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

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Abstract

In the recent years, the progress in communication systems needs the expansion of affordable, least weight, low profile antennas that have ability for maintaining high performance over a good spectrum of frequency. This technological drift has centered abundant effort into the planning of a small strip antenna. These antennas are fully cheap to manufacture and design because of its straightforward 2-dimensional physical pure mathematics. Patch arrays will give abundant higher gains than one patch at very little extra cost. These arrays are principally utilized in airplanes and in alternative military applications. The target of this analysis is to design a microstrip patch antenna with optimized design parameters and form. Optimisation can think about the result of antenna dimensions like form parameters (length, width, radius, etc) and substrate parameters like relative nonconductor constant (εr), substrate thickness (t) on the radiation parameters of information measure and beam-width in maximising the directionality and Gain of the antenna. The optimisation of antenna parameters and form are done by exploiting biological process algorithms like Particle Swarm optimisation, Artificial Bee Colony algorithmic program, microorganism hunt algorithmic program, etc., which can converge to the worldwide answer against the standard optimisation approaches.

Keywords: Small strip patch antenna, optimisation, Particle swarm optimisation, Artificial bee colony, microorganism hunt algorithmic program

I. INTRODUCTION

For any wireless system, antennas are the key parts. Associate degree antenna may be a device that transmits and/or receives magnetic attraction waves. Most antennas are resonant devices, that operate expeditiously over a comparatively slender waveband. so as to avoid impairment, the receiver and/or transmitter should be tuned to constant waveband, that the radio system to that it's connected. For calibration the magnetic attraction waves into original type receiving antenna within the system is accountable. Patch antenna is categorised as single part resonant antenna. Once the frequency is given, graph input resistivity, etc is stable. The patch may be a terribly skinny ($t \ll \lambda_0$, wherever λ_0 is that the free house wavelength) diverging metal strip or array of strips placed on one aspect of a skinny non conducting substrate, the bottom plane is that the same metal is situated on the opposite aspect of the substrate. The aluminous patch is sometimes made from skinny copper foil plated with a corrosion resistive metal, like gold, tin, or nickel. Patch styles are on the market in several forms therein, rectangular and circular patches are the foremost fashionable shape. The substrate layer thickness is zero.01–0.05 of free-space wavelength. it's used primarily to produce correct spacing and mechanical support between the patch and its ground plane. It is additionally usually used with high dielectric-constant material to load the patch and minimize its size. Commonly, substrate materials is separated into 3 classes in keeping with the nonconductor constant.

Having a relative nonconductor constant εr within the vary of one.0–2.0. this kind of fabric is air, cinnamene foam, or nonconductor honeycomb.

Having εr within the vary of two.0–4.0 with material consisting principally of fiber glass bolstered Teflon. With a εr between four and ten. the fabric will accommodate ceramic, quartz, or alumina. Due to their low-profile structure, microstrip patch antennas are increasing in quality for the employment in wireless applications. The measure and sq. Rectangular Dipole Circular Triangular Circular Ring Elliptical communication antennas on missiles have to be compelled to be skinny and conformal. A number of their principal merits are light-weight and low volume, low profile flat configuration which may be simply created conformal to host surface, low fabrication value. Therefore it is factory-made in massive quantities, supports each, linear further as circular polarization, is simply integrated with microwave integrated circuits, capable of twin and triple frequency operations and automatically sturdy, once mounted on rigid surfaces.

These antennas have a particularly high antenna quality issue (Q). massive alphabetic character ends up in slender information measure and low potency, the losses related to the antenna are pictured by alphabetic character. Alphabetic character is reduced by increasing the thickness of the nonconductor substrate. Associate degree increasing fraction of the whole power delivered by the supply goes into a surface wave because the thickness will increase. However, by exploitation of photonic band gap structures surface waves is reduced. By exploitation of associate degree array configuration for the weather, alternative issues like lower gain and lower power handling capability is overcome.

Various ways are used for feeding microstrip patch antenna. These ways are categorised into 2categories- contacting and non-contacting. within the contacting technique, the RF power is fed on to the diverging patch employing a connecting part like a microstrip line. Magnetic attraction field coupling is completed to transfer power between the microstrip line and therefore the radiation patch within the non-contacting theme. The four preferred feed techniques used are the microstrip line, concentrical hunted for contacting schemes, aperture coupling and proximity coupling for non-contacting schemes.

A patch antenna may be a variety of nondirectional antenna with a coffee profile [1], which may be mounted on a flat surface. It consists of a flat rectangular sheet or "patch" of metal, mounted over a biggersheet of metal known as a ground plane. The assembly is often b within a plastic radar dome, so as to guard the antenna structure from harm. Patch antennas are straightforward to fabricate, straightforward to switch and customise.

II. CONNECTED WORK

Due to the mix of the many mobile communication systems like wireless native space network, world positioning system etc, there's a necessity for multi frequency antennas with high bandwidths, attributable to their slender information measure. Straightforward microstrip antennas would be unable to comprehend these wants. Many techniques as listed in [1] are used for establishing a broadband behaviour in microstrip antennas: electrical phenomenon compensation, thicker substrates, reactive matching networks, and stacked patches. Stacked patches gift several degrees of freedom like driven and parasitic dimensions, feeding purpose and gap between patches. Exploitation of Genetic algorithmic program, U-shaped slot on a microstrip patch antenna is optimized.

Antenna style has big additional firm and arduous over the years with inherent tradeoffs that exist between gain, graph, bandwidth, and physical size creating antenna style a lasting procedure. Varied techniques are wont to commit to deliver the goods. This reduction in size with varied success. Biological process algorithmic program like genetic algorithmic program and particle swarm optimisation algorithmic program were wont to optimize the patch and confirm the patch length, dimension and feeding purpose within the style of a coaxially fed circularly polarized rectangular patch antenna. To regulate the position of multiple slots or shorting pins between the patch and ground, a dual-band microstrip patch antenna was designed for exploitation of genetic algorithms.

The quantifiability within the space of Wireless communications has improved nice folds in recent years. Several efforts are created to handle the mentioned concern to some extent. Parasitic patches are used to extend the information measure [2]. 2 formed parasitic patches are situated on constant layer with the most patch. With the coincidence, the microstrip patch antenna should meet additional necessities, that build the configuration and style method additional difficult because of the quick and fast development of wireless communications. So the antenna style issues involve an oversized range of parameters that have nice result on performance of the antenna. These parameters should be taken as a full into consideration. The standard optimisation techniques aren't economical in finding such issues.

For optimum system performance, high radiation potency, tiny volumes, straightforward and low loss resistivity matching to receive and transmit methods are necessary stipulations of the antennas [3]. One amongst the most disadvantages of the microstrip antennas is their slender information measure. As a consequence, it will work solely on the brink of their resonance frequency expeditiously. For this reason, the correct analysis of this parameter is of basic importance. In recent years many algorithms are developed for optimisation of assorted styles of drawback associated with antenna style. The aim of any optimisation technique is to search out an answer that represents a world most or minimum during appropriately outlined solution domain, meaning to search out the most effective answer among several doable solutions for a thought of drawback.

To obtain high directionality, microstrip patch arrays are utilized by grouping many microstrip parts functioning essentially in their basic mode [4], [5]. Moreover, they need been wont to acquire broadband[6] and multiband [7] operations and additionally in graph synthesis [8]. Various approaches use arrays with microstrip parts functioning in higher-order modes, whereas keeping broadside patterns by utilizing the advantages of localized modes of sure fractal-inspired antennas [9]. However, of these approaches might add some quality because of the feeding network, which can additionally deteriorate the radiation properties because of losses and/or distort the graph.

Antennas for base stations or hot-spots gift a slender beam within the vertical plane and a wider beam within the horizontal plane, so as to produce coverage during a explicit spacial sector. This type of pattern is earned by linear array of antennas, which require a feeding network to feed every part. As a replacement to the current classical answer, one part microstrip patch antenna with the advantage of not requiring a feeding network is projected by suggests that of Genetic Algorithmic Program (GA).

Microstrip antennas is created conformal and similar temperament to be integrated with microwave computer circuit. In terms of fabrication, such system offers simplicity, that permits production and efficient producing further as high performance [10], [11]. However, a standard patch antenna suffers from terribly slender information measure and this causes a challenge for the microstrip antenna designer to satisfy the projected broadband IMT-2000 band specification (1.885-2.200GHz). Patch antennas that meet these necessities usually involve complicated geometries with no analytical illustration [10], [11]. Simulations usually enable analysis of the antenna, however manual optimisation needs hours of human interaction. So we tend to and should implement optimisation techniques to alter the method and speed it up. During this work, Particle Swarm optimisation (PSO) with curve fitting is employed to optimize antenna performance.

PSO relieved the necessity for normal brute-force style techniques.

With the fast development of microstrip antenna style techniques, genetic algorithms (GAs) are introduced into the planning method so as to style and optimize microstrip antenna shapes for broadband operation [12]. Form optimisation supported GA may be a promising technique as a result of the information measure improvement which is accomplished while not increasing the antenna size and producing value.

Optimization techniques are associate degree integral, a part of antenna style issues and applications, that should be resolved expeditiously and effectively. So, the planning demands the hassle from the designer for locating a particular antenna configuration that most closely fits the sketched read. In support of this necessity, there are slow advent of assorted optimisation techniques within the domain of electromagnetism specially antenna style. Among these, the alleged biological process algorithms (EAs) (e.g., genetic algorithms (GAs) [13], Simulated tempering [14], particle-swarm optimizers [15]) became wide utilized in [16 - 19] because of their simplicity, skillfulness, and lustiness. However, these ways gift sure drawbacks sometimes associated with the intensive machine effort they demand to realize the worldwide best and therefore the risk of premature convergence to a neighborhood optima.

III. PROPOSED SYSTEM

Micro strip antennas are uncomplicated to fabricate and comfy on arched surface. The directionality is fairly insensitive to the substrate thickness. The patches of the antenna are in sort of shapes like rectangular, square, triangular, circulator and elliptical, however any continuous form is possible. Since such antennas have a awfully low profile, are automatically rough and that they are often mounted on the outside of craft and ballistic capsule, or are incorporated into mobile radio communications devices. biological process algorithms show promise since, among search algorithms, they're able to effectively search massive, undisclosed styles.

3.1 Shapes of Microstrip Patch Antenna

There are an oversized range of shapes of microstrip patch antennas; they need been designed to match specific characteristics. a number of the common sorts are rectangular, square, circular and elliptical patches. The flow diagram of the form optimisation is shown in figure one.

Rectangular Antenna

The rectangular microstrip antennas are created by an oblong patch with dimensions, width, b, and length, a, over a ground plane with a substrate thickness h and nonconductor constant (εr). Non-conductor constant are sometimes utilized in the vary of one.2≤ εr ≤12. However, the foremost fascinating ones are the nonconductor constants within the lower finish of this vary along with the thick substrates, as a result of they supply higher potency, larger information measure.

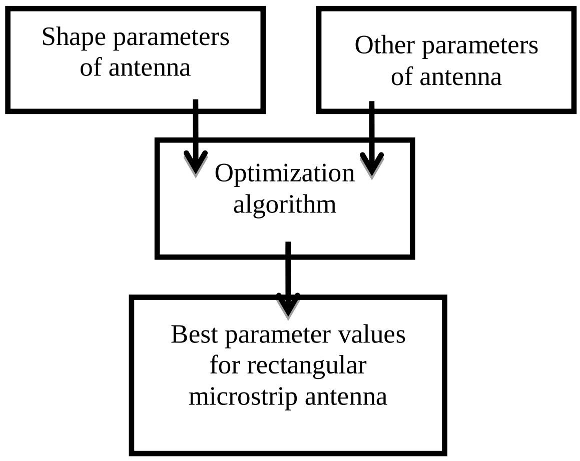

Fig..1: Block diagram of proposed antenna design

For the planning of an oblong microstrip patch antenna the very important parameters are: Frequency of operation (fo): The resonant frequency of the antenna should be chosen fitly. The frequency vary from 1850-1990 megahertz is employed in personal communication system. Therefore the antenna designed should be able to perform during this frequency vary. The resonant frequency designated for the planning is one.9 GHz. nonconductor constant of the substrate (εr): The nonconductor material designated for the planning incorporates a nonconductor constant of the vary two.2 ≤ Ɛ r ≥ twelve. To scale back the dimension of the antenna a substrate with a high nonconductor constant has been designated. Height of nonconductor substrate (h): For the microstrip patch antenna, it's essential that the antenna isn't large. Hence, the peak of the nonconductor substrate is chosen as one.5 mm. The steps of parameter calculations are given below.

Step 1: produce initial population

- Initially, choose the required resonant frequency, thickness and nonconductor constant of the substrate.

Step 2: acquire the subsequent parameters

- Width calculation
- w= one2frµ0εo 2εr+ one = C2fr 2εr+ 1
- C = free house rate of sunshine
- εr - nonconductor constant of substrate
- The effective nonconductor constant of the oblong microstrip patch antenna
- εeff= εr+12 + εr-12 (11+ twelve hw)
- The actual length of the Patch (L)
- L = Leff- 2ΔL
- Leff= C 2frεeff

- Calculation of Length Extension
- ΔLh = 0.412 (εeff+ zero.3) (wh+ 0.264)(εeff-0.258) (wh+ zero.8)

Step 3: measure fitness for all population

- Find fitness for all population.

Step 4: build changes within the population (Using optimisation algorithm)

- If the fitness of all population isn't happy there's a necessity to vary the parameters to be optimized.
- After dynamic parameter values continue step two and three till the fitness is happy

Elliptical Antenna

Elliptical microstrip patch antennas pure mathematics presents terribly high potentials for varied electrically tiny low-profile antenna applications and explores the capability of the antenna. The elliptical form has several blessings like providing massive flexibility within the style, high degree of freedom and achieves circular polarization with single feed and has three layers consisting of ground plane, substrate and patch. The pure mathematics of elliptical patch is least analyzed regular geometrical form. These techniques acquire resonant frequency for even (fe) and odd (fo) modes because the functions of input variables, the peak of the nonconductor substrate (h), nonconductor constant (εr), and therefore the antenna dimensions of major and axis. The steps of the parameter calculations are given below.

Step 1: produce initial population

- Initially, choose resonant frequency, thickness of the substrate (h), nonconductor constant (εr) and eccentricity (e).

Step 2: acquire the subsequent parameters

- aeff=a[1+ 2hπεra]12
- f11e, o= 15πeaeffq11e, oεr
- q11e= -0.0049e+3.788e2- 0.7278e3+ 2.314 e4
- q11o= -0.0063e+3.8316e2-1.1351e3+5.2229e4
- e= 1- b2a2
- Aspect Ratio= ba
- Where, a is that the semi-major axis, h is that the height of nonconductor substrate, εr is that the permittivity of nonconductor substrate, aeff is that the effective semi-major axis, e is that the eccentricity of elliptical patch, f11e, o is that the dual-resonance frequency and q11e,o is that the approximated Mathieu perform of the dominant (TM11e,o) mode.

Step 3: measure fitness for all population

- Find fitness for all population.

Step 4: Build changes within the population (Using optimisation algorithm)

- If the fitness of all population isn't happy there's a necessity to vary the parameters to be optimized.
- After dynamic parameter values continue step two and three till the fitness is happy.

Square Antenna

In sq. microstrip patch antenna, the result of antenna dimensions length (L), substrate parameters relative nonconductor constant (εr), substrate thickness (t) and dimension (W) on the radiation parameters of information measure are calculated. The key characteristics of this antenna are straightforwardconstruction, light-weight weight, cheap and either conformability to the mounting surface. In sq. antenna's the input resistivity admit the geometrical look, dimensions, and physical properties of the materials, the feed kind and placement. selecting the planning parameters is vital as a result of antenna performance depends on these parameters.

Step 1: produce initial population

Initially, choose the required resonant frequency, thickness and nonconductor constant of the substrate

Step 2: acquire the subsequent parameters

Width calculation

w= 12frμoεo2εr+1= c2fr 2εr+1

Where, c is that the free house rate of sunshine, εr is that the nonconductor constant of substrate.

The effective nonconductor constant of the oblong microstrip patch antenna

εeff= εr+ 12+ εr- 12(11+12hw)

The actual length of the Patch (L)

L= Leff- 2ΔL

Leff= C2frεeff

Calculation of Length Extension

ΔLh=0.412 (εeff+0.3)(wh+ 0.264)(εeff- zero.258)(wh+ 0.8)

Step 3: measure fitness for all population

Find fitness for all population.

Step 4: build changes within the population (Using optimisation algorithm)

If the fitness of all population isn't happy there's a necessity to vary the parameters to be optimized.

After dynamic parameter values continue step two and three till the fitness is happy.

Circular Antenna

In circular patch antenna, a circular patch of radius ‘a’ over a ground plane with a substrate of thickness ‘h’ and therefore the relative nonconductor constant ‘εr’. Initially, the planning step is to pick an appropriate nonconductor substrate material. The foremost electrical properties to contemplate are the relative nonconductor constant. Usually it's best to pick a substrate with the bottom doable nonconductor constant with house on the market for the antenna. Substrate thickness is chosen thus on maximize the information measure and potency.

Step 1: produce initial population

Initially, choose non-conductor constant of substrate, resonant frequency of substrate, height of substrate.

Step 2: acquire the subsequent parameters

Actual radius

a= F{1+ 2hπεrF [ln (πF2h) + one.7726]}12

F= 8.791 × 109fr εr

Effective radius

ae=a {1+ 2hπεra [ln(πa2h)+ one.7726]}12

Resonant frequency

(fr)110= 1.8412vo2πae εr

Height

h ≤ 0.3c2πfrεr

Step 3: measure fitness for all population

Find fitness for all population.

Step 4: build changes within the population (Using optimisation algorithm)

If the fitness of all population isn't happy there's a necessity to vary the parameters to be optimized.

After dynamic parameter values continue step two and three till the fitness is happy.

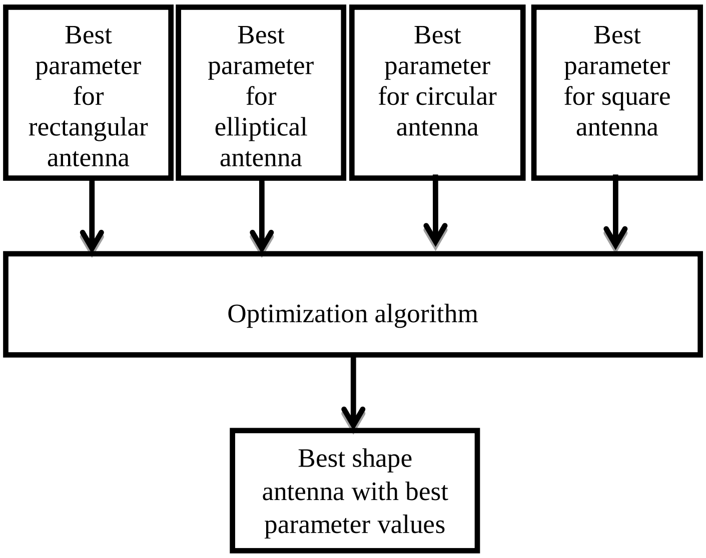

Fig. 2 Block diagram of final optimization

Fitness perform

A fitness perform is associate degree objective perform that's wont to measure, however shut a given style answer achieves the pre-determined criteria. It is a link between the physical drawback and optimization procedure. In our project, the fitness perform is S11 parameter whose price should be ≤ -10 decibel resistivity information measure. The diagram of ultimate optimization is shown in figure two.

3.2 Evolutionary Algorithm

Evolutionary algorithms are wont to analyze the assorted antenna’s and to review the result of antenna dimensions Length (L), dimension (W) and Substrate parameters: relative nonconductor constant (εr) and substrate thickness (t) on the radiation parameters of information measure and beamwidth in maximising the directionality and Gain of the antenna sure optimisation algorithms are being used. The optimisation style of antenna parameters are designed exploitation biological process algorithms like Particle Swarm optimisation, Artificial Bee Colony algorithmic program, microorganism hunt algorithmic program, etc.,,

Particle Swarm Optimization Algorithm

Particle swarm may be a machine technique that optimizes the matter to reinforce the answer of the candidate iteratively. In PSO, the particles are the potential solutions, fly on the matter house by following this optimum particles. Every particle tracks its coordinates that are connected with best fitness answer. It is achieved to this point within the drawback house. Within the drawback house every particle keeps pursuit its coordinates that is achieved by the most effective fitness answer. The obtained price is named pbest. Particle swarm optimizer tracks another "best" price, non inheritable to this point by any particle within the neighbors of the particle. This location is named lbest. All the populations are thought of as its topological neighbors by the particle and therefore the best price is that the world's best and is named gbest. The coordinates keeps pursuit every particle within the drawback house that is expounded to the most effective fitness answer it achieved. The worth obtained is named pbest. The particle swarm optimizer tracks another "best" price, non inheritable to this point by any particle within the neighbors of the particle. This location is named lbest. All the population is taken into account as its topological neighbors by the particle and therefore the best price is that the world best and it's known as as gbest. The construct of particle swarm optimisation is at anytime step the rate (acceleration) of every particle is modified towards its pbest and lbest locations. Completely different random numbers are generated for acceleration, is weighted by a random term towards pbest and lbest locations. Acceleration is weighted by a random term, with completely different random terms being created for acceleration towards pbest and lbest locations. It is established that PSO obtains higher leads to a speedy, cheap means compared with alternative ways.

The PSO algorithmic program consists of simply 3 steps:

1. Measure fitness of every particle
2. Update individual and world bests
3. Update rate and position of every particle

These steps are continual till some stopping condition is met.

Artificial Bee Colony Algorithm

Artificial Bee Colony (ABC) algorithmic program is associate degree optimisation algorithmic program supported the honey bee swarm intelligent hunt behavior. It is one amongst the foremost recently established algorithms stirred by the honey bee's intelligent behavior. it's associate degree optimization tool that contributes a population-based search strategy within which people known as foods positions are changed by the unreal bees with time and therefore the bee's aim is to search out the places of food sources with high nectar quantity and at last the one with the very best nectar. Here, during a four-dimensional search house the unreal bees select the food sources by flying around some used and spectator bees counting on the expertise of themselves and their nest mates, and their positions adjusted. Some scouts select the food sources arbitrarily with none expertise by flying. During a new supply, if the nectar quantity is above that of the previous one in their memory, the new position is memorized by them and forgets the previous one. Thus, native search ways are agreed with world search ways and disbursed by used and spectator bees, managed by onlookers and scouts, trying to balance exploration and exploitation method.

The vital steps of the algorithmic program are given below:

- For all used bees the initial food sources are created.
- REPEAT
- Each used bee in her memory goes to a food supply and neighbour supply is decided, then evaluates its nectar quantity and dances within the hive
- Each spectator observes the dance of used bees and supported the dance they choose one amongst their sources, so goes thereto supply. She evaluates its nectar quantity when selecting a neighbour around.
- Abandoned food sources are determined and are replaced with the new food sources discovered by scouts.
- The best food supply found to this point is registered.
- UNTIL (requirements are met)

Bacterial Foraging Optimization Algorithm

Bacterial Foraging Optimization Algorithm (BFOA) for distribution optimisation and management of current problems has been preponderantly accepted as a world optimisation algorithmic program. The social hunt behaviour of Escherichia coli is impressed by BFOA. It is additionally impressed by the bacteria's taxis behavior which will acknowledge the chemical gradients within the surroundings like nutrients and move towards or off from the precise signal. Microorganism establish the direction of the food supportedthe gradients chemicals in their surroundings. Similarly, microorganism secretes (produce and discharge) attracting and foul chemicals into the surroundings and might understand one another during a similar means. Exploitation locomotion mechanisms (such as flagella) microorganism will move around in their surroundings, typically moving chaotically (tumbling and spinning), and alternative times occupancy a directed manner that will be cited as swimming. Microorganism cells are treated like agents in associate degree surroundings, exploitation of their perception of food and alternative cells as motivation to maneuver, and random tumbling and swimming like movement to re-locate.

Cells might swarm a food supply and/or might forcefully repel or ignore one another counting on the cell-cell interactions. The data process approach of the algorithmic program is to permit cells to stochastically and conjointly swarm towards optima. On a population of simulated cells, it's achieved through a series of 3 processes. 1) 'Chemotaxis' wherever the value is derated by the proximity to alternative cells and cells move on the manipulated cost surface one at a time, 2) 'Reproduction' wherever solely those cells that performed spill their time period could also be contributed to successive generation, and 3) 'Elimination dispersal' wherever cells are discarded and new random samples are inserted with a coffee likelihood.

The main steps of BFOA are given below:

Step 1: Low-level formatting of Simulation Parameters

Step 2: Perform all elimination-dispersals

Step 3: Perform all reproductions

Step 4: Perform all taxis steps

Step 5: For every microorganism within the colony do the taxis

Step 6: Update the taxis step counter

Step 7: Replica

Step 8: Update replica Counter

Step 9: Perform elimination and spreading of microorganism colony

Step 10: Update eliminate-dispersal counter

IV. SIMULATION RESULTS AND DISCUSSIONS

In this section, the simulation results and therefore the parameter specifications of every antenna are given that is calculated from the on top of mentioned formulae.

V. CONCLUSION

The aim of this project is to design microstrip patch antenna of assorted shapes (rectangular, elliptical, circular and square). The assorted style parameters of every antenna are mentioned during this paper. The effective parameter specification and form of the antennas are optimized exploitation of the biological process algorithmic programs (particle swarm optimisation algorithm, artificial bee colony algorithmic program and microorganism hunt optimisation algorithm). If the fitness of all population isn't happy there's a necessity to vary the parameters to be optimized. When dynamic the parameter values the steps (obtaining the parameters and evaluating fitness for all population) are once more continuing till the fitness perform is happy. These algorithms can converge the worldwide solutions against the standard optimisation approaches.

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