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Pentagon Shaped Patch Antenna with EBG Structure for WLAN Applications

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ABSTRACT: For the past four decades, microstrip antennas have a great deal of attention due to their low cost, ease of fabrication, and low profile. In this work, a pentagonal patch antenna operating at WLAN frequency (5.8GHz) is designed and analysed. FR4 is chosen as substrate as it is easily available and it's low cost. There are several limitations in patch antennas such as constrict bandwidth, low gain and excitations of surface waves. To overcome such limitations the EBG concept is applied. The aim of this paper is to design, simulate the pentagon shaped patch antenna operating at WLAN frequency, to incorporate the circular ring shaped EBG structure along with it and to study the performance of the pentagonal microstrip patch antenna in terms of the gain, directivity, return loss, VSWR and bandwidth with and without EBG structure. Compactness of antenna is achieved by choosing higher WLAN frequency of 5.8 GHz. Size of the antenna is 30×30×1.6 mm^3 makes it more suitable for wireless communication systems. By incorporating the EBG structure in the proposed antenna, its gain is increased by 79%. High Frequency Structure Simulator (HFSS) software is used to simulate the proposed antenna design.

KEYWORDS: Pentagon, Patch Antenna, FR4, EBG, WLAN.

I.INTRODUCTION

The recent development of wireless communication system has created a need for compact, high gain microstrip patch antenna.MSA are very common antenna due to their low profile, low cost, light weight and many more. In this paper, a pentagon shaped microstrip antenna is designed with one probe feed and it is designed to operate at WLAN frequency (5.8 GHz).Rectangular patch antenna requires multiple feeds to get circular polarizations whereas the pentagonal patch antenna provides circular polarization with only one feed [9]. Hence the proposed antenna geometry operating at 5.8 GHz is chosen to be a pentagonal patch antenna and fed with a 50 ohm coaxial cable for better impedance matching [6]. Though there are numerous advantages in MSA, there are some limitations such as low gain and narrow bandwidth. Numerous techniques have been advised to apply on patch antennas to improve its gain and bandwidth. One of those techniques is Electromagnetic Bandgap Structure (EBG).EBG structures are periodic structures that are composed of dielectric, metal or metallo-dielectric materials. These structures can prevent or assist wave propagation in special directions and frequencies therefore they can be used as spatial and frequency filters. A wide variety Electromagnetic Band Gap structures design alternatives are produced for researchers working in the area of microwave and photonics. The characteristics of EBG depend on the shape, size, symmetry and the material used in their construction. Surface waves are reduced by using EBG substrate which leads to increase the directivity, bandwidth and radiation efficiency. EBG were realized to reduce and eliminate surface waves, which leads to an increase in directivity, bandwidth and radiation efficiency [2]. It is also useful to reduce the side lobes of the radiation pattern and hence radiation pattern front-to back ratio and overall antenna efficiency are improved [5]. The proposed antenna with EBG structure gives better performance compare to the pentagon antenna without EBG structure. A substantial gain and bandwidth enhancement has been obtained after incorporating circular ring shaped EBG structure [8].

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II.ANTENNA DESIGN AND ANALYSIS

A pentagonal microstrip patch antenna offers better performance when compared to rectangular patch antenna. It supports both linear and circular polarizations. Rectangular patch antenna requires multiple feeds to get circular polarizations whereas the pentagonal patch antenna provides circular polarization with only one feed. Hence the proposed antenna geometry operating at 5.8 GHz is chosen to be a pentagonal patch antenna and fed with a 50 ohm coaxial cable for better impedance matching. Fig 1. Shows the geometry of regular pentagonal shape. The relationship between the circles (r1) to the side arm of the regular pentagon (r2) is given in formula (2.1)

$$\boldsymbol{r_2^2} = \frac{\boldsymbol{\pi r_1^2}}{\boldsymbol{2.37}} \qquad (2.1)$$

side arm of the pentagon is calculated using formula (2.2)

$$\boldsymbol{r_2 = 1.175\, r_1} \qquad (2.2)$$

In the derivation of the formula (2.1), the pentagonal patch is assumed to be a resonant cavity with perfectly conducting side walls.

The resonant frequency of the dominant as well as for the higher order modes can be calculated from the formula given below

$$\boldsymbol{f_{np}} = \frac{\boldsymbol{X'_{np} C}}{\boldsymbol{2\pi r_1 \sqrt{\varepsilon_r}}} \qquad (2.3)$$

where X'_{np} are the zeros of the derivative of the Bessel function $J_n(x)$ of the order n, as is true for TE mode circular waveguides, however for the lowest order modes

$$\boldsymbol{X'_{np} = 1.84118} \qquad (2.4)$$

Using formulae 2.1 and 2.2, the proposed pentagon shaped patch is designed and the designed parameters are given in Table 1.

Geometry	Pentagonal
Side arm length	8.9mm
Substrate(FR4)	ε_r = 4.4, h= 1.6mm tanδ = 0.002
Centre frequency	5.8GHz
Feed location	Xf=1mm Yf=0.7mm
Coaxial cable dimension	Inner radius: 0.5mm Outer radius: 0.7mm

Table 1 Design specification

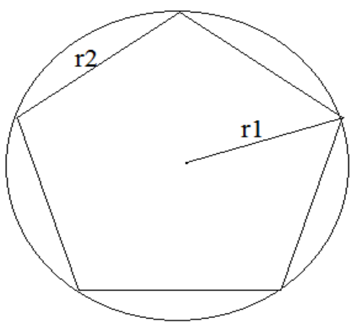

Fig 1. Geometry of regular pentagonal shape

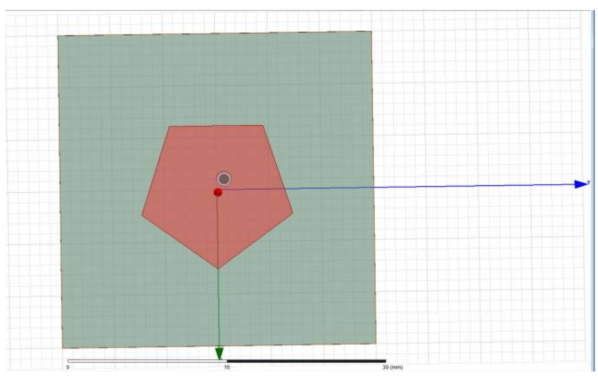

Fig 2. Geometry of proposed antenna at 5.8 GHz

Based on the calculated parameters shown in table 1, the pentagon shaped patch antenna is designed and simulated. The front view of proposed antenna is shown in Fig 2. To overcome the limitations of patch antenna such as

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low profile and low gain, EBG concept is applied. Circular ring EBG unit cell is designed for 5.8 GHz and the unit cell is shown fig 3. Designed EBG unit cell specifications are given below:

- Inner radius of the EBG unit cell 5.8 mm
- Outer radius of the EBG unit cell 6 mm

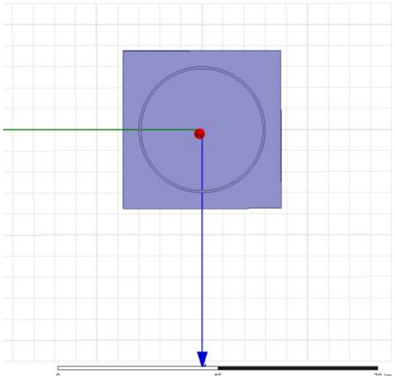

Fig 3. EBG unit cell for 5.8 GHz.

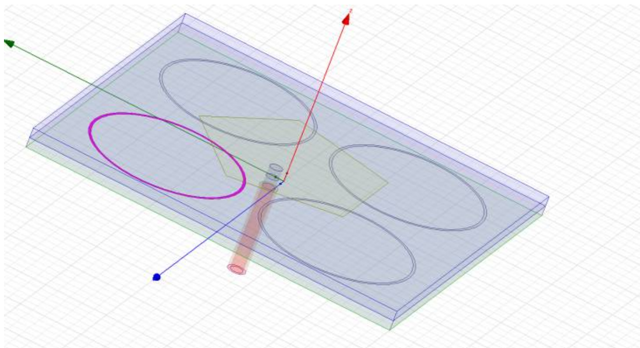

Fig 4. Side view of the proposed antenna with EBG structure and Coaxial feed

Based on the size of the antenna, the unit cell is incorporated. In the proposed antenna 2×2 array of circular ring EBG unit cell is incorporated and its side view is shown in fig 4.

III. RESULTS AND DISCUSSION

The proposed pentagon shaped antenna is designed and simulated using HFSS software. The parameters like return loss, VSWR, gain and directivity are measured using that software. Return Loss is a parameter which indicates the amount of power is reflected back to the antenna.

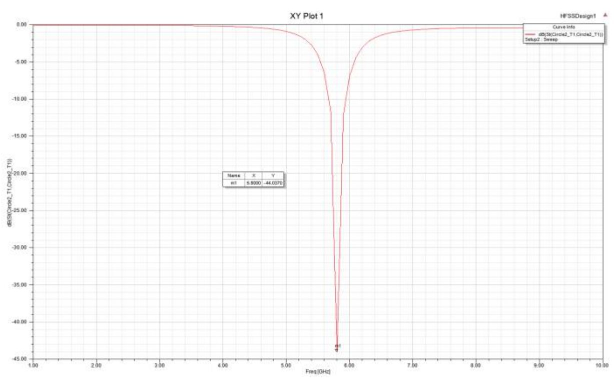

Fig 5. Return loss of the proposed antenna without EBG structure

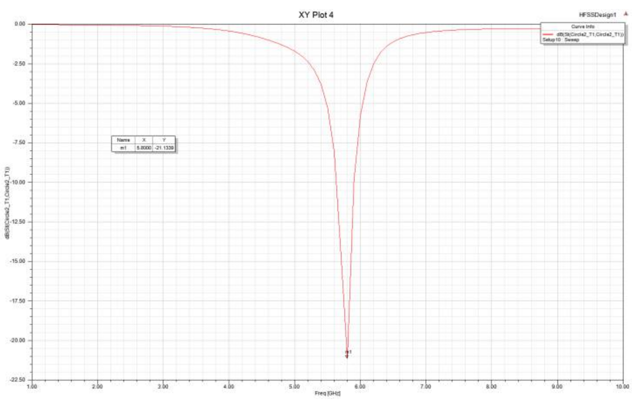

Fig 6. Return loss of the proposed antenna with EBG structure

Fig 5. shows the return loss of the proposed antenna without EBG structure and is observed that it has good impedance matching by having -44 dB. Fig 6. shows the return loss of the proposed antenna with EBG structure and is observed that it has good impedance matching by having -21.13 dB. The bandwidth of an antenna refers to the range of frequencies over which the antenna can operate correctly. The antenna's bandwidth is the number of Hz for which the

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antenna will exhibit an SWR less than 2:1. Here obtained bandwidth of proposed antenna without EBG structure and with EBG structure is 286.3 MHz and 269.4 MHz respectively

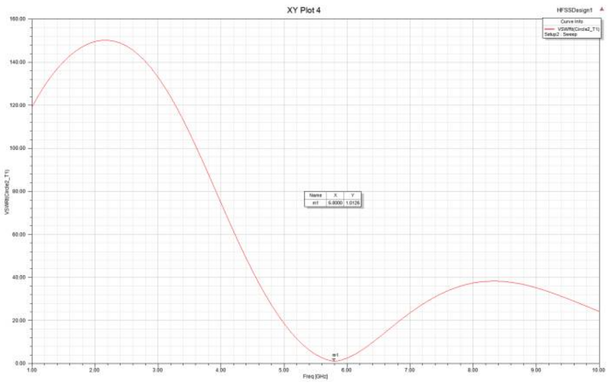

Fig 7. VSWR of the proposed antenna without EBG structure

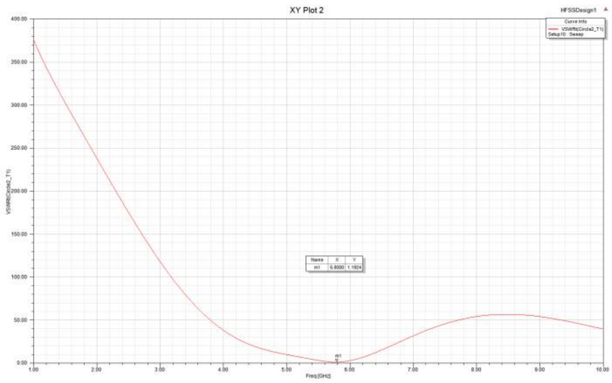

Fig 8. VSWR of the proposed antenna with EBG structure

Standing-wave ratio (SWR) is a mathematical expression of the non-uniformity of an electromagnetic field (EM field) on a transmission line such as coaxial cable. Usually, SWR is defined as the ratio of the maximum radio-frequency (RF) voltage to the minimum RF voltage along the line. For better impedance matching, VSWR value must be between 1 to 2. Fig 7.shows the VSWR of the proposed antenna without EBG structure and it is 1.01 whereas Fig 8.shows the VSWR of the proposed antenna with EBG structure and it is 1.1924. Gain is a measure of the ability of the antenna to direct the input power into radiation in a particular direction and is measured at the peak radiation intensity.

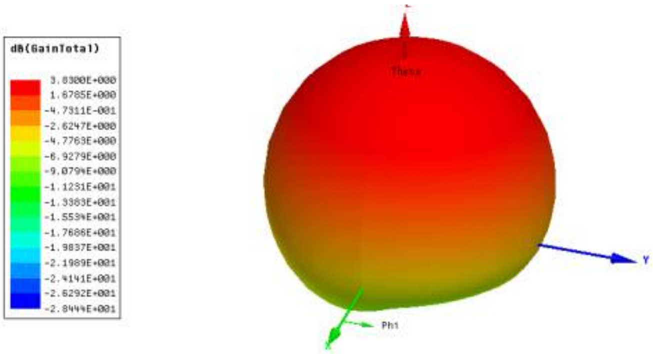

Fig 9. Gain of the proposed antenna without EBG structure

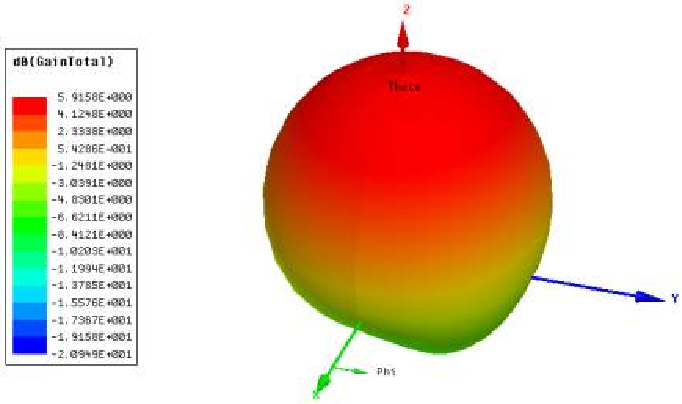

Fig 10. Gain of the proposed antenna with EBG structure

Fig 9. Shows the gain of the proposed antenna without EBG structure is 3.8 dB whereas Fig 10. Shows the gain of the proposed antenna with EBG structure. It is observed that after incorporating the EBG structure with the designed antenna, Gain is increased to 5.91 dB. Directivity is a measure of the concentration of radiation in the direction of the maximum.

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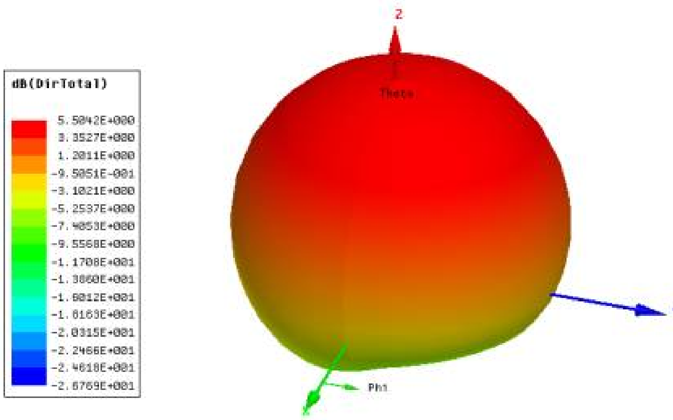

Fig 11. Directivity of the proposed antenna without EBG structure

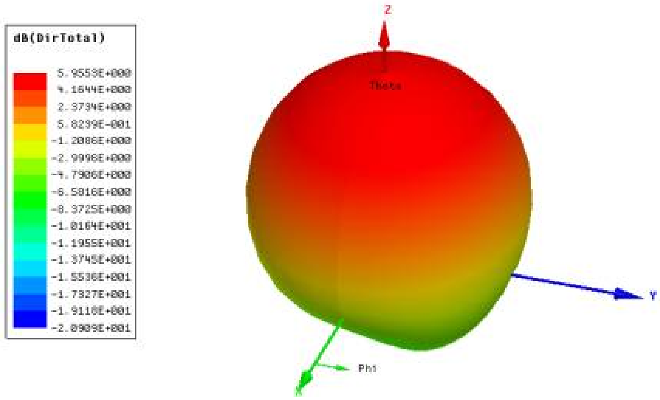

Fig 12. Directivity of the proposed antenna with EBG structure

Fig 11. Shows the directivity of the proposed antenna without EBG structure is 5.5 dB whereas Fig 12. Shows directivity of the antenna with EBG structure. It is observed that after incorporating the EBG structure with the designed antenna, directivity is increased to 5.95 dB.

PARAMETERS OBTAINED	**FR4 SUBSTRATE WITHOUT EBG**	**FR4 SUBSTRATE WITH EBG**
RETURN LOSS	-44.03dB	-21.13dB
VSWR	1.0126	1.1924
BANDWIDTH	286.3 MHz	269.4MHz
GAIN	3.8dB	5.91dB
DIRECTIVITY	5.5dB	5.95dB

Table 2. Comparison of the results

Different parameters of proposed pentagon antenna operating at 5.8 GHz with EBG structure and without EBG structure is summarized in Table 2., From this it is observe that gain and directivity of the proposed antenna is increased steeply when EBG structure is incorporated with it and there is decrease in return loss, VSWR and bandwidth.

IV.CONCLUSION

The pentagon shaped patch antenna is designed to operate at 5.8 GHz. The corresponding return loss for the proposed antenna is -44 dB and VSWR is 1.01 while the resulted gain is 3.8 dB and the directivity is 5.5 dB. Circular ring shaped EBG structure has been successfully designed for the same frequency and incorporated with the proposed antenna. After incorporating, the gain and directivity has been significantly increased to 5.91 dB and 5.95 dB respectively. The proposed antenna is aggressive miniaturised (30×30×1.6 mm^3) to meet requirements of the wireless communication systems. It was concluded that the simulated and tested results we obtained matched the theoretically predicted results. Comparing performance of the proposed antenna with different feeding techniques, different substrates and different EBG structures will be taken for future work.

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REFERENCES

[1] Ali Karami Horestani,et al., "Reconfigurable and Tunable S-Shaped Split-Ring Resonators and Application in Band-Notched UWB Antennas" ,IEEE Antennas and Wireless Propagation Letters, vol. 64, pp. 3776-3776, 2016.
[2] Lalithendra Kurra, et al., "FSS Properties of a Uniplanar EBG and Its Application in Directivity Enhancement of a Microstrip Antenna", IEEE Antennas and Wireless Propagation Letters, vol. 15, pp 1606-1609, 2016.
[3] X. Gao, et al., "Multiband Open-Ended Resonant Antenna Based On One ECRLH Unit Cell Structure", IEEE Antennas and Wireless Propagation Letters, vol. 16, pp.1273-1276, 2016.
[4] Yinting Liu,"Multiband Antenna for Satellite Navigation System", IEEE Antennas and Wireless Propagation Letters, vol. 15, pp. 1329-1332, 2015.
[5] Balaji B.Wattamwar, et al., "Effects of an EBG structure on microstrip patch antenna for LTE mobile communication systems", IJIRCCE., vol. 4, pp. 2181-2188, 2016.
[6] Anushi arora et al.,"Comparative study of different feeding techniques for rectangular microstrip patch antenna", IJIREEICE, vol.3, pp. 32-35, 2015.
[7] Jawad Y. Siddiqui, et al., "A Novel Ultrawideband (UWB) Printed Antenna With a Dual Complementary Characteristic", IEEE Antennas and Wireless Propagation Letters, vol. 14, pp. 974-977, 2015.
[8] Zheng Guo,et al., "Bandwidth Enhancement of Monopole UWB Antenna With New Slots and EBG Structures", IEEE Antennas and Wireless Propagation Letters, vol. 12, pp 1550-1553, 2013.
[9] Ravindra Kumar yadav, et al., ''Dielectric loading on multiband behaviours of pentagonal fractal patch antennas,'' Open journals of antennas and Propagation,vol.1, pp. 49-56, 2013.
[10] Ramesh et al., "Design of a rectangular microstrip antenna using ebg structure" ,IJERT, vol.2, pp.2233-2236, 2013
[11] R. Natarajan, et al., “A compact frequency selective surface with stable response for WLAN applications,” IEEE Antennas Wireless Propagation Letters, vol. 12, pp. 718–720, 2013.
[12] Wenquan Cao, et al.,"Multi-Frequency and Dual-Mode Patch Antenna Based on Electromagnetic Band-gap (EBG) Structure", IEEE Antennas and Wireless Propagation Letters, vol. 60, pp. 6007-6012, 2012.
[13] Peter kovacs et al., "Electromagnetic bandgap structures:practical tips and advice for antenna engineers" , Radio engineering,vol.21.pp. 414-421, 2012.
[14] M.E. Bialkowski, A. R. Razali, and A. Boldaji, “Design of an ultrawideband monopole antenna for portable radio transceiver,” IEEE Antennas Wireless Propagation Letters, vol. 9, pp. 554–557, 2010.
[15] J.P. Gianvittorio and Y. R. Samii, “Fractal antennas: A novel antenna miniaturization technique, and application,” IEEE Antennas Propagation Magazine, vol. 44, pp. 20–35, 2002.