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# Impact of EBG on Microstrip Patch Antenna

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***Abstract*— The correct use of electromagnetic band structures (EBG) becomes very interesting in the field of electromagnetic theory and antenna design. The use of electromagnetic band-gap (EBG) structures constructed with microstrip technology is one of the efficient techniques to reduce interconnection problems. This article proposes a three-layer dielectric substrate with four holes or air cylinders forming an EBG structure with an insert feed technique. Here the idea is to use the specified structure in the mid layer of dielectrics. In order to improve over surface wave losses, the necessity of introducing EBG structures is appeared. The achievement of higher efficiency and enhanced bandwidth is feasible by proper impedance matching during the feeding mechanism. The structure is designed for the resonant frequency of 2.4 GHz and the entire simulation is performed with Ansoft High Frequency Structure Simulator (HFSS) version 11.**

***Keywords-EBG, Microstrip Patch Antenna, MMIC, Inset feeding, Photonic Band Gap.***

## I. INTRODUCTION

A microstrip patch antenna can be widely used in different government and commercial applications as these are low profile, inexpensive to manufacture on PCB, compatibility with MMIC designs and mechanical robustness (C. A. Balanis, 1997). The rectangular shaped microstrip patch antenna has huge applications among all other shaped patches in present days. The fabrication in that case is very easy and these are very simpler to handle. In microstrip patch antenna when the source signal is applied to the patch the electromagnetic waves will be radiated. This patch is a conductor with length L and width W on a substrate with dielectric constant $\varepsilon_r$, height h and thickness t is supported by a ground plane. The rectangular patch is deserved to resonate at the desired frequency. The dielectric losses may take place during the designing which is required to be minimized. The EBG structure incorporated with the microstrip patch antenna helps in optimization of these losses. Although the microstrip patch antennas can be formed with different shapes in our design we have emphasized upon the rectangular one to perform simulation

with Ansoft HFSS version 11 after inclusion of the EBG structure (R. Garg et al. 2001). The basic microstrip rectangular patch antenna structure is shown in fig.1.

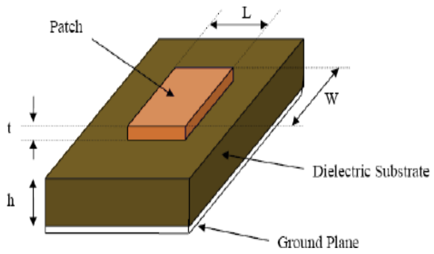


Fig. 1. Basic microstrip patch antenna structure

## II. METHODOLOGY

Rectangular patch antennas are designed to operate at resonant frequencies. Here are some important points to consider in the design process (C.A. Balanis, 1997):

- Length (L) : $0.2333\lambda 0 < L < 0.5\lambda 0$
- Height (h) : $0.003\lambda 0 \leq h \leq 0.05\lambda 0$
- Thickness (t ) : $t << \lambda 0$
- Dielectric constant ($\varepsilon_r$ ) : $2.2 \leq \varepsilon_r \leq 12$

Here the parameter λ0 is considered to be the free space wavelength of the radiated wave.

For a rectangular microstrip patch antenna, the resonance frequency for any TM $_{mn}$ mode is given by as:

$$f_o = \frac{c}{2\sqrt{\varepsilon_{reff}}}\left[\left(\frac{m}{L}\right)^2 + \left(\frac{n}{W}\right)^2\right]^{\frac{1}{2}}$$

Here c is considered to be the speed of light in free space.

Our resonance frequency is chosen to be 2.4 GHz and hence the free space wavelength (λ0) = 125 mm.

The substrate material with proper dielectric constant is another important parameter. We use FR4 epoxy as dielectric substrate where the value of $\varepsilon_r$ is considered to be 4.4. In our design the thickness of the dielectric substrate is h = 0.0128 λ0. The width of the microstrip patch antenna is given as:

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

Width is calculated to have a value of 0.304λ0.

The effective dielectric constant is established from the following relation and found to be equal with 3.7716.

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}}$$

Again we know,

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{reff}}}$$

$L_{eff}$ is 0.25744 λ0.

Again, the length extension ΔL is calculated again to be 0.0172 λ0.

Finally using proper formulations, the value of L is found to be 0.26 λ0.

Making use of all those values we need to interpret the EBG structure into the basic design.

Electromagnetic band gap (EBG) structures are periodic cells which are formed with metal or dielectric material. The major advantage of EBG structure is to suppress the surface wave propagation by introducing band gap. Thus the antenna gain enhancement and back radiation reduction can be achieved by improving the antenna performance (R. Gonzalo et al., 1999 ; M. Nemati et al., 2013). Bandwidth may be enhanced further by considering AMC/EBG structure to modify the traditional structure (R. Hadarig et al., 2012).

Three layers of dielectric substrate are used of thickness 0.0128 λ0. The design is made with minimum thickness to avoid surface waves. For proper impedance matching we have used inset feeding mechanism for the microstrip line. We concentrate on three layers of dielectric substrate in which one layer or the lower sided layer is used for the support of ground plane and other or top layer is used for patch and in middle side we can take number of FR4 epoxy layers but we used only one for middle. The cylindrical holes are created to form the air cavities and fix the radius at 4 mm for each time.

## III. RESULT

The actual pictorial representation of the proposed structure with introduced air cavities is shown in fig. 2. The corresponding $S_{11}$ (dB) plot with frequency (GHz) is shown in fig. 3. The structure is found to resonate at multiple frequencies after the incorporation of EBG. The respective radiation pattern is given in fig. 4.

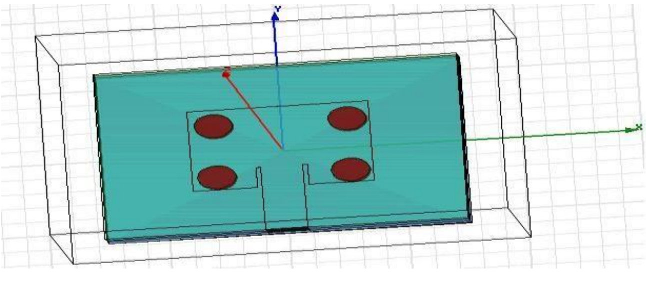

Fig. 2. Microstrip antenna with EBG Structure

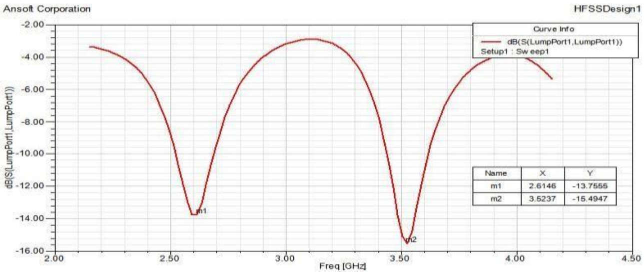


Fig. 3. $S_{11}$ (dB) and Frequency (GHz) plot of the modified structure

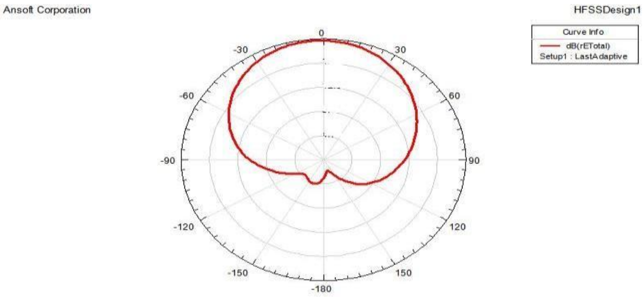


Fig. 4. Radiation pattern of the proposed antenna

## IV. CONCLUSION

In this paper the EBG structure is introduced into the formal methodology of designing the patch antenna with inset feeding structure. So, the antenna is found to resonate at multiple frequencies with its respective return loss characteristics. The bandwidth may be increased further by Artificial Magnetic Conductor (AMC)/Electromagnetic Band Gap (EBG) incorporation. The result may further be improved by considering more air cavities during the formation of the EBG structure.


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