Comparative Analysis of EBG Structure and its Application on Microstrip Patch Antenna

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Abstract: In this paper we have presented two new EBG structure with its radiation pattern, S-parameter, VSWR and Gain respectively. Also this new EBG structure is compared with different Mushroom-like EBG structure. Both of these EBG structures have a substrate with same size and same material and also there is no connecting via between its ground plane and patch, contrary to Mushroom-Like EBG structure. At the end, it was resulted that the gain of antenna has increased noticeably by using the EBG structures.

Keywords: Microstrip antenna, EBG structure, gain, Mushroom-like EBG, array of ‘+’ shape, array of ‘C’ shape and HFSS.

I. INTRODUCTION

In the 1980’s Yoblonovitch described that the PBG structure, formed by periodic variation in the refractive index of the structure, can be very useful as it can be used to eliminate the spontaneous emission of photons at certain frequency bands further research has taken the PBG structure to a new level which is the current candidate of designing antenna with EBG structure [1]. Now a days the microstrip patch antennas are one of most commonly used commercial antennas because of its advantages like, bulkiness, small in size, compatibility with different types of surfaces [2], simple in fabrication and matching with recent printed circuits, mainly in mobile and wireless communications [3]. In the area of microwave and photonics Electromagnetic Band Gap (EBG) structures produced a wide variety of design alternatives for different researchers [4].

Owing the incredible potential of EBGs, there are varieties of applications to improve the performance of devices particularly to increase the radiation patterns, gain and to decrease the noise losses in transmissions there EBG structure can be used [5]. The EBG structures are periodic in nature, which may be realized by drilling, cuffing, and etching on the metal or dielectric substrates. They may be formed in the ground plane or over the substrate [6]. The dimensions of EBG structures are categorized in three parts as one dimensional (1-D), two dimensional (2-D), and three dimensional (3-D) periodic structures which satisfies the Bragg’s conditions [7]. EBG technologies has a noble candidate for wide range of applications in RF and microwave engineering, including filters, waveguides, cavities, antennas etc [8]. In order to get the most of this technology, all of the components are designed using EBG technology then a fully integrated receiver or emitter system should be developed [9]. But these antennas also have some disadvantages like low power, low gain, low efficiency, narrow bandwidth and existence of surface waves. Formation of surface waves in substrate of Microstrip antenna decreases the radiation power and also destroys the radiation pattern of antenna. Surface waves also lead to decrease in gain and directivity of antenna. If we increase the thickness of substrate or use the substrates with high dielectric constants, we can limit the propagation of surface waves [10].

The author’s reports a lot of studies till now, are done in designing one, two and three dimensional EBG structures. Nevertheless the main aim to design EBG structure by using two dimensional Mushroom-like EBG structures. The main benefit of these structures is to operate as an artificial ground plane or to rest into the substrate of Microstrip antennas to surpass the surface waves [11-13].

In this paper a new EBG structure is introduced and this structure is designed by using two dimensional mushroom-like EBG structure. However there are certain differences between this new EBG and mushroom-like EBG structure. The main difference exists between the patch shapes on two EBG structures. The patch in mushroom-like EBG has a rectangular shape, but in the new EBG structure, patch shape is totally different as it can be seen in figure 1. Also another difference is that in new EBG there is no connectivity between patch via and ground plane that makes it easier to build the structure.

II. ANTENNA CONFIGURATION

The antenna with EBG mushroom type structure using basic coaxial feed microstrip antenna is shown in Fig.1. The total size of the antenna is LxWxH and the overall thickness (H) of the antenna is 3.45 mm.

![Figure 1: Geometry of EBG mushroom type structure using coaxial feed](image)

The design parameters of coaxial probe-fed Microstrip antenna are: W, width of patch, L: length of patch, H: thickness of substrate and εr: permittivity of substrate. Figure 1 shows the probe feed patch antenna and its physical parameters, having length (Lp) and width (Wp) is formed on the dielectric substrate above the ground plane. The Rogers RTDuroid- 5880 substrate with dielectric constant (εr) = 2.2 and thickness (h) is 3.2 mm is used for both patch and feed substrate.
**Table 1: Proposed parameters of single U-slot patch antenna**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>60</td>
</tr>
<tr>
<td>W</td>
<td>60</td>
</tr>
<tr>
<td>Lₚ</td>
<td>20</td>
</tr>
<tr>
<td>Wₚ</td>
<td>25</td>
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</table>

### III. RESULTS AND DISCUSSION

EBG structure based microstrip patch antenna are designed with coaxial line fed on square patch, which is called the reference patch using Ansoft HFSS to simulate the structure which is shown in Fig. 2a.

The proposed antenna here offers better VSWR, wide bandwidth, symmetry in radiation patterns, and high return loss. To attain better results hexahedral meshing is taken at -30 dB accuracy. The characteristic impedance $(Z₀)$ of the simulated design comes out to be $60 \, \Omega$ (approx) as shown in Figure 3.

The Figure 4 shows the plot between return losses versus frequency. In fig 4(a) it can be seen that for EBG structure antenna with arrays of ‘+’ shape on the whole substrate which is giving a 8 GHz resonating frequency with wide bandwidth and on the other hand EBG structure with array of ‘C’ shape on the whole substrate that is giving two resonating frequencies one is at 4.5 and 8 GHz respectively shown in fig 4(b).

![Figure 2: Microstrip antenna using New EBG structure around its radiation patch](image1)

![Figure 3: Meshing diagram Microstrip antenna using two EBG structure](image2)

![Figure 4: Return loss vs Frequency of Microstrip antenna using New EBG structure](image3)
For EBG structure antenna with arrays of ‘+’ shape and EBG structure with array of ‘C’ shape on the whole substrate gives less than 2 dB values for both the EBG structure based antennas as shown in Fig. 5.

The antenna is simulated and studied on the frequency of 1-10 GHz which is into the band gap of the Microstrip antenna. Figure 6 shows the radiation pattern of this antenna with new EBG structure around its patch. This antenna is simulated using Ansoft HFSS. The results show that the gain of antenna at this frequency is 4.295 dB and 6.682 dB is for the second EBG structure based Microstrip antenna.

Figure 5: VSWR vs Frequency of Microstrip antenna using New EBG structure

Figure 6: Gain of Microstrip antenna using New EBG structure

Figure 7: Radiation pattern of Microstrip antenna using New EBG structure
The radiation patterns of the proposed array for EBG structure antenna with arrays of ‘+’ shape and EBG structure with array of ‘C’ shape on the at various resonant frequencies are shown below in fig. 7 correspondingly, which shows that is Unidirectional in nature and array of ‘C’ shape antenna also shows the unidirectional nature with improvement in the pattern.

**CONCLUSION**

In this paper two dimensional mushroom like EBG structure was designed and discussed. the both EBG structure were designed using a new technique that is there is no connecting via in new EBG structure and also patch shape of this new structure is different. This new EBG structure was used on a Microstrip patch antenna. The obtained Results show that using the new EBG structure effectively improves the gain of Microstrip antenna into the band gap area.

**References**


