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Design and Analysis of Swasthik Antenna Array for Wireless Applications

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ABSTRACT:
In this paper a Rectangular Microstrip patch antenna is designed for multiband operations using low-cost substrate material FR_4. The proposed antenna is simulated using ANSYS HFSS (High frequency structure simulator). The proposed antenna consists of Swasthik shaped EBG cells on the on the ground plane of rectangular MPA.The antenna operates at frequency range 11 to 18GHz with two notch bands and enhanced gain of 7.21db. The swasthik EBG cells modified to get improvement in results than the rectangular MPA.This antenna finds applications in WLAN,Ku Band,K Band, and other wireless communication applications.

KEYWORDS: Rectangular Microstrip patch antenna, HFSS (High frequency structure simulator), EBG (Electromagnetic Band Gap), WLAN

I. INRODUCTION:

Antenna is very important component of communication system. An antenna is transducer which converts the electric signal into electromagnetic wave and vice versa. A Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side. So, the design of the patch and substrate directly affects the antenna results. Recently, several techniques have been proposed for overcoming the problem of surface waves. One of the effective methods which suits for the millimeter structures is to use photonic band gap structures.

Using photonic band gap structures has become attractive for engineers and researchers working on antennas, electromagnetic and microwaves. These substrates contain so called Photonic Crystals. Also known as electromagnetic bandgap (EBG) structures and electromagnetic band-gap materials (EBMs) are a class of periodic metallic, dielectric, or composite structures that exhibit a forbidden band, or band gap, of frequencies in which wave's incident at various directions destructively interfere and thus are unable to propagate. On the other hand, the EBG structures also reflect a part of the energy that circulate along the substrate of the antenna, thus acting as reflecting walls across the antenna and thereby the cavity effect. With elite rows of EBG structures, minus energy is reflected, and the parasitic effect becomes prevailing.

This contributes to the significant enhancement in the bandwidths. The 2-D EBG surfaces, have the advantages of low profile, light weight, and low fabrication cost, and are widely considered in antenna engineering. Two popular kind of 2-D EBG are mushroom-like EBG surface and uniplanar EBG surface. An important feature in the uniplanar EBG design is the removal of vertical vias. Thus, it simplifies the fabrication process and is compatible with microwave and millimeter wave circuits. There are several configurations of EBG structures according to their application in antenna. In this paper, an Electromagnetic Band Gap periodic structure is used which swasthik is shape in the ground plane of the microstrip patch antenna. From the experimental results characteristics such as the bandwidth, gain of the antenna are improved by adding the Electromagnetic Band Gap structure on the ground plane.

ANTENNA GEOMETRY

The geometry and the design steps of Microstrip patch antenna are described below a substrate is created with dimensions of 40 mm X

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40 mm. The substrate material is FR4_epoxy having dielectric constant of 4.4 with thickness of 1.6mm. Now, a patch element is designed on surface of substrate as shown in fig.1.1. The material used for patch element is copper. The patch antenna is of dimensions 15.24 mm X 11.33 mm. A ground plane is drawn at bottom of substrate with dimensions 40 mm X 40mm.Microstrip line feed is given to the patch with dimensions as shown in the table 1.1

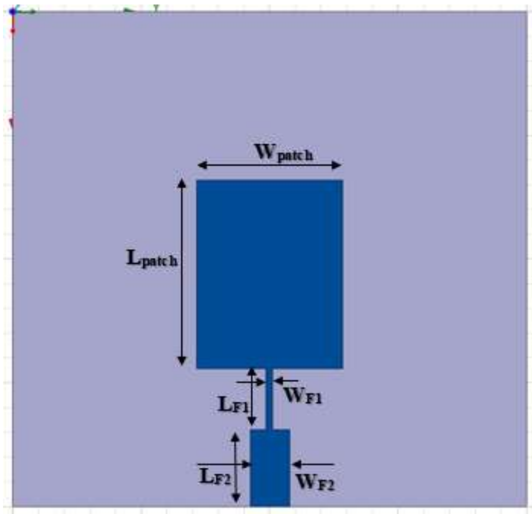

Fig.1.1: Top View of Rectangular MPA Design 1

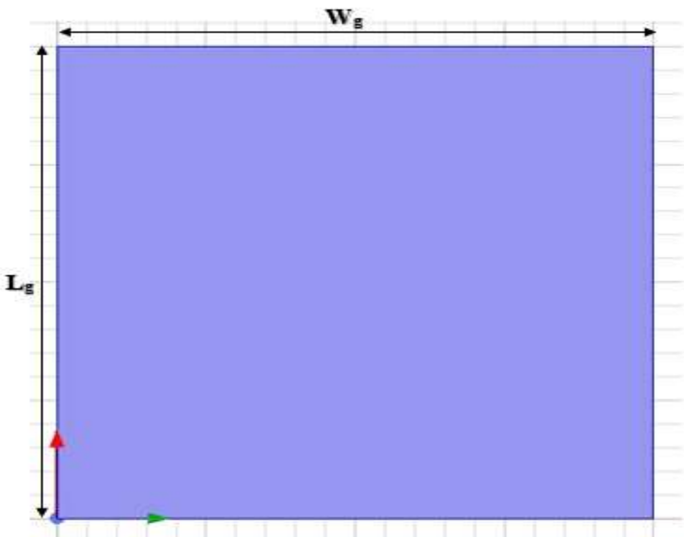

Fig.1.2: Bottom View of Rectangular MPA Design 1

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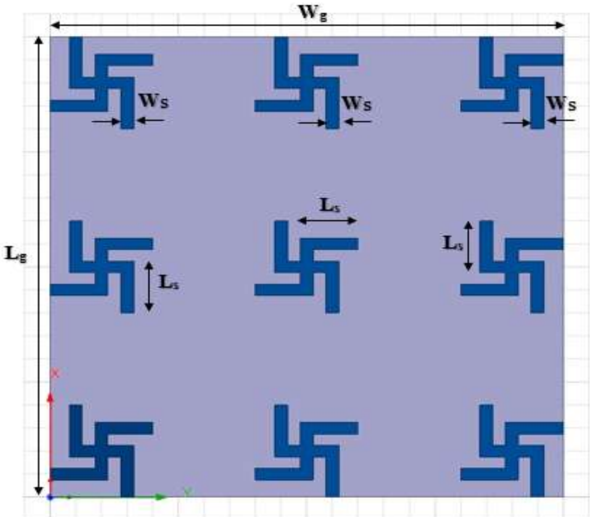
Table 1.1 Dimensions of rectangular MPA

Antenna Part	Parameters	Size in mm
Patch	Length(L_{patch})	11.33
	Width(W_{patch})	15.24
Microstrip Feed	Length(L_{F2})	6.18
	Width(W_{F2})	3.06
Quarter wave Transformer	Length(L_{F1})	4.92
	Width(W_{F1})	0.5
Ground Plane	Length(L_g)	40
	Width(W_g)	40
Thickness of Substrate	Height(H)	1.6

Further swasthik EBG structure is designed on the ground plane of the MPA by keeping all the parameters of the radiating patch, constant, the antenna is feed by strip line feed as in MPA. The ground plane is replaced by the swasthik EBG. The geometry of the MPA-swasthik EBG is same as the pervious design ,on ground plane the swasthik EBG cells are designed with dimensions 8 mmx 8mm. The dimensions of this EBG cell are shown in table 1.2, and the gap between the swasthik EBG cells is also 8mm.

Table 1.2: Dimensions of Each Enlarged EBG Cell

Antenna Part	Parameters	Size in mm
Swasthik EBG	**Length(L_C)**	**8**
	Width(W_C)	**8**
	Length of the Slot(L_{S1})	**4.5**
	Width of the Slot(W_S)	**1**
	Length of other Slot(L_{S2})	**5**



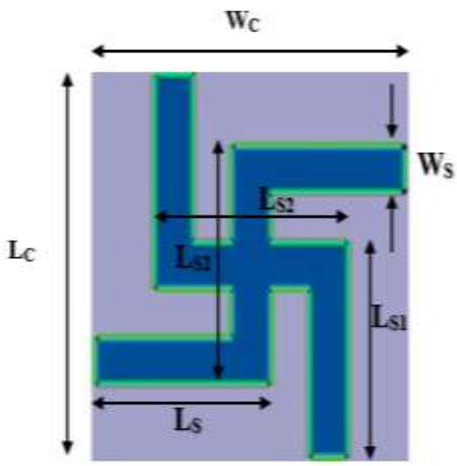


Fig.1.3: Bottom View of Swasthik EBG 1Fig.1.4 The Single Enlarged Geometry of Swasthik EBG

Another model is designed by connecting center of the swasthik EBG cell four arms to adjacent swasthikEBG cell arms,

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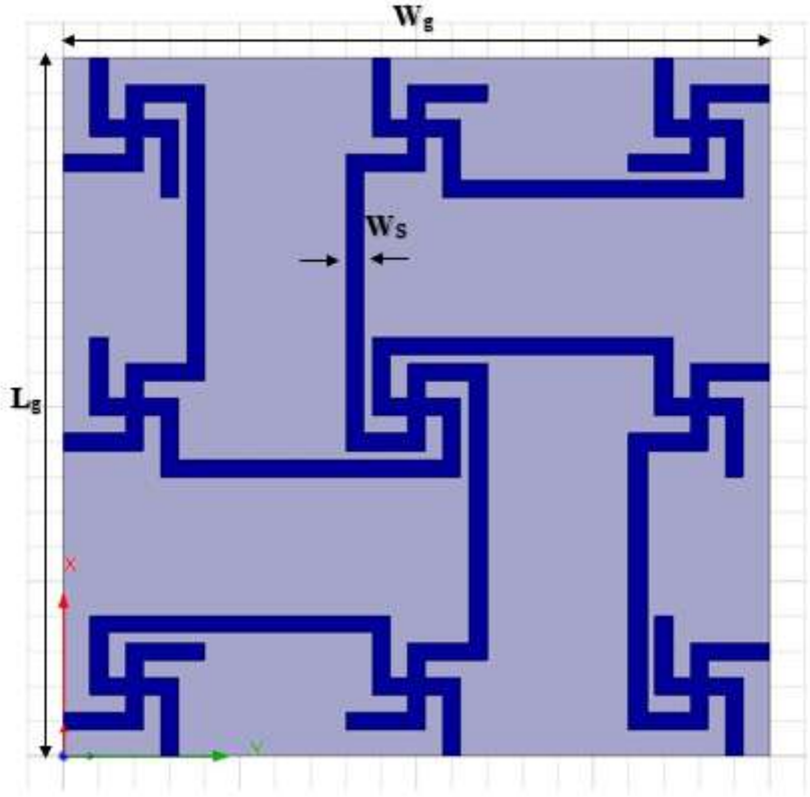

Fig.1.5: Bottom View of Swasthik EBG 2

NUMERICAL RESULTS AND DISCUSSIONS

In this section, the antenna structure based on microstrip patch is simulated in HFSS and the performance of the proposed antenna in terms of reflection coefficients, bandwidth, gain and the radiation patterns are evaluated. The design methodology is adopted to maximize the antenna gain then the basic rectangular Microstrip patch antenna. As far as the simulations are concerned, chosen criteria included the patch structure, materiel type, ground plane is structured through several iterative simulation steps to achieve the optimal performance of the proposed antennas.

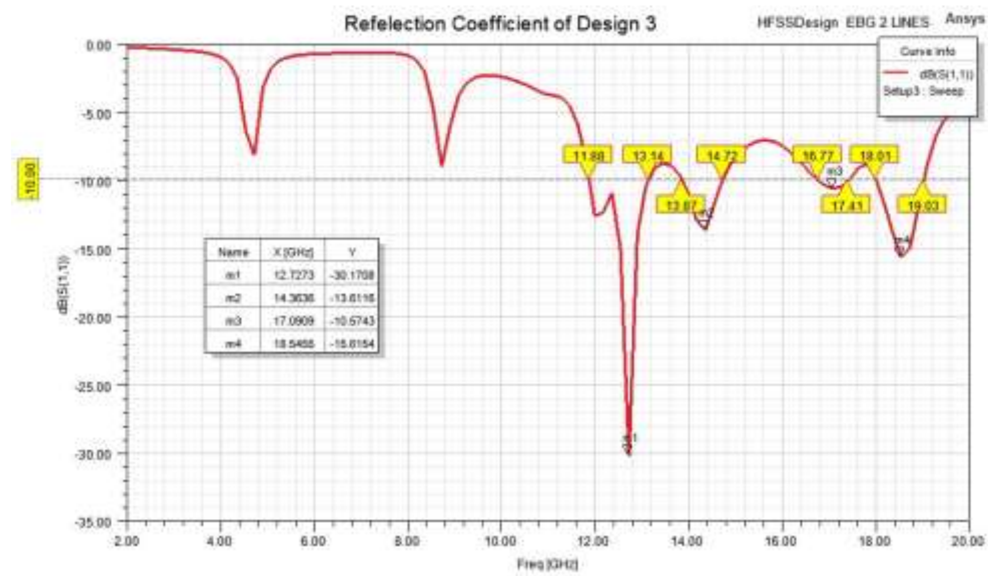

Fig.1.6: Reflection coefficient of proposed antenna

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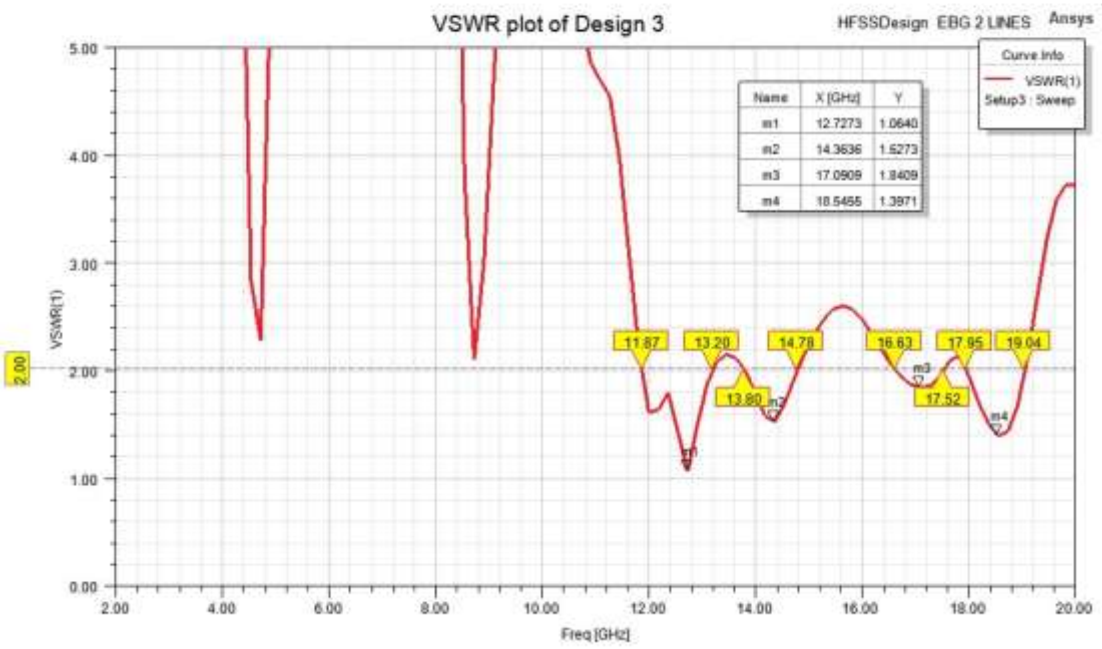

Fig.1.7: VSWR of proposed antenna

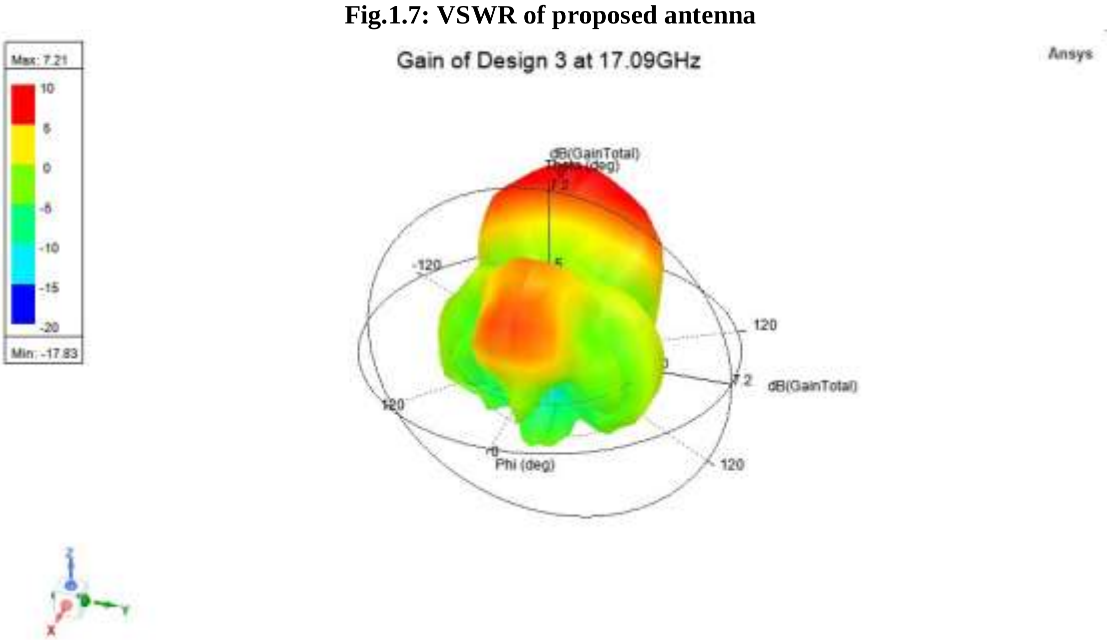

Fig.1.8: Gain of the proposed antenna

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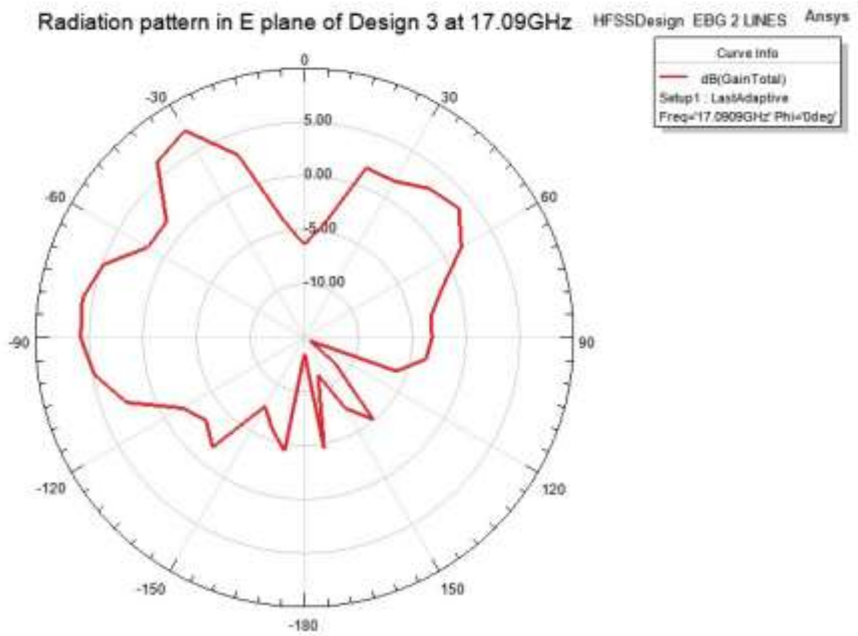

Fig.1.9: Radiation pattern in E plane of proposed antenna

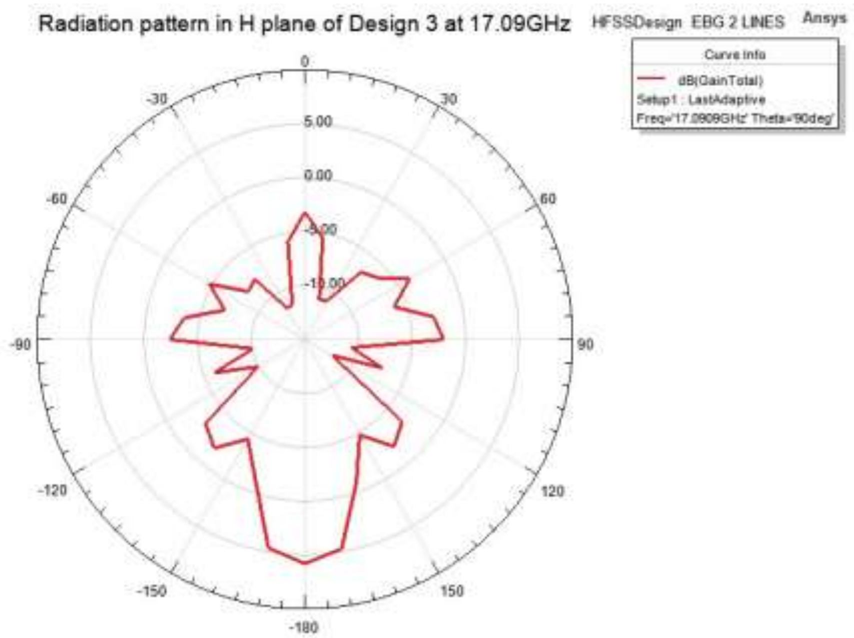

Fig.1.9: Radiation pattern in H plane of proposed antenna

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	Design-1			Design-2			Design-3		
Freq (GHz)	12.5188	13.8231	18.3375	12.710	14.375	18.740	12.7273	14.3636	17.0909
Bandwidth (GHz)	12.25-12.88 [630MHz]	13.50-14.12 [620MHz]	17.66-18.76 [1.1GHz]	11.88-13.13 [1.25GHz]	13.95-14.76 [810MHz]	17.90-19.17 [1.27GHz]	11.88-13.14 [1.26GHz]	13.87-14.72 [850MHz]	16.77-17.41 [640MHz]
S(1,1)	-39.517	-17.659	-14.811	-31.20	-13.08	-18.50	-30.17	-13.611	-10.57
VSWR	1.0214	1.3013	1.4442	1.0566	1.5700	1.2697	1.064	1.5273	1.8409
Gain	4.59	4.75	5.06	6.50	6.44	6.23	6.63	6.45	7.21

II. CONCLUSION

The Results from all the three designs are compared and observed. By comparing the results, the gain has been improved from one design to other design. The maximum gain obtained by the antenna is from the third design which is the improvement of the second design on the ground with a gain of 7.2db at a frequency 17.09GHz.The Frequency bands are having multiple notches these notches can be used for separating bands forming separate frequency bands.

III. FUTURE SCOPE

The future work that can be performed on the project are different types of feeding techniques can be changed and improvement in the results may be observed, The dimensions of the proposed design can be miniaturized, to achieve more optimized results. The above designed can modified with other materials like Roger, Arlon etc. and other shapes of Microstrip patch like circular, hexagonal, triangular can be replaced in place of rectangular Microstrip patch.

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