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Design Of Microstrip Patch Antenna For Space Environment With Minimum Returnloss.

Mekala Harinath Reddy*, Rexilin Sheeba, and S Thomas Niba.

Department of ECE, Sathyabama University, Tamil Nadu, India.

ABSTRACT

Microstrip patch antenna plays a very important role in wireless communication since they are very easy to fabricate, low cost and small size. In this paper a new type of antenna is designed in order to obtain minimum return loss, so that no leakage occurs in the space environment. The design is with two patches placed on the substrate, one is circular patch and other is rectangular patch, the circular patch acts as primary patch and the rectangular patch acts as secondary patch. Analysis has been done with various slots like circular, pentagonal, hexagonal, square and triangular slot on the circular patch for the proposed design to bring best performance characteristics. Analysis for different performance parameters like return loss, gain and bandwidth has been made. Since dual patches are used on the substrate the proposed antenna works at dual frequency. In this paper the proposed antenna operates at 7.5 GHz. The proposed design obtained the return loss -43.20 dB, gain 4.72 dB and bandwidth 0.58 GHz. The antenna is designed by using material called FR4 epoxy (FLAME RETARDANT) substrate which has relative permittivity 4.4, relative permeability 1 and dielectric loss tangent 0.02. Line feeding has been used in this design and *HIGH FREQUENCY STRUCTURE SIMULATOR* (HFSS) software is used for simulation purpose.

Keywords: FR4 epoxy, Hexagonal, Microstrip patch antenna, Relative permittivity.

***Corresponding author**

INTRODUCTION

With the evolution of wireless communication technology the need for light weighted, small sized antennas has become a compulsory requirement in today's modern world and the most popular antenna was microstrip patch antenna [1]. The main reason for the purpose of choosing the micro strip patch antenna as a compulsory requirement is that they have a very low profile, they can be horsed on a flat surface and most probably it is a type of radio antenna [2]. Because of their simplicity microstrip patch antennas are widely used in microwave frequencies. This antennas make's themselves suitable for various applications because of their advantages such as light weight, low cost, ease of fabrication etc [3]. In order to improve the performance of a communication system, either controller part can be modified or transceiver can be modified[4] ,since the modification of controller part becomes complicated every one choose the modification of transceiver as the best method. So patch antennas are being given much preference.

In this paper two patches are being used on the substrate. The circular patch on the substrate acts as primary patch and rectangular patch acts as secondary patch. These two patches resonate at different frequencies. Analysis has been made by etching various slots on the circular patch for better performance results. Slot loading technique is the most effective method. Generally slot loading technique reduces the size of antennas, shifts the resonance frequency to lower side [5]. There are different types of slots like circular, triangle, hexagonal and pentagonal slots. All these slots can be placed on patch with different radius. Along with reduction of antenna size slots are used to tune the resonant frequencies of antenna and also to increase bandwidth. The main purpose of using secondary patch is that proposed design can work for dual frequency band. Apart from dual band the advantage of secondary patch is that if both primary patch and secondary patch is resonating at the same frequency then a wider bandwidth can be achieved [6]. The proposed design operates at 7.5 GHz and the antennas operating at this frequency can be used for radar applications as well as for satellite communications in space environment.

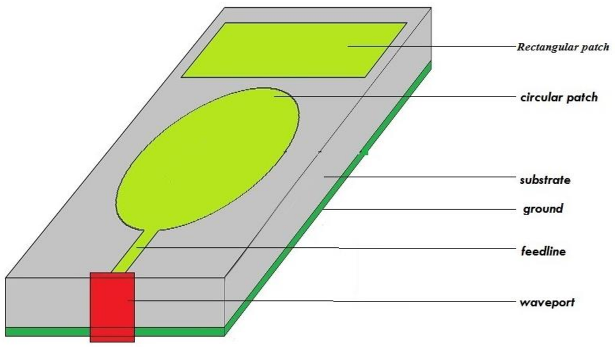

Fig 1: Outline of proposed antenna design

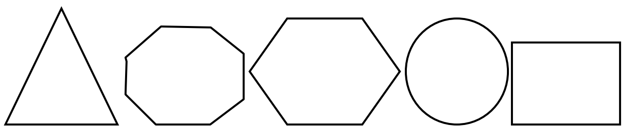

Fig 2: Various slots used on circular patch for comparison

ANTENNA DESIGN

Proposed antenna is designed by using HFSS software at 7.5 GHz. Substrate is given thickness 1.6mm by assigning FR4 epoxy material that has relative permeability 4.4 and loss tangent 0.02. This FR4 substrate material has been chosen due to its low cost and easily availability. The circular patch is given radius 5mm. The length and width of rectangular patch are 13mm and 5.5mm. The simulated structure is shown in figure 3.

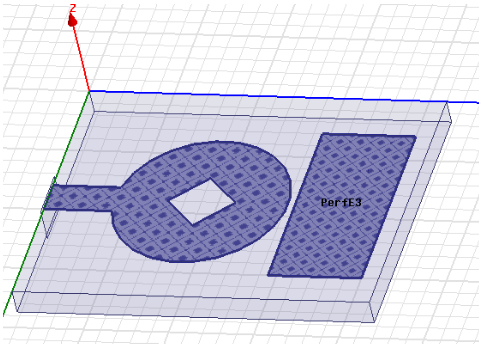

Fig 3: Simulated structure

Different slots are loaded on circular patch with same centre position (9mm, 9mm, 0mm) and starting position (9mm, 11mm, 0mm). The length and width of ground plane is 18mm and 21mm and the feed given is line feed. The rectangular patch is given excitation through the fringing fields produced by the primary patch i.e. circular patch. Before etching the slots on circular patch the proposed design achieved a resonant frequency of 8 GHz, but after introducing the slots the resonant frequency has been shifted to lower side and the design started resonating at the desired frequency. With circular patch alone the antenna is resonating at single frequency i.e. at 7.5 GHz with a gain of 4.725 dB. After introducing the secondary patch the proposed design started resonating at dual frequency i.e. at 7.5 GHz and 12.5 GHz. Comparative analyses has been done with the insertion of slots to find which slot on the circular patch of the proposed antenna is giving good performance characteristics. Figure 4 shows the designs with different slots on the circular patch.

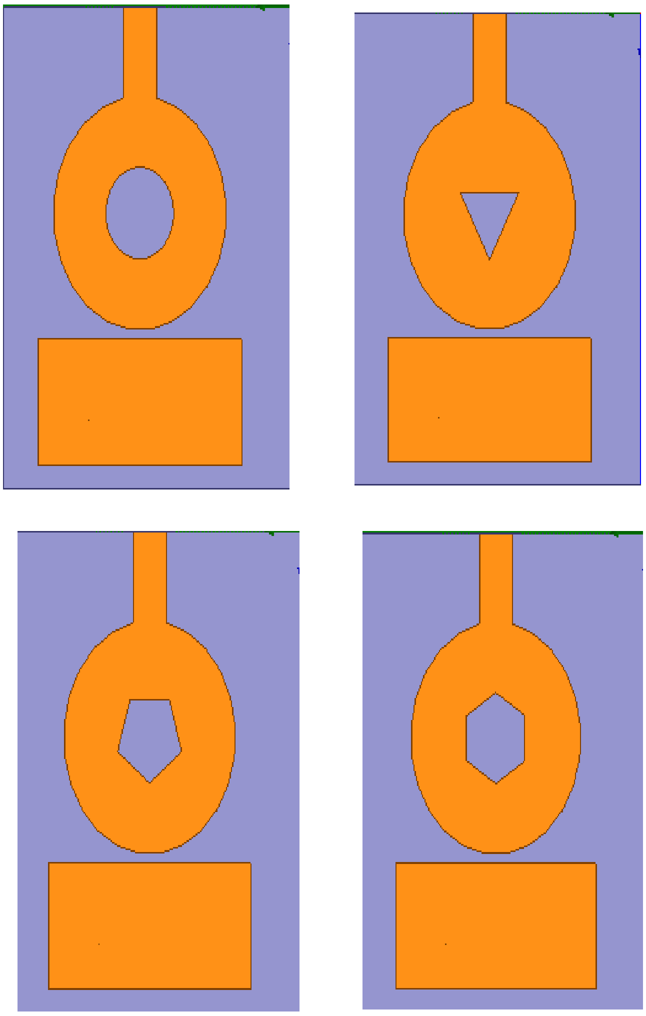

Fig 4: Design structures with various slots on the circular patch

When slots are used on the radiating patch the path of flow of current will be changed due to which minimum return loss can be achieved along with it changes in parameters like gain and bandwidth takes place. All the simulation results with various slots on the circular patch are clearly mentioned in the table 1. With the ejection of various slots on the circular patch the parameters like frequency of operation, return loss, bandwidth and gain are mentioned.

Table 1: ***Comparison of performance parameters with various slots on circular patch***

S.NO	Slot on circular patch	FREQUENCY OF OPERATION (GHz)	RETURN LOSS (dB)	BAND WIDTH (GHz)	GAIN (dB)
1.	With circular slot	i)7.55	i)-28.35	i)0.45	4.58
		ii)12.15	ii)-19.39	ii)0.50	
2.	With pentagon-al slot	i)7.59	i)-32.44	i)0.43	4.55
		ii)12.16	ii)-19.65	ii)0.52	
3.	With hexagonal slot	i)7.61	i)-34.08	i)0.48	4.66
		ii)12.19	ii)-19.13	ii)0.53	
4.	With square slot	i)7.65	i)-43.20	i)0.58	4.72
		ii)12.23	ii)-19.78	ii)0.57	
5.	With triangle slot	i)7.77	i)-30.47	i)0.46	4.60
		ii)12.21	ii)-19.03	ii)0.50	

From the above table it is observed that square slot on circular patch gives better results compared to the remaining slots with return loss -43.20 dB, bandwidth 0.58 GHz and gain 4.72 dB with the operating frequency 7.65 GHz. When compared circular slot gave least gain and return loss whereas pentagonal slot gives least bandwidth.

SIMULATION RESULTS

The simulation results obtained for the proposed design with square slot on the circular patch is shown. The performance characteristics like return loss, gain and radiation pattern are shown in figure 4, 5 and 6. The is return loss obtained -43.20 dB for the resonating frequency 7.65 GHz and gain obtained is 4.7250 dB. Since the return loss is very minimum we can conclude that the excitation given to the antenna is alomost accepted and also a very power might be refclected backand we can also conclude that the feed line is almost perfectly matched with the patch.

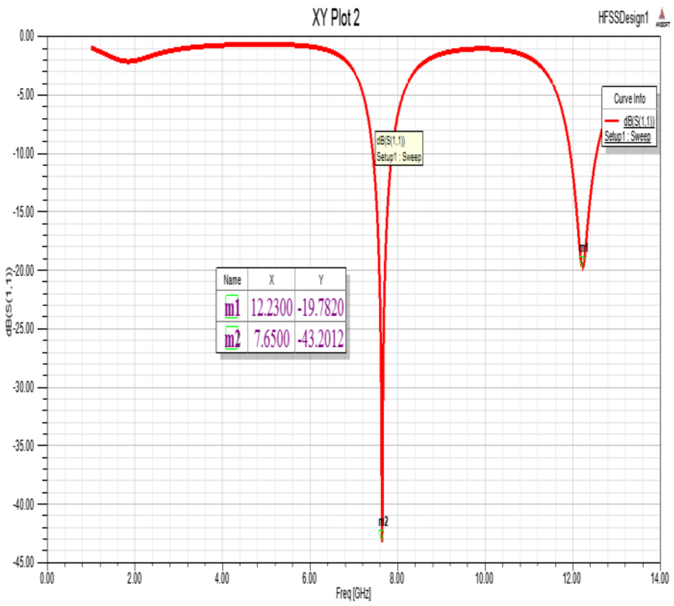

Fig 4: Return loss plot for the design with square slot on circular patch

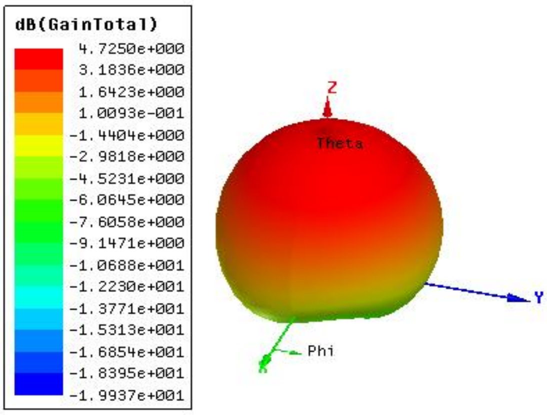

Fig 5: Gain plot for the design with square slot on circular patch

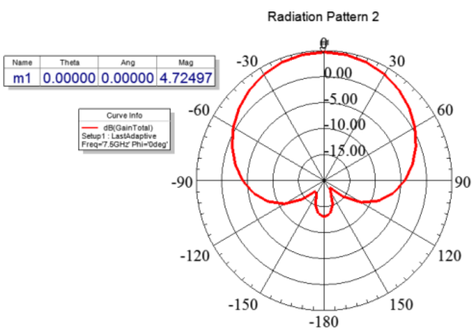

Fig 6: 2D Radiation pattern plot for the design with square slot on circular patch

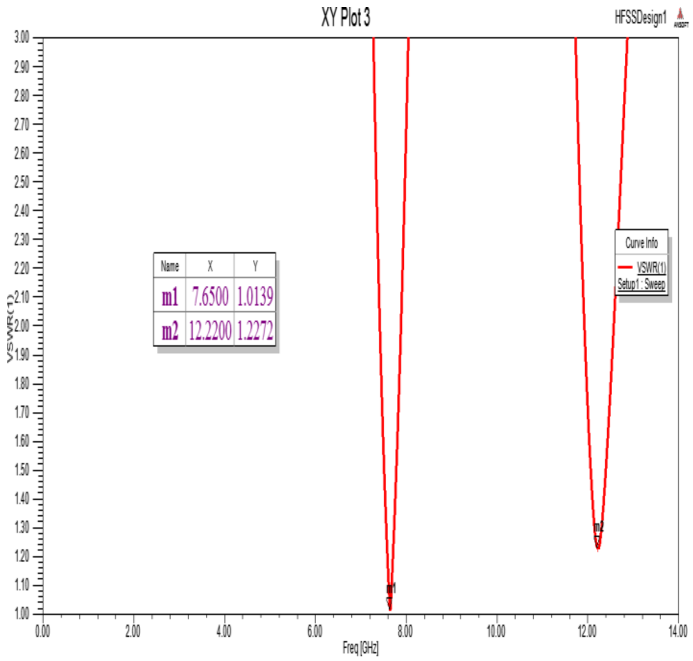

Fig 6: VSWR plot for the design with square slot on circular patch

Generally VSWR is away to find whether the system is matched perfectly or not, it is a ratio between maximum voltage and minimum voltage. If the VSWR is equal to 1 then it can be said that the system is perfectly matched. From the VSWR plot from the figure 6 the obtained value is 1.0139 so we can conclude that the proposed design is perfectly matched.

CONCLUSION

A new design for dual band operation is designed at 7.5 GHz. In this dual band operation has been achieved by adding two slots at a time on top of the substrate. From the simulation analysis it has been observed that square slot on the circular patch gives good performance characteristics compared to other slots with return loss -43.20 dB, bandwidth 0.58 GHz and gain 4.7 dB. Since the designed antenna operates at 7.5 GHz it can be used in space environment for satellite communication for both uplink and downlink process and since return loss is very minimum no leakage can occurs in the antenna when used in space environment. Apart from all these miniaturization can also be achieved by etching of slots on the patch and ground.

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