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Design of Multiband Circular EBG Antenna for Different Applications

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Abstract—*In this manuscript we have presented three design of multiband circular Electromagnetic Band Gap (EBG) patch antenna for different application in 2 GHz to 6 GHz frequency range. In the design procedure we are able to reduce the overall dimension of our final proposed design, which is about 87.6% compact as compared to the two proposed design and simultaneously achieve our prime objective of multiband application. In this design, we achieve three radiating band with center frequency of 3.1 GHz, 4.8 GHz and 5.8 GHz with bandwidth of 135 MHz, 300 MHz and 600 MHz respectively. on the other hand second proposed design and third design has only two radiating zones with maximum bandwidth of 320 MHz only.*

Keywords- Electromagnetic Bandgap circular patch antenna(EBG , Gain, VSWR and Return Loss (S_{11}).

I. INTRODUCTION

Antenna designing is among one of the buzz word between RF design engineering community. Antenna array, high gain antenna, multi-band antenna and patch antenna are Some the hot topic on which the researcher are working on. As we can realized that the average wireless device used in an indoor environment is increasing very rapidly. Hence the demand for multiband antenna is also increasing [12,13,14]. Here we have take three antenna design based on circular EBG structure to fulfill the need of multiband antenna and achieve a triple band of operation with compact size. All the three design is simulated on Ansys HFSS software for frequency range of 2 GHz to 6 GHz on a Glass epoxy FR-4 substrate with dielectric constant 4.4 and thickness 1.6. mm. Theory of Circular Patch Antenna (CPA) is consists of three parts [14,15] viz. circular patch, substrate and ground plane as shown in figure 1.

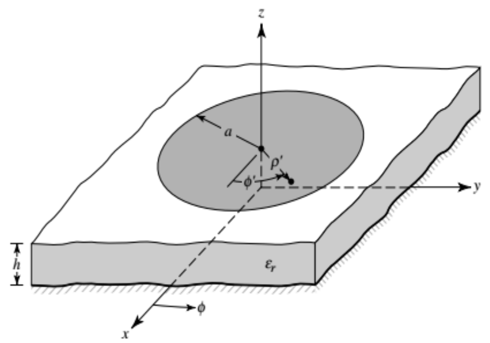

Figure 1. Geometry of circular microstrip patch antenna.

The rest of the paper is organized in four sections. Section II is used to describe all of the three proposed design with its dimension. Section III presents the various performance parameters such as Return Loss S_{11}, radiating frequency, impedance bandwidth, VSWR, Antenna Gain and Axial Ratio. And finally a conclusion is presented in Section IV with best proposed design.

II. DESIGN

In this section, we present three circular EBG patch antenna design using glass epoxy FR-4 as our substrate with dielectric constant (ε_r= 4.4) and thickness of 1.6. mm.

A. Antenna Model For Design A

The idea of circular EBG antenna design rise from the Mushroom type EBG structure[1,2,3], here we use half of the antenna area for circular EBG and other half is used for feeding structure. Top view of patch is shown in figure 2. Here we use circular patch of diameter 8 mm. and feed structure of Dimension 22 mm by 37 mm. With overall area of 6724 mm^2 as presented in the above mention figure.

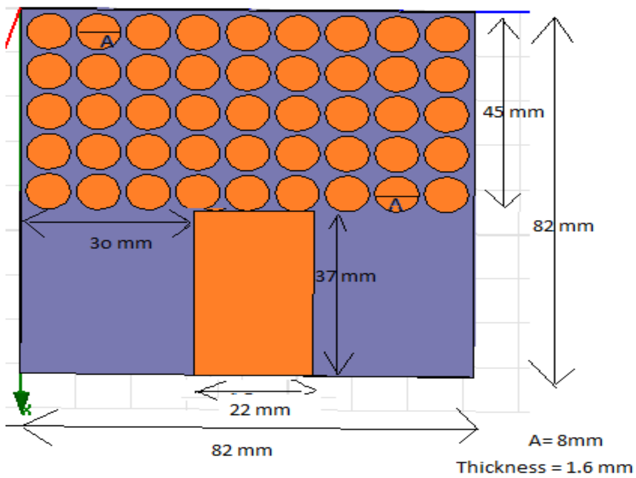

Figure. 2. Top view of the Design A.

We are using perfect electric conductor PEC or copper as our ground plane with area same as substrate of 6724 mm^2 and its dimensions is shown in figure 3 below.

Figure 3. Ground plane of design A.

B. Antenna Model For Design B

The basic structure of design B is almost same in terms of overall dimension that is again having the area of 6724 mm^2 and half of the patch is filled with circular patch EBG structure [4,5,6] and the other half with feed line, the only change is to reduced the feed line to 16. mm. and in right of the feed line, we introduced a circular ring with dimension of inner radius of 10. mm and outer radius of 15. mm. As shown in figure 4 and the dimension of ground plane is same as that of the dimension of first design with FR-4 substrate [7.8.9].

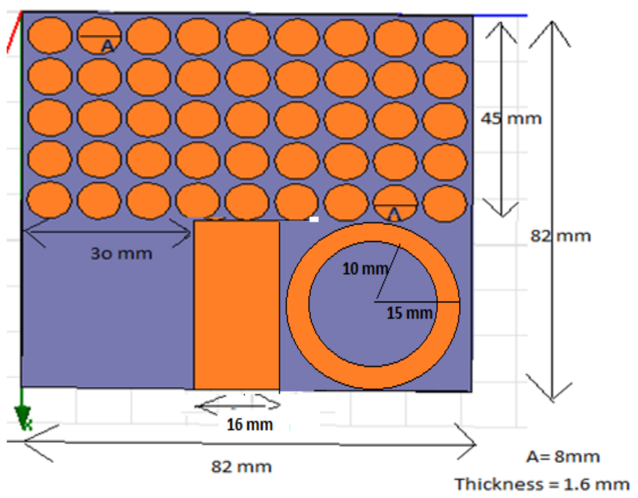

Figure. 4. Top view of the Design B.

C. Antenna Model For Design C

From the idea of design A and design B we Present final design C with reducing size and overall area of antenna is 832 mm^2 only. Here we are using circular EBG embedded on a rectangular cavity and one parasitic patch is added opposite to that of the feed line with little shift in feed position. On the other hand on the left of the design we add an additional parasitic patch of 2 mm × 17 mm dimension and two additional circle of radius 2 mm on both side of the feed line is also added in this design as shown in figure 5.

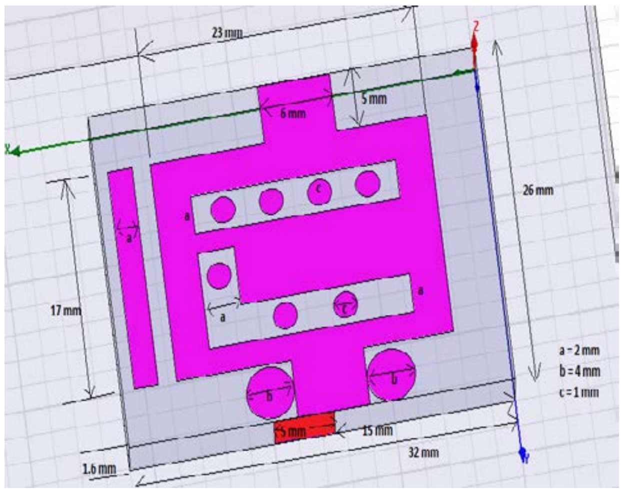

Figure 5 Top view of Design C.

The ground plane again has a overall area of 832 mm^2 with PEC or copper as ground plane and substrate material of FR-4 of thickness 1.6 mm.

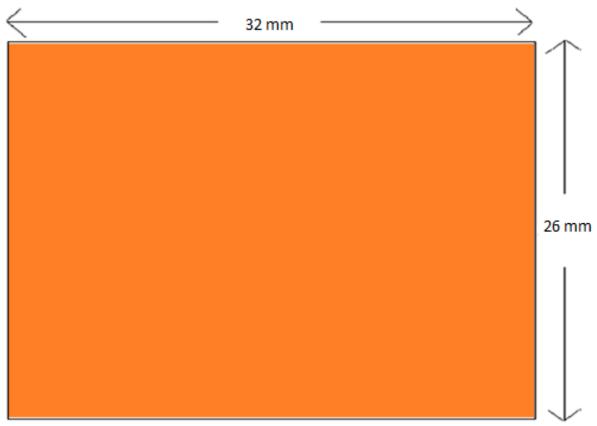

Figure 6. Ground plane of design C.

III. RESULTS AND DISCUSSION

Result of various performance parameter of the proposed design such as return loss S_{11}, VSWR, antenna gain, axial ratio and Impedance bandwidth [10,11,12] is calculated for the three proposed design in this section. For first and second design we can achieve dual band of operation with maximum bandwidth of 320 MHz at Center frequency 5.1 GHz for second design.

Other than that, we get 160 MHz and 140 MHz bandwidth for first design at Center frequency 3.1 GHz and 4.7 GHz, respectively. The purpose of multi-band antenna is solved by design C, where we achieved triple band of operation with impedance bandwidth of 135 MHz 300 MHz and 600 MHz at Center frequency 3.1 GHz, 4.8 GHz and 5.8 GHz respectively with best return loss of -30.9 1 dB at 4.8 GHz and axial ratio of 10 dB at 5.8 GHz. Summary of the outcome of various performance parameter is tabled in table 1 for all three design and result of all proposed design is shown in the following figures, figure 7, 8, 9 and 10 represents S_{11} return loss, Gain , VSWR and Axial Ratio of design A respectively. Figure 11, 12, 13 and 14 represents S_{11} return loss, Gain , VSWR and Axial Ratio of design B respectively, and finally figure 15, 16 17 and 18 present S_{11} return loss, Gain , VSWR and Axial Ratio of design C respectively.

Table I: Result analysis of Patch antenna.

Design	Radiating Frequency (GHz)	BW (-10 dB) (MHz)	Gain (dB)	Return Loss (dB)	VSWR	Axial Ratio (dB) minimum
A	3.1	160	-6.44	-21.26	1.19	28.76
	4.7	140	-2.07	-15.19	1.42	42.49
B	3.9	200	-2.59	-20.95	1.20	10.55
	5.1	320	-1.35	-25.62	1.11	8.5
C	3.1	135	-9.33	-16.63	1.35	27.63
	4.8	300	-4.0	-30.91	1.06	15.60
	5.8	600	-3.07	-15.81	1.4	10.0

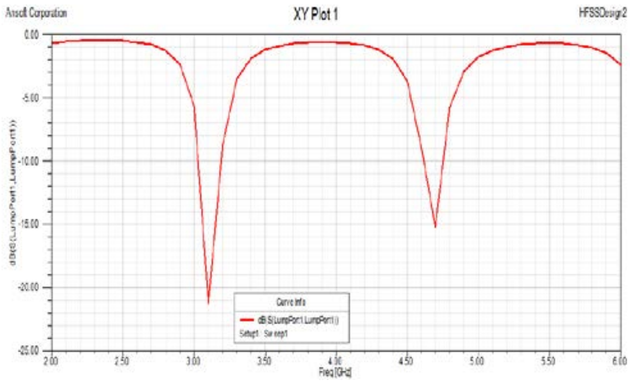

Figure 7. S11 For Design A

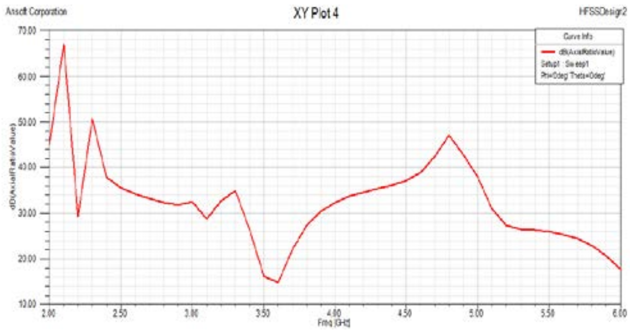

Figure 10. Axial Ratio For Design A

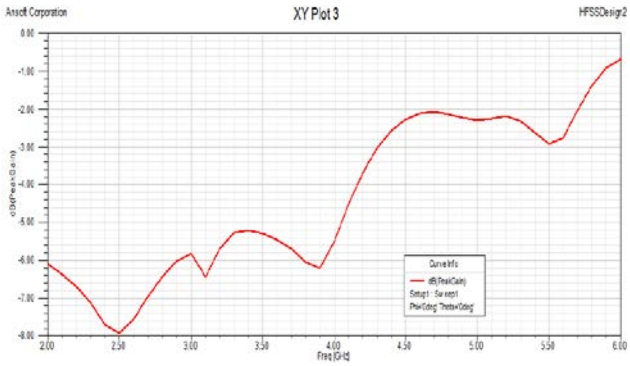

Figure 8. Gain For Design A

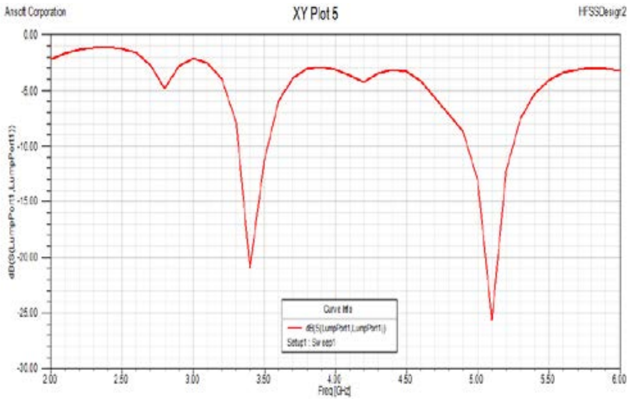

Figure 11. S11 For Design B

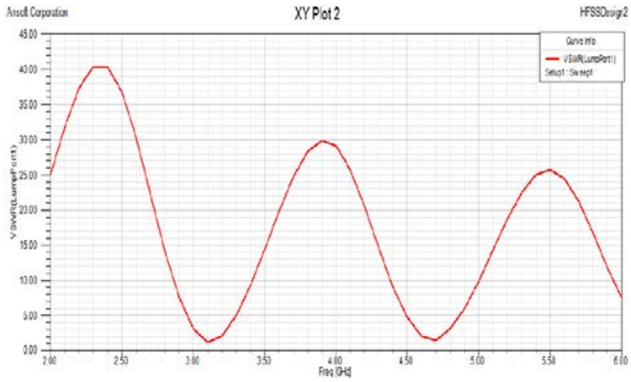

Figure 9. VSWR For Design A

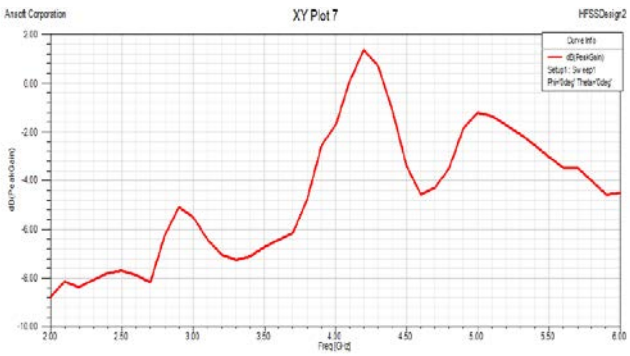

Figure 12. Gain For Design B

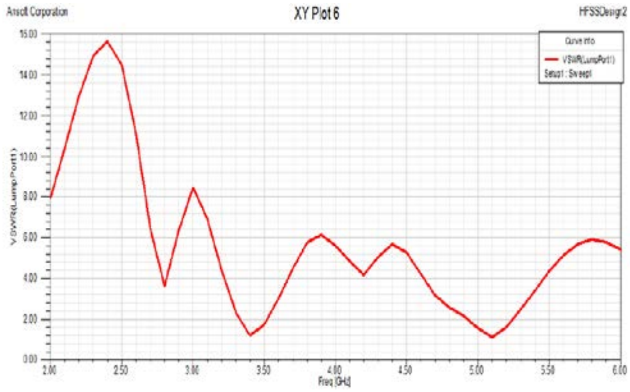

Figure 13. VSWR For Design B

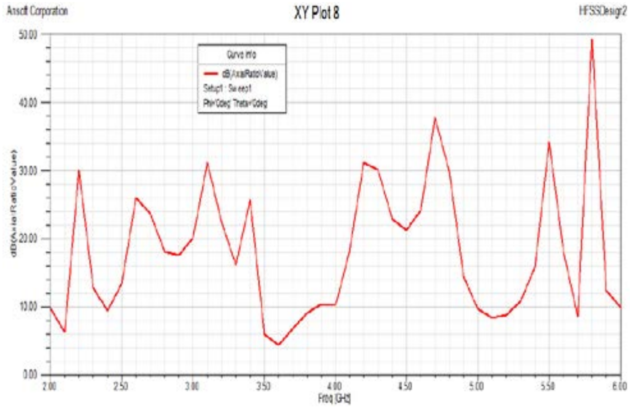

Figure 14. Axial Ratio For Design B

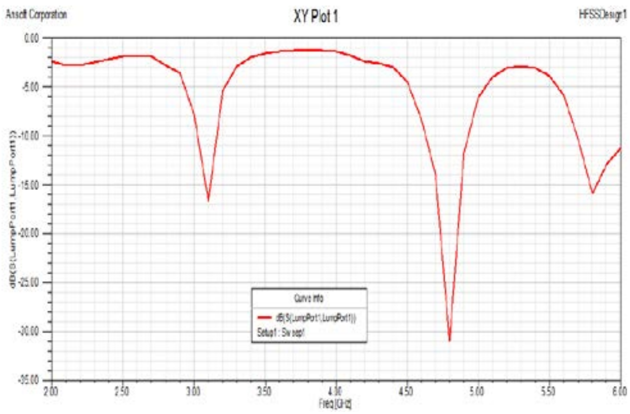

Figure 15. S11 For Design C

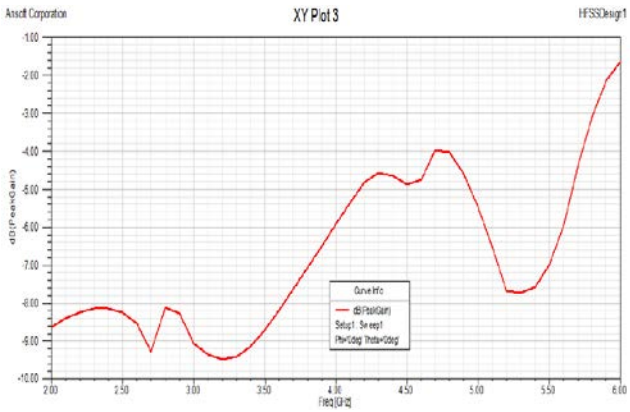

Figure 16. Gain For Design C

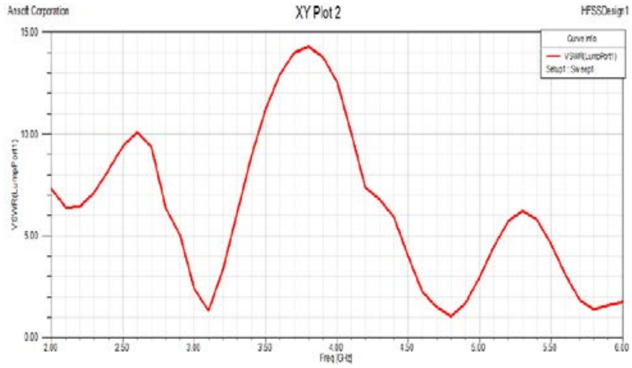

Figure 17. VSWR For Design C

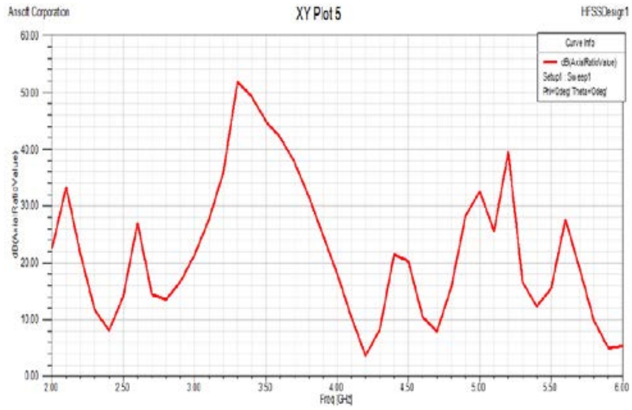

Figure 18. Axial Ratio For Design C

IV. CONCLUSION

On concluding the result of this manuscript we can find that the design compactness is achieved in third design that is design C with fulfilling the need of multiband requirement. Here, we get a compactness of around 87.6% as compared to the previous two design A and design B. When we analyze the maximum bandwidth is achieved again in design C which has been improved by around 87.5% better as compared to the result of maximum bandwidth of design B and around 3.75 times better than design A, The return loss in this design is also improved to - 30.91 dB. and axial ratio is around 10 dB for the proposed third design. Hence, we can conclude that after introducing rectangular cavity embedded with circular patch EBG structure, reduce the size of patch antenna and introducing parasitic patch in EBG structure improve the multiband capabilities of the antenna along with improved return loss and axial ratio.

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