International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391

Design of Micro Strip Patch Antenna for Ku Band Applications by Using Hybrid Algorithms

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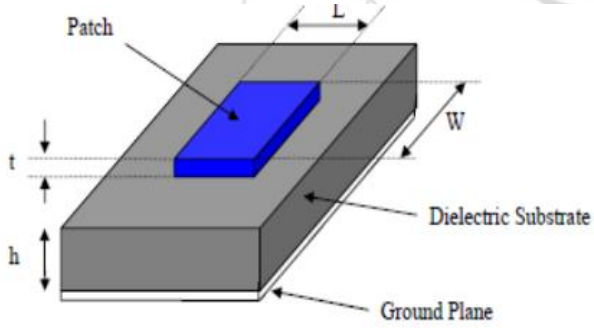
Abstract: ***As the micro strip patch antennas has small in size these are mostly used in the devices of wireless communication that have small sizes. In present time antenna with a reduced size is the major field of experiment in antenna for a given band. Improvement has been achieved in the calculations that are explored by the scientists for calculating the various parameters of the patch of antenna and the receiving device at a particular resonance frequency. In this paper a microstrip receiving device is designed for Ku band. The results that are achieved are improved by the previous work.***

Keywords: Input Impedance, Particle Swarm Optimization, Patch Antenna, Return Loss, VSWR.

1. Introduction

Generally a micro strip patch antenna has a dielectric substrate in the center of radiating patch and ground plane as the figure shows below. Because the patch is made by a conducting material so, copper is used for patch construction. The process of photo etching is used for connecting the radiating patch and the feed lines on dielectric substrate.



There various types of the substrate materials that can be used for making microstrip patch antenna. During fabrication in industries patch can be moulded in any shape. An antenna is classified by its parameters such as length, width, height and dielectric constant. By the operating resonant frequency (f) of antenna the length of the patch can be controlled using first equation. As we know in case of mobile phones the small patch antennas are preferred. The substrate of the high permittivity material is proffered in the used method so that it results shrinkage of patch antenna.

$$f = c/(2L\sqrt{\in r}) \quad (1)$$

Second equation describes that an enhanced bandwidth can we found by reducing the permittivity value. This equation also shows that bandwidth can be controlled by the height or thickness of the patch , more the thickness more will be bandwidth.

$$B\infty(\varepsilon r - 1/\varepsilon r2)(\mathrm{W/L})\mathrm{h} \quad (2)$$

Therefore for getting impressive results, a substrate of high thickness that is of less dielectric constant is mostly preferred. For fabricating a microstrip patch antenna of small size it is must that high dielectric constant is present but on the other hand it gives less efficiency and bandwidth is also narrower. So by meeting all these criteria's a designed antenna is of bulkier size. Then for getting better results we choose only one thing between antenna dimension and antenna performance. Different feeding techniques used such as line feed, aperture coupled feed, coaxial probe feed and proximity coupled feed.

In the manufacturing process and setting of dimensions manufacturer face many complications. So it is designed by using the trial and error method. For getting best results the scientist always utilize the evaluation techniques. This paper used the particle swarm optimization and genetic algorithms for getting the best antenna parameters. The return loss and voltage standing wave ratio are evaluated for the the performance of the patch.

2. Basics of Particle Swarm Optimization

Particle swarm optimization is bioinspired algorithm. It is given by Dr. Rusell C. Eberhart and dr.Kennedy in 1995. In this we will take an example of the swarm of birds. A population of birds is referred as particle. Each bird want to achieve the most secure position, which is at the center. Because at this position there is more security and tendency of getting food. But achieving this most secure position particle or the bird should have to follow some systematic process. The particles that have more physical fitness will overtake the other bird which is in this process known as crossover. Particle for achieving crossover will be selected on the basis of fitness. After crossover those particles get its secure position. Thus this optimization technique will follow four main steps that are, population that are swarm, fitness, selection and then crossover.

Two basics of the operation are velocity update and position update. Now the process start as, each particle will try to get crossover on other when, every time that particle can crossover an other particle when that will have a velocity more than the second particle and also after crossover its position is changed. Thus upto the most secure position that particle will try again and again. Every time a new velocity value is used for getting the new position. It means every

time the velocity value is an improvement over the previous velocity and position. Thus this process automatically becomes an iteration based algorithm. Thus there is a best value of velocity that will particle used and get secure position. This value is known as particle best value (pBest). The same process is follow by each swarm and each one has there own particle best value (pBest). Thus if we calculate the best value for the complete population there will be one best value. The best value of complete population in is known as global best value (gBest). The particle swarm optimization algorithm is widely used in engineering for solving the problems.

3. Basics of Genetic Algorithm

In the field of artificial intelligence there is an algorithm known as genetic algorithm. This algorithm is same as PSO at some extent. The basics of the genetic algorithm are to perform crossover and mutation. This algorithm is derived from the Drawin's theory about evolution.

Algorithm is initialized with a set of solution that are known as chromosomes or population. Chromosomes are selected on the basis of physical fitness. After that the steps of crossover and mutation are performed. In this algorithm solution from one chromosome or population are taken as new value and used for producing the new population.

In GA operation two basic steps are crossover and mutation. Crossover is important for getting new population or chromosomes. If there is no crossover the new generation or results are exactly similar to the parent chromosome. If crossover probability is 100% then all the results are made by crossover. And if it is 0% then the new results or chromosomes are the same copies of parent chromosomes.

There we used both the algorithms to design an antenna. It is designed by taking a number of iterations in both the algorithms. Then results for the performance are compared and suitable best results are considered for designing of antenna.

4. Design of Proposed Patch Antenna

To design the antenna software used is MATLAB. This is mostly used in the designing process of all kinds of planar structures as strip line, coplanar or microstrip such as patch antennas and stubs. For the calculations of VSWR, return loss plot, current distribution and radiations patterns etc. this software can be used. Parameters for designing the rectangular microstrip patch antenna are taken as same as given in the following table 1.

Table 1: Design parameters of rectangular micro strip patch antenna

Frequency of operation	Ku band
Dielectric constant of the substrate	2.4
Thickness	1.578
Feeding Method	Probe feed

By using MATLAB the PSO and GA are used for getting optimal parameters of a rectangular micro strip patch antenna. Table 2 shows the parameters that are used in the designing of a MSA in the earlier work done. For this purpose PSO is used.

Table 2: Optimized Design Parameters Using PSO

Frequency (GHz)	Optimized Patch Length(mm)	Optimized Patch Width(mm)	Return Loss	VSWR
12	6.63	10.24	-5.08	3.51
13	6.02	9.46	-4.4	3.96
14	5.52	8.78	-3.9	4.45
15	5.17	8.19	-3	5.83

In the designing process we have taken same parameters as taken in earlier workdone but the optimization techniques used are a little bit different. We use in this PSO and GA together and the optimized results are shown in Table 3.

Table 3: Optimized Design Parameters Using PSO and GA

Frequency (GHz)	Optimized Patch Length(mm)	Optimized Patch Width(mm)	Return Loss	VSWR
12	8.03003	9.58706	-8.5	2.30
13	7.40936	8.8496	-7.3	3.71
14	6.87735	8.21748	-5.8	4.01
15	6.41628	7.66965	-4.1	5.11

5. Simulation Results

The return loss (in dB) is plotted as a function of frequency. For an antenna to radiate effectively, the reflection coefficient should be less than −10Db which is equivalent to 2:1 VSWR. Return loss should be minimum at the center frequency. Return loss plot obtained after optimization for12 to 15 GHz are shown as below:

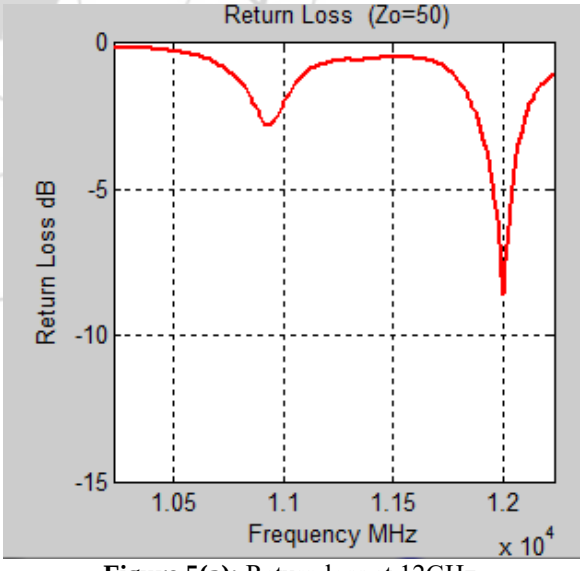


Figure 5(a): Return loss at 12GHz

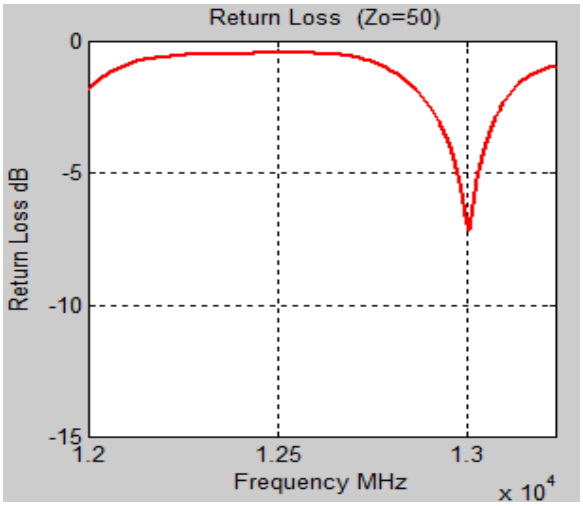


Figure 5(b): Return loss at 13 GHz

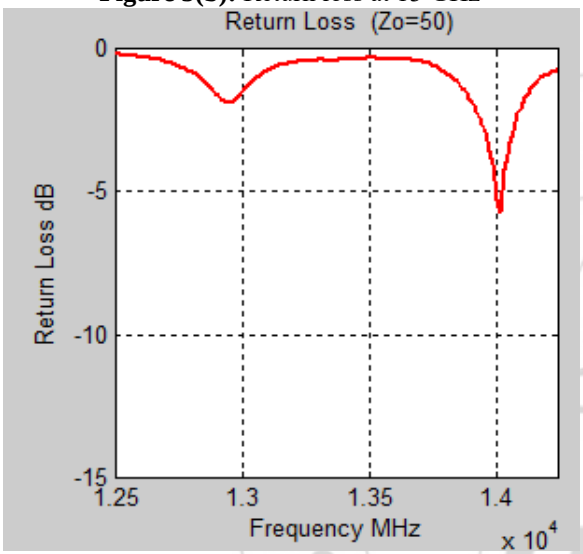


Figure 5(c): Return loss at 14 GHz

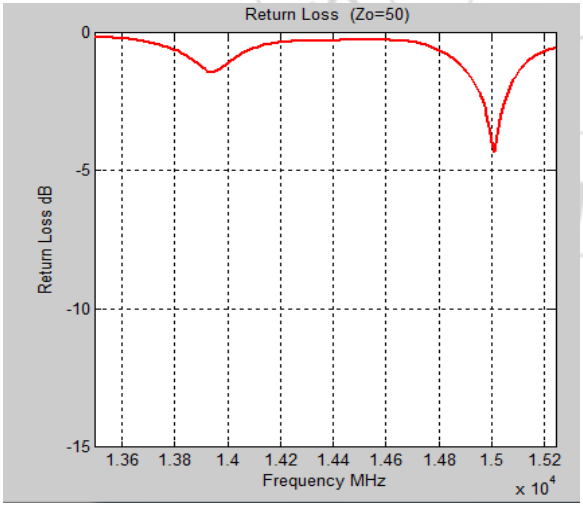


Figure 5(d): Return loss at 15 GHz

The VSWR is to be considered as an important parameter while designing an antenna. VSWR of 1.5 is considered excellent, while a value of 1.5 to 2.0 is considered good and values higher than 2.0 may be inacceptable. Moreover, VSWR, bandwidth is specified as the range of frequency over which VSWR is less than 2.

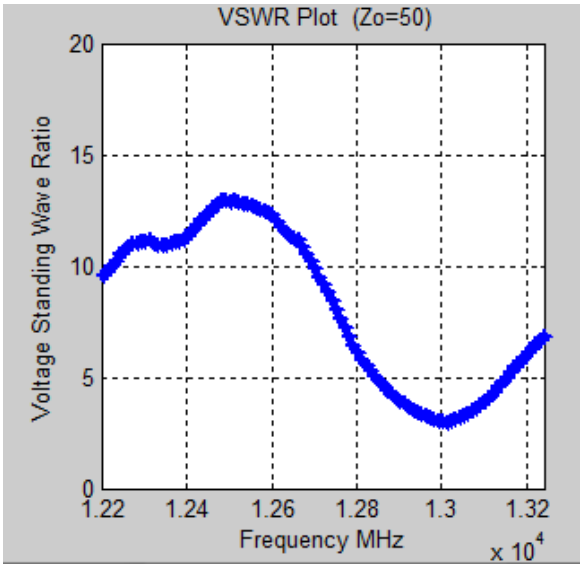


Figure 5(e): VSW R at 12 GHz

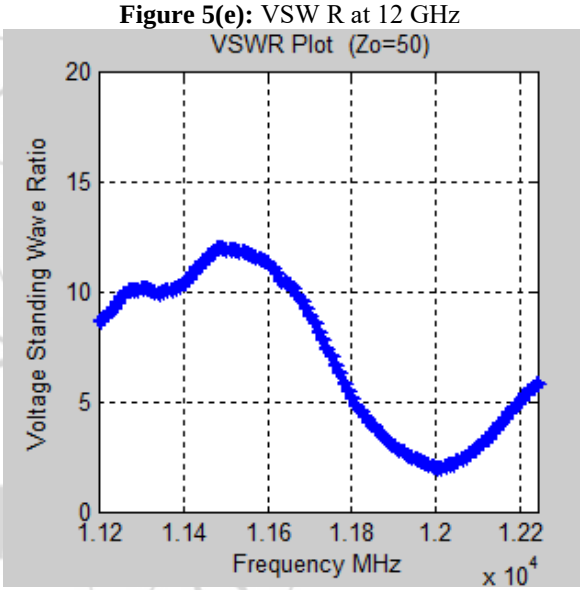


Figure 5(f): VSWR at 13 GHz

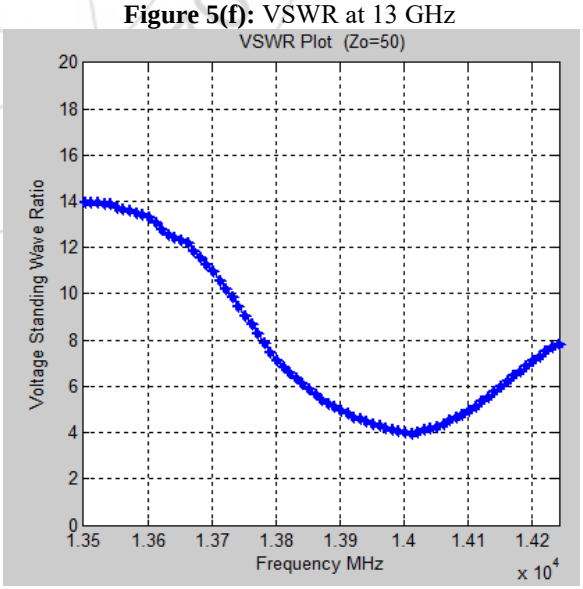


Figure 5(g): VSWR at 14 GHz

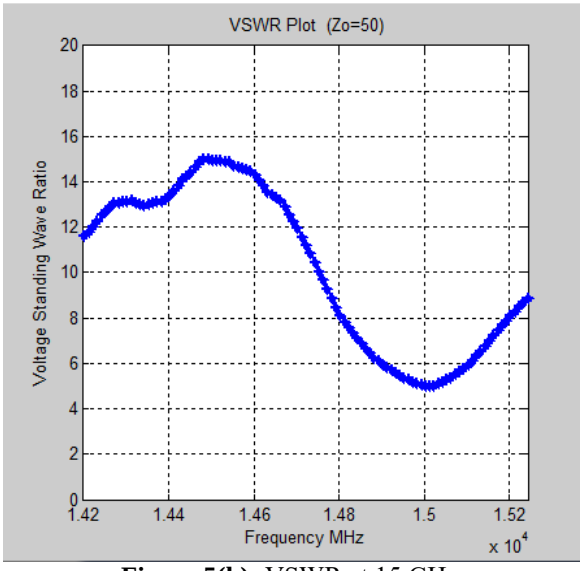


Figure 5(h): VSWR at 15 GHz

6. Conclusion

MSA gets more attraction because of their small size and thus they are widely used in portable communication devices. It is a difficult work to get the accurate or optimized results for a given resonant frequency. To solve like these problems we can use the various optimization techniques. In the proposed work design of MSA using PSO and GA has been proposed for KU band wireless communication system. The results that are achieved are compared with the previous work. These results show an improvement over the previous work and also these shows an effectiveness of the proposed patch antenna.

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