Analysis of Elliptical Patch Antenna using Particle Swarm Optimization Algorithm

Sonia Chhabra[1], Er. Sukhdeep Kaur[2]
[1, 2]Electronics and Communication, JCDM College of Engineering, Sirsa, India

***Abstract*—** The work have been carried out to analyze the design parameters of hexagonal patch Antenna with coaxial feedings. With the use of coaxial cable as a radiating element in microstrip antenna efficiency up to 98.64% has been achieved. Different ground dimensions have been taken for better current distribution results. The dimension of the microstrip antenna also has an effect on the antenna performance because the current is distributed along the edge on the radiator. Moreover different slots have been made in ground to make better current distribution. Also different substrate materials have been used to study material effects on antenna performance. The Microstrip Antenna design technology is having a wide future scope in communication.

Keyword: Hexagonal Patch, PSO

I. INTRODUCTION

Microstrip patch antenna is used for high-performance spacecraft, aircraft, missile and satellite applications, where size, weight, cost, performance, ease of installation, and aerodynamic profile are constraints. These patch antennas are low-profile, conformable to planar and non-planar surfaces, simple and inexpensive to manufacture using modern printed circuit technology. They are also mechanically robust when mounted on rigid surfaces and compatible with MMIC designs. When a patch shape is selected they are very versatile in terms of resonant frequency, polarization, radiation pattern, and impedance.

Since particle swarm optimization (PSO) was introduced [1], many modifications to the original algorithm have been proposed .In many cases, the changes may be seen as algorithmic components that provide a better performance. These algorithmic components range from added constants in the particles' velocity update rule [5] to stand-alone algorithms that are used as components of hybrid PSO algorithms [6]. In this work, it is presented the results of various PSO algorithms. The comparison focuses on the difference between updating a particle's velocity, although other factors such as the selection of the population topology, the number of particles, and the strategies for updating at run time various parameters that influence performance are also considered. The comparison of PSO variants is performed with their most commonly used parameter settings. The experimental setup and the choice of the PSO variants allow the identification of performance differences that can be ascribed to specific algorithmic components and their interactions and, hence, contribute to an improved understanding of the PSO approach.

II. PSO ALGORITHM

Particle swarm optimization (PSO) is a population based optimization technique developed by Dr. Eberhart and Dr. Kennedy in 1995, inspired by social behaviour of bird flocking or fish schooling [1]. PSO shares many similarities with evolutionary computation techniques such as Genetic Algorithms (GA). The system is initialized with a population of random solutions and searches for optima by updating generations. However, unlike GA, PSO has no evolution operators such as crossover and mutation. In PSO, the potential solutions, called particles, fly through the problem space by following the optimized particles.

Each particle keeps track of its coordinates in the problem space which are associated with the best solution (fitness) it has achieved so far. (The fitness value is also stored.) This value is called *pbest*. Another "best" value that is tracked by the particle swarm optimizer is the best value, obtained so far by any particle in the neighbours of the particle. This location is called *lbest*. When a particle takes all the population as its topological neighbours, the best value is a global best and is called *gbest* [1].

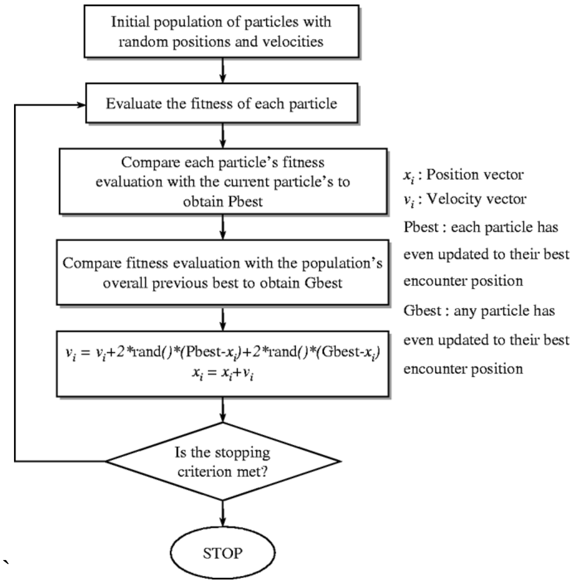
The particle swarm optimization concept consists of, at each time step, change in the velocity of each particle toward its p*best* and *lbest* locations. Acceleration is weighted by a random term, with separate random numbers being generated for acceleration toward *pbest* and *lbest* locations.

In past several years, PSO has been successfully applied in many research and application areas. It is demonstrated that PSO gets better results in a faster, cheaper way compared with other methods.

Another reason that PSO is attractive is that there are few parameters to adjust. One version, with slight variations, works well in a wide variety of applications. Particle swarm optimization has been used for approaches that can be used across a wide range of applications, as well as for specific applications focused on a specific requirement.

v[] = v[] + c1 * rand() * (pbest[] - present[]) + c2 * rand() * (gbest[] present[]) (a)
present[] = persent[] + v[] (b)

v[] is the particle velocity, persent[] is the current particle (solution). pbest[] and gbest[] are defined as stated before. rand () is a random number between (0,1). c1, c2 are learning factors. usually c1 = c2 = 2.



III. ANTENNA DESIGN

The proposed elliptical antennas with coaxial feeding is illustrated in Fig 1 The antenna has been designed on FR4 substrate with height of 1.6 mm with relative dielectric constant 4.4. The elliptical patch has radius 10mm with A/B ratio 1.6. Some slot has been cut on the patch with width 0.5mm.

Different defected ground with different slots(L and T) and different dimensions have been chosen for study of their effects on the performance.

A. DGS with T slot using coaxial feeding with single slot patch

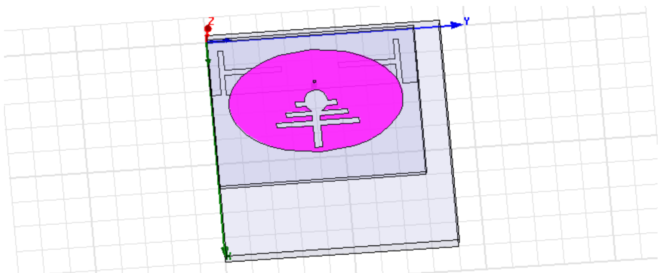


Fig.1 design with single slot

B. DGS with T slot using coaxial feeding with double slot patch

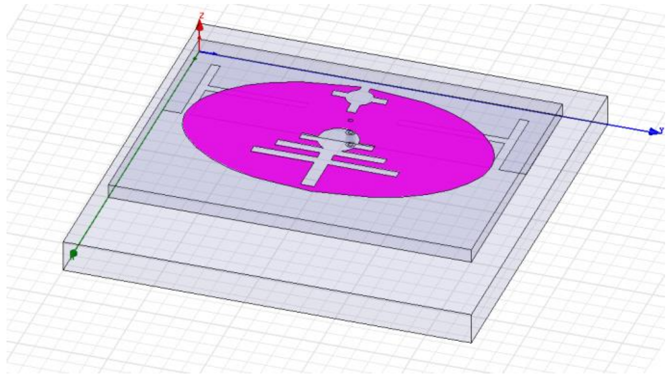


Fig.2 Design with double slot

TABLE 1: DIMENSIONS USED

Component	**Dimensions in mm**
Ground	30*40
Substrate	30*40*1.6
Elliptical patch major radius	10.6
Elliptical patch ratio	1.6
Radiation box	45*45*3.5
Feeding position	(10,20) from center
Coaxial radius	0.5
Coaxial pin and probe radius	0.25
Feeding length	1.5
Ground slots width	0.5
Patch slots width	0.5

IV. RESULTS AND DISCUSSION

In this paper the performance of elliptical microstrip antenna for various applications are investigated through the simulations and numerous techniques have been exploited to improve their performance. Efficiency obtained is 98.66 and radiated power is 0.078103W and accepted power is 0.079151W The antenna is fed by a 50 Ω microstrip line and printed on a dielectric substrate of dimension (40mm X 30 mm) permittivity εr =4.4 and height h = 1.6 mm. The optimization on the planar elliptical microstrip has been done at various frequencies for different application such as WLAN, WI–max, satellite communication, USART. Basic results obtained through simulation are given below:

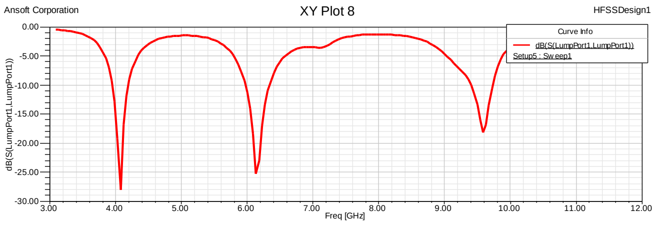


Fig. 3 Results obtained

V. CONCLUSION AND FUTURE SCOPE

In this thesis, a planar elliptical microstrip slot antenna is investigated for various parameters affecting its performance. The antenna have various applications in Radar, Spacecraft & satellite communication devices. Effects of different slotted grounds with different dimensions have been observed. Also effect of different materials on the performance have been studied.

The optimization of the Microstrip Patch is partially realized which concludes that the PSO code was functioning correctly. The further scope of work revolves around increasing up efficiency and decreasing the run time of the PSO code by using a better computing platform. Realization of results by the modified PSO would be concluded with the comparision of the patch of the Microstrip Patch Antenna simulation. The investigation has been limited mostly to theoretical study due to lack of distributive computing platform. Detailed experimental studies can be taken up at a later stage to find out a design procedure for balanced amplifying antennas.

As a methodological approach, in-depth proper studies can help in identifying positive and negative interactions among algorithmic components and provide strong guidance for the informed design of better algorithms. Another portion of PSO variants would have probably ends up with a different PSO algorithm. For this reason, further research is required to understand which components are better suited and whether some components can be integrated into the same composite algorithm or not. Methods to quantify the contribution of each component on the composite algorithms' final performance are also needed to achieve this goal.

The result obtained with PSO optimization is given below

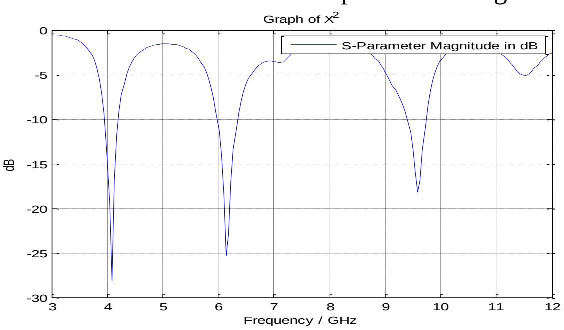


Fig.4: Analysis results through PSO

It is clear that optimized result very closely match with the simulated results.

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