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# Minimization of Circular Polarized Patch Antenna for 5 GHz applications Based on the Current Distribution and Genetic Algorithm

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**Abstract**

This paper focuses on minimizing the microstrip patch antenna and discusses about design of a rectangular patch antenna with circular polarization, having strip line feed. To get the circular polarization, a rectangular slot has been cut in the corner of the patch, then continuously cutting the slot until we get the optimal design at the operating frequency (5 GHz) with reduced size of (68.6%) depending on the current distribution on the patch with the assistance of genetic algorithm (GA). An increasing in the bandwidth is observed using the proposed design. The simulation is done using IE3D simulating software has been used. The operating frequency of the first antenna design is chosen at (6 GHz) then it is forced to operate at (5 GHz).

**Key Words:** Genetic algorithm (GA), patch antenna, slot antenna.

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## 1. Introduction

According to the electromagnetic and microwave theory, Microstrip antennas (MSAs) were found perfectly accepted among the practitioners due to their several advantages. and for that, great number of studies have been devoted to the characterization of these structures with different geometries [1]. Slot antennas as well are having a very positive features which have determined it to be considerable to be used in the broadband communication systems, lightweight, wide frequency bandwidth, easy integration with monolithic microwave integrated circuits, low profile low cost, and easy to be fabricated [2]. were the best features to make this type of antennas nominated to be used.

These antennas overcome the other microstrip antennas with several features making them the best ones to be selected, providing wide bandwidths, decent resistivity matching, and dual directional or one way radiation patterns [3].

Microstrip antennas were found the most suitable choice to be taken by any airborne and spacecraft systems their low profile and conformal nature are well needed there. For that many of these applications demand a reducing in the size of the radiating element to provide light weight, smaller size.

In this paper a traditional rectangular patch antenna resonating on (6 GHz) band will be forced to resonate on additional band (5 GHz) by means of GA, which leads to reduction in the size of the patch after modifying its shape making slots with different size.

## 2. Literature view

For long time, the minimal size of antennas considers more important, especially in transmission and receiver devices for cellular systems. The physical size is critical not like the scattering conditions and the antenna cross polarization attributes are less significant. In the past, the trials to reduce the antenna size utilized old style strategies, for example, embed the antenna in a protection mechanism of a high permittivity, connect a resisting component with the antenna in series connection and etc. In this part, attempts to highlights on previously studies about different algorithms that adopted by a number of researchers to study the patch antenna. These are some examples to reduce size of patch antenna as; Naveen Jaglan and Samir Dev Gupta who have used electromagnetic band gab (EBG) which it has surface selective to support the waves of surface so EBG assist to improvement of bandwidth by reducing excitation waves in surface of patch antenna [3]. To build the patch antenna with resonating frequency that found in substrate of EBG and analysis the achievement the one patch antenna and array embedded of patch antenna with substratum EBG. It is noted the achievement of the realized antenna is found more suitable comparing It with the micro strip patch antenna which using the natural substrate through return losses and impedance [1]. The Broadband Internet cannot be used in residential areas and rural +blackout areas, Wi-MAX can eliminate this problem by using antennas with higher bandwidth and gain. Therefore A.S.M. Bakibillah, Md. Sakhawath Hossain, Ivy Saha Roy are proposed design microstrip patch antenna of a rectangular procedure at 3.5 GHz to perform the highest bandwidth range and the performance of the antenna at multiple operating frequencies [4]. Because of the different dissipating conditions and the practically indefinable operating situation, the cross polarization

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attributes of the antenna are less significant, anyway its actual size is critical. The endeavors to decrease the actual size of the antenna which were made before, utilized traditional techniques, for example, installing the antenna in a dielectric medium of a high permittivity, inserting a resistive component in series with the antenna, and so forth, yet little exertion was put resources into essentially creating different calculations, which by their characteristic properties, transmit at a lower frequency than the notable old style antennas which possess a similar actual volume. This leads the group of researcher as Naftali Herscovici, Manuel Fuentes Osorio, etc. to find new instructions for building a micro strip patch antenna with a low resonance frequency, which makes 'a more proficient utilization' of its actual volume [5]. As we know microstrip patch antenna is used for military and civilian purposes because of its importance and the pursuit of obtaining a small antenna are an essential goal for many researchers, so the researcher Muhammad Aamir Afridi has designed an antenna in CST Microwave Studio at a resonant frequency of 2.4 GHz. The rise of the built antenna is 8.27 dB and VSWR of 1.18. [6]. While another researcher team as Mohammed Lamsalli, Abdelouahab El Hamichi [7], etc. used new method to reduce size microstrip patch antenna by using genetic algorithm, the underlying patch is partitioned into 10×10 little uniform square shapes (Pixel), and the genetic algorithm investigations, the ideal design for the ideal objective. The resonance frequency of a micro-strip patch is moved from 4.9 GHz to 2.16 GHz and a pace of scaling down is up to 82%, test the result through fabricated antenna by FR4 substrate and noted the agreement with the result of simulation. Yash Vedi,S. Siddhartha, M. Susila,Mitali Gulati were suggested genetic algorithm as method to optimize the design of antenna work in a frequency range of (2 GHz) to (9 GHz). The patch surface is divided into a total of 625 cells. The cells are arranged in an array of 25x25, each of which may or may not be radiating for that given antenna. A genetic algorithm is calculating the parameters of antenna such as the patch dimensions and reflection factor, also it has 50Ω feed line impedance [8].

## 3. (GA) The Genetic Algorithm

The Genetic Algorithm can be a great example for the evolution theory for that the theory provision for the fact that the survival is for the fittest. However, it is a must for the fittest to survive the theory requires from it to pass the test for random injection of genes. As Genetic Algorithm directly pulls the string of matrixes the GA is typically operated through the Matlab software usage. It is shown below by steps the process of the software program generating [1, 6]:

Step 1: Any variants are marked with a number of pair of digits so that the requested accuracy of these variants are reached at the end of this step.

Step 2: The variants will be gathered in their pair of digits form into a string that is known as chromosome.

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Step 3: choosing a fixed number of any possible chromosomes is called a population out of all possible number of chromosomes that are displayed through Matlab software. This is known as the current generation.

Step 4: by switching the digital value of each variable in a chromosome to an analogue value, It will then determine the relative fitness of each chromosome (Pi) and the objective function (F) to be evaluated. This relative fitness is determined by:

$$F = \sum_{i=1}^{n} eval_i[P_i]$$

Step 5: The selective probability is defined as:

$$P_{si} = \frac{eval_i[P_i]}{F}$$

The cumulative probability of the chromosomes is provided in the following form:

$$q_i = \sum_{j=1}^{n} P_{sj}$$

Step 6: New off-springs are produced through applying a Crossover for random chromosomes between the parent and next generation.
Step 7: We can modify the population by changing the value of the genes randomly with the minimal considerable bit having the highest chance of mutation and the most significant the least.
As the time passes by, the generation becomes more likely a parent generation and the steps that are mentioned above are used frequently the genetic variation in the population is below a certain threshold.
While the generations number increases both of the mutation rate and the cross over rate are reduced gradually.

**3. Antenna Design**

In the design below, the geometry of the antenna adjusted using the GA. A lot of areas can be found removable from the antenna patch to get the longer path for the surface current for the patch. This would result to transfer the operation of the antenna from the (6 GHZ) band to the (5 GHz) band while the dimensions (length and width) are the same. it would regularly minimize the size. The election of the field that are required to be detached depends on its surface current division that has a specific effect on the patch impedance. Using (GA), the area is removed to get the good resonance of the antenna. The basic circular polarized antenna before the minimization is shown in the figure (1).

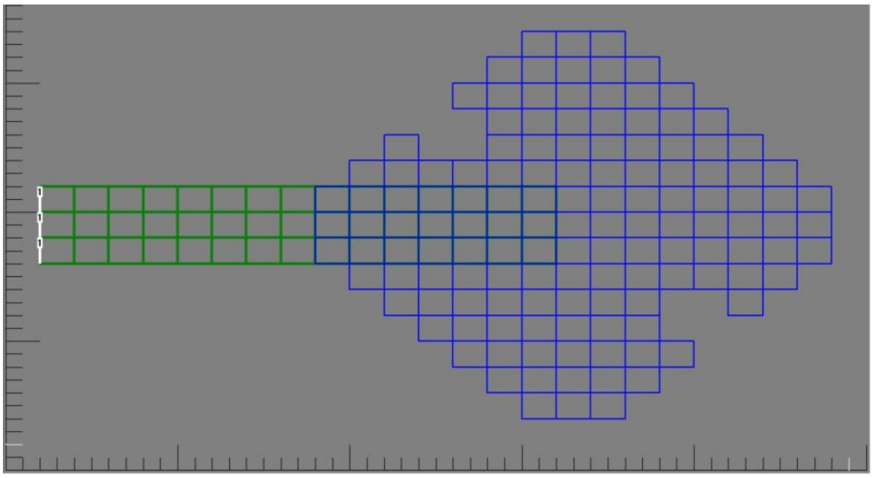

**Figure.1 Basic patch antenna (6 GHz) with circular polarization.**

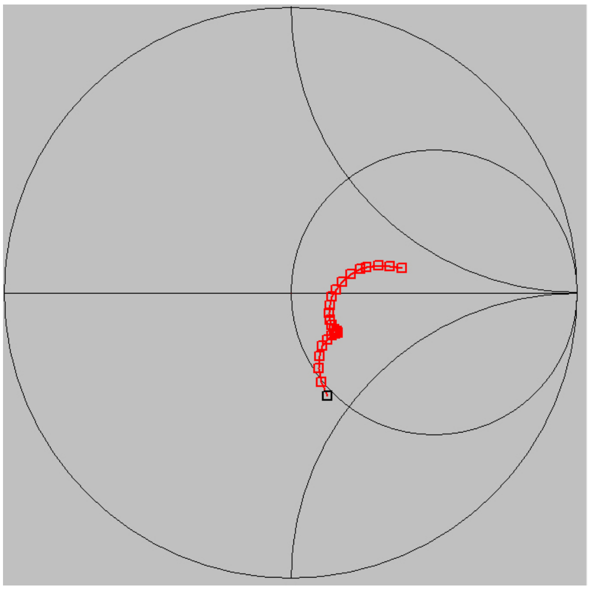

**Figure.2 Smith chart for the basic patch antenna.**

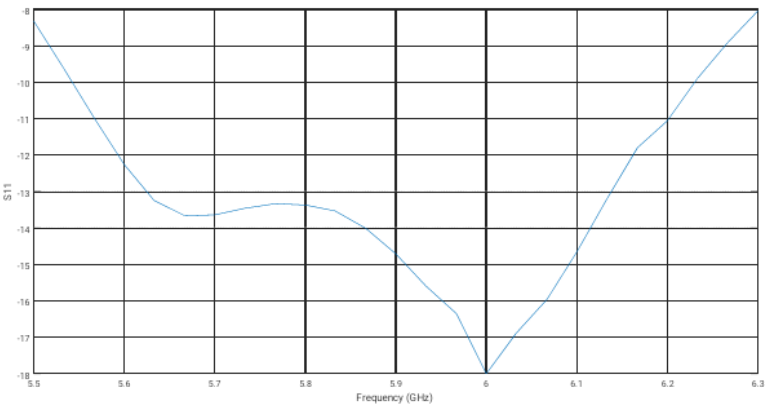


**Figure.3 $S_{11}$ parameter chart with the frequency for the patch antenna.**

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**4. Simulation and Results**

These results are un optimization for the patch in [1], where the patch was resonating at single frequency. The use of the genetic algorithm is to have control over the process of removing the slots within the metal in the patch antenna. The growth in electrical length of any patch antenna can get as a result of the surface current meanders, that results to a descendant shift in the resonant frequency. A standard rectangular microstrip patch antenna that resonates at (6 GHz) (figure.3) is chosen to be the standard antenna where the slots are split as seen in the figure (1) with the dielectric permittivity of (2.2) and the dielectric height of (0.79 mm) are all factors in the optimization problem. A Special slot shape is marked alongside to all the other familiar slots that are urged to be erased from the patch surface to the genetic algorithm and this is seen in figure (4). This led to the size reduction.

Figures (5,6) show the smith chart and return loss (S11) with the frequency respectively, which demonstrate that this antenna is operating at (5 GHz). As the resonance frequency decrease, the patch dimension will increase [10], while using Genetic Algorithm the patch dimensions remain same for the two bands. Therefore, a size reduction is done.

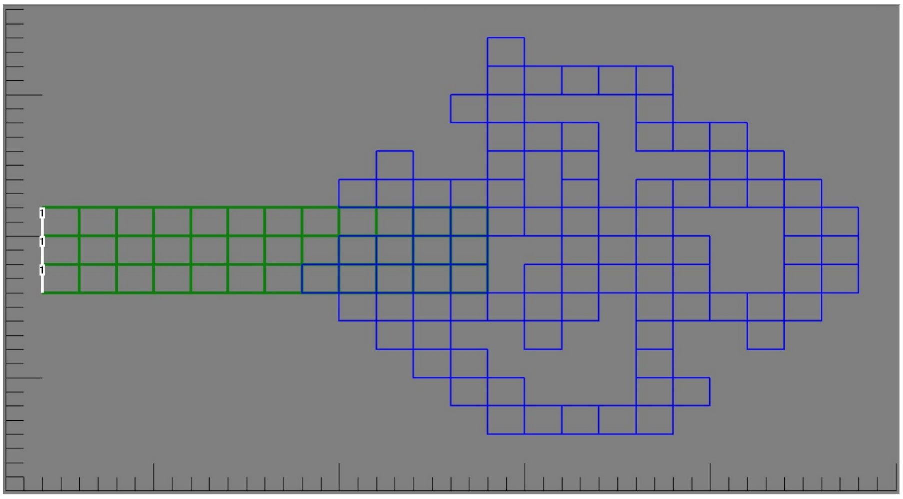

**Figure.4 Resultant patch antenna (5 GHz) from which slots would be cut.**

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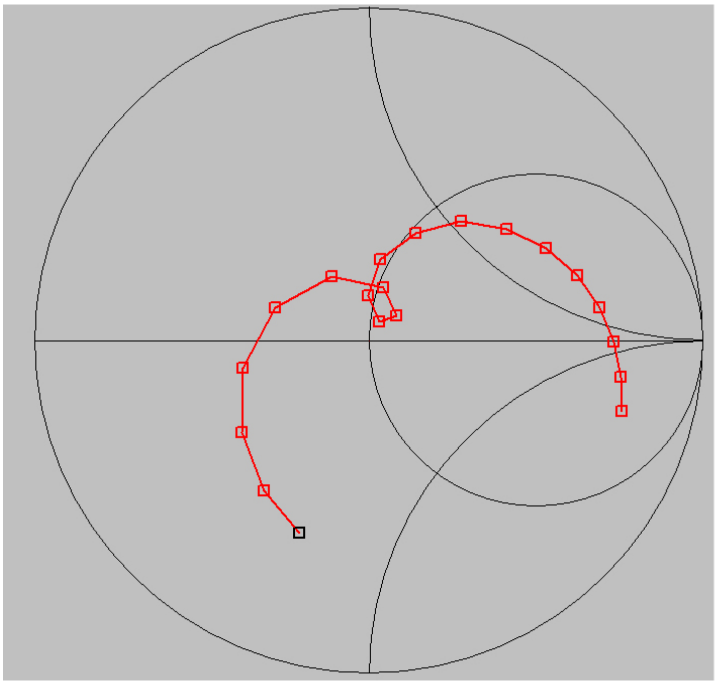

**Figure.5 Smith chart for the patch antenna resonating at (5 GHz).**

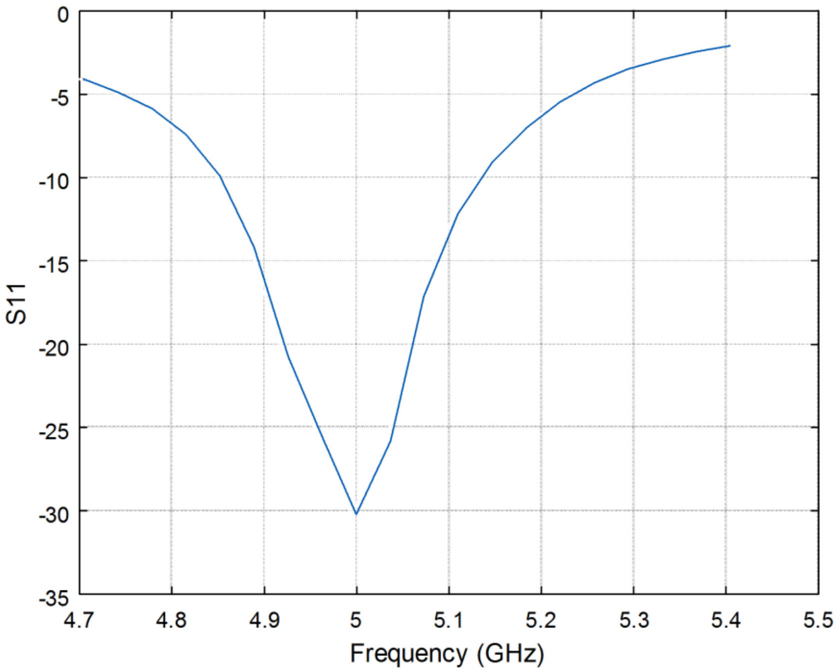


**Figure.6: Return loss S(11) with frequency using Genetic Algorithm using.**

## 5. Conclusion

A genetic algorithm is an active tool for modification that can be made to the standard rectangular patch antenna that will cause the properties of the antenna to change to reduce a rectangular patch antenna size by removing slots (rectangular

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areas) from the copper patch which causes meandering of the surface current. The increase of the current path results a raise in the electrical length of the patch antenna, that would provoke a descending shift in the resonant frequency. This shift in resonant frequency is analogous to a reduction in size, as a solid patch antenna that would resonant at this new reduced frequency would be much larger than the slotted antenna. The patch can be divided into two symmetrical parts and each one can be seen as single patch, then by mean of GA, the slots can be removed to cause the resonance.

Specifying the amount and any slot and its shape, the genetic algorithm is used to adjust the location a slot on the patch and its size. The current path can be increased by the slot, were the patch size will be effected and will resonate at a lower frequency instead of increasing its dimensions.

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