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Gain Improvement of Stepped Patch Antenna with EBG

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Abstract - *A multi band microstrip patch antenna with stepped geometry is proposed. This proposed antenna consists of a new EBG (Electromagnetic Band Gap) structure at feed-line. The performance parameters of the antenna with EBG structures are then compared with the conventional stepped patch antenna. EBG structures suppress the electromagnetic waves in a particular frequency band. It is realized that a significant improvement in gain and return loss compared to the conventional structure. The antenna operates in the frequency 3.5GHz, 8.5GHz, 11GHz and 13GHz. The proposed antenna achieves a gain of 6.26 dB and it is built in FR-4 material.*

Key Words*: *Stepped Patch Antenna, EBG Structure, electromagnetic waves, gain, and return loss.

1. INTRODUCTION

An extensively researched antenna over the past many years is the Microstrip Patch Antenna. The popularity of these antennas is because of its low profile simple structure, light weight and low cost in fabrication. They are extremely compatible for embedded antennas in handheld wireless devices such as cellular phones, pagers etc. These low profile antennas are also useful in aircraft, satellite and missile applications, where size, weight, cost, performance, ease of installation, and aerodynamic profile are strict constraints. Recent communication gadgets require an essentially wider bandwidth which is also capable of suppressing unwanted harmonics. Some of the principal advantages of this type of antennas are low profile nature, conformability to planar and non-planar surfaces, low fabrication costs, compatibility with MMIC designs, and mechanically robust flexibility when mounted on rigid surfaces [1].

The demand for speed and clarity of services enhanced the idea of improvement in antenna structure. A new face of patch antenna is originated, by change in structure, including EBG structure, reconfiguration of antenna are some of them.

Recently, there has been much interest in investigating electromagnetic band-gap structures or photonic band gap structures (PBGs) [2, 3]. Varieties of EBGs have been proposed and studied, because the EBGs represent some unique characteristics, such as forbidden band-gap, in- phase reflection, etc. [4]. It has been reported that EBGs used in microstrip antenna community can improve characteristics of antennas, such as improving their radiation patterns, enhancing their gain, and minimizing the side and back lobe levels, etc. [5-7]. Since the period of an EBG lattice has to be a half-wavelength at the stop-band frequency in early EBG design, the EBGs usually have difficulty in practical applications accommodating its physical size. So many small and compact periodic EBGs have been investigated to solve this problem, such as mushroom-like EBG [8], UC-PBG [9], fork-like EBG [10] and spiral-like EBG [11].

The proposed antenna consists of EBG at the feed-line of patch antenna. EBG structures are those structures, in which each element follow periodicity and consist of grounded metallic patches [12, 13]. The major application of the EBG is to suppress the noise and interference, in other words an EBG acts either as stop-band filter or as band-pass filter.

2. DESIGN PROCEDURE

Two designs have been discussed in this paper, a modified stepped patch antenna and another with EBG structure on feed-line. The designs are then compared with respect to various parameters like gain, return loss. Figure 2 and Figure 1 shows a modified stepped patch antenna on FR-4 substrate with relative permittivity 4.4, loss tangent 0.02 and substrate height 1.5748 mm [15]. The EBG designs are introduced in a feed-line of the antenna which is explained in Figure 3. The new EBG structure gives a better performance compared the antenna having no EBG. The antenna's ground plane is having a dimension of 40 x 30 mm^2. The software used is HFSS. The gap between EBG structures are chosen to be 0.4mm. All the other dimensions of EBGs are maintained the same. The dimensions for the structure are shown in table 1 and table 2.

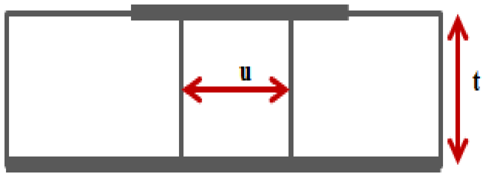

Fig 1: Side view of antenna

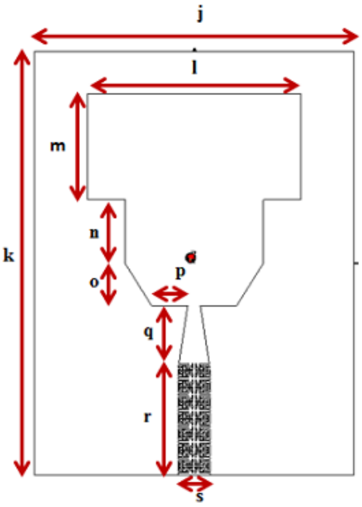

Fig 2: Stepped Patch Antenna

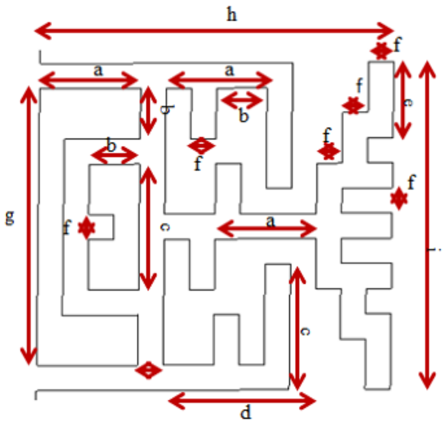

Fig 3: Single EBG design

j	30mm	o	4mm
k	40mm	p	3.4mm
l	19mm	q	5.9mm
m	9.81mm	r	9.74mm
n	5.93mm	s	3mm
u	3mm	t	1.5748mm

Table 1: Dimensions of Patch

a	0.4mm	f	0.1mm
b	0.2mm	g	1.1mm
c	0.5mm	h	1.4mm
d	0.6mm	i	1.3mm
e	0.3mm		

Table 2: Dimensions of EBG

3. The effect of Electromagnetic Band Gap

The simulations of two antennas i.e. the modified stepped patch antenna and patch antenna with EBG design on the feed-line are done using Ansoft's HFSS software. The return loss and gain of both the antennas are calculated between 3GHz to15GHz. The proposed EBG structure increases the gain and return loss which is shown in Table 3. The graphical representation of return loss for the two antennas is shown in Fig. 4. The proposed antenna can achieve a wide range of frequencies because of this reason the antenna can be used in wireless communication gadgets. Other applications of such antennas are outdoor WiFi, Band A and Band B, indoor/outdoor WLAN and Hiperlan/2 [14].

	Antenna without EBG (dB)	Antenna with EBG (dB)
Gain	-2.7107	+6.2625
S_{11} at 3.75GHz	-12.5	-19.5
S_{11} at 8.75GHz	-13	-17
S_{11} at 11.25GHz	-14	-16.5
S_{11} at 13.25GHz	-14.5	-19

Table 3: Comparison of two structures

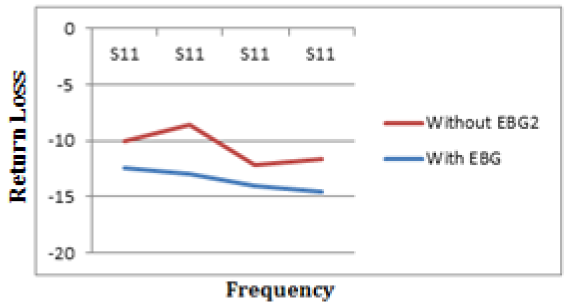

Fig 4: Graphical representation of return loss

4. CONCLUSION

The EBG structure is successfully implemented in the proposed modified patch. With this method a good improvement in gain and return loss has been seen. Since the antenna supports large frequencies, it can be used in wireless indoor/ outdoor communication gadgets.

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