

Novel Miniaturized Multiband and Wideband PIFA Antenna for Wireless Applications

L.WAKRIM, S.IBANYAICH, M.M.HASSANI

I2SP Research team ,Faculty of Sciences Semlalia, Cadi Ayyad University

Marrakech, Morocco

E-mail: layla.wakrim@gmail.com

Abstract— Design of multiband antennas with low volume is of practical interest for the ever growing wireless communication industry. In this paper, the design of PIFA antenna with multiband resonance for WiMAX, WLAN, HIPERLAN/2 applications by using genetic algorithm (GA) is presented.

Genetic algorithm (GA) method was 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.

I. 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.

GA is used to optimize the antenna parameters [5], to the design of ultra-wideband antennas [6], to design dual band antenna [7-9].

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 and the section 3 simulation results of the new PIFA. Finally conclusions are given.

II. METHODOLOGY

1. Genetic Algorithm Theory

Our strategy employs Genetic algorithm (Fig.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.

- 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].

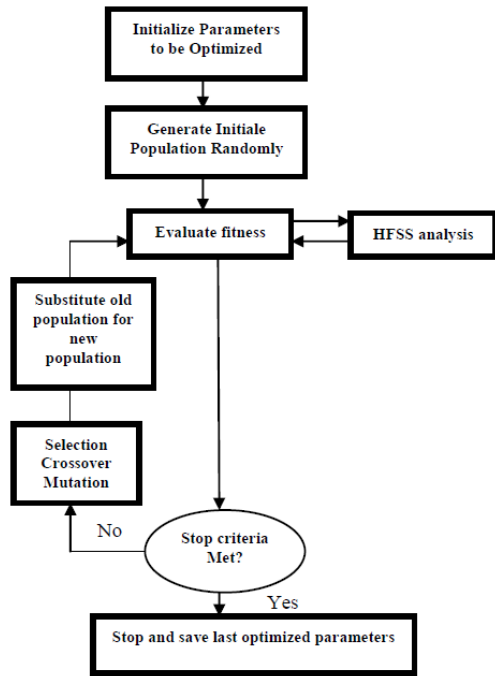


Fig. 1. : Genetic algorithm block diagram

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 $\epsilon_r=4.4$.

The initial PIFA design parameters are Top radiating plate Length = 38mm, Width = 24 mm, ground plane (40×40 mm²), and height (distance between ground and patch) is 3.4mm, Feed is microstrip line. We use Air as dielectric; Fig. 2 shows the geometry of the basic PIFA antenna.

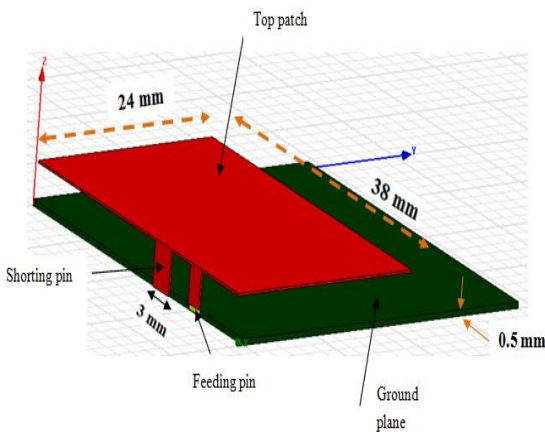


Fig. 2. The geometry of the basic PIFA antenna

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.

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:

$$F = \min \left(\sum_{i=1}^N S_{11}(f(i)) \right) / N \quad (1)$$

In the equation above, f (i) is the sampling frequency, N is the number of the sample, and the S_{11} 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

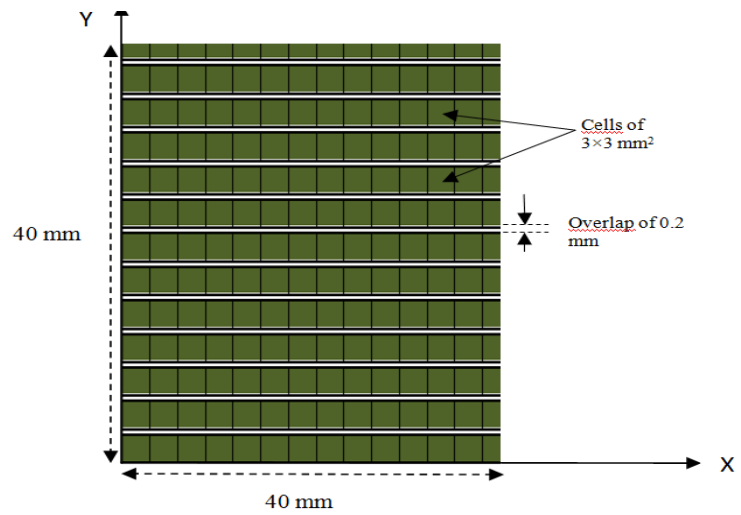


Fig. 3. Cell distribution of the ground plane.

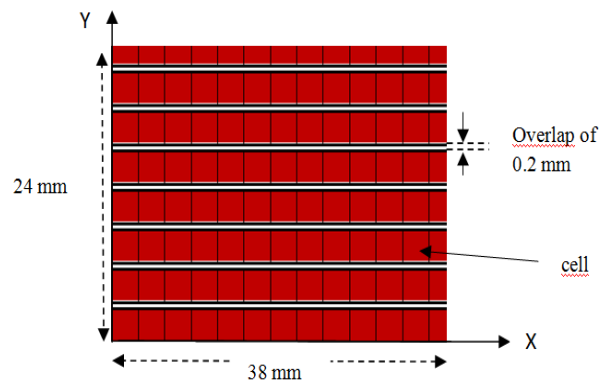


Fig. 4. Cell distribution of the patch

III. RESULT AND DISCUSSION

Fig.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 reflection 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 Fig.5.

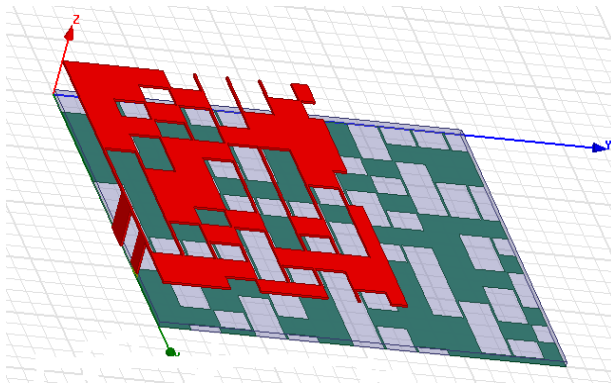


Fig. 5. The PIFA antenna design by GA

Return loss characteristics for the structure (Fig. 5) is shown in Fig.6.

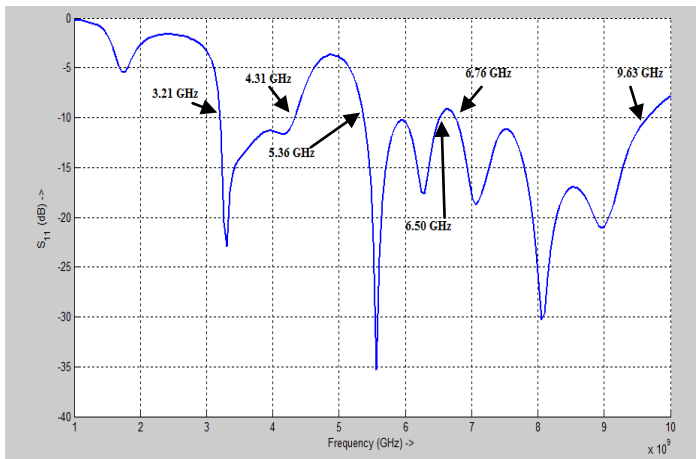


Fig. 6. Return loss characteristics for the antenna

As illustrated in Fig.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 (bandwidth value 20.29 %) covering HiperLAN/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 Fig.7 for same frequency, we got the VSWR value less than 2 for all the three bands.

The Fig.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 Fig.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.

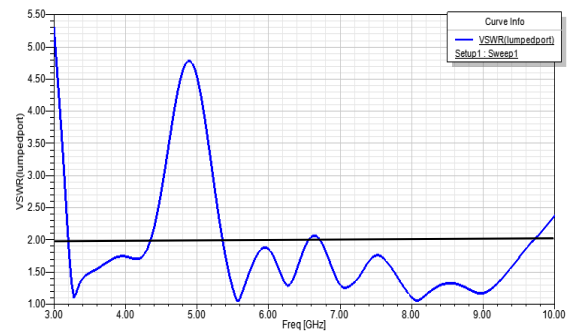
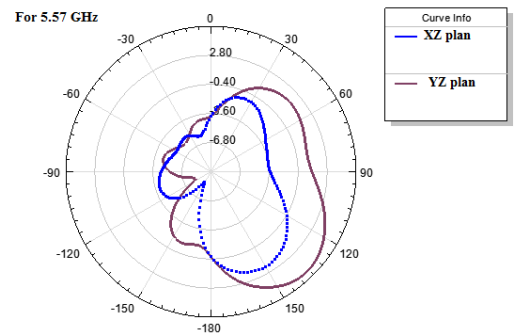
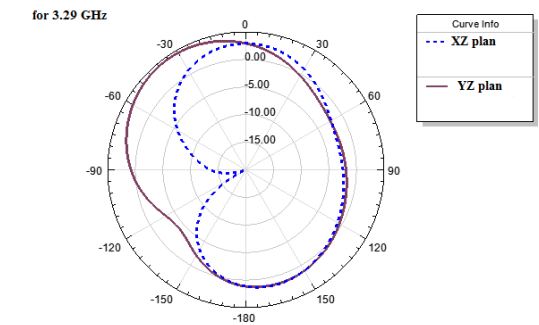


Fig. 7. VSWR Plot



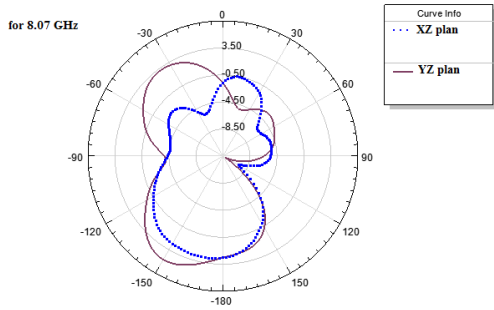


Fig. 8. 2D radiation pattern for the three resonant frequencies 3.29 GHz, 5.57 GHz and 8.07 GHz

Antenna Parameters:			
	Quantity	Value	Units
	Max U	0.21467	W/st
	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	

Fig. 9. The antenna parameters

IV. 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.

REFERENCES

- [1] N.Ojaroudi1, H.Ojaroudi , and N.Ghadimi” Quad-Band Planar Inverted-F Antenna (PIFA) for Wireless Communication Systems”, Progress In Electromagnetics Research Letters, Vol. 45, pp:51–56, 2014.
- [2] D. Y. Su, D. M. Fu, and D. Yu “Genetic algorithm and method of moments for the design of PIFAS”, Progress In Electromagnetics Research Letters, Vol. 1, pp:9–18, 2008
- [3] P.Pinho, J.F Rocha Pereira. “Design of a PIFA antenna using FDTD and genetic algorithms” Antennas and Propagation Society International Symposium, IEEE (Volume:4), Boston, MA, USA, 8-13 July 2001
- [4] Johnson, J.M. ; Rahmat-Samii, Y. Genetic algorithm optimization and its application to antenna design”, Antennas and Propagation Society International Symposium, 1994. AP-S. Digest (Volume:1) 20-24 June 1994, Seattle, WA, USA
- [5] R. S´anchez-Montero, S. Salcedo-Sanz and J. A. Portilla-Figueras « Hybrid pifa-patch antenna optimized by evolutionary programming”, Progress In Electromagnetics Research, Vol. 108, 221–234, 2010
- [6] Kerkhoff, A. ; Rogers, R. ; Hao Ling “The use of the genetic algorithm approach in the design of ultra-wideband antennas” Radio and Wireless Conference, 2001. RAWCON 2001. IEEE, 2001, Waltham, MA
- [7] Jayasinghe, J.M.J.W. ; Uduwawala, D.N. “Design of a dual band antenna for Bluetooth and HIPERLAN2 applications using genetic algorithm optimization”, Industrial and Information Systems (ICIS), 2011 6th IEEE International Conference on, 16-19 Aug. 2011, Kandy
- [8] L.Wakrim, S.Ibnyaich, M.M.Hassani “Dual band PIFA antenna for WiMAX application obtained by using gridded ground plane and genetic algorithm”, The MacroTrend Conference on Physical and Life Sciences, December 19-20, 2014 in Paris, France
- [9] L.Wakrim, S.Ibnyaich, M.M.Hassani, “Dual band antenna by combining PIFA and fragmented ground plane using genetic algorithm”, 2nd workshop on smart cities, 30 mai 2015, Agadir-Morocco
- [10] L.Wakrim, S.Ibnyaich, M.M.Hassani,” Optimization by genetic algorithm of a PIFA antenna parameters for Wifi application” (2014 International Conference on Multimedia Computing and Systems (ICMCS), April 14-16 Marrakech) .