WIDEBAND SLOTTED PATCH ANTENNAS USING EBG STRUCTURES

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ABSTRACT

A slotted microstrip patch antenna is designed with Electromagnetic Band gap (EBG) structures. The performance parameters of the presented antenna are then compared with the conventional patch antenna. It is realized that there is a significant increase of bandwidth and better suppression of harmonics than the normal patch antenna. This antenna is thus operating in the frequency band 5 -6 GHz which is one of the most usable bandwidth regions for wireless applications such as WiMAX, WiFi outdoor, WLAN, Hiperlan/2 and many more. The proposed antenna achieves a gain between 4 to 6 dBi built in FR-4 material.

INTRODUCTION

Recent developments in microstrip patch antennas make them acceptable world wide as low profile radiators[1]. The conventional microstrip patch antenna got number of design challenges including narrow bandwidth and spurious feed radiations. In an actual scenario, there are numerous trade-off's associated with these antennas to realize a high performance versatile antenna. Although there are many methods to increase the performance of conventional patch antenna, using a slotted patch antenna on Electromagnetic Bandgap structures is of particular interest[2]. Despite these numerous advantages, there are number of trade-off's associated with conventional patch antenna in order to enhance its performance [3]. In mobile communications, a wider bandwidth is really essential. Also the unwanted harmonics is quiet unacceptable features of these antennas. There are number of bandwidth enhancement techniques used such as coplanar patch and stack configuration which are able to improve the bandwidth for about 25%. Another method of increasing bandwidth is by impedance matching network. An increase of 13% in bandwidth is possible, if proximity coupled patch element with a stub tuning network is employed. This will give spurious radiations which is quite unacceptable. Double tuning can also increase the bandwidth (20%) by varying the length of slot. A disadvantage of which is higher back lobe radiation. Another technique of bandwidth enhancement is stagger-tuned resonator for a log periodic array to achieve multi octave bandwidths.

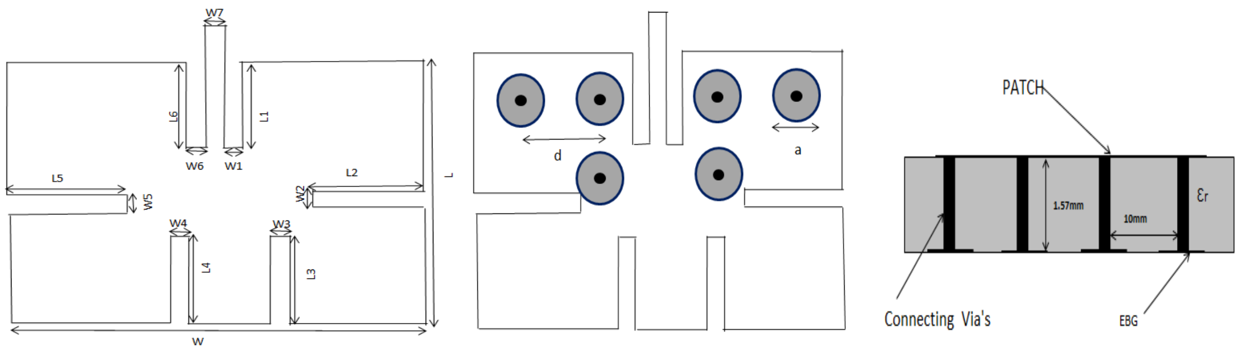
The method of bandwidth enhancement shown in this paper is by the introduction of EBG structures in slotted patch antenna. EBG structures are those structures, in which each element follow periodicity and consist of grounded metallic patches [4] [5]. In other words we can say that EBG structures control the free propagation of electromagnetic waves for a desired frequency or band of frequencies, thus enhancing the overall antenna performance. These structures possess properties like a band-pass and band-reject filters. The basic properties of these structures include increasing antenna gain and provide low profile structures . They also provide uniform electromagnetic field distribution with good suppression of surface waves for better antenna performance. All the properties of EBG structures leads to increased antenna efficiency, wider bandwidth and enhanced performance [6].

DESIGN PROCEDURE

In this paper two designs are discussed, a slotted patch antenna and another with EBG structures. These designs are than compared with respect to various field parameters like gain, return loss and radiation pattern. Figure 1 shows a slotted patch antenna on lossy FR-4 substrate with relative permittivity 4.4, loss tangent 0.02 and substrate height 1.57mm. Six slots as shown in Fig 1 are introduced in a rectangular patch of dimensions 30.5 x 46 mm^2. The width of each slot is kept around 1.12mm and length 11.21mm. The reason for choosing these slot dimensions is to get better radiation patterns. Also, these slots change the current distribution on the patch antenna and thereby varies the antenna inductance which is governed by [7],

$$L = \mu_0 h$$

Where, μ_0 is the permeability of free space and h is the substrate height. As shown in figure 1, six circular EBG structures are introduce in the previous design with 2mm radius each. The gap between EBG structures are chosen to be 10mm. All the other dimensions are maintained the same. The ground plane for both structures is 50 x 60 mm^2. The dimensions for the same structure are also shown in table 1.



(a) *(b)* *(c)*

Fig.1The proposed Slotted patch antenna with EBG structure (a)Top layer, (b) bottom layer and (c) cross section view.

Table 1: Dimensions for Patch antennas

L1=L2=L5=L6	L3=L4	W1=W2=W3=W4=W5=W6	W7	a(diameter)	d(gap)	L	W
11.21mm	11.1mm	1.12mm	3mm	2mm	10mm	30.5mm	46mm

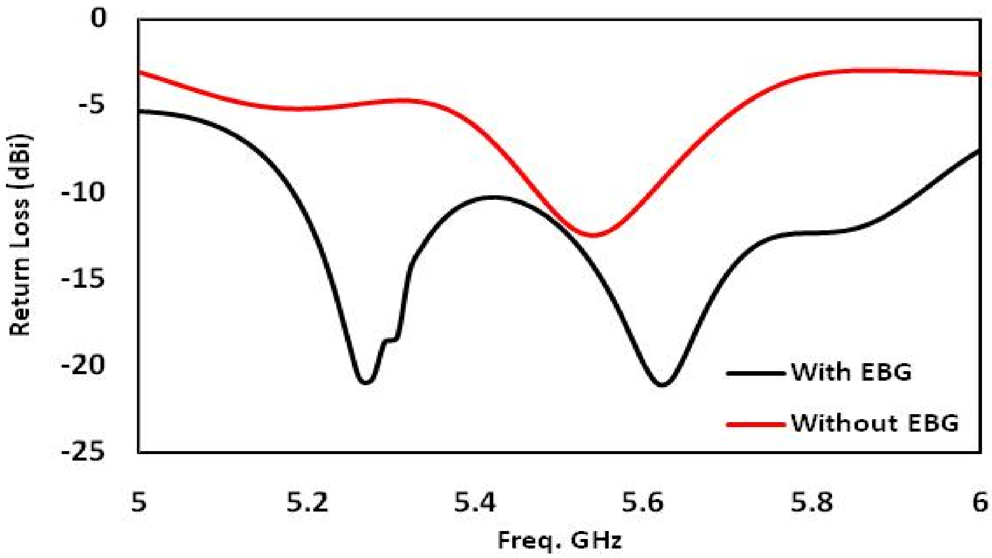


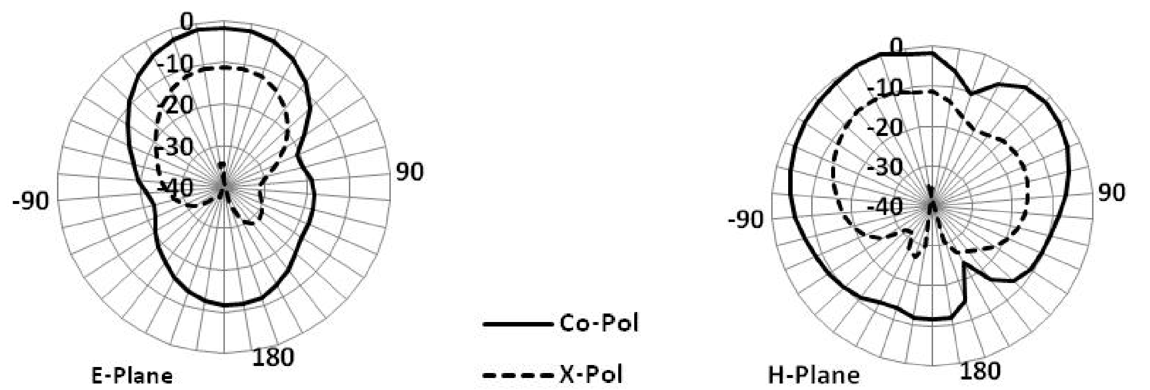
Fig.2 Return loss comparison for two patch antennas between 5-6GHz.

THE EFFECT OF THE ELECTROMAGNETIC BANDGAP STRUCTURE

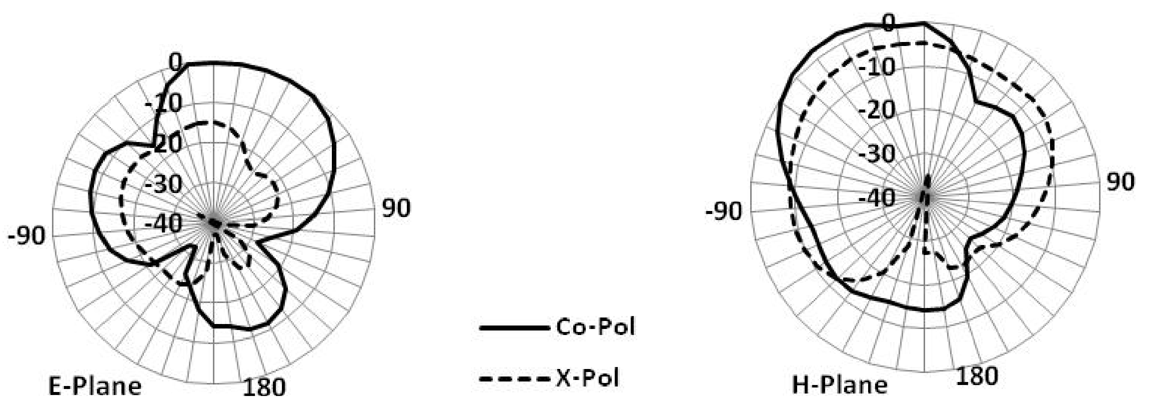
The simulation of the two patch designed are done by Ansoft's HFSS software. The return loss is calculated between 5 to 6 GHz for both antennas as shown in Fig. 2. The bandwidth of the patch antenna with and without EBG is shown in table 2. The proposed slotted EBG antenna achieved a bandwidth of 8.63% and is for one of the most usable bands for wireless communications (5 – 6 GHz). This new antenna is thus quiet versatile and can be used in many applications in UK/EU (5.15 -5.35 GHz and 5.47-5.725 GHz). Other applications of such antennas are outdoor WiFi, Band A and Band B, indoor/outdoor WLAN and Hiperlan/2 [8]. Moreover, the gain of EBG patch antenna has increase by a considerable amount of 3.2dB at 5.85 GHz in compared to 1 dB for the normal patch antenna at the same frequency. The gain for the two antennas were calculated between 5 – 6 GHz as shown in Fig 3. As seen from Fig. 3 there has been a considerable increase in the bandwidth of normal patch antenna by using the EBG structures. Fig. 5 shows the co-Pol and X-Pol for E and H plane radiation patterns for the two bands at 5.4 and 5.3GHz.

Table 2: Bandwidth of the two patch antennas between 5-6 GHz

Frequency	Normal patch antenna	EBG patch antenna
5 - 6 GHz	1.91%	8.63%



(a)



(b)

Fig.5 Co-Pol and X-Pol for E and H plane radiation patterns for the EBG patch antenna at (a) 5.3GHz and.5.6GHz.

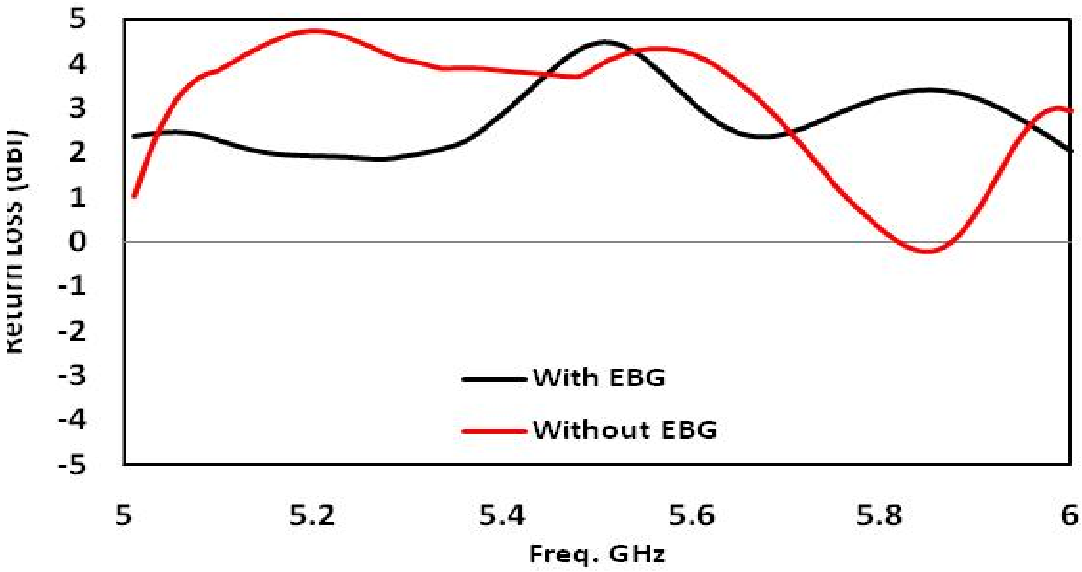


Fig. 3: Gain comparison for two patch antennas between 5-6 GHz.

CONCLUSION

The EBG structures are successfully implemented in the slotted patch antenna. The radiation patterns at 5.3 and 5.4 GHz is provided in this paper. The gain of the patch antenna with EBG is around 3.2 dB at 5.85 GHz. It has been shown that impedance bandwidth of slotted patch antenna is increased from 1.91% to 8.63% in a useful frequency band (5 – 6 GHz) making them more versatile for different wireless applications.

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