ISSN: 2277-9655
Impact Factor: 3.785

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

OPTIMIZATION OF A NOVEL SHAPE MICRO STRIP PATCH ANTENNA USING GENETIC ALGORITHM

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DOI: 10.5281/zenodo.51465

ABSTRACT
In this paper Genetic Algorithm based optimization technique has been utilized in HFSS software for optimization of the patch antenna dimensions in order to achieve better return loss and height directivity. Micro-strip patch antenna is one of the important elements in modern wireless communication systems and hence its design optimization is an important aspect for improving the overall performance of the system. The microstrip patch antenna is designed to operate in S band with the frequency of 2.4GHz and various important performance metrics of the patch antenna are analyzed.

KEYWORDS: Patch Antenna, HFSS, Genetic Algorithm, Return Loss, and Directivity.

INTRODUCTION
Micro-strip patch antennas have been extensively used in many applications due to their low profile, ease of manufacture, and the possibility of integration with other circuits. However, most patch antennas provide wide beam-width and low radiation efficiency. With the rapid development of wireless communications, the microstrip patch antennas have to meet more requirements [1], which make the configuration and design process more and more complicated. Thus the antenna design problem involves a large number of parameters having great effect on the performance of the antenna. These parameters must be taken as a whole into account. In order to overcome the shortcomings of the patch antenna it is important to make an optimal antenna design for best performance. Various existing optimization algorithms can come handy in this case and genetic algorithm which is one of the global optimization algorithms has been used widely in the past by antenna designers [2][3] for the optimization of the patch shape and size in order to achieve better overall performance of the antenna. In this paper, genetic algorithm is used for optimization of rectangular micro-strip patch antenna dimensions. It was exactly used to optimize the patch length, the slot dimensions in the ground plane and the dimensions of the feed line [4] [5].

The work has been performed by interfacing the genetic algorithm to Ansoft High Frequency System Simulator (HFSS). The paper is organized as follows: Section II presents a brief about genetic algorithm and the flowchart used, Section III tells about design of micro-strip rectangular patch antenna, in section IV simulation results are presented and finally in section V conclusion is drawn.

GENETIC ALGORITHM
Genetic algorithms are stochastic search algorithms, which act on a population of possible solutions. They are loosely based on the mechanics of population genetics and selection. The potential solutions are encoded as 'genes' strings of characters from some alphabet. New solutions can be produced by 'mutating' members of the current population, and by 'mating' two solutions together to form a new solution. The better solutions are selected to breed and mutate and the worse ones are discarded. They are probabilistic search methods; this means that the states, which they explore, are not determined solely by the properties of the problems. A random process helps to guide the search [6-8]. Genetic algorithms are used in artificial intelligence like other search algorithms are used in artificial intelligence to search a

space of potential solutions to find one, which solves the problems [9] [10].The most important components in a GA consist of:
Initialization: While genetic algorithms are generally stated with an initial population that is generated randomly, some research has been conducted into using special techniques to produce a higher quality initial population. Such an approach is designed to give the GA a good start and speedup the evolutionary process evaluation function (or fitness function)[11][12].

Reproduction: there are two kinds of reproduction: generational reproduction and steady-state reproduction.
Parent selection mechanism: the effect of selection is to return a probabilistically selected parent. Although this selection procedure is stochastic, it does not imply GA employ a directionless search. The chance of each parent being selected is in some way related to its fitness.

Crossover operator: the crossover operator is the most important in GA. Crossover is a process yielding recombination of bit strings via an exchange of segments between pairs of chromosomes. There are many kinds of crossover.

Inversion: inversion operates as a kind of reordering technique. It operates on a single chromosome and inverts the order of the elements between two randomly chosen points on the chromosome. While a biological process inspired this operator, it requires additional overhead.

Mutation: mutation has the effect of ensuring that all possible chromosomes are reachable. The mutation operator can overcome this by simply randomly selecting any bit position in a string and changing it. This is useful since crossover and inversion may not be able to produce new alleles if they do not appear in the initial generation [13-15].
GA used for this antenna parameters optimization is presented as the help of the genetic algorithm optimization. This is also done with the help of the optometric functionality of the Ansys HFSS.

GA repeatedly modifies a population of individual solutions. At each step, GA selects randomly a set of individual from the current population as the parents and uses them to produce the next generation children. This is repeated until an optimum solution is met. Since GA uses random selection in a systematic way, it is generally a slower process [16].

The algorithms proceeds with the help of the following inputs
1) Specified the stopping criteria as the" maximum no of generations" as 20
2) Specified the no: of parents as 10
3) Specified the no: of individuals in the mating pool as 10
4) Simulated binary cross over is selected with an individual cross over probability and variable cross over probabilityas 1 polynomial mutation is selected with uniform mutation probability as 0.05 and individual mutation probability as 1
5) Specified the pare to front value as 10
6) Specified the Next Generation parameters i.e. the no of individuals as 5. The Next Generation is selected from the Parents, the children, and the Pare to front. The block diagram of genetic algorithm function is shown in Figure 1.

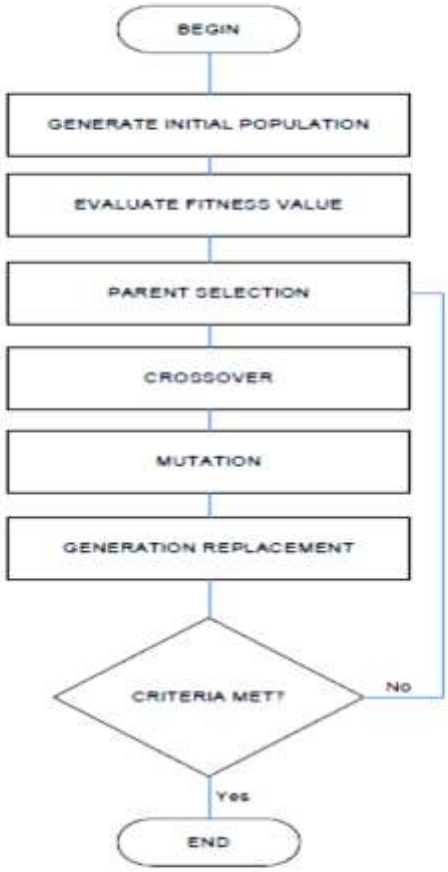

Fig. 1.Block Diagram of Genetic Algorithm Function used in this Design [15]

ANTENNA DESIGN

Primarily the micro-strip patch antenna has 3 layers namely
i) Metallic layer as a radiating element.
ii) Dielectric substrate.
iii) Metallic layer as a ground plane.

The rectangular patch antenna is made onto "Rogers RT/duroid 5880 (tm)"dielectric substrate which has dielectric constant of 2.2 and height of dielectric substrate is 1.5875mm. The Width and length of the patch is 48mm and 36mm respectively. The design consideration of the practical antenna is given below

A) Effective Dielectric Constant:

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}[1 + 12\frac{h}{W}]^{-0.5} \qquad (1)$$

Where W is width of patch is height of substrate

B) Fringes Factor:

$$\Delta L = 0.412h\frac{(\epsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\epsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)} \qquad (2)$$

Where W is width of patch h is height of substrate

C) Calculation of Length:

$$L = L_{eff} - 2\Delta L \qquad (3)$$

Where

$$L_{eff} = \frac{c}{2f_r\sqrt{\epsilon_{reff}}} \qquad (4)$$

Where L is length of patch ΔL is extension in length due to fringing

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D) Calculation of Width:

$$W = \frac{c}{2f_r\sqrt{\frac{\epsilon_r+1}{2}}} \qquad (5)$$

Where c is speed of light in free space f_r is resonant frequency

E) Calculation of Ground Plane Dimensions:

$$L_g = L + 6h,\ W_g = W + 6h \qquad (6)$$

Where h is height of substrate, L is length of patch, W is width of patch [17] [18]. The design of the antenna and its dimensions, which are used in software, is shown in Figure 2 given below in Table 1. Figures 3 and 4 shows the design in the software with its coaxial probe feed design and the return loss or the gain of this antenna in Figures 5 and 6.

Table 1. Antenna Parameters

Antenna Variables	W	L	W1	W2	W3	R
Values (mm)	18	24	16	14	12	2.5

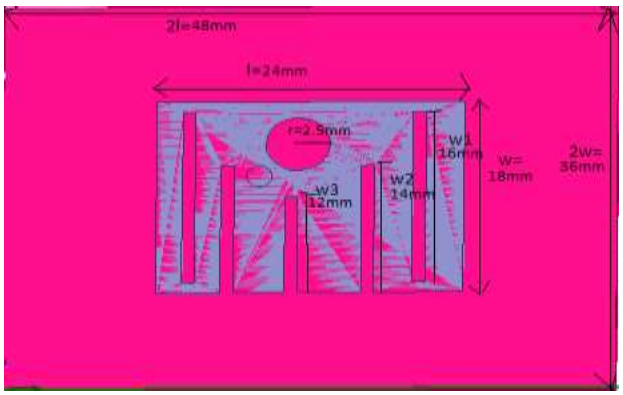

Fig. 2.Dimension of the Antenna

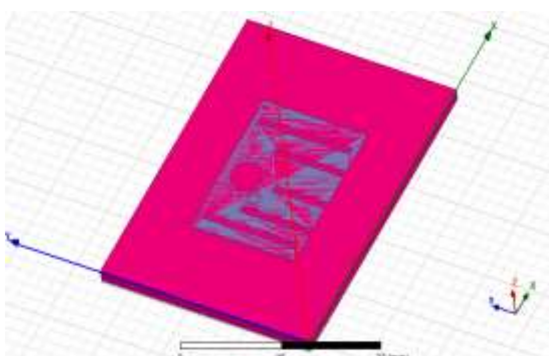

Fig. 3.Antenna Structure in the Software

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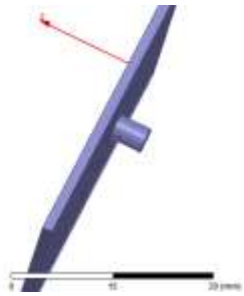

Fig. 4 Coaxial Probe Feed of the Antenna

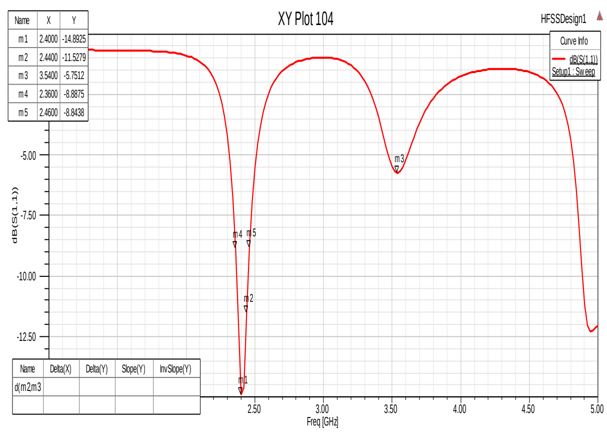

Fig.5 Return Loss of the Antenna

Fig.6 Gain of the Antenna

SIMULATION RESULTS

In this paper, the performance of the antenna is achieved by cutting 5 slits in the shape of parabola and a circle in the middle. By these slits of antenna, it works as meander antenna. This behaviour result in a greatly lowered antenna fundamental resonant frequency and thus a large antenna size reduction at a fixed operating frequency can be obtained. After the optimization we get more promising result for the better bandwidth and return loss by applying genetic algorithm optimization in it. Figure 7, 8, 9 and 10 shows the optimized result of the design as the return loss, gain and VSWR. we apply the genetic algorithm for optimization of different parameter of antenna like length and width as discussed earlier. The analysis of optimization is shown in the table-2 which we get by the software result. Figure 11shows the comparison between optimized and un-optimized antenna.

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Table:2 optimization parameter

Variation	length	width
1	66.17mm	32.71mm
2	43.35mm	32.88mm
3	55.60mm	47.64mm
4	69.36mm	28.19mm
5	24.10mm	40.18mm

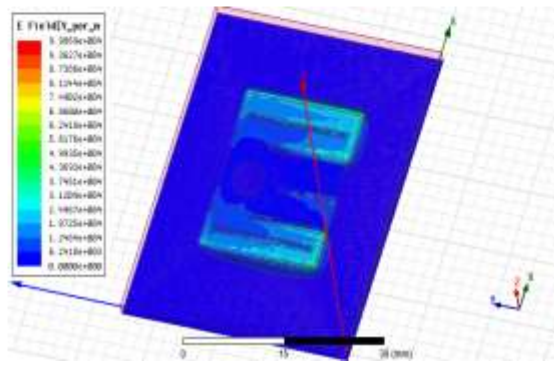

Fig.7 Optimization of Antenna

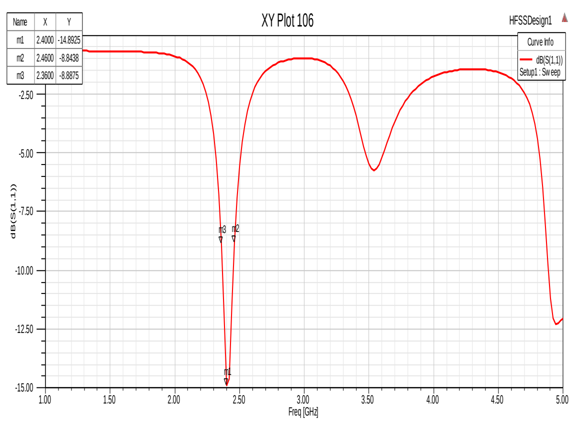

Fig.8 Return Loss of the Optimize Antenna

Fig.9 Gain of the Optimize Antenna for 2.4 Ghz

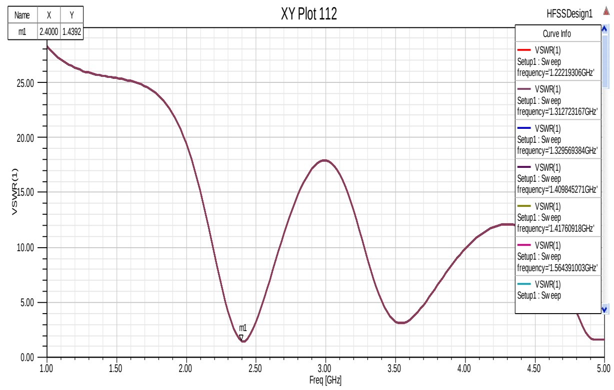

Fig.10 VSWR of the Optimize Antenna

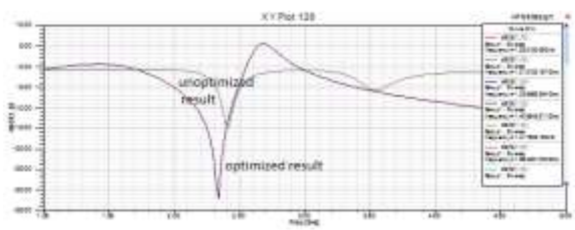

Fig.11 comparison of the Optimize Antenna's return loss with un-optimized Antenna's return loss

CONCLUSION

From the simulation, result of HFSS it is quite clear that the optimization of the micro-strip patch antenna design is very important aspect for achieving desired performance goals. The optimized patch antenna gives better result with the optimization as compared to the un-optimize antenna. A lot of work in this field has been done by employing patch of different shapes or by introducing some kind of slot in the patch for obtaining desired goals. Future research work should aim at utilizing genetic algorithm optimization technique to further improve the performance of the patch antenna and its array of different shapes and configuration.

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