



Design and Optimization of Microstrip Patch Antenna for UWB Applications Using Moth–Flame Optimization Algorithm

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Abstract

The design of microstrip patch (MP) antenna using Moth–Flame optimization (MFO) algorithm for UWB applications is presented in this article. MP antennas are designed to operate in dual and multi-band application as it possess the following advantages such as low cost, light weight and easy installation. To reduce the microstrip patch cross-polarized radiation and to attain the essential radiation parameters, the MP antenna is designed with a defected ground structure. The substrate of liquid crystal polymer is used here to reduce the material cost and the applicable geometry parameters are used to improve antenna performance. The MFO optimized antenna represents 50 mm×50 mm compact size, which improves the performance of antenna. However, the simulation procedure is done by the MATLAB tool along with high frequency structure simulator for parameter optimization and performance analysis respectively. The operational bandwidth of the antenna is 3.1 GHz and the return loss is –20 dB that covers the UWB (3.1–10.6 GHz) applications. The simulation outcomes exhibit good impedance bandwidth, radiation pattern, directivity, and relatively constant gain over the entire band of frequency comparing with the earlier methods. Finally, the proposed system can be a better option for the design of microstrip antenna in the communication system, to cover Bluetooth operations, Wi-Fi, Wi-MAX, Telemedicine and UWB applications.

Keywords Microstrip patch antenna (MPA) · Moth–Flame optimization · Liquid crystal polymer (LCP) · Defected ground structure (DGS)

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1 Introduction

Antennas are assuming a greater job with technological advancements. The utilization of antennas in UWB frameworks with high communication link capacity is highly demanded [1]. Ultra wide band antennas are gaining obvious quality and very attractive in present and future remote communication frameworks [2]. The patch is fixed on a substrate across a bottom plane, valuable for superior presentation in extraordinary applications [3]. The rectangular patch is the most generally utilized arrangement for MP antennas. Design involves low profile, comparable, straightforward as well as economical, precisely strong, and adaptable [4].

The microstrip antennas are fabricated at microwave frequencies by employing a microstrip scheme on Printed Circuit Board. In this scheme, main parts of microstrip antenna are dielectric substrate, patch, feed line and ground plane. This antenna have some benefits like less weight, low cost, less dimension, and low profile [5]. A simple arrangement named defected ground structure is utilized on the way to advance the antenna operation also reduces the microstrip patch cross-polarized radiation [6].

For monitoring the radiation features, the antenna is arranged over the ground plane in addition substrate is essential to give better performance. Liquid Crystal Polymer substrate is preferred because it is a low-cost dielectric material that offers extraordinary performance. LCP is flexible, recyclable as well as constant up to melting temperature at higher range. LCP is a perfect decision for devices working in a wide range of conditions [7].

Moreover, the switched circuits are fabricated under the frequency range of about 20 GHz to 40 GHz so LCP substrate can be performed well [8]. Because of their compatibility, front end outlines are further attractive and it is necessary for the design procedures to balance the amplified antennas. The probe location is found out to equalise the input impedance with patch impedance [9].

Due to its high gain, the flexible LCP substrate (40 GHz) is eminent with MPA, and then moulded into any forms and stable at high temperature and also appropriate for circuits in all kind of surroundings as well as used in millimetre wave communication applications [10]. The microstrip antenna with four elements of phased array can be designed by coaxial feeding methods. It is more compatible when comparing with the reflector antenna via PCB [11].

The electrical and mechanical LCP material can act as a substrate due to the attractive things in microwave application [12]. It will distress the radiation pattern while folding the radiation patch and microstrip feed line in a flat surface where radiating elements are located [13]. However, the chip packages make high reliability and multilayer integration which is attractive for system packages. The substrate material is mainly used to make the antenna flexible since it has attractive properties to make high performance antenna [14]. In an LCP substrate, many transmission lines are categorised until 110 GHz. The transmission lines are used to calibrate the total loss tangent [15]. Instead of finding the lost data on a wide frequency range, calibrate the total loss in every frequency range [16].

1.1 Contribution

There are many challenges in microstrip antenna design for UWB applications. One of the important part of antenna designing is the selection of substrate which has particular dielectric constant and should not change its characteristics at any circumstances. Even a

small change in dimensions of patch affects the fringing fields from the edges. This affects the effective length, thereby changing the resonance frequency. The main drawback of microstrip patch antenna is low gain and narrow-bandwidth. The problems in designing the microstrip patch antenna is to get the desired resonant frequency. When the length and the width of the patch is chosen correct then the antenna resonates at the corresponding frequency.

1.2 Objectives

- To achieve wide impedance bandwidth suitable for UWB applications.
- To achieve high gain and high efficiency.
- To reduce the power loss lesser than 10% also the operational cost.
- To advance the antenna operation and
- To reduce the microstrip patch cross-polarized radiation.

1.3 Applications

- Microstrip patch antenna provides application in the field of wireless communication such as satellite communication and Global Positioning Satellite (GPS) systems.
- Radio Frequency Identification (RFID) and mobile communication.
- Tele-medicine application and Wi-Max based communication.
- Remote sensing, intruder alarms and direct broadcast services.

The remaining portion of this documentation is systemized as follows; the related research of microstrip antenna plan in subdivision 2. Motivation is presented in subdivision 3. The proposed methodology for the design of antenna is labelled detail in subdivision 4. The implementation results and discussion are presented in Sect. 5. Then the subsequent Sects. 6 and 7 gives the experimental verification, conclusion and reference to the paper respectively.

2 Related Work

Mustafa et al. [17] introduced a practical approach to minimize the size of planar microstrip patch antenna, to attain lower frequencies. The size reduction approach was based on slicing the antenna into different slots mainly in saw teeth shape. As the demand of the mobile devices was increasing, the miniaturization approaches were widely used besides the size reduction of devices. The design consists of two sections. At first, the microstrip patch antenna was designed then to obtain saw teeth shape the slots were divided. Using this approach, the patch antenna size was reduced to 87.88% with an operation frequency equivalent to 1.7 GHz.

Liao et al. [18] defined the problem of Minimum Mobile Relay Path Selection (MMRP) to distribute minimum mobile relays to patrol fixed relays at the time of busy schedule. At first, to predict the fixed relays busy period, Markov chains were used. Maximum flow and matching approaches were implemented to discover heuristic algorithms. The busy stages of fixed relays were characterised as Busy Period Graph (BPG). This represents the mobile relay efficiency also signifies the fixed relays spatial and temporal relation. The performance of the proposed method was evaluated using simulation results.

Kaur et al. [19] introduced a circular microstrip patch antenna design for UWB applications. The antenna was designed on FR-4 substrate with dimension equivalent to $30 \text{ mm} \times 35 \text{ mm} \times 0.9 \text{ mm}$. To expand the impedance matching, a thin strip line 1.8 mm was inserted among the feed port and circular radiating patch. The parameters such as feed dimension, inner and outer radius, ground plane also substrate dimension were carried out using the HFSS (High Frequency Structure Simulator) simulation software.

Fei Yu [20] proposed a $0.18 \text{ }\mu\text{m}$ CMOS LC tank Voltage Controlled Oscillator (VCO) for low voltage and low power S-band wireless applications. The condition of low voltage applications were met with dual cross-coupled pairs using admittance-transforming approach. VCO proposed was intended to operate at 0.4 V supply voltage, using forward-body-biased (FBB) metal oxide semiconductor field effect transistors. To minimize the power consumption FBB approach was adopted by NMOS devices.

Sudeep et al. [21] proposed a planar monopole microstrip patch antenna with diagonally cut partial ground plane and U-shaped patch for Mobile Satellite Services (MSS). By optimizing the partial ground plane length and cut in patch, the proposed antenna was miniaturized. At both the frequency bands, stable radiation patterns were obtained. Thus the simulation outcomes proved that the maximum radiation efficiency obtained was 13% for $2\text{--}2.1 \text{ GHz}$ frequency and efficiency was 75% for $4\text{--}4.7 \text{ GHz}$.

3 Motivation

There are various challenges in antenna design particularly for UWB applications. One of the main challenge is to achieve wide impedance bandwidth. MPA is designed, as it contains low profile, light weight along with low fabrication cost. It consists of a thin metallic patch placed above a conducting ground-plane. The conductor of the patch is generally copper and can be made in various shapes. The microstrip patch is generally photo etched on the dielectric substrate. The substrate of the antenna utilized is often non-magnetic in nature. The recent wireless communication systems require a low profile, light weight, high gain, and simple antenna structures to ensure reliability and high efficiency. In order to achieve these parameters Rectangular Micro strip patch antenna is proposed in this article.

4 Proposed Methodology for the Microstrip Antenna Design

The proposed microstrip antenna is designed using defected ground structure and cross-shaped strip line. The overview of DGS advances the antenna performance, for instance destruction of surface wave propagation, cumulative antenna gain, also enhance alteration. The presentation of defected ground structure in the arrangement advances the antenna exhibition, for example, suppression of surface wave proliferation, expanding the antenna gain, and upgrade adjustment. The ground plane also radiator are stable on differing edges of PCB in this design. In the cross-shaped strip lines, vertical and horizontal strips are included. The overall ground plane dimensions is evaluated using dimensions $L \times W$.

By suitably selecting the size of the patch and position of the probe the ultimate microstrip antenna routine considered with substrate named LCP. In this paper, the Moth-Flame Optimization is presented to analyze the antenna design characteristics. The antenna configuration contains size, thickness of cross-fashioned strip line and protruding pieces. The patch length and width are used to control radiation pattern, impedance input and resonant

frequency. If width is large, the bandwidth also increases. The antenna design is applied for the wideband application by the best possible choice of measurements, where size of antenna can be limited. Defected Ground Structure is the innovative research area related to antennas in addition to printed circuits.

4.1 Microstrip Patch Antenna—Feeding Techniques

The most common types of printed antenna is Microstrip antenna. It signifies one side with a radiating patch and dielectric substrate with ground plane on other side. Microstrip antenna plays a vital role in wireless communication systems. As the fabrication process is equivalent to PCB, Microstrip antenna is named as printed antenna. The microstrip element that involves an area of metallization support above the ground plane is termed as microstrip patch. The substrate is called as supporting element, which is positioned among the ground plane and patch. Moreover, the antenna performance characteristics mainly depends on the physical parameters and substrate material. Conventional antennas possess some drawbacks such as difficult to perform multiband operations, bulky structure and conformability problems. To overcome these issues, MPA is designed. Some advantages of MPA are:

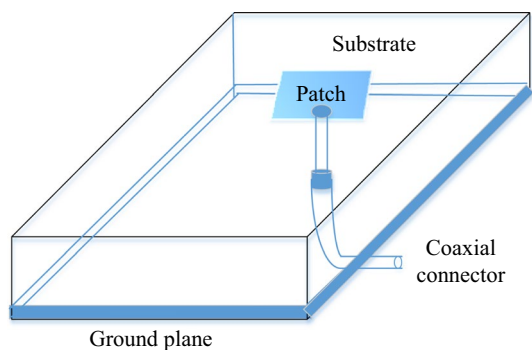
- Integration with circuit elements.
- Generate with printed circuit technology.
- Smaller surface.
- Designed for dual and multiband frequencies.

The most eminent feeding process in MPA are: coaxial probe, microstrip line, aperture and proximity coupling methods. Two categories of feeding processes are described. With contact category, the feeding method is powered by means of microstrip line into radiating patch. Without contact category, power transfer among radiating element as well as microstrip line is accomplished through electromagnetic field coupling.

4.1.1 Coaxial Probe Feed

Figure 1 represents the coaxial probe feed approach. Coaxial probe feed is also known as probe coupling method. The coupling of power is performed using probe coupling method. The coaxial connector's outer conductor is close to ground plane, whereas the interior

Fig. 1 Coaxial probe approach



extends across the dielectric then welded at the radiating element antenna. It is necessary to discover the position of feed point over the antenna element, to attain perfect impedance matching. This feeding approach is popular due to the following advantages such as adjustment of input impedance via positioning of fed point and simpler design. The drawback of this approach is, it is difficult to produce a narrow bandwidth and soldering of array elements.

4.1.2 Microstrip Linefeed

Figure 2 signifies the microstrip line feed approach. The edge of microstrip patch is linked directly to the conducting strip. The main benefit of this method is the conducting line is fixed on same substrate of patch antenna given that a planar shape. Also, comparing to the patch antenna width the conducting element width is minimum. Microstrip line approach is used to offer excitation to antenna. This method is easy to fabricate and simpler in design. The surface waves and radiation increases, if the substrate thickness is increased in the design.

4.1.3 Aperture Coupled Feed

Figure 3 represents the aperture coupled approach. In aperture coupled feed, microstrip feed line is detached by means of the ground plane to the radiating patch. The feed line as well as the radiating element is coupled using slot in ground plane or else an aperture. Depending on the length, width of slot there exists coupling variations. The slot is usually centered under the radiating element. In this method, the ground plane is placed in between two substrates. The feed line is placed on lower substrate and slot is positioned on ground plane. Both of them are connected to the patch electromagnetically through ground plane slot.

4.1.4 Proximity Coupled Feed

Figure 4 signifies the proximity coupled approach. The proximity coupled feeding technique utilize dual dielectric substrates. At first the feed line is among two substrates besides the radiating element is on the top of the upper substrate.

In this method, the patch is positioned on upper substrate and microstrip line is located on lower substrate. Proximity couple feed is also termed as electromagnetically couple

Fig. 2 Microstrip line approach

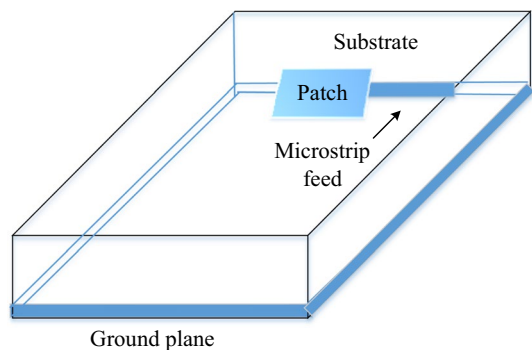


Fig. 3 Aperture coupled approach

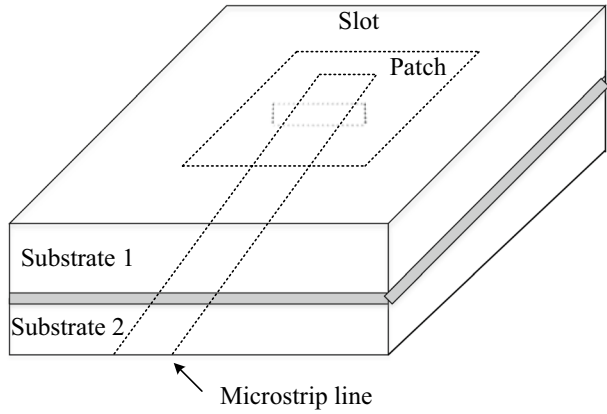
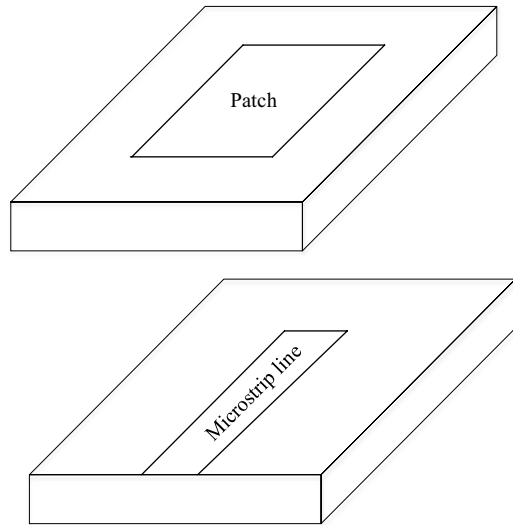


Fig. 4 Proximity coupled approach



feed. The radiation is reduced and bandwidth is improved by choosing thin lower substrate layer and positioning patch on top layer. As the patch is located properly and the alignment problems in feed makes the fabrication process difficult.

The parameters of antenna are calculated using the following equations:

4.2 Calculation of Width (W)

$$W = \frac{c}{2f_o \sqrt{\frac{\epsilon_r + 1}{2}}} \tag{1}$$

where c = light velocity, ϵ_r = Substrate dielectric constant, f_o = operating frequency.

Fringing field uses microstrip antennas effective dielectric constant. The expression for this can be,

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left(\frac{1}{\sqrt{1 + 12 \left(\frac{h}{w} \right)}} \right) \quad (2)$$

where ϵ_{eff} represented as effective dielectric constant, h represented as height and w is represented as width.

4.3 Actual Length of the Patch (L)

$$L = L_{eff} - 2\Delta L \quad (3)$$

where ΔL = Fringing length, L_{eff} = Effective Length.

$$L_{eff} = \frac{C}{2f_o \sqrt{\epsilon_{reff}}} \quad (4)$$

$$\Delta L = 0.824h \left(\frac{(\epsilon_{eff} + 0.3) \left(\frac{w}{h} + 0.264 \right)}{(\epsilon_{eff} - 0.258) \left(\frac{w}{h} + 0.8 \right)} \right) \quad (5)$$

The optimal length for the design of patch is evaluated using the above mathematical formula. The characteristics of antenna which is defined in below section.

4.4 Antenna Radiation Characteristics

The antenna therefore has to be characterized from radiation parameters. Following parameters namely directivity, antenna gain, efficiency also return loss are used for characterizing an antenna.

4.4.1 Bandwidth

The scope of frequencies above that it meets the probe requirements is termed as bandwidth. It characterizes the frequency range over which the reception apparatus reasonably transmit or else get vitality.

4.4.2 Return Loss

The reflections are produced by the presence of discontinuities in the transmission line due to this more signal power will be loosed. The loss of power can be retained the term is called as return loss and it can be represented by decibels (dB). In advanced work reduction of the antenna return loss is a vital feature.

$$RL(\text{dB}) = 10 \log_{10} \frac{P_{IN}}{P_{REF}} \quad (6)$$

where P_{IN} incident power, P_{REF} power reflected.

The return loss of proposed work seems to be in the acceptable range that reduce the error in designing an antenna. The proposed antenna fulfils the switching characteristics as concerns the four requirements namely directivity, antenna gain, efficiency and return loss following a relatively simple design, which ensures reliability, robustness and high fabrication yield.

4.4.3 Antenna Gain

It is typically characterized as a result of efficiency and the directivity of the antenna and expressed as dB.

$$G = \epsilon_r D \quad (7)$$

where G Antenna Gain, ϵ_r Relative permittivity, D Directivity.

Directivity characterizes parameter of a receiving wire that estimates how much the radiation produced is concentrated in a solitary path.

4.4.4 Antenna Efficiency

Radiation competence is another vital factor to describe how efficiently an antenna transmits and receives RF signals, which is characterized as the proportion of the complete power transmitted by a reception apparatus to the absolute information power acquired from the generator. A receiving wire with extraordinary radiation effectiveness productively transmits the information capacity to free space.

$$\epsilon_R = \frac{P_{rad}}{P_{input}} \quad (8)$$

where P_{input} = Input power (W), P_{rad} = Power radiated.

The architecture of the proposed microstrip patch antenna design is given based on the flow model. Design of antenna is characterized with initial geometry value that comprises of radiation characteristics namely return loss, antenna gain and antenna efficiency.

The design of planned technique is presented in Fig. 5. The physical and appropriate antenna size selection is important because the features depend on their material type and geometric size. In this work, antenna is designed with the LCP substrate. LCP suggests a magnificent mix of automated, warm air, machine-driven as well as synthetic possessions suitable for gadgets bundling with low cost. The four basic categories of microstrip antennas are MPA, microstrip dipoles, printed slot antennas also microstrip travelling wave antennas. Microstrip antenna includes radiating patch on one side of dielectric substrate then ground plane on the other side. Some of the principal advantages of microstrip patch antenna are:

- Easiness of manufacturing.
- MPAs are mechanically robust when mounted on rigid surfaces.
- Due to low profile planar configuration MPA can be easily conformed to a host.
- Due to low cost of fabrication they can be produced in large quantities.
- They allow two type of polarization-Linear and circular.
- They are easily adopted into MICs.
- Can conform to multiple frequency requirements.

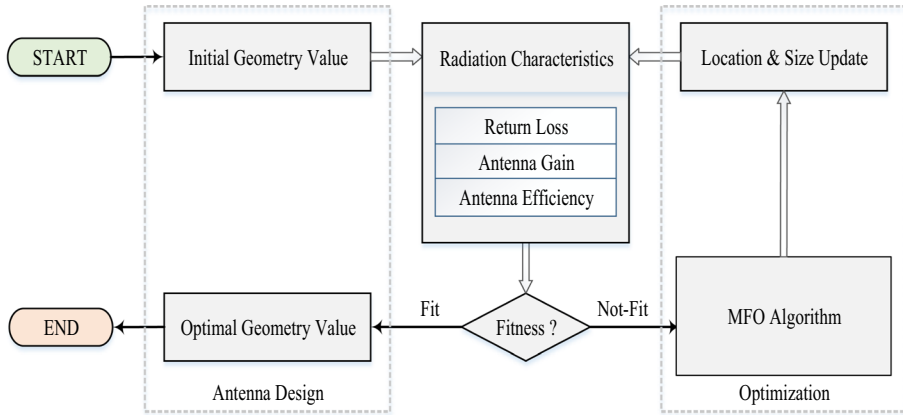


Fig. 5 Structural design

4.5 Moth–Flame Optimization Algorithm

Moth–Flame Optimization is one of the nature encouraged population-based procedure. Recently, population-based approaches are used in different applications than the traditional techniques. MFO is effective than other optimization algorithms namely, Cuckoo Search algorithm, Ant Colony algorithm, Genetic algorithm, Particle Swarm and Dragon Fly algorithm because of its following advantages.

- Global optimum ability in optimization problem for week dimensional function extreme.
- Robustness and Higher convergence accuracy.
- Fast convergence speed.

In this work, MFO algorithm is used to optimize the antenna parameters. The direction-finding process at darkness by means of moths is discussed here. Moth maintains stable angle regarding moon called transverse orientation. These moths are also trickled by false lights and attempt to keep up a comparative edge to the light source and due to the nearby separation they get captured in a winding way.

MFO algorithm assign moths to different weights with each moth representing its own fitness value. Every moth additionally has a glow that stores finest arrangement set up by that moth. In every cycle, the moths examine the arrangement space by flying via a winding way proximate their glow and update their positions. MFO begins with positions of moths arbitrarily modified inside the arrangement space. The fitness estimations of moths are determined which are considered as the best individual fitness ideals. The proposed work is compared with MFO algorithm. The algorithm is initialized by defining the antenna parameters. Then create the first functions arbitrarily. Finally compute fitness function as well as tag the finest solution using Moth–Flame optimization algorithm.

In the present work, MFO is applied on the ground plane of the design. MFO is executed in MATLAB environment in which a random matrix (M) of moths is created and moth fitness (OM) is computed. Further, a matrix of flames is calculated. Here, moths are interchanged by means of antenna parameters for example geometric size is

considered as moth position. The glow represents material type. The nodes consists of the dimension equals 3. The moth position is specified using the matrix Eq. (9) as

$$S_T = \begin{bmatrix} S_{T_{1,1}} & S_{T_{1,2}} & S_{T_{1,3}} \\ S_{T_{2,1}} & S_{T_{2,2}} & S_{T_{1,4}} \\ \vdots & \vdots & \vdots \\ S_{T_{n,1}} & S_{T_{n,2}} & S_{T_{n,3}} \end{bmatrix} \tag{9}$$

The fitness value is evaluated using the following equation

$$S_{T_1} = \sqrt{(S_{T_{d,1}} - S_{T_{1,1}})^2 + (S_{T_{d,2}} - S_{T_{1,2}})^2 + (S_{T_{d,3}} - S_{T_{1,3}})^2} \tag{10}$$

The equivalent fitness value matrix is specified as

$$U_{S_T} = \begin{bmatrix} U_{S_{T_1}} \\ \vdots \\ U_{S_{T_n}} \end{bmatrix} \tag{11}$$

The flame matrix offers the updated position given by,

$$P_T = \begin{bmatrix} P_{T_{1,1}} & P_{T_{1,2}} & P_{T_{1,3}} \\ P_{T_{2,1}} & P_{T_{2,2}} & P_{T_{1,4}} \\ \vdots & \vdots & \vdots \\ P_{T_{n,1}} & P_{T_{n,2}} & P_{T_{n,3}} \end{bmatrix} \tag{12}$$

The fitness value matrix of the position update is given by

$$U_{P_T} = \begin{bmatrix} U_{P_{T_1}} \\ \vdots \\ U_{P_{T_n}} \end{bmatrix} \tag{13}$$

The logarithmic spiral is given by

$$S_{S_i T_j} = |T_j - S_i| * e^{bt} * \cos(2\pi t) + T_j \tag{14}$$

The distance matrix is given by

$$D_{S_T} = \begin{bmatrix} D_{S_{T_1}} \\ \vdots \\ D_{S_{T_n}} \end{bmatrix} \tag{15}$$

The fundamental phase of optimization method is explaining the cost capacity. Thus, the cost capacity of presented antenna arrangement will be the contrast among attained contamination factors besides ideal showings. The antenna geometrical measurements are improved utilizing the condition given beneath:

$$F = \frac{1}{m} \sum_{j=1}^m W_j [E_1(f_j) + E_2(f_j)] \tag{16}$$

$$E_1(f_j) = W_a [(|S_j| + S_j)/2] \tag{17}$$

$$S_j = [S_{11}(f_j) - (S_{11desired})] \tag{18}$$

$$E_2(f_j) = W_b (G_{desired}(f_j) - G(f_j)) \tag{19}$$

where E_1 relative error of desired S_{11} ($S_{11} = -10$ dB), E_2 difference among obtained as well as chosen gains, m sampling frequencies in number, f_j j th sampling rate, W_j weighting factor at j th sampling rate.

Finally, optimized antenna efficiency by means of bandwidth, gain, directivity and return loss are associated via the previous works.

5 Results and Discussion

The microstrip antenna design for this work is executed using Matlab, and HFSS tools. The globally used commercial Finite Element Method (FEM) for electromagnetic structures is HFSS. This is very helpful for antenna engineers to optimize the antenna parameters very accurately. Initial phase of the suggested approach is applied in Matlab. Then optimal results obtained from the Matlab are utilized for the antenna design and validated using HFSS. The initial parameter setting for the parameter optimization stated in Table 1.

The evolution of proposed microstrip patch antenna on LCP substrate is designed as follows:

Figure 6 presents the physical fabric of draft microstrip probe; also aerial drawn have the geometry of Patch length 12.72 mm, Patch Width 17.22 mm, Substrate Thickness 2 mm, Dielectric Constant 0.04 and Feed line width 8 mm. As the fringing fields are placed among the ground plane and patch edge, radiation takes place in microstrip antenna. The feed lines and radiating patch are photo-etched on the dielectric substrate. For good antenna performance, a thick dielectric substrate having a low dielectric constant (less than 6) is desirable since it provides higher efficiency, larger bandwidth and better radiation.

Return loss obtained from the proposed model shown in Fig. 7a; due to the terminal mismatch the transmitted signal gets reflected which makes the loss of signal. In our system the return loss is the acceptable level, the average return loss of -20 dB resonates at 20.3 GHz with bandwidth of 3.1 GHz. Return loss is defined as the ratio

Table 1 Parameters of Antenna

S. no.	Description	Value/mm
1	Patch length	12.72
2	Patch width	17.22
3	Substrate thickness	2
4	Dielectric constant	0.04
5	Feed line width	8

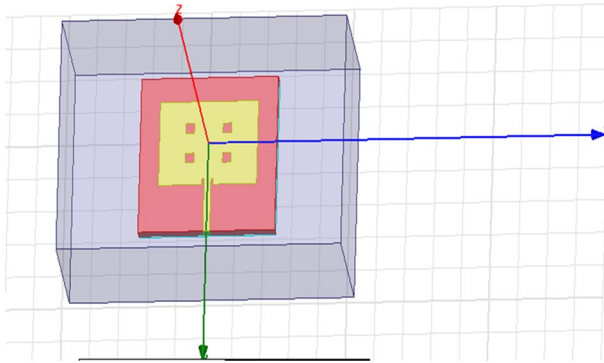
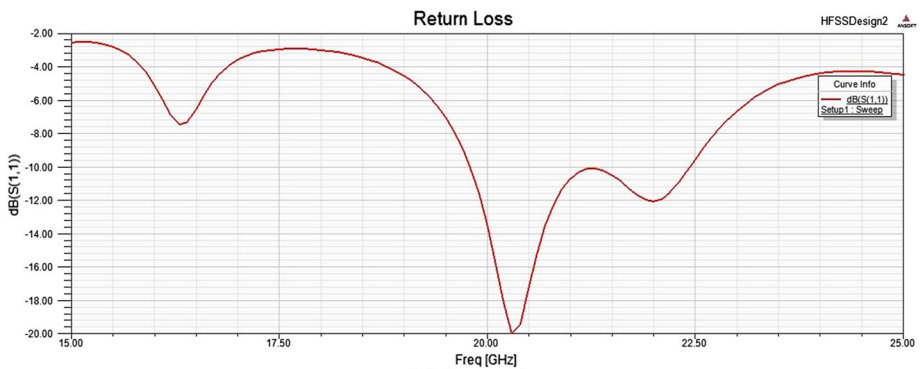
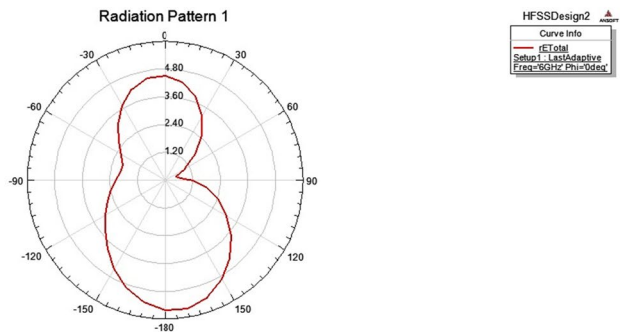


Fig. 6 Proposed microstrip antenna arrangement



(a) Return Loss



(b) Input Impedance

Fig. 7 Proposed antenna characteristics

of reflected power to incident power and the unit is dB. At antenna input, the reflection coefficient is the ratio of reflected to incident voltage. Return loss is used to measure the degree of mismatch. The frequency equivalent to minimum return loss is denoted as the resonant frequency of antenna.

The input impedance plot as presented in Fig. 7b, where range of input impedance should be higher to yield maximum antenna efficiency. The spatial distribution of electromagnetic field radiated by the antenna is represented as radiation pattern. Two planes in radiation pattern are E-plane and H-plane. First plane is defined as the plane containing electric field vector and maximum radiation direction. H-plane is the plane containing magnetic field vector. At multiple test frequency points, the antenna radiation pattern is measured with single rotation of test antenna positioner, measurement software.

The corresponding 3d and 2d plot of antenna gain obtained are presented in Fig. 8a as well as Fig. 8b; the gain plot shows its effectiveness. The ratio of antenna radiation intensity to the reference antenna is termed as Antenna gain. If the reference antenna is an isotropic antenna, then gain is expressed in units of dBi. If the gain of the antenna is represented as a passive phenomenon, then the power of antenna is redistributed to provide more radiated power in definite directions.

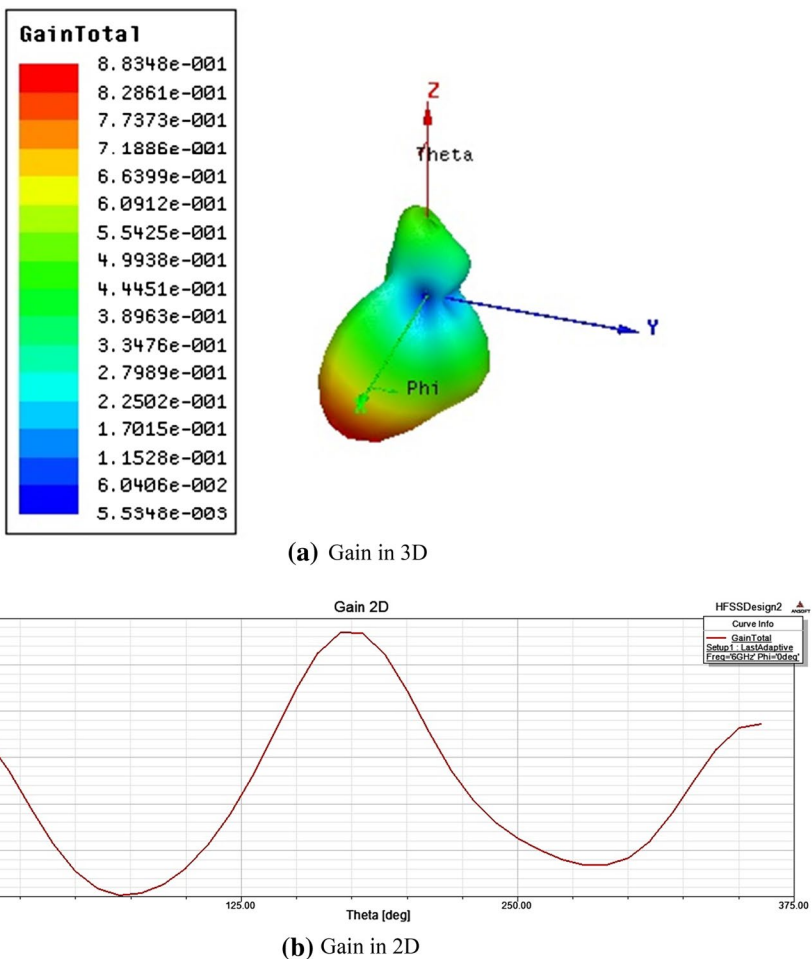


Fig. 8 Antenna Gain

Fig. 9 Directivity

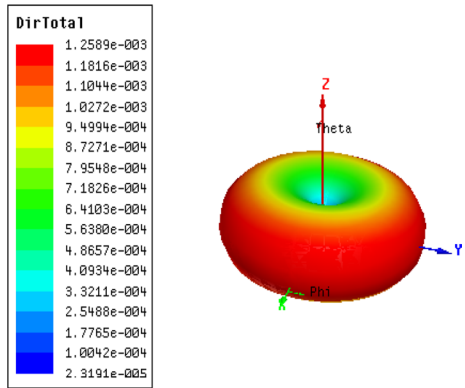


Table 2 Comparison of proposed method with existing methods

Parameters	MSPA [22]	EBG [23]	Proposed method
Directivity (dB)	11.59	11.78	12.6
Return loss (dB)	17.34	28.24	-20
Band width (GHz)	1.5	2.4	3.1
Gain (dB)	7.33	8.55	8.9

Figure 9 displays the 3D directivity characteristics of MPA. The reduced cost of LCP material makes this suitable for the microstrip antenna design as the substrate. Along with the cost reduction by choosing the proper material, the performance also increased by a suitable antenna geometry. The overall performance of suggested antenna design system is appropriate for rational design besides validation of a microstrip antenna.

The above Table 2, presents that the effective comparison of the suggested scheme with existing methods like microstrip semi-circular patch, as well as EBG structures. Patch antenna performance is well defined in table, from which the proposed antenna is better than the existing antennas. The proposed design offers directivity of 12.6 dB, return loss -20 dB, bandwidth 3.1 GHz also gain 8.9 dB.

6 Experimental Verification

In order to confirm the simulated results, the fabrication process of antenna is done. The parameters for the dielectric substrate = 4.4, loss tangent = 0.02, height = 1.59 mm and a probe radius of 0.4 mm. For the fabricated antenna, there was an air gap among dual dielectric layers, due to the soldering tips of the shorting pins. The approximate height of this air gap was about h = 0.2 mm. This air gap was not included in the antenna optimizations, and its presence reduced their performance. However, since the experimental studies were conducted to verify the simulations, new simulations were conducted on antenna models with the air gap included, which are presented below.

The Table 3 shows the simulated as well as experimental outcomes. At simulation the antenna will resonate at -20 dB at frequency 20.5 GHz. By experimental analysis the antenna measurement is reduced to -18 dB at frequency 20.5 GHz. Considering the small differences among the measured and simulated results, we therefore conclude that using a

Table 3 Simulation and experimental results

Antenna	Impedance bandwidth (GHz)	Gain (dB)
Simulation	3.1	8.9
Measurement	2.9	8.6

high impedance LCP layer as the ground plane of microstrip antennas improves their performance, both in bandwidth and gain.

7 Conclusion

The proposed method is to design an inexpensive, high-performance microstrip patch antenna using MFO algorithm. In this work, UWB structured MPA is offered. The design and enquiry of antenna based on obtained geometry parameter are executed. The return loss value of proposed method is -20 dB with a bandwidth of 3.1 GHz. The proposed system performance is analysed based on return loss as well as antenna gain. Finally, the analysis provided the acceptable performance; and thus the proposed antenna can provide good performance at low cost. The use of such an antenna would reduce the size of the wireless navigation setup significantly accompanied by a reduction in fabrication cost of the antenna. Also it is integral with the wireless setup, hence, improving system reliability. Rectangular Microstrip Patch Antenna is a narrowband antenna because of which it has low bandwidth. By increasing the width of the patch, the Bandwidth can be increased but the impedance of the patch antenna will also get reduced. In future, the design can be further extended to match the gain with that of the dish antenna. Once the gain is achieved experiment can be done for replacing existing dish with that of the patch array. The benefit will be size and cost reduction and can be kept even in a small place.

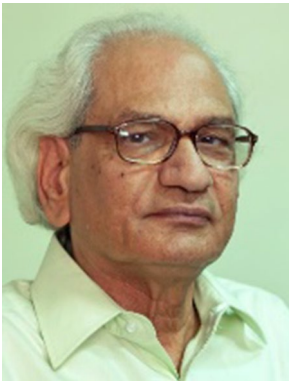
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