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Bandwidth Enhancement with Ψ-Shape Microstrip Patch Antenna Using Photonic Bandgap

Santosh Tyagi, Kirti Vyas

Abstract **- A specific design strategy using Photonic band gap structure on ground to achieve wider bandwidth and large gain for microstrip patch antenna is presented in this paper. Proposed antenna has wide band operation from 3.8GHz to 6.5GHz with large impedance bandwidth and gain using modified patch and PBG on ground. Impedance bandwidth has improved upto 53% and gain has measured upto 6dB. Square patch antenna's geometry is modified with ψ-shape to improved antenna characteristics. All results are verified in IE3D simulator. This proposed antenna is used for various applications of C band such as C-band ISM (802.11a), satellite and wireless communication (WLAN Europe and WIMAX).**

Keywords **- Bandwidth, Directivity, Microstrip Antenna, Method of Moment (MOM), Photonic Band Gap Structure.**

I. Introduction

The microstrip antenna is now an established type of antenna that is confidently used by designers worldwide, mainly when low-profile, light weight, low cost and easily fabricated radiators are demanded. In spite of its attractive features single layer microstrip patch antenna suffer from narrow impedance bandwidth and low gain. This can be improved significantly by employing slots on the patch in a controlled manner such as U-slot loaded patch and E-shape patch [1]. Both U-slot and E-shape patch have impedance bandwidths of 30-35% [2]. Recently PBG structure [3] is used to improve microstrip antenna performance. In this paper a wideband microstrip antenna is presented with enhanced bandwidth and gain by introducing ψ-shape patch antenna with PBG structure in ground. PBG structures are periodic structures in which propagation of certain bands of frequencies is prohibited. Photonic band gap structures (PBG) are very promising building blocks of novel photonic components and devices representing the highest level of innovation in light generation, routing, and switching. PBG structures are used to suppress surface wave propagation in the antenna substrate to improve performance [4]. The coaxial probe feed technique is used for the analysis of this antenna because it occupies less space and has low spurious radiations by using Teflon connector. In this paper ψ-shape patch is designed with square patch of dimension 30X30 mm. The proposed antenna is compact in geometry, having effective patch area is very less than conventional square patch. Given antenna find their application in WLAN (5.15-5.35 GHz) and WIMAX (5.15-5.825 GHz). The Method of Moment (MOM) [5] is used to discuss the electromagnetic radiation characteristics of the microstrip antenna.

II. Antenna Configuration

The geometrical configuration of proposed microstrip antenna with PBG structure on ground is shown in Fig. 1. Position of coaxial probe feed is shown in figure 1. Essential parameters of designed antenna are shown in table 1. The bandgap associated with a specific crystal structure is completely independent of the design of the antenna. Therefore, when designing a patch antenna on a substrate containing photonic bandgap structure, the dimensions of the antenna, i.e. width, length, or substrate thickness, remain constant.

Table1: Dimensions of proposed microstrip antenna

Parameters	Value
Length of ground plane(L)	45 mm
Width of ground plane (W)	45 mm
Length of Patch (Lp)	30 mm
Width of Patch (Wp)	30 mm
L1 and W1	5 mm
L2	5 mm
W2	20 mm
L3	7.5 mm
W3	25 mm
L4 and W4	5 mm
Height of dielectric substrate (h)	1.6
Dielectric constant of substrate (FR4 epoxy)	4.4
Dielectric loss tangent	.0005
No. of PBG square cut on ground plane	9

III. Result Analysis

In recent trends, it is a common practice to analyze the system performance through simulation software before any real time implementation. In this paper IE3D V9.0 based on MOM method has been used to calculate return loss, impedance bandwidth, vswr, gain, antenna efficiency and radiation pattern. Fig. 2 shows return loss versus frequency curve for proposed antenna. For the same Fig. 2, impedance bandwidth can be calculated for frequency with return loss less than -10db. It means bandwidth and relative bandwidth are 3.768-6.5GHz (2.732 GHz) and 53% respectively.

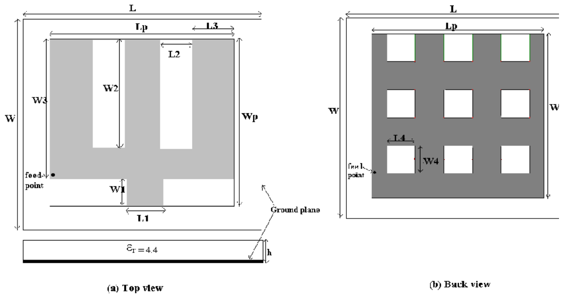

Fig.1.Geometry of the proposed antenna

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The value of return loss at two peak frequencies 4.374 GHz and 6.132 GHz are -41.82dB and -26dB respectively. Fig. 3 shows vswr versus frequency curve for given antenna. Fig. 4 shows gain versus frequency curve for given antenna. Maximum gain is 6dB and for entire band relative gain is greater than 4dB. This shows satisfactory performance of proposed antenna. Fig. 5 shows antenna efficiency versus frequency curve. Fig. 6, 7 and 8 shows E and H plane radiation patterns at frequency 4, 5 and 6 GHz respectively.

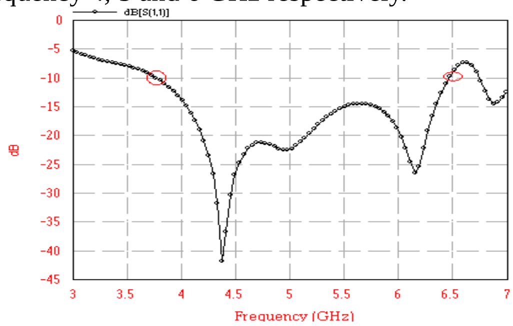

Fig.2. Return loss vs frequency

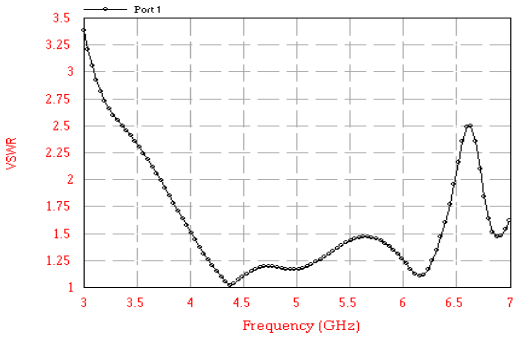

Fig.3. VSWR vs frequency

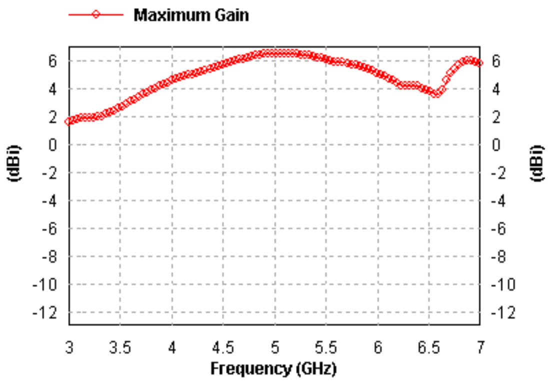

Fig.4. Gain vs frequency

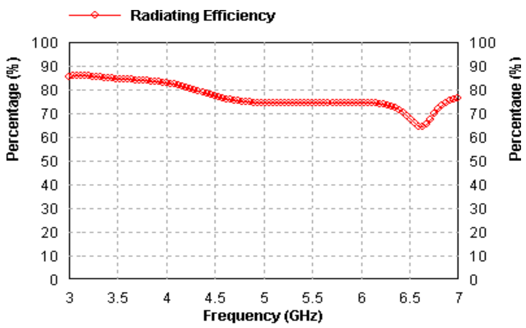

Fig.5. Antenna efficiency vs frequency

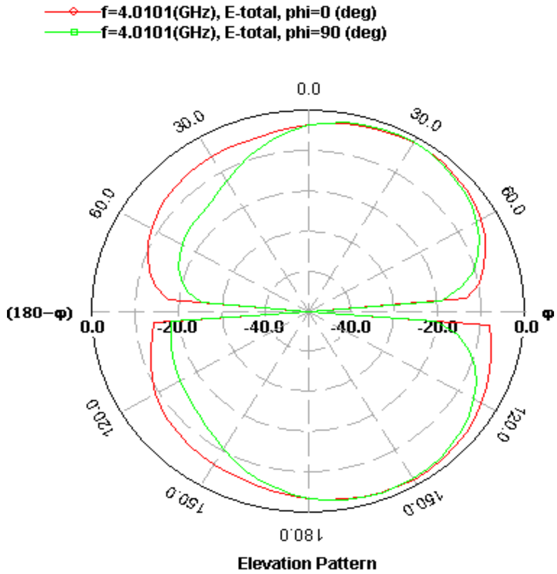

Fig.6. Radiation pattern at frequency 4GHz

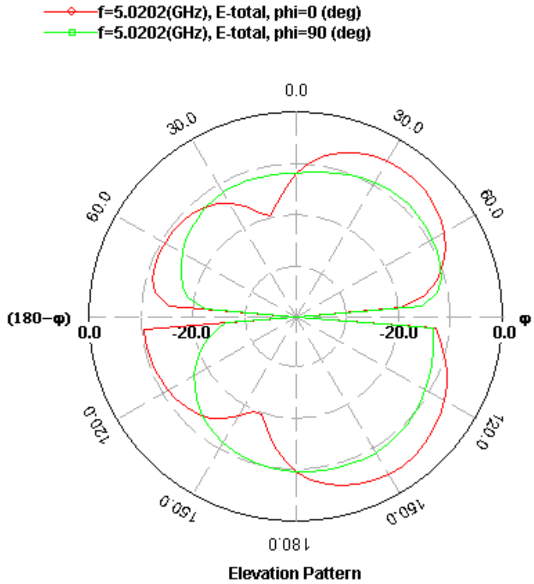

Fig.7. Radiation pattern at frequency 5GHz

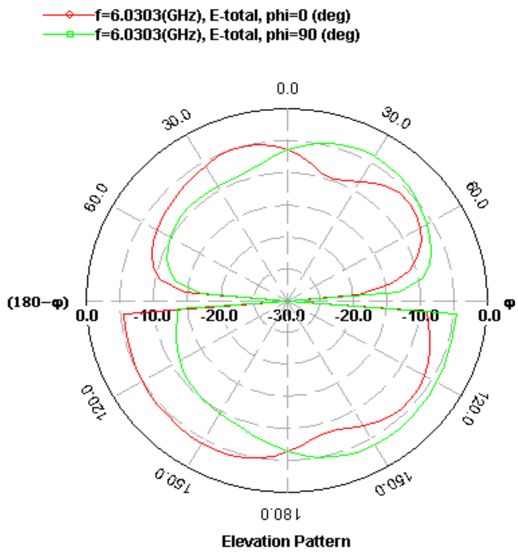

Fig.8. Radiation pattern at frequency 6GHz

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IV. Conclusion

Based on the analysis of the microstrip antenna with PBG structure, we have discussed the size and design parameters of ψ-shape patch antenna. Then we simulated the antennas that can run at centre frequency of 5.2 GHz and calculated its return loss and VSWR by using IE3D based on Method of Moment. The modifications with the help of insertion of PBG structure and conversion of square patch into ψ-shape gives a good result as the bandwidth and gain enhancement with promising efficiency. Overall bandwidth and relative bandwidth are 3.768-6.5GHz (2.732 GHz) and 53% respectively with gain of 6dB. Increase in bandwidth and gain provides various advantages like as increasing in channel capacity, increase power handling capacity etc. Hence the proposed antenna deserves perfectly for various wireless applications due to its compact size and improved performance.

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Author's Profile

Santosh Tyagi

received his B.tech degree in Electronics and Communication Engg (2007) with distinction from Faculty of Engg and Technology R.B.S. College, Agra (U.P.), India. She is pursuing M.Tech degree in Digital Communication System from Arya College of Engineering and IT, Jaipur, Rajasthan, India.

Kirti Vyas

received the B.E. degree in Electronics & communication (2004) from MCET, Laxamangarh and M.Tech. in communication system (2008) from MNIT, jaipur. She is also pursuing in Ph.D. She is currently Asst. Prof. In the department of E&C, Arya college of engineering and I.T, jaipur. Her current research includes antenna & communication system. She has many national and international publications to her credit.