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Microstrip Patch Antenna Array with EBG Structure for Improvement of Performance Characteristics

Shital Lahamge[1], Prof. Vaishali Dhede[2]
ME Student[1], Assistant Professor & HOD[2]
Department of Electronics and Telecommunication
JCOE, Kuran, Pune, India

Abstract:
Technology for processing of radio waves on the small platforms is rapidly changing to meet the requirement for robustness and reliability of communication link. It is becoming common for each radio channel to use more than one antenna element in order to enhance gain, bandwidth and directivity. Microstrip patch antenna is of great interest for this purpose due to its advantages like geometry, low cost, design flexibility, planer structure etc. In this paper, a miniaturized 4x1 one eight patch array antenna with and without electromagnetic band gap (EBG) is proposed and investigated. A half/quarter/eighth Patch antenna with microstrip feed is designed as a reference antenna and optimized for its gain behavior. First, the miniaturization is investigated by bisecting 1/6 part to the reference antenna through its symmetry plane. The high gain behavior with further miniaturization is achieved by using serial feed 4x1 patch array with EBG techniques. The antenna has been designed on FR4 substrate 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 90MHz impedance bandwidth from (2.47-2.54GHz). The proposed antenna has a compact size and exhibits high gain behavior, good radiation characteristics, and directivity is around 8.0 dBi.The radiation pattern, return loss, VSWR and gain of the proposed antenna are described and simulated using the HFSS software package.

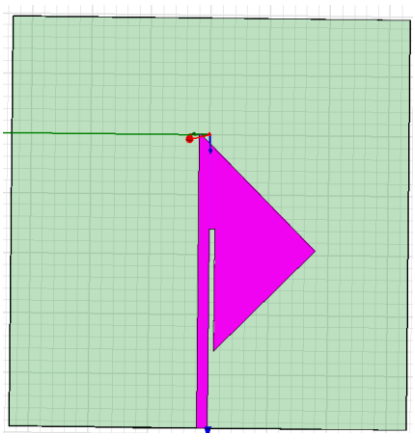
Keywords: Microstrip patch, Antenna array, EBG structure, Return loss, WLAN band and half/quarter/eighth patch.

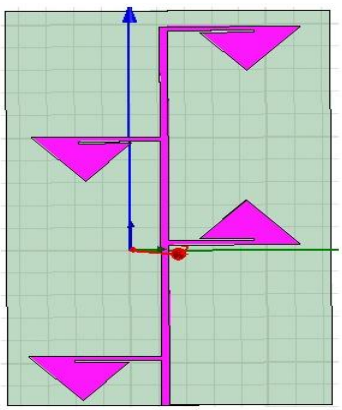
I. INTRODUCTION

The multi-element smart antenna array has attracted attention of researchers as a result of its wide range of applications in the field of wireless communication. Different multi-element antenna prototypes are designed and implemented for the applications in the base stations (BS) to improve the quality of transmission and enhance the cellular capacity, coverage and reliability [1-4]. On the other hand, recent advances within the study of the electromagnetic band gap (EBG) structures have established these structures to be simple solutions towards raising the antenna performance [5]. An EBG structure is a periodic structure that forbids the propagation of all electromagnetic waves among a spesific frequency band called the band gap. The performance improvement occurs due to the stop bands of these periodic structures. These structures provide a simple and effective solution to the problems of surface and leaky waves [6]. Several types of microstrip based EBG structures have been analysed for variety of applications. These structures are studied by utilizing both finite difference time domain and finite element method techniques [7]. 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 to enhance 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 been investigated integrating regular square shaped EBG structure at edge of resonating patch and a significant improvement has been observed in both radiation pattern at the designed frequency.

II. ANTENNA DESIGN

A simple hexagonal microstrip patch antenna is designed to operate at 2.47GHz. The half hexagonal antenna is designed which operates at 2.47GHz. Further to develop a light weight antenna, with the help of FR4 substrate material with the length and width of the patch are 39mm and 28.2mm the 1/6 4X1 patch array with and without EBG is designed. The feed point is 7.5mm from the centre of the patch as shown in Fig1.





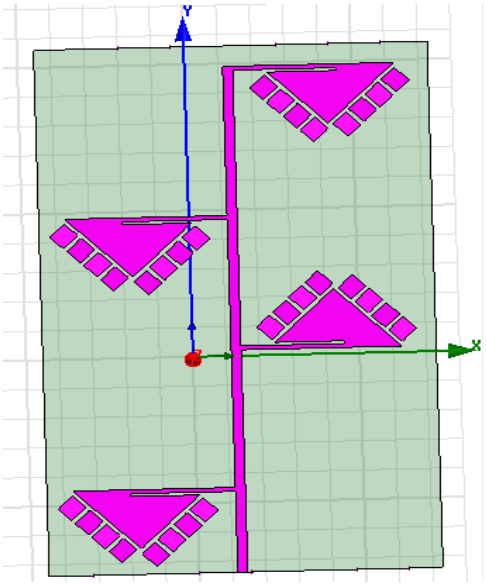


Figure.1. Evolution of simple patch Configuration of (a) 1/6 th patch of hexagonal antenna, (b)4X1 path array without EBG, (c) 4X1 path array with EBG

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. SIMULATION RESULTS FOR SINGLE RADIATING ELEMENT

The 1/6 th patch of hexagonal antenna is simulated using HFSS software. And results of respected antenna is also given below. Figure 2 shows the 1/6 th patch of hexagonal antenna.

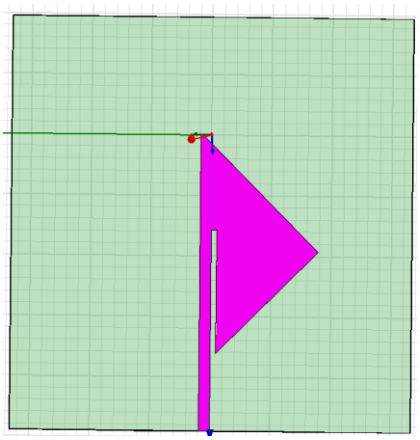


Figure. 2. 1/6 th patch of hexagonal antenna

As shown in figure: 3 the value of Return loss of 1/6 th patch of hexagonal antenna is -14.04.

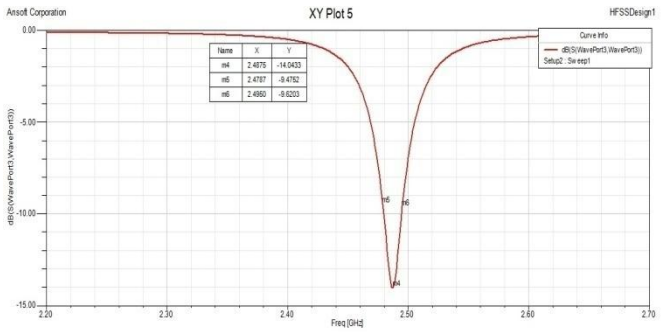


Figure.3. Return loss of 1/6 th patch of hexagonal antenna

Figure: 4 Shows the VSWR Plot of 1/6 th patch of hexagonal antenna is 1.49.

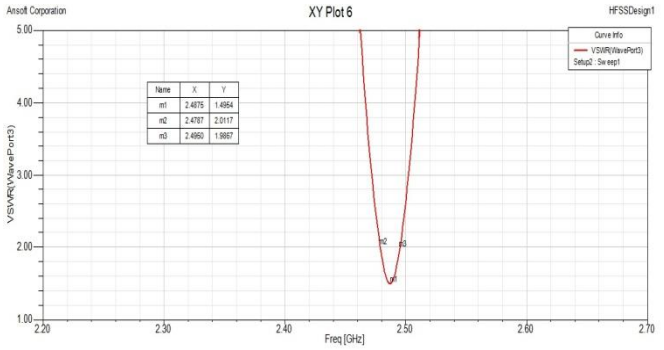


Figure.4. VSWR Plot of 1/6 th patch of hexagonal antenna

Figure: 5 shows the Directivity of 1/6 th patch of hexagonal antenna, Which is 4.7.

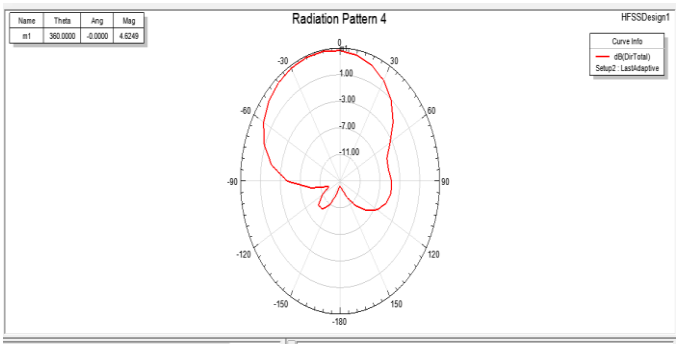


Figure.5. Directivity of 1/6 th patch of hexagonal antenna

IV. SIMULATION RESULTS FOR 1/6 4x1 MICROSTRIP PATCH ANTENNA ARRAY WITHOUT EBG

The microstrip patch antenna array is simulated by arranging these two microstrip line feed patch antennas in linear configuration. Each patch element is excited individually using separate port and the integrated response i.e. overall radiation pattern of the 2 element linear array antenna is simulated using HFSS software.

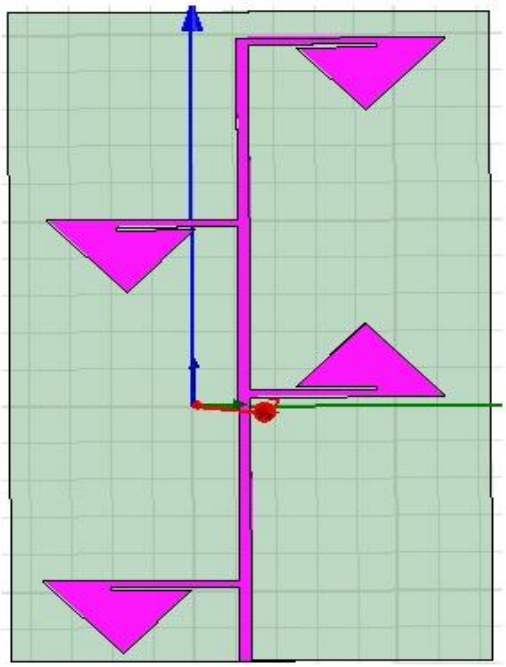


Figure.6. 1/6 4X1 patch array without EBG

As shown in figure: 7 the value of Return loss of 1/6 4X1 patch array without EBG antenna is -18.34.

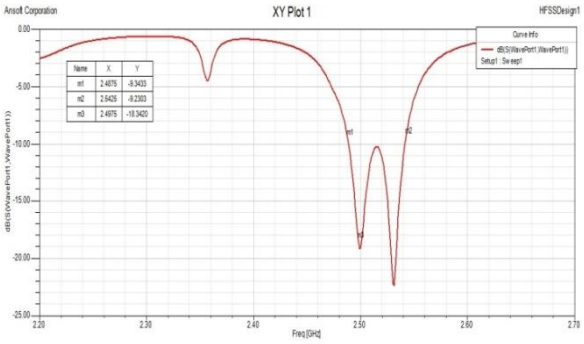


Figure.7. Return loss of 1/6 4X1 patch array without EBG

Figure: 8 Shows the VSWR Plot of 1/6 4X1 patch array without EBG antenna is 1.27.

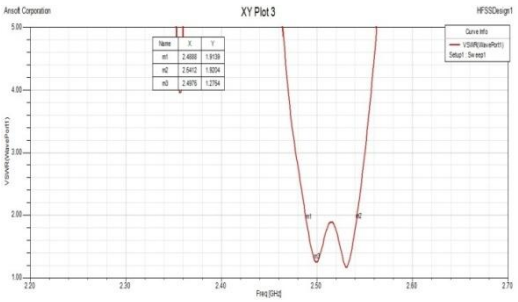


Figure.8. VSWR of 1/6 4X1 patch array without EBG

Figure: 9 show the Directivity of. 1/6 4X1 patch array without EBG antenna, which is 6.4.

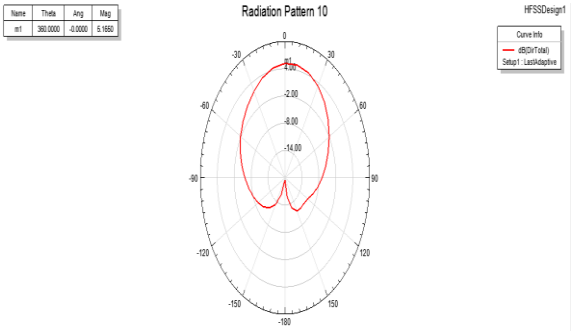


Figure.9. Radiation pattern of 1/6 4X1 patch array without EBG

V. SIMULATION RESULTS FOR 1/6 4x1 MICROSTRIP PATCH ANTENNA ARRAY WITH EBG

The 1/6 4x1 microstrip patch antenna array with EBG is simulated by using HFSS software. The simulated results for this antenna are obtained as follows. With comparison to the 1/6 4X1 patch array without EBG 1/6 4x1 microstrip patch antenna array with EBG has very good results.

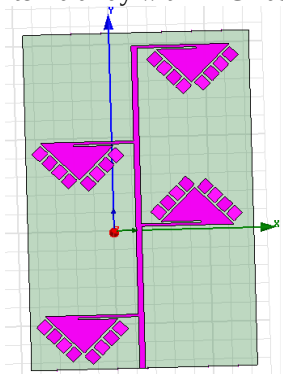


Figure.10. 1/6 4X1 patch array antenna array with EBG

As shown in figure: 11 the value of Return loss of 1/6 4X1 patch array antenna array with EBG is -37.68.

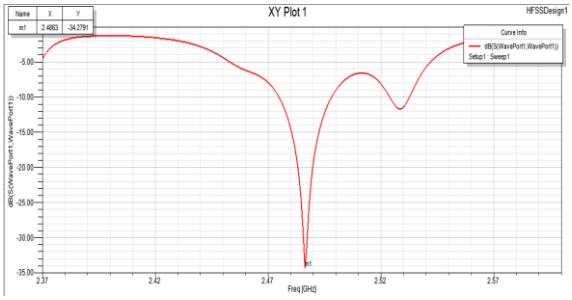


Figure.11. Return loss of 4 x 1 Microstrip Patch Antenna array with EBG

Figure: 12 Shows the VSWR Plot of 1/6 4X1 patch array antenna array with EBG is 1.02.

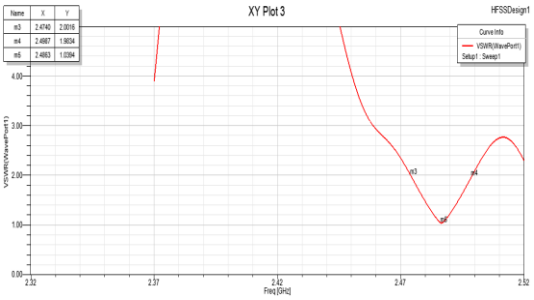


Figure.12.VSWR of 4 x 1 Microstrip Patch Antenna array with EBG

Figure: 13 show the Directivity of 1/6 4X1 patch array antenna array with EBG, Which is 8.0.

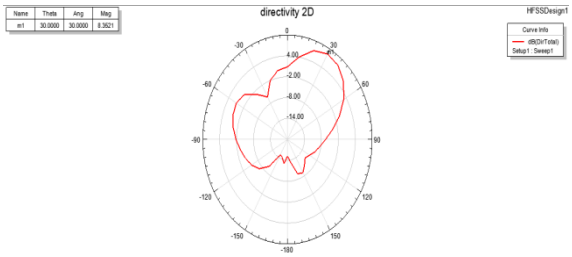


Figure.13. Radiation pattern of 4 x 1 Microstrip Patch Antenna array with EBG

VI. COMPARISON TABLE

Table .1. Comparison of characteristics obtained for single element, 2 x 1 and 4x1 array.

Sr. no.	Type of MSA	Freq (GHz)	Return loss (dB)	VSWR	BW (MHz)	Directivity (dB)
1.	Single patch without EBG	2.48	-14.04	1.49	18	4.7
2.	2x1 patch without EBG	2.48	-16.88	1.33	30	5.4
3.	4x1 Patch array without EBG	2.48	-18.34	1.27	60	6.4
4.	4x1 Patch array with EBG	2.46	-37.68	1.02	110	8.0

Figure: 3, 4, 5 shows simulated results of 1/6 th patch of hexagonal antenna. The corresponding response of 1/6 4X1 patch array without EBG are shown in figure: 7, 8, 9. The results obtained for 4 x 1 Microstrip Patch Antenna array with EBG are shown in figure: 11, 12, 13. The comparison of the parameters obtained for 1/6 th patch of hexagonal antenna, 1/6 4X1 patch array without EBG and 4 x 1 Microstrip Patch Antenna array with EBG are shown in table 1. The results for 4 x 1 Microstrip Patch Antenna array with EBG are obtained from simulations are return loss is -37.68, VSWR is 1.02 and directivity is 8.0.

VII. CONCLUSION

The proposed 4 x 1 Microstrip Patch Antenna array with EBG is electrically small, suitable to handle easily and it is applicable to WLAN band at 2.47GHZ. From the simulated results, it is observed that the half/quarter/sixth 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 8.0dBi has been achieved. It is clearly observed that the impedance bandwidth and radiation efficiency are improved significantly by employing proposed 4 x 1 Microstrip Patch Antenna array with EBG structure. The gain improved significantly by introducing EBG structure. The proposed array antenna would be suitable as base station antenna of the WLANs.

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