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Micro strip Antenna Array with Square EBG Structure

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Abstract: *The periodic structure like electromagnetic band gap (EBG) is a very popular topic within the academia and RF-microwave industry due to their surface wave suppression property. In this paper the combination of the rectangular microstrip patch antenna fabricated on the top of the substrate FR4 with Electromagnetic Band Gap (EBG) structures at patch is proposed and investigated. A reduced sized antenna with microstrip feed is designed for its gain behaviour. First, the small size antenna is investigated by reducing its patch size. Further its gain behaviour is achieved by using serial feed 4x1 array with Square EBG. The antenna has been designed on FR4 substrate with dielectric constant 4.4 and thickness h=1.6 mm & its dimension is 118.0 mm × 175.0 mm × 1.6 mm. The proposed antenna exhibits 80MHz impedance bandwidth from (2.45-2.53GHz). The proposed antenna has a compact size and exhibits high gain behaviour, good radiation characteristics, and directivity is around 8.3dBi.The radiation pattern, return loss, VSWR and gain of the proposed antenna are described and simulated using the HFSS. Measurement results are in close agreement with the simulation results. The proposed EBG Square unit Array antenna is compact, low profile, and offers very high gain required for long way Communication system.*

Keywords: *Antenna array, EBG structure, Microstrip patch, Square unit cell,WLAN band and half/quarter/sixth part of patch.*

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I. Introduction

The multi-element smart antenna array has attracted attention of researchers due to its wide range of applications inthe field of wireless communication. Different multi-elementantenna prototypes are designed and implemented for theapplications in the base stations (BS) to improve the qualityof transmission and enhance the cellular capacity, coverage and reliability [2-6]. On the other hand, recent advances withinthe study of the electromagnetic band gap (EBG) structureshas established these structures to be simple solutionstowards improving the antenna performance [7]. An EBGstructure is a periodic structure that forbids the propagationof all electromagnetic waves within a particular frequencyband called the band gap. The performance improvementoccurs due to stop bands of these periodic structures.These structures provide a simple and effective solution tothe problems of surface and leaky waves [8]. Several types of microstrip based EBG structures have been analysed forvariety of applications. These structures are studied by utilizing both finite difference time domain and finite element method techniques [9,10].

In this paper, we Firstly designed the hexagonal antenna. It is referred as reference antenna for the purpose of miniaturization. After that to obtained half hexagonal antenna bisection to the reference antenna through its symmetry plane is done. Further to reduced the size of antenna reduced sized antenna with microstrip feed is designed. The 4x1 patch array antenna with Square EBG is designed as follows[1]. In this article, we propose a new analytical method based on transmission line theory to design the EBG of the microstrip patch antenna in particular toenhance its performance. We describe a serial feed 4x1 patch array antenna with EBG structure with wide impedance bandwidth and high gain. This array structure has further beeninvestigated integrating regular circle and rectangular shaped EBG structure at edge of resonating patch and a significant improvement has been observedin both radiation pattern at the designed frequency.

II. Proposed Antenna Design

A simple hexagonal microstrip patch antenna is designed to operate at 2.47GHz. Further to develop a light weight antenna, with the help of FR4 substrate material withthe length and width of the patch are 39mm and 28.2mm the reduced sized antenna with microstrip feed with EBG structure is designed. The feed point is 7.5mm from the centre of the patch as shown in Fig1.

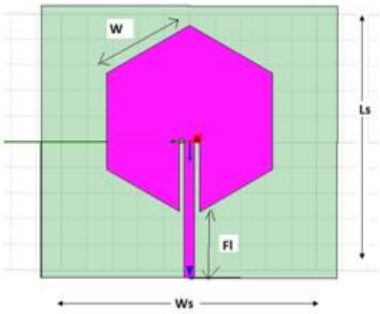

Fig.1. Hexagonal microsrtip antenna

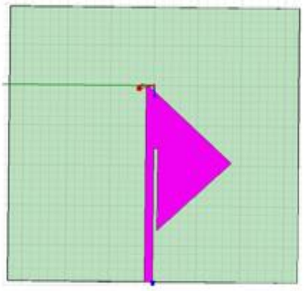

Fig.2 Reduced sized antenna

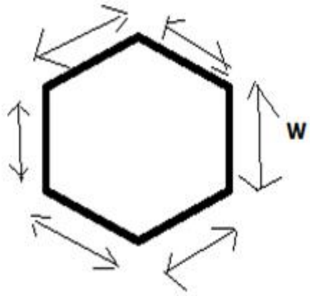

Fig.3. Design of hexagonal antenna

Simulation of this antenna has been carried out in HFSS. The simulation results of a single radiating element are given in the following section as shown below.

III. Methodology

Design procedure for hexagonal microstrip patch antenna:- Calculations are done by using $C = 3 \times 10^8$ m/s, ε_r= 4.4 and f_r = 2.48GHz :-

a. For width (W):The width of single element microstrip patch antenna isgiven by,

$$W = \frac{C}{2f_r\sqrt{\left(\frac{\varepsilon_r + 1}{2}\right)}}$$

b. For effective dielectric constant (ε_{reff}):-

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left\{1 + 12\frac{h}{w}\right\}^{-1/2}$$

c. For effective length extension:-

$$L_{eff} = \frac{C}{2f_r\sqrt{\varepsilon_{reff}}}$$

d. For actual length of patch (L):-

$L = L_{eff} - 2\Delta L$

e. For fundamental mode the resonant Frequency:-

$$f_r = \frac{2C}{6W\sqrt{(\varepsilon_r)}}$$

f. Patch side length W

$$W_{mm} = \frac{2C}{f_r\sqrt{(\varepsilon_r)}} = \frac{2\times3\times10^8}{2.48\times10^9\sqrt{4.4}} = 20.5\text{mm}$$

g. Calculation of Substrate dimension-
For this design this substrate dimension would be lam/2
Ls=Ws=lam/2=125/2=61mm
Ls=Ws=58mm
h. Calculation of feed Length-
Feed length (fl) =lam/4*sqrt (4.4)
Fl=14.5mm

IV. Simulation Results For Reduced Size 4x1 Microstrip Antenna Array With Ebg

The reduced size 4x1 microstrip patch antenna array with EBG is simulated by using HFSS software. The simulated results for this antenna are obtained as follows.

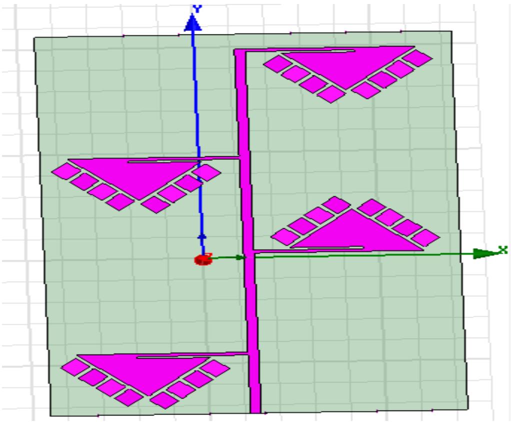

Fig.4. reduced size 4x1 microstrip patch antenna array with EBG

As shown in figure: 5 the value of Return loss of 1/6 4X1 patch array antenna array with EBG is -7.68.

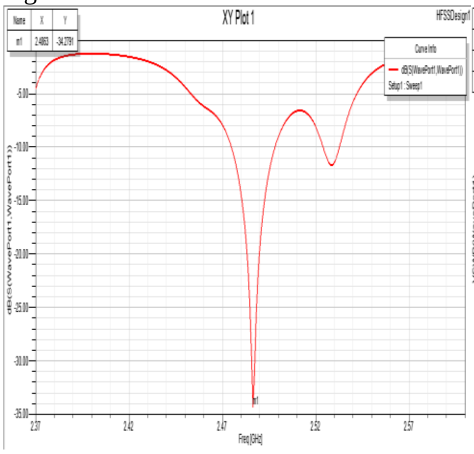

Fig.5. Return loss of reduced size 4 x 1 Microstrip antenna array with EBG

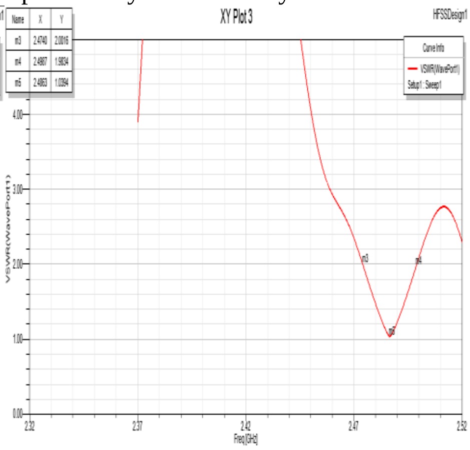

Fig.6.VSWR of reduced size 4 x 1 Microstrip antenna array with EBG

Figure: 6 Shows the VSWR Plot of reduced size 4x1 microstrip patch antenna array with EBG is

1.02.Figure: 7 shows the Directivity of reduced size 4x1 microstrip patch antenna array with EBG, Which is 8.3.

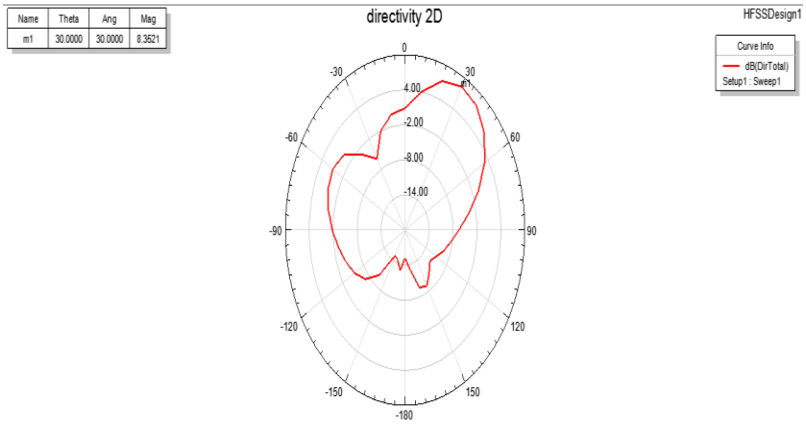

Fig.7. Radiation pattern of reduced size 4 x 1 Microstrip antenna array with EBG

I. PERFORMANCE OF FABRICATED REDUCED SIZE 4X1 ARRAY WITH EBG

The Proposed 4x1EBG array antenna has been fabricated and tested. These antennas have been tested using vector network analyzer Agilent technology N9923A series. The Measurement results of proposed fractal antenna getting bandwidth of 70MHz (from 2.45GHz to 2.53 GHz) at VSWR 2:1. The Fabricated of the Proposed 4x1 EBG Patch Arrayhas been shown in fig.8.

Fig.8. Fabricated antenna design

The measured return loss versus frequency of fabricated 4x1 EBG patch antenna has been shown in fig.9.

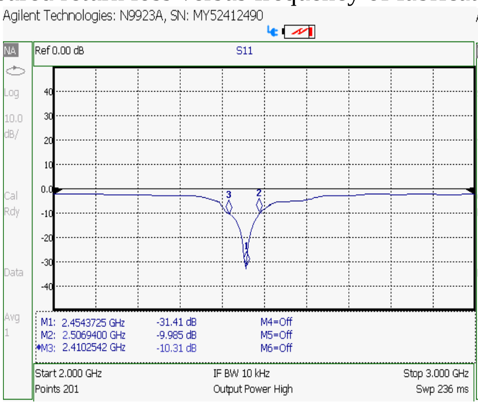

Fig.9. Measured return loss of fabricated antenna

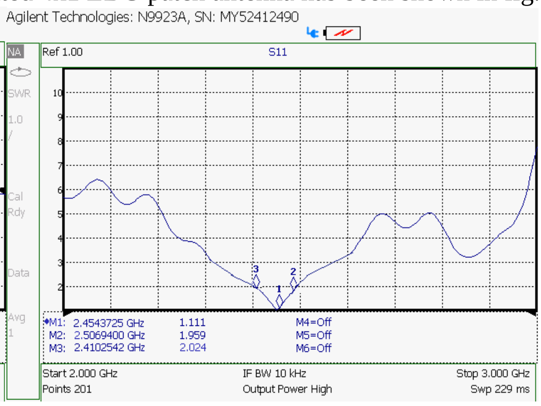

Fig.10. Measured VSWR of fabricated antenna

The measured VSWR versus frequency of fabricated 4x1 EBG patch antenna has been shown in fig.10. The measured return loss versus frequency of fabricated 4x1 EBG patch antenna has been shown in fig.11.

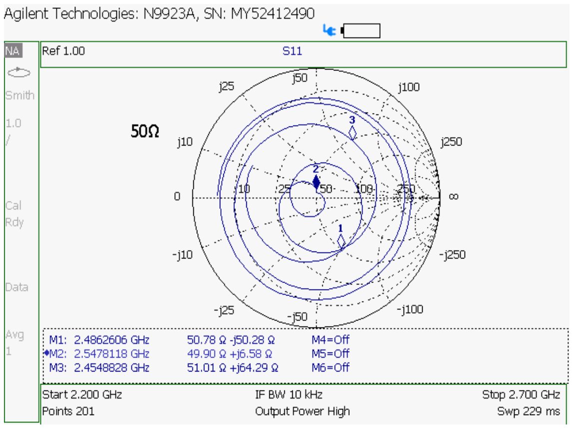

Fig.11. Measured return loss of fabricated antenna

A good agreement between experimental and simulated results is observed except some slight variation. This may be due to the tolerance in manufacturing, uncertainty of the thickness and/or the dielectric constant of the substrate and lower quality of SMA connector (VSWR = 1.3), larger tan delta= 0.02 of the substrate and soldering effects of an SMA connector.

II. COMPARISON TABLE

Figure: 4 shows fabricated reduced size 4x1 array with EBG. The corresponding responses of reduced size 4X1 array with EBG are shown in figure: 9, 10, 11.

Sr.No.	Results	Freq(GHz)	Return loss(dB)	VSWR	Gain(dB)	Impedance(Ohms)
1.	**Simulation Results**	**2.47**	**-34.27**	**1.15**	**6.8**	**52.0**
2.	**Measured Results**	**2.45**	**-31.41**	**1.11**	**7.0**	**51.0**

Table I. Comparison of simulated and measured result

The comparison of the parameters obtained for reduced size 4 x 1 Microstrip Antenna array with EBG are shown in table 1. The results for 4 x 1 Microstrip Antenna array with EBG are obtained from fabrication are return loss is -31.41, VSWR is 1.11 and directivity is 7.0.

III. Conclusion

A novel approach to enhance the Gain of microstrip patch antenna using Square EBG structure is proposed in this paper. It is found that microstrip antennas have exhibited distinctly higher gain as compared to the conventional patch antenna. Also, the microstrip antenna with square EBG exhibits higher gain. The proposed reduced size 4x1 microstrip antenna array with square EBG structure is electrically small size, suitable to easy handling and it is applicable to WLAN band at 2.45GHZ. From the simulated results,it is observed that thehalf/quarter/sixth part of Patch antenna structure the gain is increased and radiation pattern obtained with EBG are much better than without EBG. In this investigation, with a serial feed array structure the high gain 8.3dBi has been achieved. It is clearly observed that the impedance bandwidth and radiation efficiency are improved significantly by implementing proposed 4x1 patch array with Square EBG. The gain improved significantly by introducing EBG square unit structure. The proposed array antenna would be suitable as base station antenna of the WLANs.

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