

# Analysis of Elliptical Patch Antenna using Particle Swarm Optimization Algorithm

Sonia Chhabra<sup>1</sup>, Er. Sukhdeep Kaur<sup>2</sup>

<sup>1, 2</sup>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 *pbest* and *lbest* locations. Acceleration is weighted by a random term, with separate random numbers being generated for acceleration toward *pbest* and *lbest* locations.

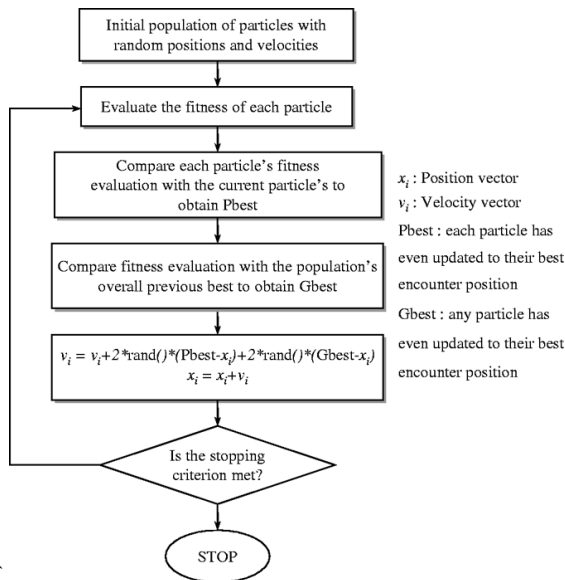
In past several years, PSO has been successfully applied in many research and application areas. It is demonstrated that PSO gets better results in a faster, cheaper way compared with other methods.

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.

$$v[] = v[] + c1 * \text{rand}() * (pbest[] - \text{present}[]) + c2 * \text{rand}() * (gbest[] - \text{present}[]) \quad (a)$$

$$\text{present}[] = \text{present}[] + v[] \quad (b)$$

$v[]$  is the particle velocity,  $\text{present}[]$  is the current particle (solution).  $pbest[]$  and  $gbest[]$  are defined as stated before.  $\text{rand}()$  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

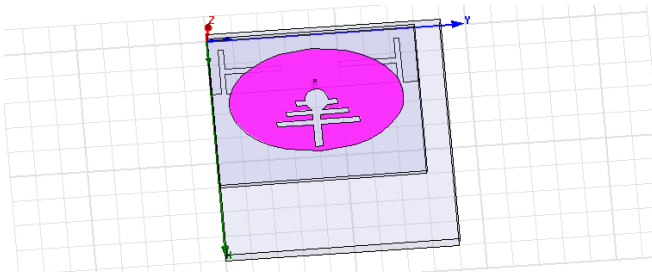


Fig.1 design with single slot

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

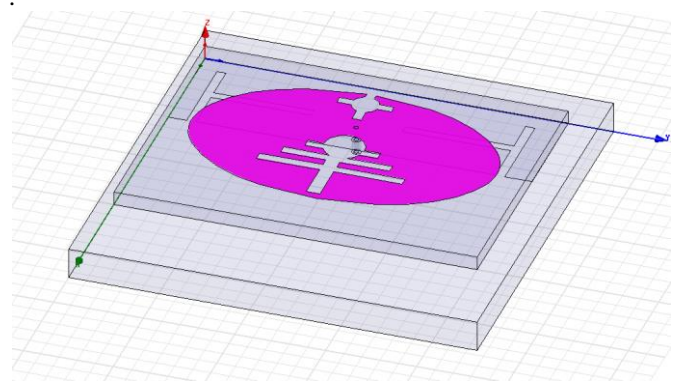


Fig.2 Design with double slot

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  $\epsilon_r = 4.4$  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:

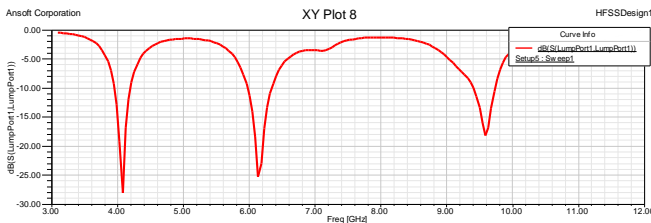


Fig. 3 Results obtained

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 comparison 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

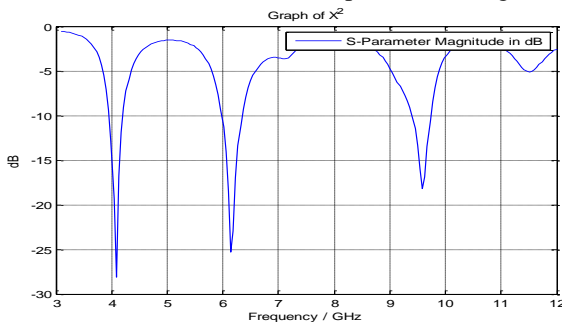


Fig.4: Analysis results through PSO

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

ACKNOWLEDGMENT

Authors acknowledge the support of all the staff of Department of Electronics Engg., JCDM college of engg, sirsra.

REFERENCES

- [1] J. Kennedy and R. Eberhart, "Particle swarm optimization," in Proc. IEEE Int. Conf. Neural Netw., 1995, pp. 1942–1948.
- [2] A. P. Engelbrecht, Fundamentals of Computational Swarm Intelligence. 1st ed. Chichester, U.K.: Wiley, 2005.
- [3] M. Clerc, Particle Swarm Optimization. 1st ed. London, U.K.: Wiley-ISTE, 2006.
- [4] R. Poli, J. Kennedy, and T. Blackwell, "Particle swarm optimization. An overview," Swarm Intell., vol. 1, no. 1, pp. 33–57, 2007.
- [5] M. Clerc and J. Kennedy, "The particle swarm—explosion, stability, and convergence in a multidimensional complex space," IEEE Trans. Evol. Comput., vol. 6, no. 1, pp. 58–73, Feb. 2002.
- [6] S.-K. S. Fan and E. Zahara, "A hybrid simplex search and particle swarm optimization for unconstrained optimization," Eur. J. Oper. Res., vol. 181, no. 2, pp. 527–548, 2007.
- [7] Y. Shi and R. Eberhart, "Parameter selection in particle swarm optimization," in Proc. 7th Int. Conf. Evol. Program., LNCS vol. 1447, 1998, pp. 591–600.
- [8] R. Eberhart and Y. Shi, "Comparing inertia weights and constriction factors in particle swarm optimization," in Proc. IEEE Congr. Evol. Comput. 2000, pp. 84–88.
- [9] I. C. Trelea, "The particle swarm optimization algorithm: Convergence analysis and parameter selection," Inform. Process. Lett., vol. 85, no. 6, pp. 317–325, 2003.
- [10] Y. Shi and R. Eberhart, "A modified particle swarm optimizer," in Proc. IEEE Int. Conf. Evol. Comput., 1998, pp. 69–73.
- [11] Y. Shi and R. Eberhart, "Empirical study of particle swarm optimization," in Proc. IEEE Congr. Evol. Comput. 1999, pp. 1945–1950.
- [12] Y.-L. Zheng, L.-H. Ma, L.-Y. Zhang, and J.-X. Qian, "On the convergence analysis and parameter selection in particle swarm optimization," in Proc. IEEE Int. Conf. Mach. Learning Cybern. 2003, pp. 1802–1807.
- [13] Y.-L. Zheng, L.-H. Ma, L.-Y. Zhang, and J.-X. Qian, "Empirical study of particle swarm optimizer with an increasing inertia weight," in Proc. IEEE Congr. Evol. Comput. 2003, pp. 221–226.
- [14] R. Eberhart and Y. Shi, "Tracking and optimizing dynamic systems with particle swarms," in Proc. IEEE Congr. Evol. Comput. 2001, pp. 94–100.
- [15] R. Mendes, J. Kennedy, and J. Neves, "The fully informed particle swarm: Simpler, maybe better," IEEE Trans. Evol. Comput., vol. 8, no. 3, pp. 204–210, Jun. 2004.
- [16] A. Ratnaweera, S. K. Halgamuge, and H. C. Watson, "Self-organizing hierarchical particle swarm optimizer with time-varying acceleration coefficients," IEEE Trans. Evol. Comput., vol. 8, no. 3, pp. 240–255, Jun. 2004.
- [17] S. Janson and M. Middendorf, "A hierarchical particle swarm optimizer and its adaptive variant," IEEE Trans. Syst., Man, Cybern. B, Cybern., vol. 35, no. 6, pp. 1272–1282, Dec. 2005.
- [18] J. J. Liang, P. N. Suganthan, and K. Deb, "Novel composition test functions for numerical global optimization," in Proc. IEEE Swarm Intell. Symp., 2005, pp. 68–75.
- [19] P. N. Suganthan, N. Hansen, J. J. Liang, K. Deb, Y.-P. Chen, A. Auger, and S. Tiwari, "Problem definitions and evaluation criteria for the CEC 2005 special session on real-parameter optimization," Nanyang Technological Univ., Singapore and IIT, Kanpur, India, Tech. Rep. 2005005, 2005.
- [20] M. A. Montes de Oca, T. Stützle, M. Birattari, and M. Dorigo. (2008, July). Frankenstein's PSO: Complete Data [Online]. Available: <http://iridia.ulb.ac.be/supp/IridiaSupp2007-002/>

- [21] R. Mendes, "Population topologies and their influence in particle swarm performance," Ph.D. dissertation, Escola de Engenharia, Universidade do Minho, Portugal, 2004.
- [22] A. Mohais, R. Mendes, C. Ward, and C. Posthoff, "Neighborhood restructuring in particle swarm optimization," in Proc. 18th Australian Joint Conf. Artificial Intell., LNCS vol. 3809. 2005, pp. 776–785.
- [23] H. H. Hoos and T. Stützle, *Stochastic Local Search: Foundations and Applications*. 1st ed. San Francisco, CA: Morgan Kaufmann, 2004.
- [24] J. Niehaus and W. Banzhaf, "More on computational effort statistics for genetic programming," in Proc. 6th Eur. Conf. Genetic Program. EuroGP 2003, LNCS vol. 2610. pp. 164–172.
- [25] M. A. Montes de Oca, T. Stützle, M. Birattari, and M. Dorigo, "comparison of particle swarm optimization algorithms based on runlength distributions," in Proc. 5th Int. Workshop, Ant Colony Optimization Swarm Intell. (ANTS '06), LNCS vol. 4150, 2006, pp. 1–12.
- [26] M. A. Montes de Oca and T. Stützle, "Convergence behavior of the fully informed particle swarm optimization algorithm," in Proc. Genetic Evol. Comput. Conf. (GECCO), 2008, pp. 71–78.
- [27] R. Poli, "On the moments of the sampling distribution of particle swarm optimisers," in Proc. Workshop Particle Swarm Optimization: 2nd Decade. Genetic Evol. Comput. Conf. (GECCO). 2007, pp. 2907–2914.
- [28] J. Wang and D. Wang, "Experiments and analysis on inertia weight in particle swarm optimization," in Proc. Int. Conf. Service Syst. Manage., 2004, pp. 655–659
- [29] Marco A. Montes de Oca, Thomas Stützle, Mauro Birattari, "Frankenstein's PSO: A Composite Particle Swarm Optimization Algorithm" in IEEE TRANSACTIONS ON EVOLUTIONARY COMPUTATION, VOL. 13, NO. 5, OCTOBER 2009