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Slotted Multiband PIFA antenna with Slotted Ground Plane for Wireless Mobile Applications

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ABSTRACT

This paper presents the design of a new slotted PIFA antenna structure for multiband operation service. The proposed antenna is suitable to operate at several resonance frequencies for WiMAX, WLAN, HIPERLAN/2 applications by using genetic algorithm is presented.

Genetic algorithm method is used to design the shape of the patch and the shape of the ground plane simultaneously in order to achieve multiband and wideband antenna instead of single band antenna.

Keywords: PIFA antenna, Genetic algorithm, multiband antenna.

1. INTRODUCTION

Recently, the increasing use of microwave mobile communication systems demands antennas for different systems and standards with properties such as reduced size, wideband, multi-band operation[1].

The wireless communication device provides the ability to integrate multiband. Therefore, a dual or multiband antenna is attractive in many commercial applications as it is designed to have a single radiator with a capability to transmit and receive multiple frequencies.

It is a well-known fact that PIFA antenna presents really appealing physical features, such as simple structure, small size, and low cost. Because of all these interesting characteristics, PIFAs are extremely attractive to be used in multi-band applications, and growing research activity is being focused on them.

Genetic algorithm optimization is proposed as a powerful optimization technique for designing PIFA antenna [2-4]. It is a robust, stochastic-based search method, which can handle the common characteristics of electromagnetic optimization problems that are not readily handled by other traditional optimization methods.

Genetic algorithm (GA) is used to optimize the antenna parameters [5], to the design of ultra-wideband antennas [6], to design dual band antenna [7-9]. Some recent control methods are discussed in [11-14].

The objective of this study is to demonstrate a very effective method of bandwidth enhancement and multiband for PIFA antenna. It was done by using slotted patch and ground plane simultaneously.

This paper presents a small novel multiband PIFA antenna for wireless communication systems while keeping the antenna size small. GA is used to optimize the patch geometry and the ground plane shape simultaneously. Section 2 presents the methodology used. Section 3 details the simulation results of the new PIFA. Finally conclusions are given in Section 4.

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2. METHODOLOGY

2.1. Genetic Algorithm Theory

Our strategy employs Genetic algorithm (Figure.1). GA is considered to be a robust and stochastic search methods modeled on the principles and concepts of nature selection and evolution because no restrictions on the solution space are made during the process.

The important parameters of GA can be summarized as:

1. Crossover type and crossover rate
2. Mutation type and mutation rate
3. Population size
4. Selection procedure
5. Number of generations

They are defined as given below:

- *Crossover*: this is an exchange of substrings denoting chromosomes, for an optimization problem. It may be a single point crossover, two points cross over.

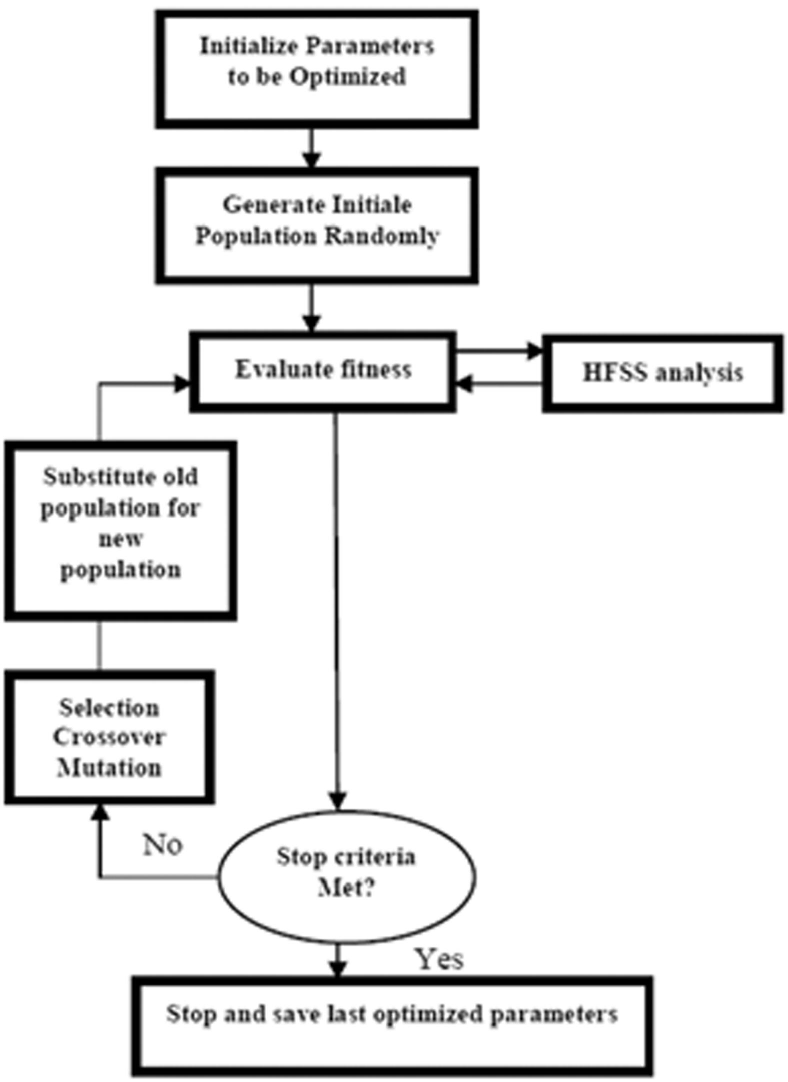


Figure 1: Genetic algorithm block diagram

- *Mutation*: the modification of bit strings in a single Individual.
- *Population*: the number of chromosomes considered in one generation.
- *Selection*: evaluation of the fitness criterion to choose which individuals from a population will go on to reproduce. Some general methods used are Roulette Wheel Selection and Tournament Selection.
- *Number of generations*: the maximum number of generations that the genetic algorithm can evolve into, before terminating [10].

2.2. PIFA Antenna Configuration

The PIFA antenna is composed of ground plane, top patch, feeding pin, and shorting plate connecting the ground plane. The dielectric material selected for the design is FR4 which has dielectric constant of$r = 4.4$. The initial PIFA design parameters are Top radiating plate Length = 38 mm, Width = 24 mm, ground plane (40 × 40 mm2), and height (distance between ground and patch) is 3.4 mm, Feed is microstrip line. We use Air as dielectric; Figure. 2 shows the geometry of the basic PIFA antenna.

In this paper, The Genetic algorithm (GA) procedure is employed to search for the right geometry to find multiband with small area of the patch and ground plane simultaneously. There are divided into several cells with overlapping of 0.2 mm (Figure 3 and 4); the existing or non-existent property to each cell is defined by using binary code.

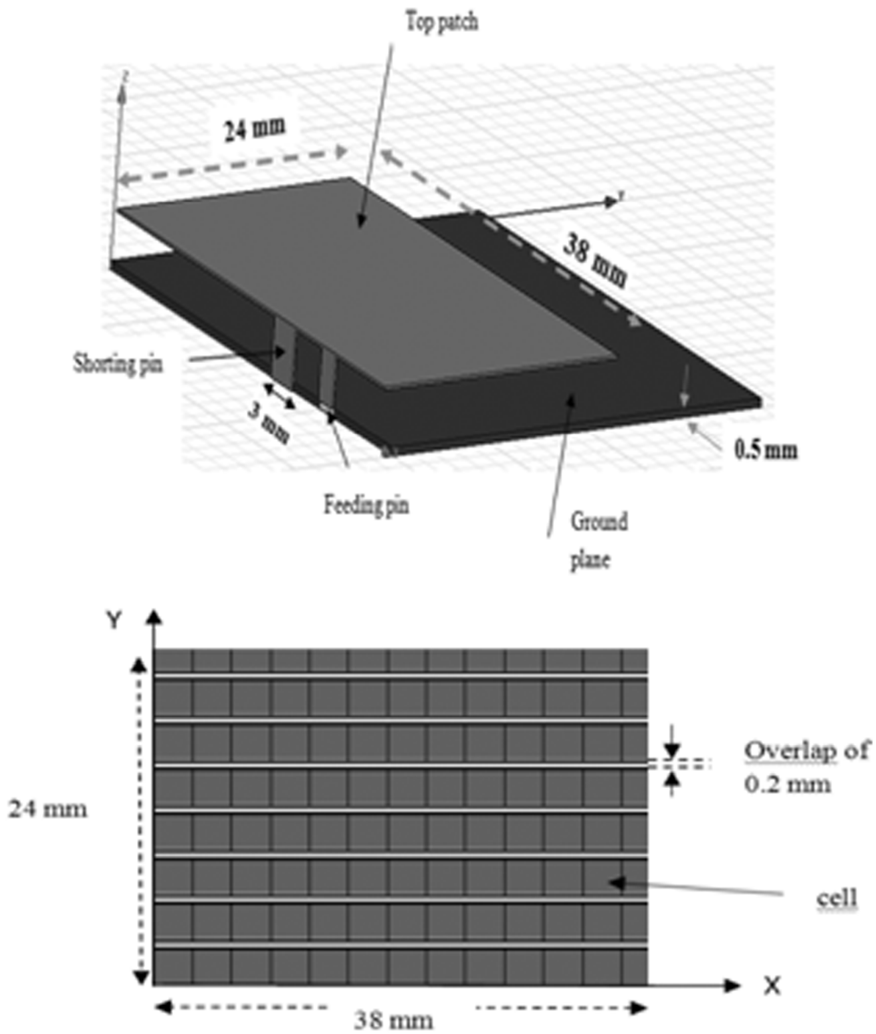


Figure 2: The geometry of the basic PIFA antenna

If a cell is existing , then the corresponding gene is assigned "1" and if a cell non-existent considered as slot, the gene takes the "0" value.

The fitness function F which is minimized in the search for the optimum solution is written as:

$$\frac{\sum_{i=1}^{N} S11(f(i))}{N} \tag{1}$$

In the equation above, $f(i)$ is the sampling frequency, N is the number of the sample, and $S11$ is the reflection coefficient.

In this GA procedure, 20 individuals are included in a generation. The simulations are carried out until convergence is achieved.The patch area was gridded into 104 cells and the ground plane was gridded into 182 cells.

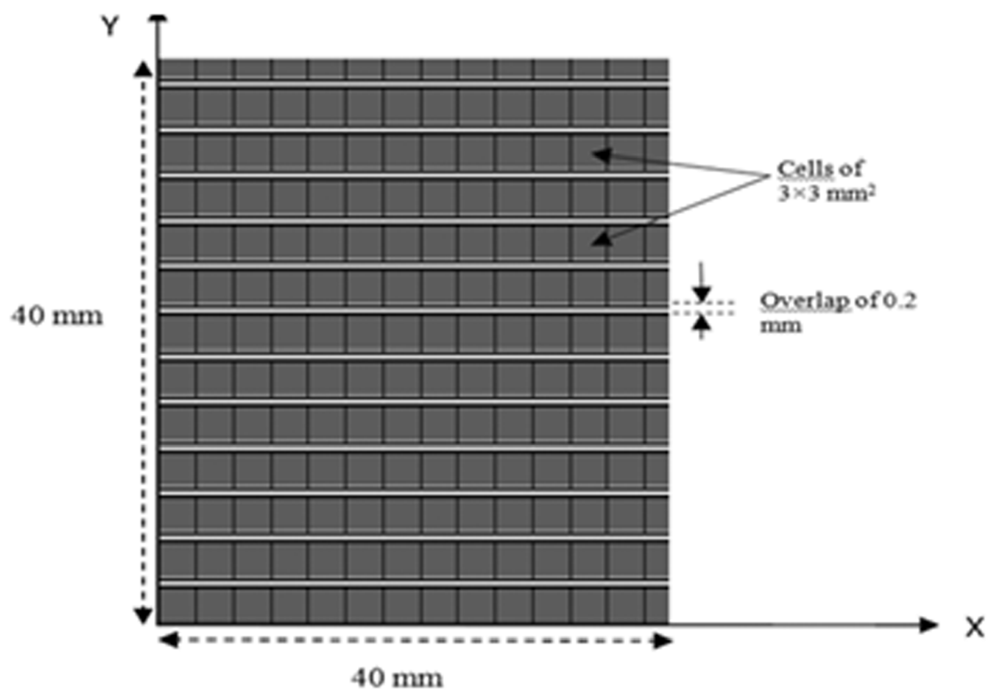


Figure 3: Cell distribution of the ground plane

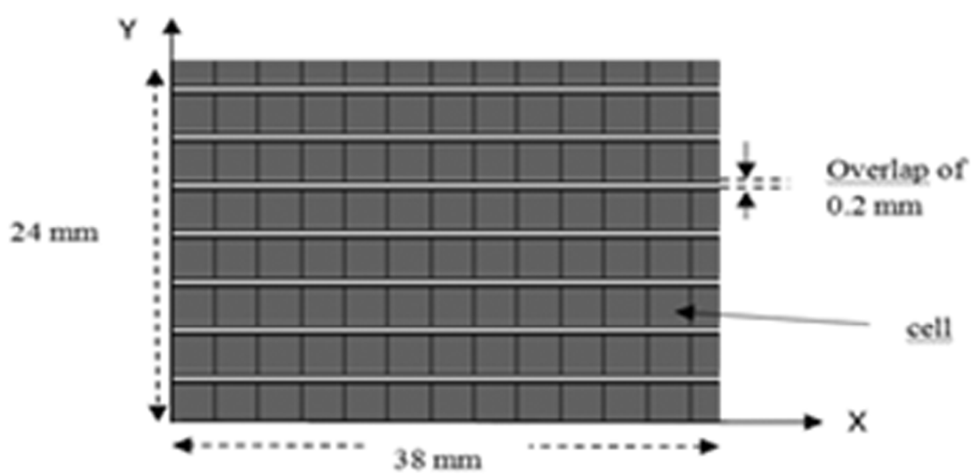


Figure 4: Cell distribution of the patch

3. RESULTS AND DISCUSSION

Figure.6 shows simulation results of the reflection coefficient. The valid radiating frequency of antenna is described by two parameters of antenna is “reflection coefficient” And “Voltage Standing Wave Ratio (VSWR)”. If reflection coefficient of antenna for specific frequency is more than -10dB it indicate that whatever power fed to antenna out of maximum power is rejected. So for good radiator return loss less than -10dB and VSWR is less than 2.

The purpose of our research is to found multiband antenna with GA that achieves a refection coefficient less than -10 dB in the frequency bands given from 3 GHz to 10 GHz, the GA determines the shape of the ground plane and the patch simultaneously which give better performance. The design of the antenna obtained by GA is shown in Figure 5.

A return loss characteristic for the structure (Figure 5) is shown in Figure 6.

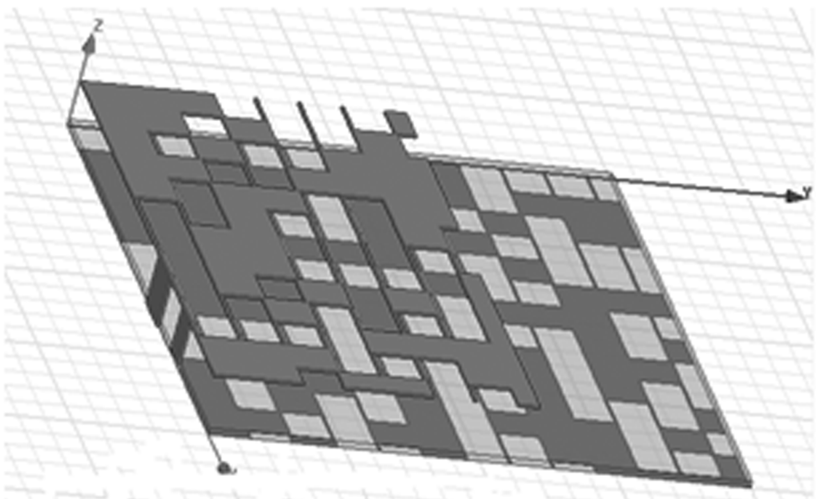


Figure 5: The PIFA antenna design by GA

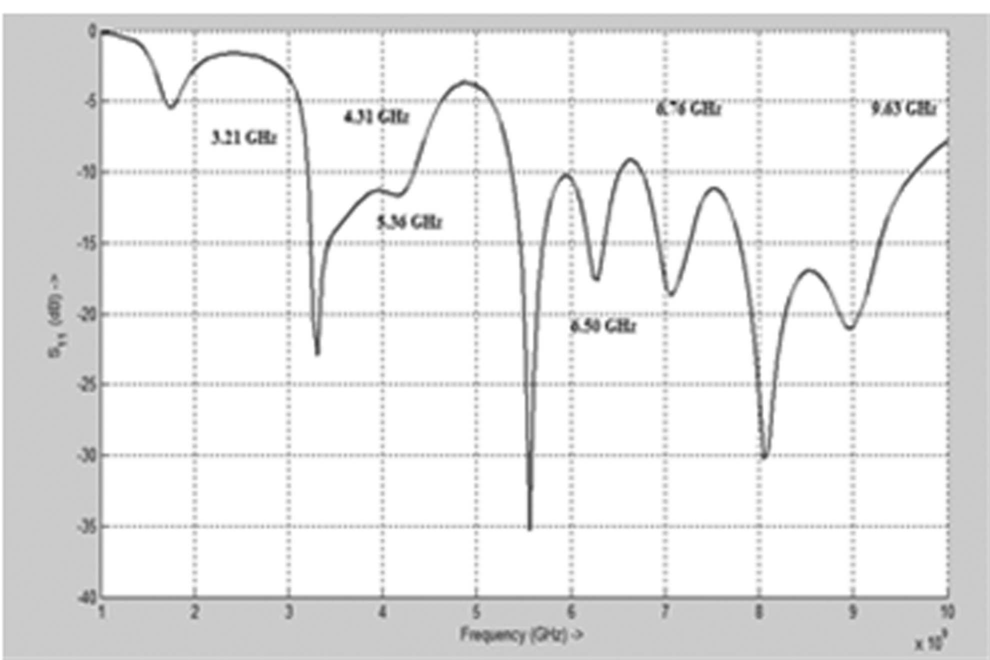


Figure 6: Return loss characteristic for the antenna

As illustrated in Figure.6, it is observed that by the new antenna shape, the lower frequency bandwidth is improved from 3.21 to 4.31 GHz covering middle band in WiMAX (3.3-3.7 GHz) and The bandwidth is 33.59%. The Second band start from 5.36 GHz to 6.50 GHz (band width value 20.29%) covering Hiper LAN/2 (5.47-5.725 GHz), WLAN (5.725-5.825 GHz) and WiMAX (5.25-5.85 GHz). The third band represents wideband starting from 6.76-9.63 GHz (38.82% bandwidth).

The VSWR was also observed in Figure.7 for same frequency, we got the VSWR value less than 2 for all the three bands.

The Figure 8 presents respectively the 2D radiation pattern at xz-plane and yz-plane for the three resonant frequencies 3.29 GHz, 5.57 GHz and 8.07 GHz. It can be observed that this antenna has a nearly omni-directional pattern.

The Figure 9 summarizes the mean antenna parameters as peak directivity, peak gain and radiation efficiency. The antenna presents good values for these parameters especially the gain and radiation efficiency. We can see from the figure that the value of gain (2.69 dB), directivity (2.85 dB) are important as well as the radiation efficiency (94.59%).

In the proposed antenna structure, by using both modified patch and ground plane with genetic algorithm we can give multi-band function and bandwidth improvement.

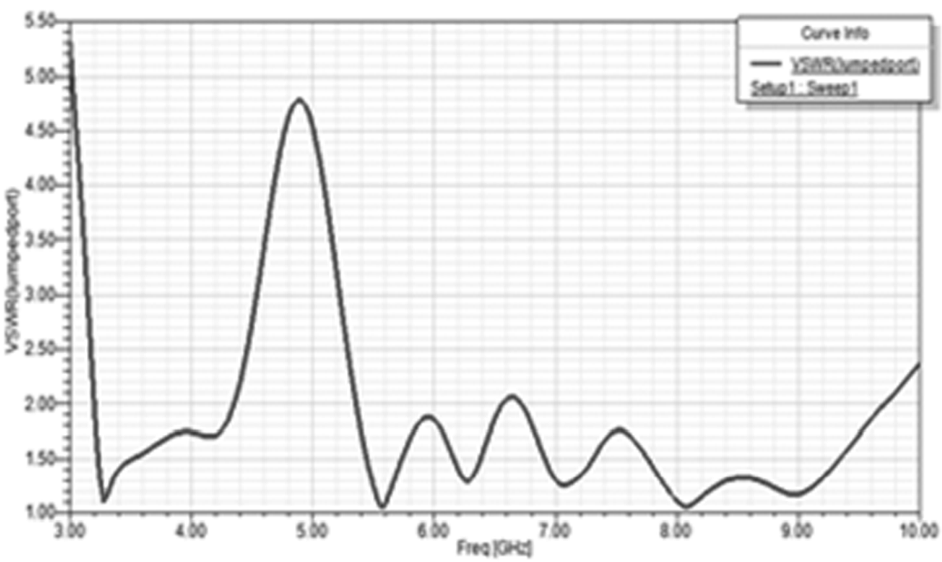
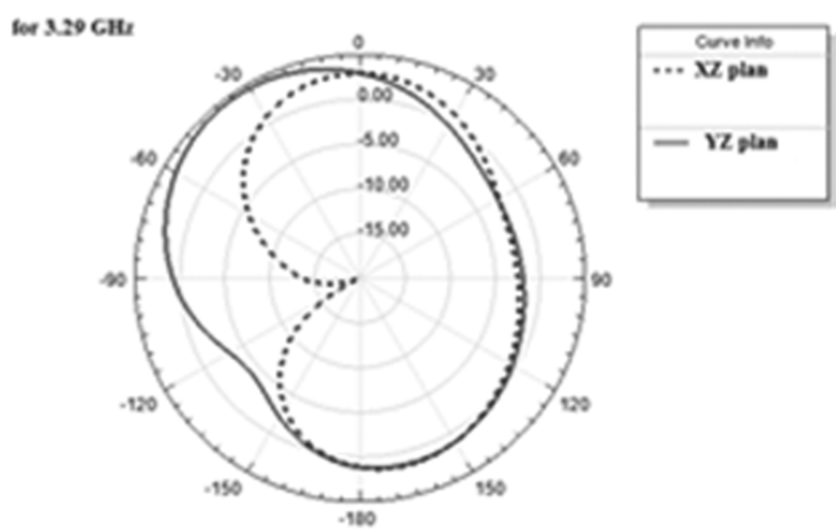


Figure 7: VSWR plot



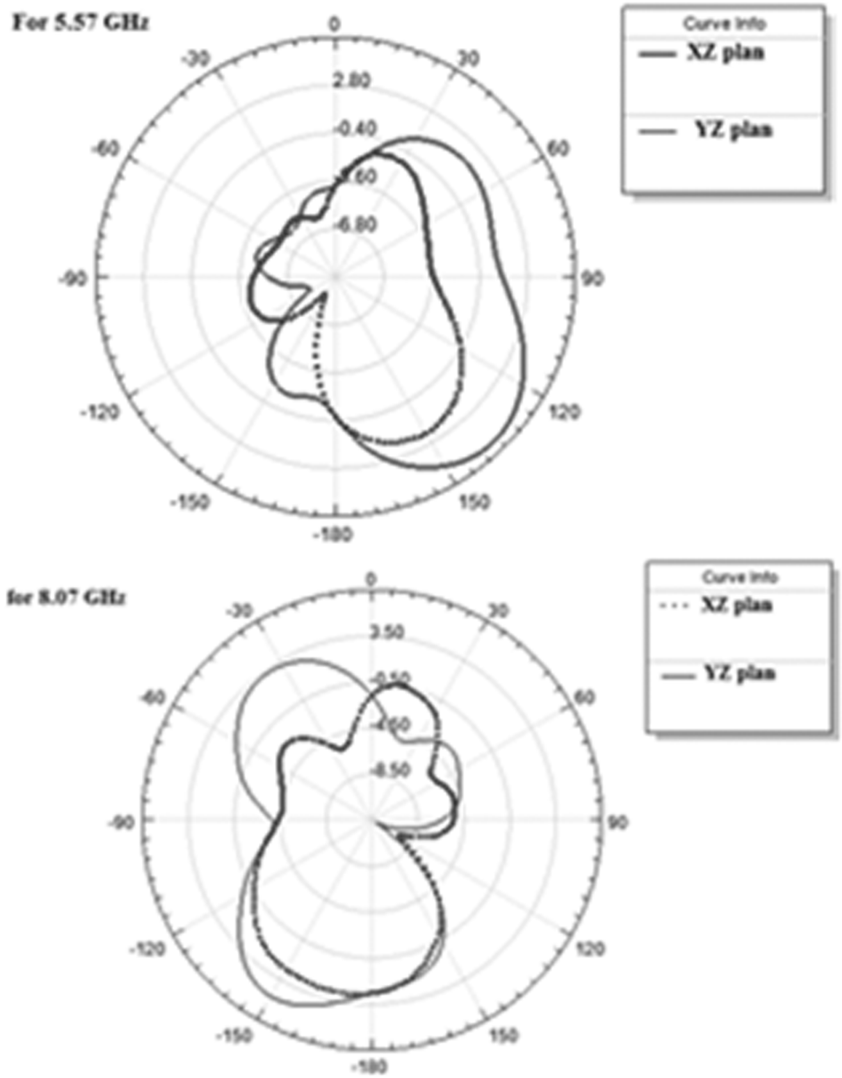


Figure 8: 2D radiation pattern for the three resonant frequencies 3.29 GHz, 5.57 GHz and 8.07 GHz

Antenna Parameters:

Quantity	Value	Units
Max U	0.21467	W/sr
Peak Directivity	2.8536	
Peak Gain	2.6992	
Peak Realized Gain	2.6977	
Radiated Power	0.9454	W
Accepted Power	0.99945	W
Incident Power	1	W
Radiation Efficiency	0.94592	
Front to Back Ratio	2.0626	

Figure 9: The antenna parameters

4. CONCLUSION

In this paper, genetic algorithm optimization method has been used to optimize the antenna shape, by using modified both ground plane and top patch with overlapping cells. This technique is demonstrated by the simulation results, which give new method to design PIFA antenna for multiband function and improve the bandwidth. This new designed antenna has small volume. Results show that the bandwidth is improved, obtaining a radiator useful for multiband function.

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