

1. INTRODUCTION

Antenna is one of the important elements in the RF system for receiving or transmitting the radio wave signals from and into the air as the medium. The microstrip antenna has been said to be the most innovative area in the antenna engineering with its low material cost and easy fabrication. Microstrip patch antennas have various application in satellite communications, wireless systems such as ATM Wireless Access (AWA) and millimeter-wave automobile sensors, aerospace, radars, biomedical applications, reflector feeds, because of their advantages of a low profile, light weight. With Advance of wireless communication systems and increasing importance of other wireless applications, wide band and low profile antennas are in great demand for both commercial and military applications [1-2].There many disadvantages in Microstrip antenna to overcome those by using a metamaterial to apply with the microstrip antenna [2]. The metamaterial refers to an engineered material whose behaviors or properties are naturally non-existent Another metamaterial suitable for the electromagnetic applications is the electromagnetic band gap (EBG) structure [3]. By loading the EBGs periodically on the substrate, a band gap can be created for frequencies around the operating frequency of the antenna. Such structure can stop the propagation of surface waves, which can be excited along the high dielectric substrate material [4]. Several types of EBG structures have been proposed for performance improvement of the microstrip patch antennas [5].The inclusion of EBG in microstrip antenna design allows gain enhancement, enhanced directivity, relative bandwidth improvement and size miniaturization [6]. EBG structures possess unique electromagnetic properties that have led to a wide range of applications [7].

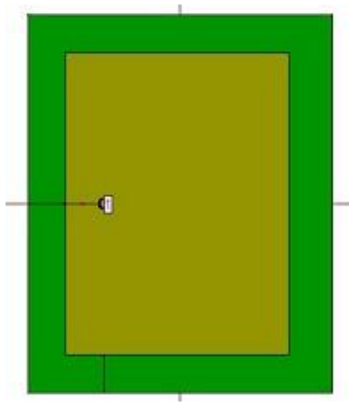

Fig1 (a) Geometry of patch antenna

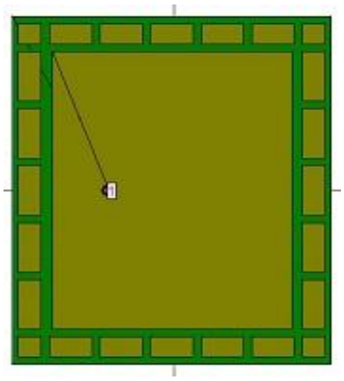

Fig 1(b) Geometry of Patch with EBG

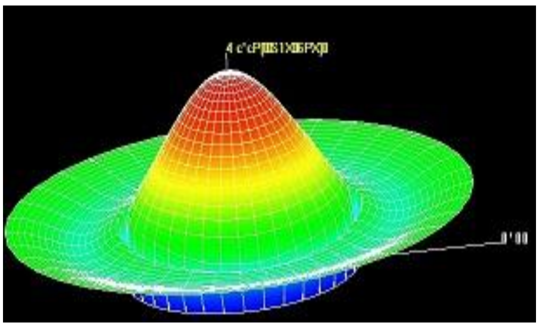

Fig 1(c) 3D View of Base antenna

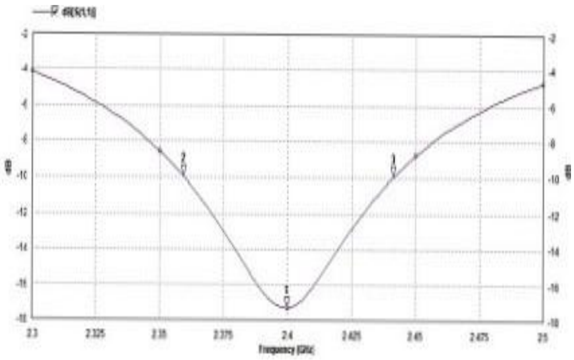

Fig 2(a) Simulated result of Base antenna

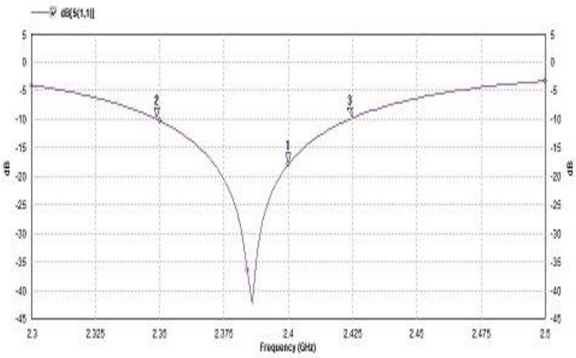

Fig 2(b) Simulated result of patch with EBG

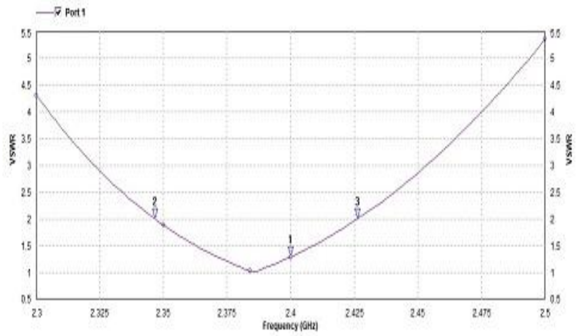

Fig 2(c) VSWR of Base antenna with EBG

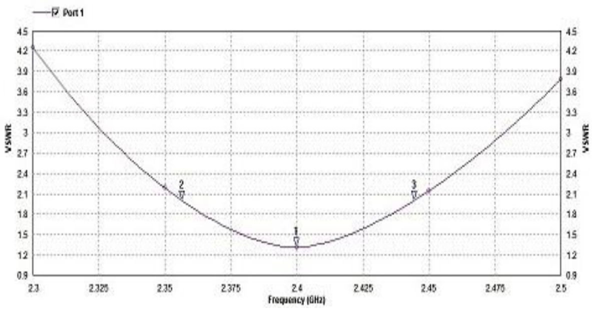

Fig 3(a) VSWR of Base antenna

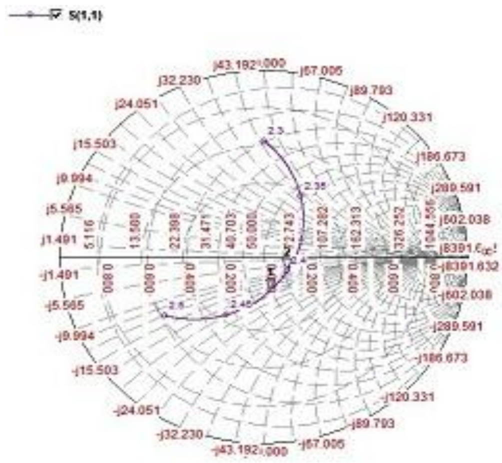

Fig 3(b) Smith Chart of Base antenna

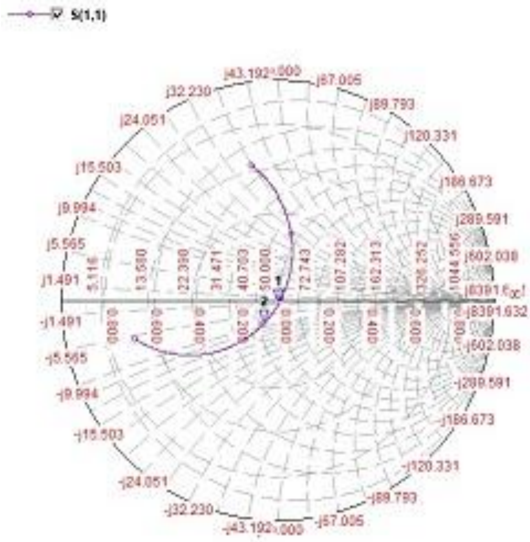

Fig 3(c) Smith Chart of Base antenna with EBG

The patch is surrounded by rectangular shape EBG structure as indicated in the below figures 4(c) & 4(d). The total area occupied by the base shape patch is 29.44x38.036mm^2. The total length of the patch is equally divided into five EBG slots the length of each slot = 5.088mm and its width = 2.8mm. Similarly the total width of the patch is divided into five EBG and each of length = 6.8072mm and with =2.8mm .The gap between the EBG slot=1mm, four corner EBG length=2.8mm and width=2.8mm. Probe feed is used to feed the antenna and the location of probe is DP= (-9.75mm, 0) from the origin which is shown in Fig 4(c). Geometry of designed antenna is implemented practically using fabricated technology by selecting material of type glass epoxy having dielectric substrate with €r=4.4 and height of substrate as 1.6mm.

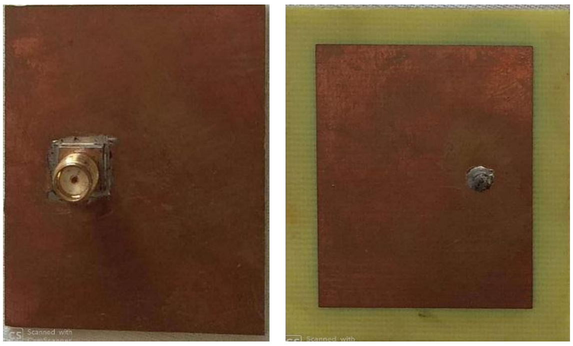

Fig 4(a) & 4 (b): Fabricated antennas with top view and bottom view of Basic microstrip antenna

Fig 4(c) & 4 (d): Fabricated antennas with top view And bottom view of Patch with EBG

6GHz spectrum analyzer, a 12.4 GHz tracking generator, and a 6GHz directional coupler. By connecting these devices together (with the included cables) the system functions as a scalar network analyzer, providing the tools you need to perform VSWR and return loss measurements at frequencies up to 6 GHz. For all cases, the simulated results are obtained and are compared to the experimental results.

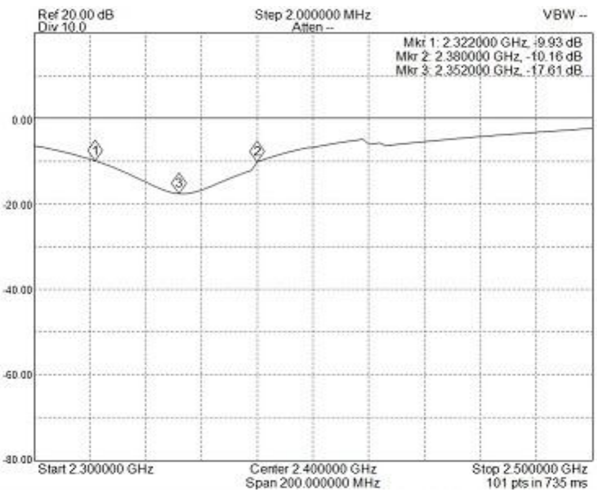

Fig 5(a) Practical Simulated result of Base antenna

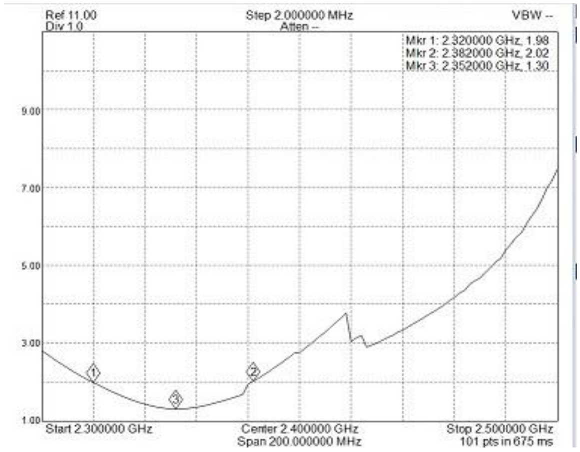

Fig 5(b) Practical VSWR result of Base antenna

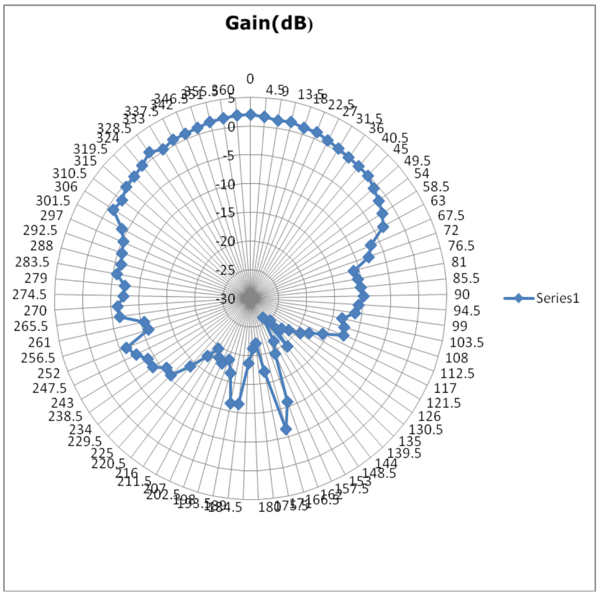

Fig 5(c) Practical Radiation pattern of Base antenna

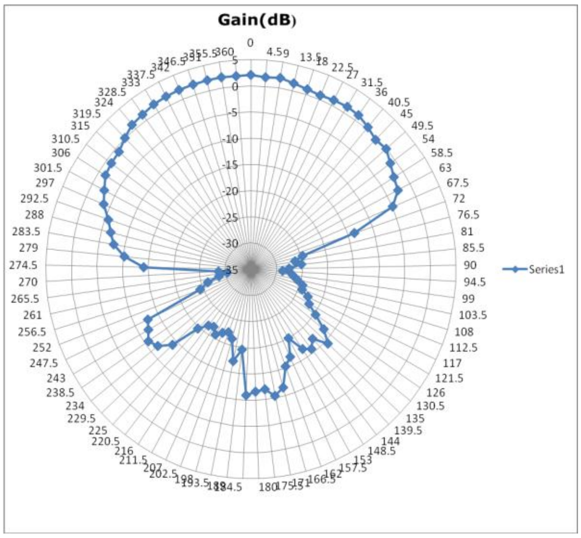

Fig 6(a) Practical Radiation pattern of patch with EBG

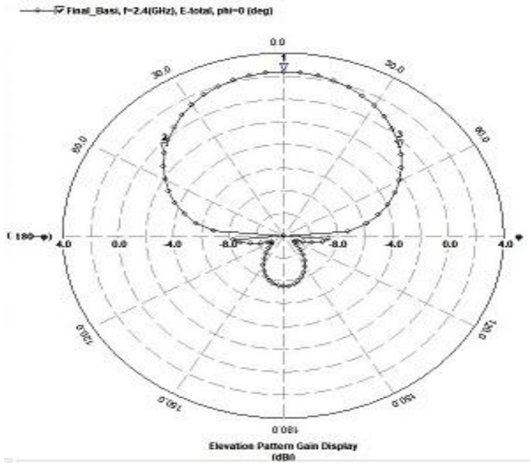

Fig 6(b) Gain plot in polar of Base antenna without EBG

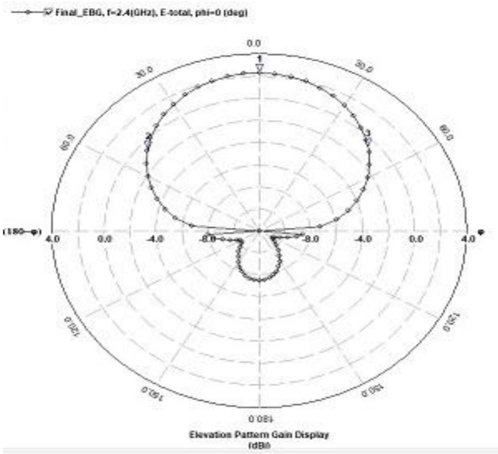

Fig 6(c) Gain plot in polar of patch With EBG

The Simulated and measured return loss characteristics of antenna are shown in fig 2(a) & 5(a). And also VSWR characteristics of antenna shown in fig 3(a) & 2(c). Agreement between measured and simulated results is good. The results are shown in table 1. The results indicate that the proposed antenna performance with periodic EBG structures is improved i.e., the Return loss and gain are enhanced.

Prototype antenna	**Resonance frequency Fr(GHz)**		**Return loss(db)**		**Gain(db)**	
	Sim	Prc	Sim	Prc	Sim	Prc
Base antenna without EBG	**f_1=2.4**	**f_1=2.35**	**-17.28**	**-17.61**	**2.35**	**1.99**
With EBG	**f_1=2.4**	**f_1=2.34**	**-17.9**	**-18.3**	**2.27**	**2.09**

Table 1: Results of proposed antenna with EBG structure

The directivity of proposed antennas are also studied, It has been observed that with EBG there is an improvement in directivity of all antennas. The base antenna gives directivity of 5.23 dBi without EBG and 6.32 with EBG. Also the radiation patterns have been studied for all the antennas with EBG structure and it is shown in fig 5(c) to 6(a). It is observed that the radiation patterns are broadside.

The characteristics of proposed antennas were simulated by using software IE3D and verified experimentally by using Scalar network analyzer. For all cases, the simulated results are obtained and are compared to the experimental results. They are shown in figure 5(a) &5(b). From the results it is clear that simulated results are in good agreement with measured results.

1.2. Conclusion

The performance improvement of a microstrip patch antenna with the EBG structure has been investigated. The EBG structure demonstrated the effects of surface wave suppression and reduction on broadside radiation power. The Gain obtained is 2.14 dBi and broadside radiation patterns are achieved. Measured values of resonant frequencies and return loss -18.30dB and VSWR 1.90 for these antennas have been found to agree well with the simulated ones. The EBG structure may find various applications for antenna and array in communications.

1.3. REFERENCES

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