International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 3.45 (SJIF-2015), e-ISSN: 2455-2585
Volume 4, Issue 5, May-2018

Performance Enhancement of Microstrip Patch Antenna Using EBG Structures for Wireless Applications

Shrawan Kumar Patel[1]
[1]*Department of ECE, School of Engg. & Tech., GGV Bilaspur (CG), shrawankpatel@gmail.com*

Abstract - ***Micro-strip patch antennas have been widely used for the application of RF and wireless system because of their small size, light weight and easy realization. In this paper improvement of gain and bandwidth of microstrip patch antenna is presented by using some special type of structures i.e. Electromagnetic Band Gap (EBG) structures. Electromagnetic Band Gap (EBG) surfaces have been of intense interest in recent years given their ability to suppress the propagation of electromagnetic waves in a frequency band. This suppression of electromagnetic waves leads to an enhancement of the maximum gain when a microstrip patch antenna is designed with EBG structures.The proposed antenna design is simulated on CST software using FR4 substrate with relative permittivity of 4.3 and thickness of 1.6mm. In this proposed antenna mushroom type EBG structures are used for suppressing the surface wave. The bandwidth and gain of MPA is improved at same operating frequency.***

Keywords - Bandwidth, Gain, Electromagnetic Band Gap (EBG) structure, Patch Antenna, Wireless Application.

INTRODUCTION

Microstrip antenna was proposed in early 1970 [11] and it provides a great revolution in the field of antenna design and research. Nowadays, microstrip patch antenna has become very popular and is widely used in various types of wireless applications. Microstrip antenna provides various features such as conformability and compatibility. Microstrip patch antennas have many admirable properties such as, high performance, high gain and low cost. The well-known feature of the microstrip patch antenna is that they are reliable and robust in nature. In addition to these properties, it provides an easy user interface and is simple to understand. It has a very simple design and gives very high performance in terms of bandwidth and gain. Major disadvantages of MPA are their low efficiency, low power, very narrow bandwidth and existence of surface wave. To improve this poor performance leads to development of EBG structure [2, 4, 7]. For conventional mushroom type of EBG structure gap width, patch size, dielectric constant of the substrate and thickness plays an important role in deciding the band gap property of Unit EBG unit cell [3, 6]. Section II discuss the design of Single Patch, section III discuss the design of mushroom type EBG Cell.

PATCH ANTENNA DESIGN AND RESULT

In this section design of microstrip patch antenna discussed having resonating frequency 2.4 GHz. patch and ground are made of copper having thickness 0.017 mm and 1.6 mm respectively. Material used for substrate is taken as FR-4 having relative permittivity 4.3.transmission line feeding technique used as feed line. The directivity, gain of single patch is 7.11 dB and 2.16 dB respectively. The antenna design and respective results are shown in figure 1, 2 and 3.

TABLE I
PHYSICAL PARAMETERS OF PATCH ANTENNA

Parameter	**Dimension**
Width (W)	37 mm
Length (L)	38 mm
Permittivity (ε_r)	4.3

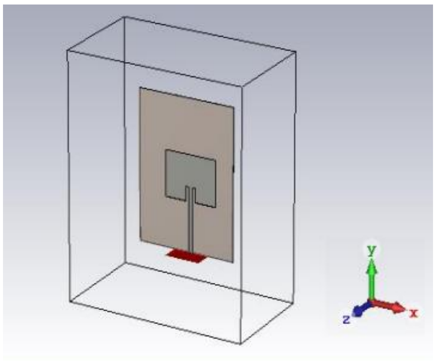

Fig. 1: MPA without EBG structures

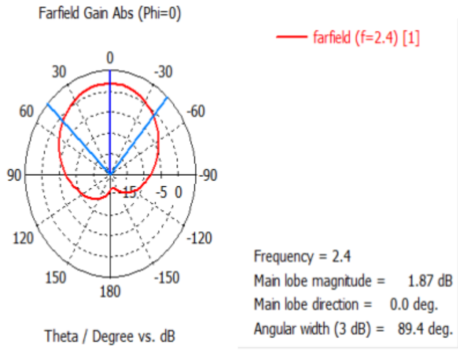

Fig. 2: Farfeild Pattern of MPA without EBG

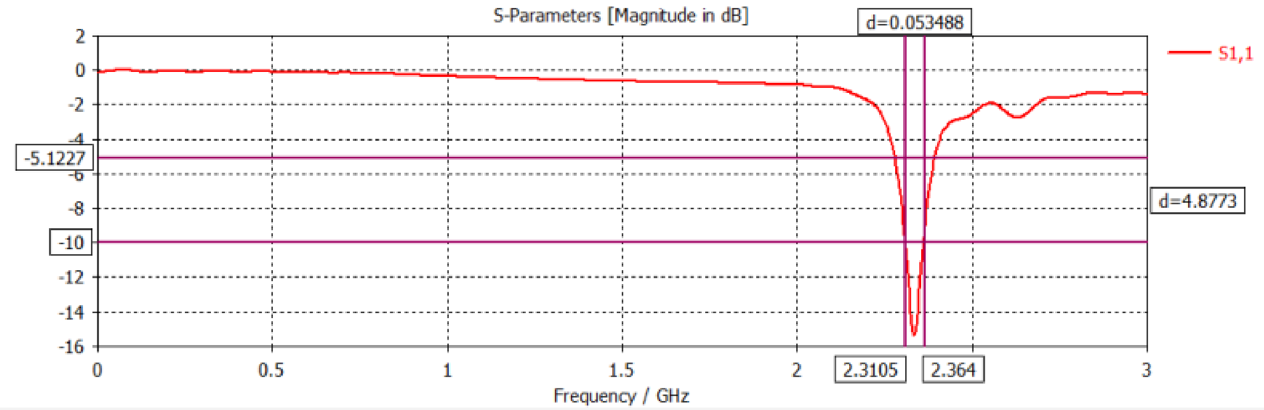

Fig. 3: S-parameter of the antenna without EBG structures

UNIT CELL STRUCTURE OF EBG

A. Mushroom Type EBG

The mushrooms like EBG structure is made of patches, vias connected with patches and ground and the dielectric substrate backed by PEC ground. This type of structure can be modelled as parallel LC equivalent circuit. the equivalent LC circuit acts as two dimensional electric filter to block the flow of surface wave. The inductor L results from the current flowing through vias and capacitor C due to gap effect between the adjacent patch. For mushroom like EBG four parameters are responsible for the performance analysis such as patch width, gap width, substrate thickness and substrate permittivity of EBG. EBG unit cell dimensions are as follows:

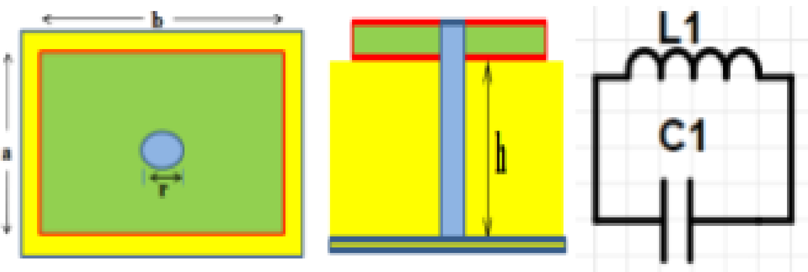

Fig. 4: Geometry of mushroom type EBG (a) Top View (b) Cross sectional View (c) Equivalent Circuit Model

TABLE III
PHYSICAL PARAMETERS OF EBG UNIT CELL

Parameter	Dimension
'a'	14 mm
'b'	14 mm
'r'	0.5 mm
'h'	1.6 mm

B. Dispersion Diagram

Dispersion diagram gives the relation between the wave number and frequency. the dispersion diagram can be obtained using Eigen mode solver. The band gap shown by the dispersion diagram fulfils the requirement of ISM frequency range.EBG model can be explained with the help of lumped model. Lumped model is equivalent circuit to parallel LC Network. At low frequency the circuit behaves as inductive in nature and supports the TM surface wave. At higher frequency it behaves like a capacitor when nature and support TE surface wave. The dispersion diagram gives band gap between the 2 to 3 GHz frequency ranges.

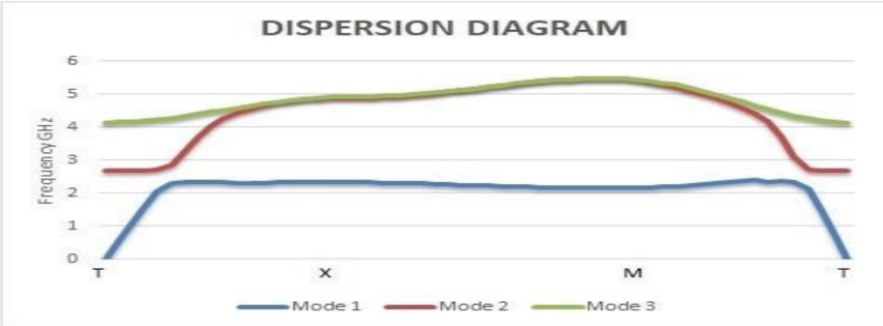

Fig. 5: Dispersion diagram of mushroom type EBG structure

C. Antenna with EBG Cell

EBG structure improves the overall gain, directivity by suppressing the surface wave. The obtained gain and directivity are 3.57 dB and 7.23 dB. In this structure gap width taken is 1 mm and 1 mm distance from the patch. To increase the bandwidth of antenna we increase the thickness of substrate. Gap width effect on the resonance frequency, as the gap width increases the capacitive value decreases and resonance frequency increases. The microstrip patch antenna with mushroom type EBG structures is shown in figure 6, where 6 unit cells of mushroom type EBG is placed at the other end of the patch i.e. opposite side of the inset line feed of the MPA. Further figure 7 and 8 shows the farfeild pattern and return loss (S11 parameter) of proposed antenna with EBG.

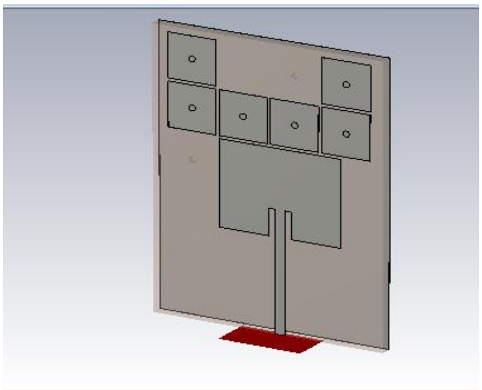

Fig. 6: MPA with EBG structures

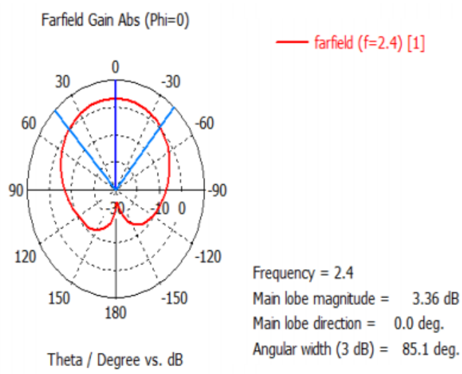

Fig. 7: Farfeild Pattern of MPA with EBG

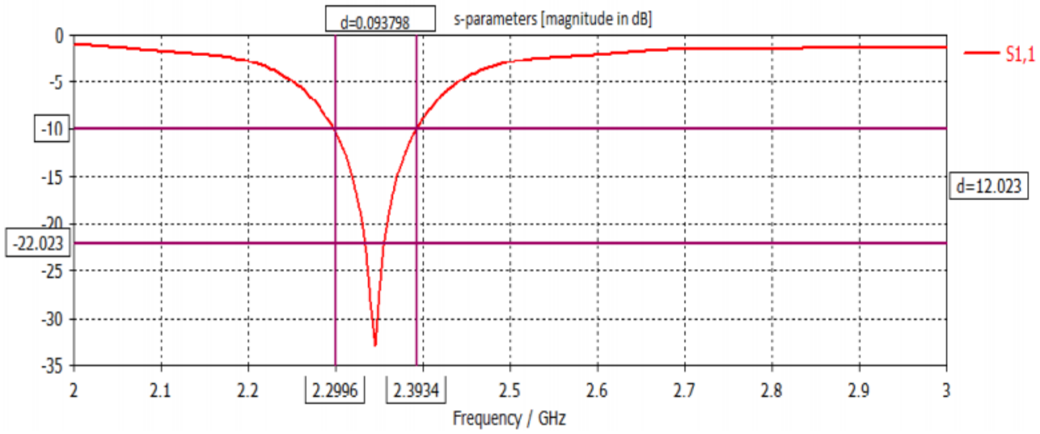

Fig. 8: S-parameter of the proposed antenna with EBG structures

D. Comparison of designed antennas (With and Without EBG)

TABLE IIIII
COMPARISON TABLE

Parameter	**Without EBG**	**With EBG**
Bandwidth	0.053	0.093
Gain	2.17 dB	3.57 dB
Directivity	7.11 dBi	7.23 dBi

CONCLUSIONS

The microstrip patch antenna is most widely used antenna design in the wireless communication system. In this paper, the performance of the antenna has been increased by improving certain essential parameters of the antenna such as radiation pattern, gain and return loss. Some modifications are done here by inserting a mushroom like EBG structure without changing the dimensions of the microstrip patch antenna. This improved performance is achieved due to suppression of surface waves by EBG structures in the patch antenna. The modified design give us gain of 3.57 dB and directivity of 7.23 dB, which are enhanced than that of gain (2.17 dB) and directivity (7.11 dB).

REFERENCES

[1] W. Akaram, D. Rano, M. S. Hashmi, A. Q. Ansari, “Design of a New UC-Planar EBG Cell and its Application in Performance Enhancement of Microstrip Patch Antenna /Antenna Array” *IEEE 28th Asia Pacific Microwave Conference (APMC), New Delhi, India, Dec. 2016.*

[2] Ajay Kumar, Dwejendra Arya, D.K Srivastava, “Band Width of Microstrip Antenna Improved by using Mushroom type EBG Structure” *Proceedings of International Conference on Multimedia, Signal Processing and Communication Technologies (IMPACT), 2013*

[3] Cason Neo and Yee Hui Lee, "Patch Antenna Enhancement using a Mushroom-like EBG Structures" *IEEE International Symposium on Antennas and Propagation, 2013*

[4] Ruchika Gupta, Mithilesh Kumar, "Bandwidth Enhancement of Microstrip Patch Antennas by Implementing Electromagnetic Bandgap (EBG) Structures" *Proceedings of Fourth International Conference on Computational Intelligence and Communication Networks, November 03 - 05, 2012*

[5] M T Ali, H. Jaafar, S. Subahir, and A.L.Yusof, "Gain Enhancement of Air Substrates at 5.8GHz for Microstrip Antenna Array" *Proceedings of 2012 IEEE Asia-Pacific Symposium on Electromagnetic Compatibility, pp: 477-480.*

[6] G. Gnanagurunathan and U.G. Udofia, "Performance analysis of the mushroom-like-EBG structure integrated with a Microstrip patch antenna" *Proceedings of IEEE Asia-Pacific Conference on Applied Electromagnetic (APACE), 2010*

[7] D. N. Elsheakh, H. A. Elsadek, E. A. Abdallah, H. Elhenawy, and M. F. Iskander, "Enhancement of Microstrip Monopole Antenna Bandwidth by Using EBG Structures" *IEEE Antennas and Wireless Propagation Letters 2009*

[8] Preeti Sharma and Shubham Gupta, "Bandwidth and Gain Enhancement in Microstrip Antenna Array for 8GHz Frequency Applications" *Students Conference on Engineering and Systems (SCES), 2014*

[9] Ainor Khaliah, Binti Mohd, "Electromagnetic Band Gap (EBG) For Microstrip Antenna Design" *Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 2007*

[10] M. Fallah-Rad and I,.Shafai, "Enhanced Performance of a Microstrip Patch Antenna using a High Impedance EBG Structure" *IEEE Proc. Microw., Antenna Propag., Vol. 149, No. 3, pp. 141-146, Jun. 2002*.

[11] Balanis C.A., *Antenna Theory Analysis and Design*, John Wiley & Son,2005