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Optimal Design and Analysis of Micro-Strip Antenna's Using Evolutionary Algorithms

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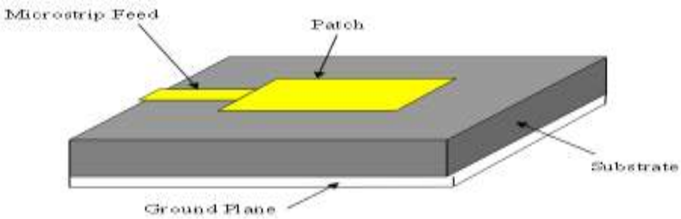
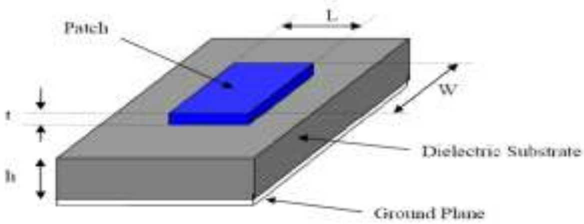
Abstract: In the recent years the development in communication systems requires the development of low cost, minimal weight, low profile antennas that are capable of maintaining high performance over a wide spectrum of frequency. This technological trend has focused much effort into the design of a Micro strip patch antenna. A single patch antenna provides a maximum directive gain of around 6-9dBi. The most commonly employed micro strip antenna is a rectangular patch. The objective of the research is to design an rectangular Microstrip Patch Antenna with optimized design parameters and to study the effect of antenna dimensions Length (L), Width (W) and substrate parameters relative Dielectric constant (ε_r), substrate thickness (t) on the Radiation parameters of Bandwidth and Beam-width in maximizing the Directivity and Gain of the antenna. The optimization design of antenna parameters are designed using evolutionary algorithms like Particle Swarm Optimization, Artificial Bee Colony Algorithm, Bacterial foraging algorithm, etc., which will converge to the global solution as against the conventional optimization approaches.

I. INTRODUCTION TO MICRO-STRIP ANTENNAS

[1] One type of antennas that fulfills most of the wireless systems requirements is the microstrip antennas. These antennas are widely used on base stations as well as handheld devices. Microstrip antennas have a variety of configurations and are currently the most active field in antenna research and development. The microstrip antennas, due to their great advantages, have increasingly wide range of applications in wireless communication systems as handheld mobile devices, satellite communication systems, and biomedical applications.



[2] Patch antennas are popular for their well-known attractive fea- tures, such as a low profile, light weight, and compatibilitywith monolithic microwave integrated circuits (MMICs). Some modern communication systems, such as those for satellite links (GPS, vehicular, etc.), as well as emerging applications, such as wireless local networks (WLAN), often require antennas with compactness and low-cost, thus rendering planar technology useful, and sometimes unavoidable.



II. MICROSTRIP PATCH ANTENNA BASIC STRUCTURE

[3] The rectangular patch antenna is approximately a one-half wavelength long section of rectangular Microstrip transmission line. When air is the antenna substrate, the length of the rectangular Microstrip antenna is approximately one-half of a free-space wavelength. As the antenna is loaded with a dielectric as its substrate, the length of the antenna decreases as the relative dielectric as its substrate, the length of the antenna decreases as the relative dielectric constant of the substrate increases.

Micro strip antennas are easy to fabricate and comfortable on curved surface. The directivity is fairly insensitive to the substrate thickness. Microstrip patch antennas patches are in variety of shapes such as rectangular, square, triangular, circulator and elliptical, but any continuous shape is possible. Some patch antennas do not use a dielectric substrate and instead made of a metal patch mounted above a ground plane using dielectric spacers; the resulting structure is less rugged but has a wider bandwidth.

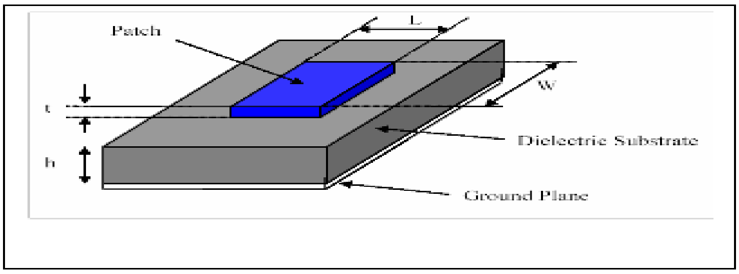
Patch antenna - A patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane.

Because such antennas have a very low profile, are mechanically rugged and can be shaped to conform to the curving skin of a vehicle, they are often mounted on the exterior of aircraft and spacecraft, or are incorporated into mobile radio communications devices.

The size of a microstrip antenna is inversely proportional to its frequency. At frequencies lower than microwave, microstrip patches don't make sense because of the sizes required. At X-band a microstrip antenna is on the order of 1 centimeter long. It has a very broad frequency range of about 1 GHz to 100 GHz.

III. EVOLUTIONARY ALGORITHMS

In order to study the effect of antenna dimensions Length (L) , Width (W) and substrate parameters: relative Dielectric constant (εr) & substrate thickness (t) on the Radiation parameters of Bandwidth and Beam-width in maximizing the Directivity and Gain of the antenna certain optimization algorithms are being employed. The optimization design of antenna parameters are designed using evolutionary algorithms like Particle Swarm Optimization, Artificial Bee Colony Algorithm, Bacterial foraging algorithm, etc.,



(i) Particle Swarm Optimization PSO is a computational method that optimizes a problem by iteratively trying to improve a candidate solution with regard to a given measure of quality. In PSO, the potential solutions, called particles, fly through the problem space by following the current optimum 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 neighbors of the particle. This location is called *lbest*. When a particle takes all the population as its topological neighbors, the best value is a global best and is called *gbest*.

The particle swarm optimization concept consists of, at each time step, changing the velocity of (accelerating) each particle toward its p*best* and *lbest* locations (local version of PSO). 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. [4]

(ii) Artificial Bee Colony (ABC) algorithm is an optimization algorithm based on the intelligent foraging behavior of honey bee swarm. Artificial Bee Colony (ABC) is one of the most recently defined algorithms by Dervis Karaboga in 2005, motivated by the intelligent behavior of honey bees.

ABC as an optimization tool provides a population-based search procedure in which individuals called foods positions are modified by the artificial bees with time and the bee's aim is to discover the places of food sources with high nectar amount and finally the one with the highest nectar. In ABC system, artificial bees fly around in a multidimensional search space and some (employed and onlooker bees) choose food sources depending on the experience of themselves and their nest mates, and adjust their positions. Some (scouts) fly and choose the food sources randomly without using experience. If the nectar amount of a new source is higher than that of the previous one in their memory, they memorize the new position and forget the previous one. Thus, ABC system combines local search methods, carried out by employed and onlooker bees, with global search methods, managed by onlookers and scouts, attempting to balance exploration and exploitation process. **[5]**

(iii) Bacterial foraging optimization algorithm (BFOA) has been widely accepted as a global optimization algorithm of current interest for distributed optimization and control. BFOA is inspired by the social foraging behavior of *Escherichia coli*.

The BFOA is inspired by the chemotaxis behavior of bacteria that will perceive chemical gradients in the environment (such as nutrients) and move toward or away from specific signals. Bacteria perceive the direction to food based on the gradients of chemicals in their environment. Similarly, bacteria secrete (produce and discharge) attracting and repelling chemicals into the environment and can perceive each other in a similar way. Using locomotion mechanisms (such as flagella) bacteria can move around in their environment, sometimes moving chaotically (tumbling and spinning), and other times moving in a directed manner that may be referred to as swimming. Bacterial cells are treated like agents in an environment, using their perception of food and other cells as motivation to move, and stochastic tumbling and swimming like movement to re-locate. Depending on the cell-cell interactions, cells may swarm a food source, and/or may aggressively repel or ignore each other.

The information processing strategy of the algorithm is to allow cells to stochastically and collectively swarm toward optima. This is achieved through a series of three processes on a population of simulated cells: 1) 'Chemotaxis' where the cost of cells is derated by the proximity to other cells and cells move along the manipulated cost surface one at a time (the majority of the work of the algorithm), 2) 'Reproduction' where only those cells that performed well over their lifetime may contribute to the next generation, and 3) 'Elimination-dispersal' where cells are discarded and new random samples are inserted with a low probability. [6]

IV. CONCLUSION

PSO gets better results in a faster, cheaper way compared with other methods.ABC system combines local search methods, carried out by employed and onlooker bees, with global search methods, managed by onlookers and scouts, attempting to balance exploration and exploitation process. Chemotaxis , Reproduction and Elimination-dispersal processes will enhance the analysis work of the Design of Micro-Strip Antenna

V. FUTURE ENHANCEMENT

The modern trend Micro-Strip Antenna's will be designed using evolutionary algorithms like Particle Swarm Optimization, Artificial Bee Colony Algorithm, Bacterial foraging algorithm, which will converge to the global solution as against the conventional optimization approaches.

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