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# OPTIMIZATION OF DUAL BAND MICROSTRIP ANTENNA USING PSO

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**Abstract-This paper presents particle swarm optimization (PSO) method based design of a dual-band patch antenna using IE3D™. The method effectively obtains the geometric parameters for efficient antenna performance. Maximum return loss obtained at 2.4 GHz is -43.95 dB and at 3.08 GHz is -27.4dB. Its bandwidth of 33.54 MHz ranges from 2.38355 GHz to 2.41709 GHz.**

Index Terms: Microstrip antennas, PSO, Dual band antennas, IE3D E M Simulator

## I. INTRODUCTION

Recent developments in communication systems such as the global positioning systems (GPS), Wireless local network (WLAN), vehicular satellite communication and wireless communications often require antennas with compact size, low cost and capable of operating more than one band of frequencies. For these applications, new research motivations have evolved for design of dual band Microstip antenna [1-6]. One such proposed technique is the embedding of slots inside a Microstip antenna to produce dual frequency response. To achieve this, narrow slots are positioned parallel to the non-radiating edges of a rectangular patch.

In recent years, many Electromagnetic simulation software are available for design of Microstrip antennas. Among them, the one of the powerful electromagnetic simulation software is IE3D. Besides the optimization schemes viz. Random optimizer, Powell optimizer, Adaptive optimizer & Genetic optimizer available in IE3D, there are several other optimization techniques available such as (i) Particle swarm optimization (PSO) (ii) Genetic Algorithm (iii) Simulated annealing etc [7-8]. The PSO algorithm is very suitable and relatively simple method for optimization of electromagnetic problems [9].
In this paper, a combination of IE3D and PSO algorithm is used to design dual band Microstip patch antenna and simulation and optimization results are presented.

## II. DESIGN OF DUAL BAND MICROSTRIP ANTENNA (IE3D/PSO)

The antenna structure (Fig. 1) consists of a rectangular patch dimension W × L with two slots into one of the radiating edges, and is excited using an inset planar feed [3]. The patch design consists of two stages. The first stage involves the creation of an additional TM0δ resonant mode at a resonant frequency above that of the fundamental TM01 mode, with the same polarization sense. The second stage is to simultaneously reduce the input impedance of both modes to 50Ω at resonance through the use of an inset feed.

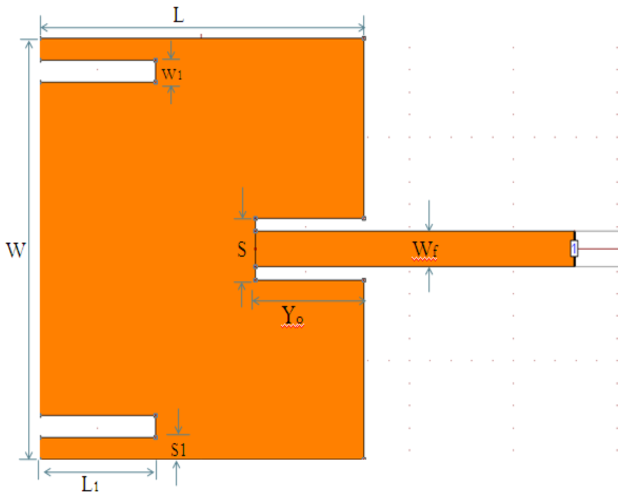


Figure 1: Geometry of inset-fed dual-frequency patch antenna

Since the operating frequencies of this resonant-type antenna are closely related to current path lengths in the patch, the six geometrical parameters in Figure 1, including the patch length $L$, the patch width $W$, the slot length $L_1$, the slot width $W_1$, the slot position $P_1$, and the feed position $Y_0$ are optimized using

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IE3D/PSO. The parameters defined by IE3D are generally controlled by bound and direction with fixed rate.

In this paper, design method by combining Particle swarm optimization (PSO) with IE3D is used to obtain the parameters of dual band rectangular patch antenna in order to avoid overlapping problems arising in IE3D simulation. Particle swarm optimization (PSO) is a robust stochastic evolutionary computation technique based on the movement and intelligence of swarm. The algorithm is formulated using the equations given below [8]-[10].

$$v_{id} = w \times v_{id-1} + c_1 \times \eta_1 \times (p_{id-1} - x_{id-1}) + c_2 \times \eta_2 \times (p_{gd} - x_{id-1}) \quad (1)$$

$$x_{id} = x_{id-1} + v_{id} \quad (2)$$

Where $v_{id}$ is the velocity & $p_{id}$ is the best position of $i^{th}$ particle along the *d*th dimension, $x_{id}$ is the position of particle and $p_{gd}$ is the global best particle position, $c_1$ & $c_2$ are two positive constants. $\eta_1$ and $\eta_2$ are two random functions in the range (0, 1). $W$ is the inertia weight.

Table 1

Design parameter of microstrip patch antenna ($\varepsilon_r$=2.4, h=1.58 mm) all dimensions are in **mm**

| Bounds | Length | Width | Inset Depth | Slot length | Slot width |
|---|---|---|---|---|---|
| Lower | 35 | 40 | 10 | 10 | 0.5 |
| Higher | 45 | 50 | 18 | 18 | 2.5 |

Table 2

Optimization parameter of microstrip patch antenna using IE3D/PSO ($\varepsilon_r$=2.4, h=1.58) all dimensions are in mm

| Length | Width | Inset Depth | Slot length | Slot width |
|---|---|---|---|---|
| 39.6226 | 49.000 | 13.2726 | 14.310 | 1.400 |

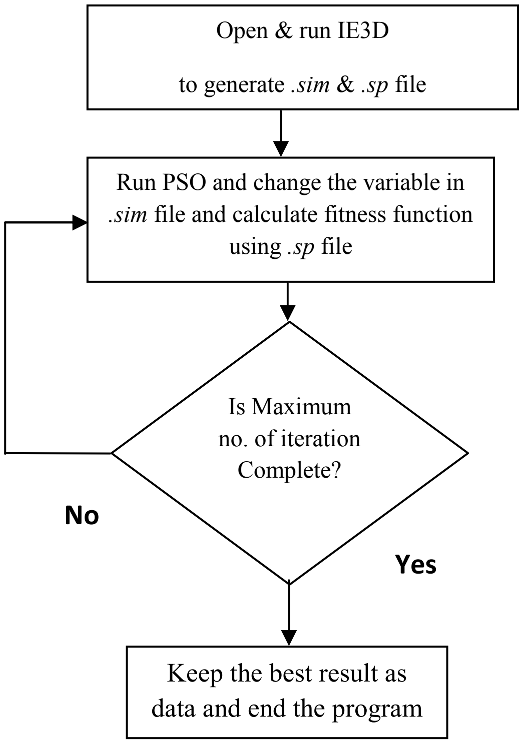


Figure 2: Flow chart of IE3D/PSO

## III. Method of Design and Optimization

The flow chart of interfacing between IE3D/PSO is shown in fig. 2. The variables for optimization defined by IE3D are saved in a *.sim* file, and the simulated results of return loss are saved in a *.sp* file. By changing the variables saved in the *.sim* file using the PSO program, an optimization for complicated structure can be performed. Fitness function value is obtained by calculating the simulated results saved in the *.sp* file. The design parameters for the antenna are listed in Table 1 and optimized parameters of the antenna are listed in Table2.

In this paper, the number of particles in a swarm is set to be 10 and the maximum number of iterations is set as 1000. The rectangular patch antenna is designed with resonant frequency at 2.4 GHz. the fitness function is given by eqn. (3) for optimization of VSWR.

$$\text{Fitness} = \min(S_{11}{}^{2}{}_{n}) \quad (3)$$

Where subscript n refers to sample points in the return loss versus frequency. The simulation took 8-hours

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(approx) on a HP Pentium-IV desktop with 2GB RAM.

## IV. RESULTS AND DISCUSSION

The patch antenna was designed with operating frequencies of 2.4 GHz, with a dielectric constant ($\epsilon_r$) of 2.4 and thickness of $1/16^{th}$ of inch. The patch was fed with a 50Ω inset-fed Microstrip-line (Fig. 1). This optimized antenna is simulated using IE3D$^{TM}$ (version14.0). The simulated return loss curves are shown in Figure 3. It shows a maximum return loss at 2.4 GHz is -43.95dB and at 3.08 GHz is -27.41dB.The lower bandwidth of 33.54 MHz (< -10dB) ranges from 2.38355 GHz to 2.41709 GHz. The plots of radiation pattern in Polar form are shown in Figure 4& 5.The maximum gain of 6.67 dBi in the broadside direction for both V = 0 and V = 90 degrees and a half power beamwidth (HPBW) is obtained.

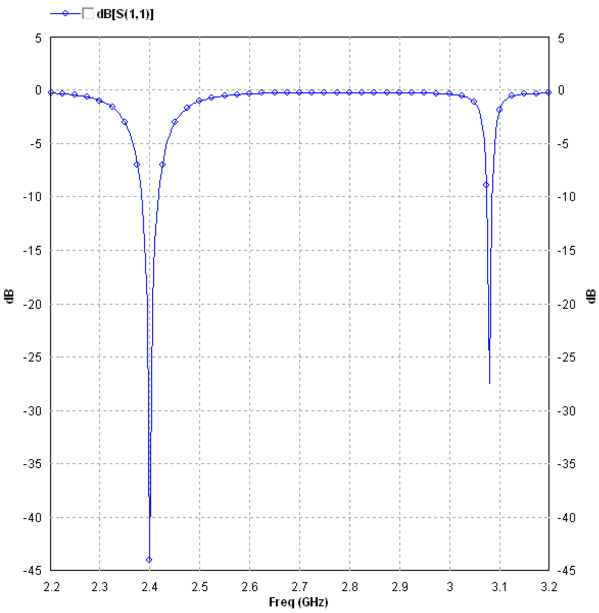


Fig.3: Return Loss versus Frequency plot for Optimized Antenna

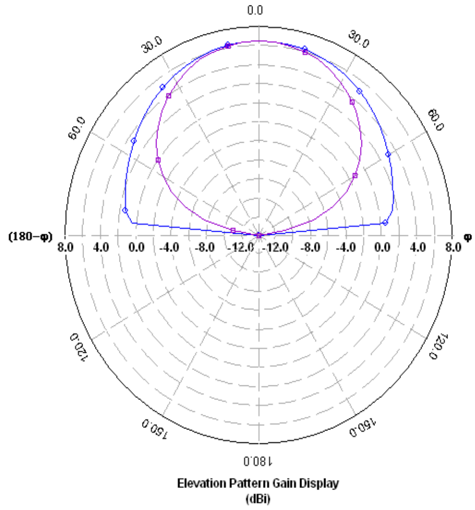


Fig. 4: Radiation Pattern in Polar form for the Optimized Antenna at frequency 2.4GHz

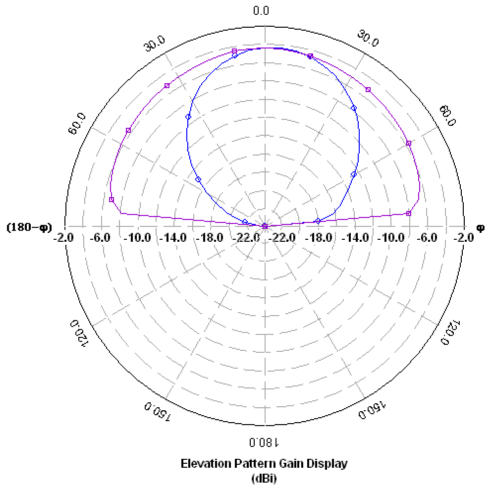


Fig. 5: Radiation Pattern in Polar form for the Optimized Antenna at frequency 3.08 GHz

## *V. CONCLUSION*

The design optimization of a dual slot patch antenna has been presented and discussed. It has been shown that with correct selection of slot dimensions and positions, a dual frequency response can be achieved. This design is obtained by combining PSO, an evolutionary optimization method, with IE3D. The use of a planar feed presents a significant advantage as it allows easier integration with associated microwave circuitry and can also be easily extended for incorporation into antenna arrays. Experimental verifications are underway.

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