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Compact Dual Band Patch Antenna with EBG Structure with U Shaped Slot for Dual Band Operation

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Abstract: ***A patch antenna which is performed in dual band operation with u shaped slot cut in the front part and the EBG structure with square EBG structure in the back side of the antenna is reviewed in the paper. The analysis is based on by doing careful consideration of the microstrip patch antenna in different iterations. In iteration 1 first the simple microstrip patch antenna with electronics band gap structure at back portion of antenna is simulated. In the iteration 1 the antenna is operated in single band frequency at 2.472 GHz and the reflection coefficient of the antenna is operated at the -29.472. To enhance the frequency and the antenna that to be operated in the dual band and the antenna size to reduce we have done the operation in phase wise iteration. In the iteration first the microstrip patch antenna is simulated with EBG structure at the back side of the antenna and after careful consideration of the different iteration the final antenna that to be evaluated is of patch antenna with EBG structure at the back side of the antenna and in the front side dual u shaped slots are to be cut in the front position of the antenna is need to be proposed and the antenna is need to be operated at the dual band and the frequency of the antenna to be operated at the 2.448 GHz at reflection coefficient at -17.54 and another frequency of operation at 4.7732 GHz and the reflection coefficient of the antenna is at the -14.17. The final antenna that is proposed is the microstrip patch antenna the substrate of the antenna is of FR4 and the patch of the antenna is built of copper material. The final antenna with dual u shaped slot and the EBG structure at the back side of the antenna the gain of the antenna is 2.168 db and the directivity of the antenna is at 5.221 db. The antenna is shows the 2.168 db gain and directivity 5.221 GHz at the 2.448 Ghz and at 4.7732 GHz frequency the antenna shows the 5.009 db directivity and the 2.098 db gain. The proposed antenna is suitable for working in dual band operation at 2.4 Ghz frequency and another at 4.7732 GHz frequency and working at a high gain of the 2.168 db and directivity at the 5.221 db. The antenna performance and the simulation results are analysed by using the CST STUDIO SUITE Software. The antenna is free for working with wide range of frequency and free to work in like ISM band operation(2.4-2.5 GHz) band.***

Keywords: EBG Structure, U Shaped Antenna

1. Introduction

An antenna is a metallic structure that allows the electromagnetic waves and radio waves that can be captured or transmitted electromagnetic signals in to radio waves. The antennas are mainly useful in the ultra wideband application and in IOT application and various types of antennas are useful to use in the ISM Band frequency. Dual band antennas are the type of antennas that are used in the dual range of frequencies they are suitable in working at both the frequencies individually and simultaneously. Dual band antennas are useful in the mobile communication and it also useful in the wifi and the 5g application. Microstrip patch antennas are the most useful and popular antennas in today's generation. The antenna is readily accepted in the communication system because of its lesser size and the robustness and the antenna is easy to construct. The reduction in size of the antenna is the main concern in today's researcher's diasporas. The antennas those are fulfil the demand of the dual band operation criteria is on demand among the researchers. The dual band criteria achieved by using the microstriop patch antenna is a blessing in disguise for the researchers. The antennas are used to operate in the criteria between the $\lambda/2$ to $\lambda/10$. The antenna to be simulated by u shape slots are front side are helpful in the achieving the dual band operation. By using the u shaped slot cut technique the antennas size to be minimised. The wavelength and the frequency of operation of the antennas are mainly depends on the size of the microstrip patch antenna so the patch antennas are useful in opearing at the high frequency range of application.

The EBG structure known as the electronics band gap structure are the artificial periodic structure that can helpful in the achieving the specific band of the electromagnetic waves at the every angle of incidence. The EBG structure is helpful in achieving the higher gain and also helpful in the increasing the efficiency of the antenna. The EBG structure is helpful in reducing the patch resonant time and bandwidth of the antenna. The EBG structure is mainly of different types like square circle. In the proposed antenna the square shaped EBG is taken for consideration. The main concern of the work is to propose a microstrip patch antenna with u shaped slot cut in the front part with a small u shaped and a larger u shaped with square shaped EBG structure on the back side so that the antenna is operated at dual band of frequency with high gain and the directivity by doing different iteration. The iteration procedure follows by construct a simple microstrip patch antenna with EBG structure at the back side that antenna is operated in the single band operations then in subsequent operations the work is to be followed by the designing of the antenna from

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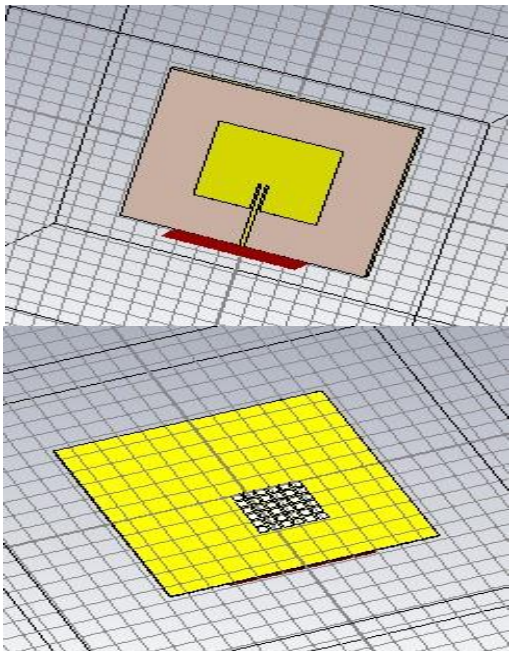
simple microstrip to antenna with single u shaped that is followed by the bigger u slot and the smaller u slot and the single u shaped slot with EBG structure and then both the u shaped slot. Then the antenna with both the u shaped slots with EBG structure at back position is proposed for operation the antenna is lesser in size than the simple microstrip patch antenna and u shaped slot cut antenna is achieved higher gain and higher directivity. The proposed antenna is operated at the 2.448 and 4.732 Ghz that is dual band characteristics of the antenna.

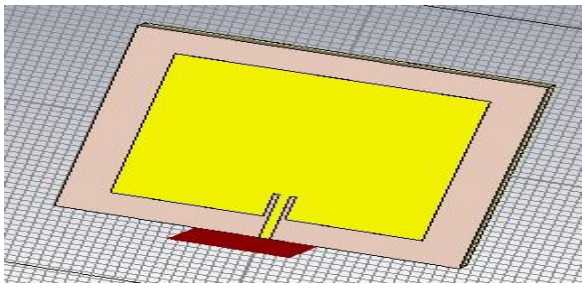
1.1 Design Consideration of Antenna

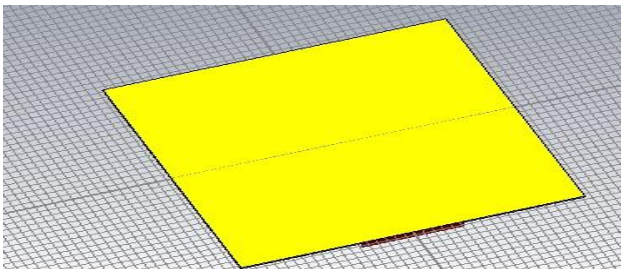
The design consideration of the antenna is followed by the different types of iterations from simple microstrip antenna with square EBG structure at the back side of the antenna to the microstrip antenna with 2 u shaped slots with smaller u shaped slot and bigger u shaped slots cut at the front side of the antenna with square EBG structure at the back side of the antenna. The microstrip antenna is constructed with FR4 material is used as a substrate and the copper which is lossless medium is used as a patch. The main purpose of the work that the antenna is operated at a dual band frequency and the size of the antenna is lesser than the antenna which is operated at a single band frequency. The proposed antenna is also operated at a 2.448 GHz and 4.7732GHz which is helpful in using in the BIOMEDICAL or ISM band application purpose or it is used in the mobile communication or 5g communication fields due to its dual band characteristics. It is also cost effective while designing the antenna because of its small size. In the iteration 1 the microstrip patch antenna is designed with EBG structure at the back side of the antenna in which the antenna is operated at a single band frequency and the size of the antenna is the (56.9*56.9*1.6) and the frequency of operation of the antenna is 2.46 GHz and the s parameter of the antenna is -33.43 and it is a single band operation of the antenna. The gain of the antenna is 1.834db at 2.46 GHz and directivity of the antenna is 6.296db. Then by trying for the decreasing the size of the antenna and to be operating the antenna at the 2.4 GHz then we try to construct a antenna with the simple microstrip antenna with 36.8*36.8*1.6 but the antenna is to be operating at 5.61 GHz but it is showing multiband character other frequency at 2.44 GHz and 4.873 GHz the s parameter of the antenna is at 5.61 GHz at -43.39 and 2.44 at -16.52 and -10.73 at 4.873 GHz. But the focus is to build a dual band antenna due to multiband character it is not for consideration. In iteration 3 we cut the u shaped slot at the microstrip patch antenna but the antenna shows the multiband character at 2.442 GHz the frequency operation and the s parameter of the antenna is -16.65 and 4.7874 GHz and 5.485 GHz but due to the multiband character we did not consider the antenna after in iteration 4 we checked the antenna character with the EBG structure and in iteration 5 we checked the antenna with small u shaped slot and in iteration 6 small u shaped slot of the antenna with EBG structure in iteration 7 with both small and bigger u shaded slot antenna is taken for consideration but due to the multiband properties and showing less gain and directivity the antennas are not taken for the consideration. In final iteration both u shaped slot are cut at the front position of the antenna and EBG structures at the back side of the antenna with lesser size than the iteration 1 (36.8*36.8*1.6) the antenna shows the dual band character. The antenna then operated at 2.448GHz and 4.7732 GHz it shows s parameter at the -17.54 and -14.17. The gain of the antenna is 2.168 db at 2.448GHz and 5.221 db at 2.448 GHz and 5.009 db directivity at 4.7732 GHz and 2.098 db gain at 4.7732 GHz. Due to the high gain and high directivity nature of the antenna and dual band property of the antenna the antenna is finally considered for operation.

2. Designing Part

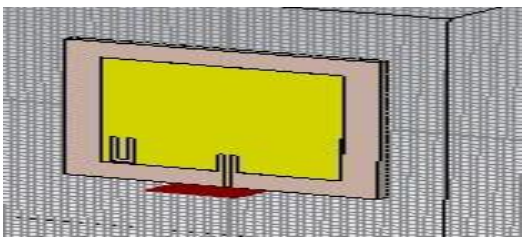


Iteration-1





Iteration-2



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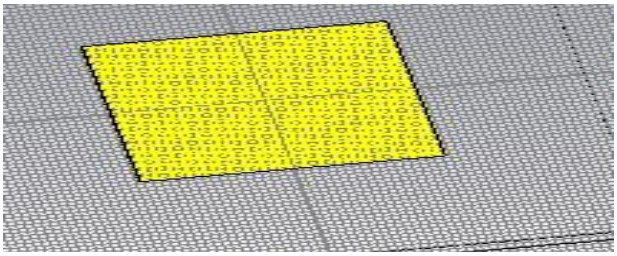

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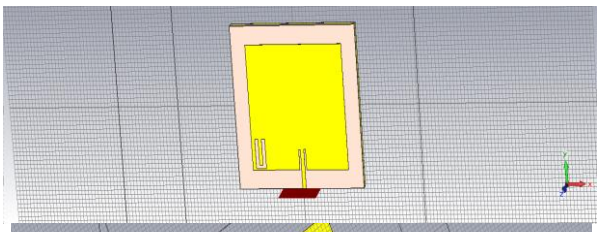
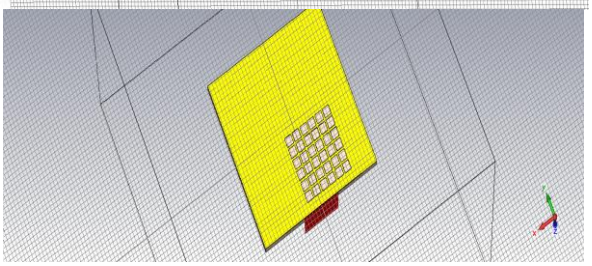
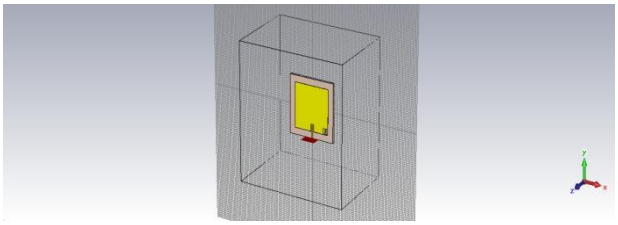
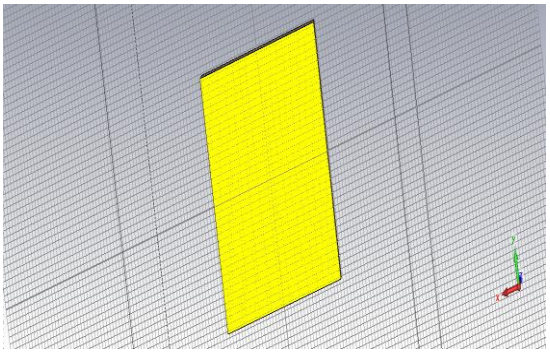


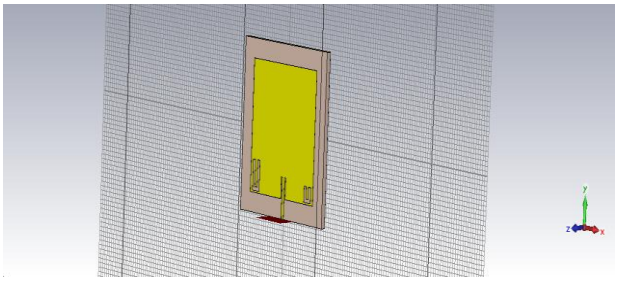


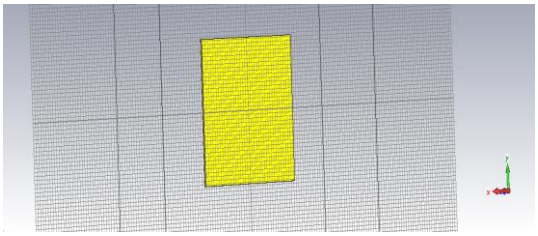
Iteration-4



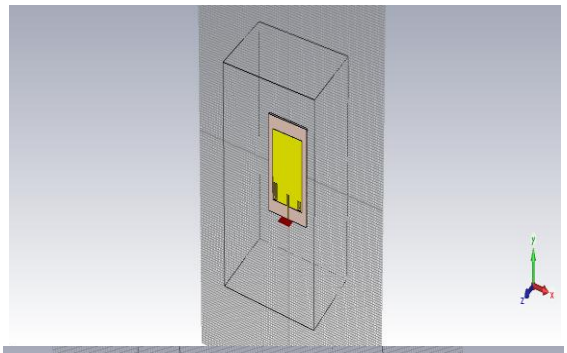


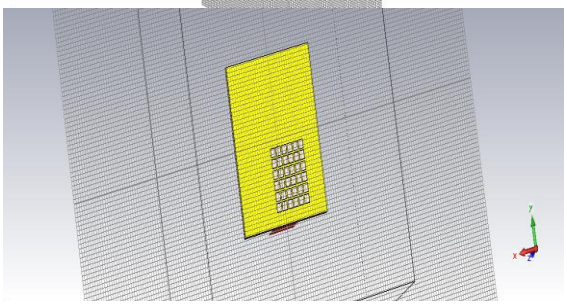
Iteration-5





Iteration-6





Iteration-7

Parameter Table

Length of Substrate	36.8
Width of Substrate	36.8
Length of Patch	28.3
Width of Patch	28.3
Feed Length	8.4
Feed Width	1.6
U Shaped Slot Length(Bigger)	4.1
U Shaped Slot Length(Smaller)	2.1
Length of EBG	2
Width of EBG	2
Gap between EBG	0.5
Thickness of Patch	0.035
Height of Substrate	1.6

Simulation Result

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S. No.	Frequency	Freq of operation	S parameter	gain	directivity
1	2.466	2.466	-33.43	1.834	6.296
2	5.616	5.616, 2.4467	-43.39at 5.616 -16.52 at 2.4467	0.4556 at 5.616 -2.679 at 2.4467	6.463 at 5.616 6.251 at 2.4467
3	2.442	2.442, 4.7874, 5.485	-16.65 at 2.442 -12.25 at 5.485 -13.12 at 4.7874	1.682 at 2.442 2.103 at 4.7874 -0.1838 at 5.485	5.144 at 2.442 4.887 at 4.7874 6.036 at 5.485
4	4.818	4.818, 2.482, 5.520	-16.54 at 4.818 -10.613 at 5.52 -15.00 at 2.482	1.689 at 2.482 -0.7991 at 5.52 1.549 at 4.818	5.214 db at 2.482 5.816 at 5.52 4.841 at 4.818
5	5.646	5.646, 2.472	-15.45 at 2.472 -38.42 at 5.646	0.5646 at 5.646 1.559 at 2.472	6.036 at 5.646 5.223 at 2.472
6	2.454	2.454, 5.50, 4.8045	-13.94 at 4.8045 -11.79 at 5.50 -15.73 at 2.454	2.113 db at 4.8045 -0.668 at 5.50 1.686 at 2.454	4.935 db at 4.8045 5.873 db at 5.50 5.184 db 2.454 db
7	2.448	2.448, 4.7681	-14.20 at 4.7681 -17.54 at 2.448	2.168 at 2.448 2.052 at 4.7681	5.221 at 2.448 4.966 at 4.7681

3. Comparison

By performing the different iteration the antenna in iteration 7 is better performing antenna than other iterations. The iteration 1 of the result is a single band antenna which is perform at the 2.466 GHz but in the iteration 7 of the result is dual band antenna that is performing in 2.448 and 4.7681. The gain of the antenna of the iteration 7 is 2.168 and 2.052 at 2.448 and 4.7681 and directivity of the antenna is 5.221 and 4.996 at 2.448 and 4.7681 which is better in performing than other antenna.

Final Comparison

The final comparison between the iteration 1 and iteration 7 of the antenna in the iteration 1 it is operated at 2.466 GHz and in the iteration 7 it is operating at the 2.448 GHz and in the iteration 1 it is single band operation and in the iteration 7 it is dual band operation and iteration 1 of the antenna is larger in size and iteration 7 of the antenna is smaller in size and iteration 7 of the antenna is showing high gain than the iteration 1 of the antenna. The iteration 1 of the antenna is operated at the λ/6 but in iteration 7 of the antenna is operated at λ/4 operation.

S. no	size	Frequency of operation	gain	Type of operation
Iteration-1	56.9*56.9*1.6	2.466	1.834	λ/6
Iteration-7	36.8*36.8*1.6	2.448,4.7681	2.168 and 2.052	λ/4

The iteration 7 of the antenna is better in performance in terms of the gain frequency of operation and it is smaller in size than the iteration 1 of the antenna by using different u shaped slots.

4. Conclusion

From the above research we concluded that the antenna with both u shaped slot like bigger slot and smaller slot with front side and with EBG at the back side is better performing antenna than others. The antenna is performing in ISM band or it is helpful in wifi and mobile communication.

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