Optimization of Koch Dipole Fractal Antenna Using PSO: The OKDFNP Approach

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ABSTRACT

In this paper, simulation of PSO (Particle Swarm Optimization) based dipole fractal antenna at different UWB (Ultra Wide Band) frequencies is considered. The antenna design is based on PSO fed with KOCH dipole fractal antenna. Parametric analyses are calculated for the radiation pattern, return loss, power gain, and real, imaginary voltage impedance. The structure of the antenna is four directional star which helps in the improvement of directionality of the antenna along with the gain in power. Comparing the directivity of PSO with genetic algorithm helps in analysing PSO provides better directionality compared to GA along with reduction of Side lobes. The design and simulation work is done by using MATLAB 2012a software. These simulations were tested and plotted under different frequencies 2.5GHz, 7.5GHz and 10GHz on array elements of 9.

Keywords: *PSO, Koch, Fractal, Dipole, GA, Radiation pattern, UWB, Voltage impedance and return loss.*

I. INTRODUCTION

Communication is process transferring message or information or intelligence from one place to another place. The electromagnetic waves or radio waves were used for transferring message then the communication is known as radio communication. Radio communication is made possible by Lee De Forest with invention of TRIODE tube in the year 1906. Transmitting of an electromagnetic waveform into a free space with velocity light from a height is known as radio wave transmission by a transmitter.

By creating an L-slot multi frame on a host dipole to achieve the multi band and by loading the host dipole antenna comprises with a single micro strip line for generating a shunt couple and capacitive gaps with an inductive strip in series forms an LC resonators [1].

The discretized Hallen system of equations for a dipole antenna can be written as (1). Constituting an antenna array are centre fed by voltage generatorsV_i and the respective currents distributions included by the generators and the radiators' mutual interaction are noted as$I_i(z)$. Z_{ij} are the impedance values using kernel function for$i \neq j$ [2].

$$\sum_{j=1}^{K}\sum_{m=-M}^{M} Z_{ij}(n,m)\, I_j(m) = C_i \cos(KZ_n) + V_i \sin(k|Z_n|) \; (1)$$

Statistical method of approach is characterizing wideband emissions from planar antennas and circuits with multiple radiating elements. Source currents can be obtained using space time and space frequency correlation function approach. Over a combined spectrum of uncorrelated sources for an arbitrary configured emitting dipoles [3].

Evaluation of four different types of dipole antennas with curved forms, optimization with the purpose of obtaining the greater and maximum directivity. This is simply optimized with simple genetic algorithm for UHF. The VSWR, radiation pattern the maximum gain and the magnitude of normalized printed density of the different purpose antenna [4].

Enhancing the directivity by using front to back ratio of a metamaterial inspired electrically small linearly polarized, under Egyptian axe dipole antenna these helps in particular augmentation of the near field resonant plastic antenna [5].

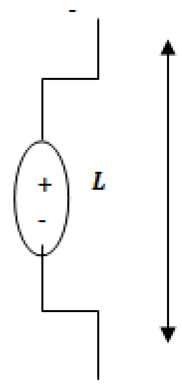


Figure1. Short dipole antenna of length L

The word "Short" indicates that the wavelength will be small. Here L is the length of the dipole and is derived from the following (2).

$L < \frac{\lambda}{10}(2)$, Where λ is the wavelength of the dipole antennas depends on velocity of the light and carrier frequency or Doppler frequency.

For the afar field radiations from the short dipole antenna are given as (3) & (4). These equations are given for Electric field radiation(E_θ) and Magnetic field radiation$\left(H_\phi\right)$ respectively.

$$E_\theta = \frac{j\eta k I_0 L e^{-jkr}}{8\pi r} \sin\theta \; (3)$$

$$H_\phi = \frac{E_\theta}{\eta} (4)$$

The radiation resistance and loss can be calculated as (4) & (5).

$$R_{rad} = 20\pi^2 \left(\frac{L}{\lambda}\right)^2 \; (4)$$

$$R_{loss} = \frac{L}{6\pi a}\sqrt{\frac{\pi f \mu}{2\sigma}} (5)$$

Input impedance dependent on the area of the radiation and derived from (4) and (5) is given as follows

$$Z = R_{rad} + R_{loss} + jX (6)$$

Radiation pattern
A graph which shows the variation in actual field strength of EM field at all points for equal in distance from the antenna. This is also known as "Field Strength Pattern".

Power gain
POWER gain is also known as directive gain and is defined as directivity and gain are only difference were seen that for the directive antenna and power input to the antenna is considered. The power gain can be written as $G_p = \eta G_d (7)$

II. COMPARATIVE ANALYSIS BETWEEN PSO AND GA

Using radiation pattern side lobe levels of GA and PSO these analyses will calculate and shows the efficient one with their graphs output. As the side lobes were high in number the directionality will be poor. Especially in the case of UWB antennas it is very important to note that SLL should be less. Comparing figures 1 and 2 this will be solved that the SLL were high in the case of GA compare to PSO. So, the efficient PSO method is considered for the next level at different operating frequencies.

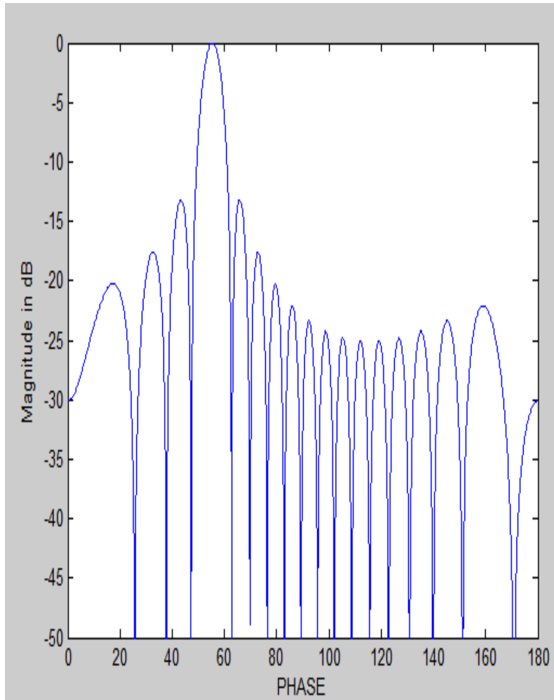


Figure 2: Radiation pattern of GA with high SLL.

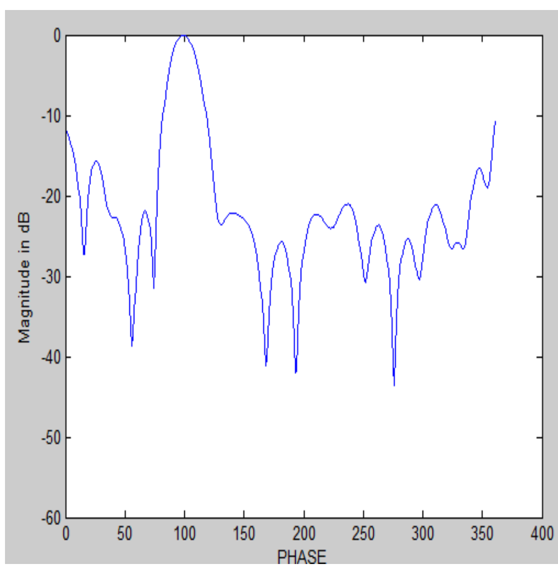


Figure 3: Radiation pattern of PSO with SLL

The directionality along with beam width is explained with low values in figure 1. Such that beam width of the antenna array is restricted 20db. While in the case of Figure 2 the directionality with the increment in beam width i. e, 100db. From the above two figures we can observe the reduction of side lobes in PSO compared to GA. These patterns of radiation were shown using 18 antenna array elements. Therefore n = 18 is considered for optimization.

Fractals are fun shaped architectures whenever it was zoomed in or zoomed out there is no change in the shape of the antenna. These are constrained with finite area and but infinity parameter. Different Fractal antennas are Snail like fractal antennas, Triangle fractal antennas, Koch curve antennas [9].

Conventional circular microstrip patch antenna is used to observe the return loss behaviour using vector network analyzer. The operating frequencies for CCMP are 0.85-4 GHz band. To reduce the iterations of a fractal antenna using conventional patch antenna. The reduction is observed at multiband back scattering by variation in the substrate dielectric constant and thickness [6].

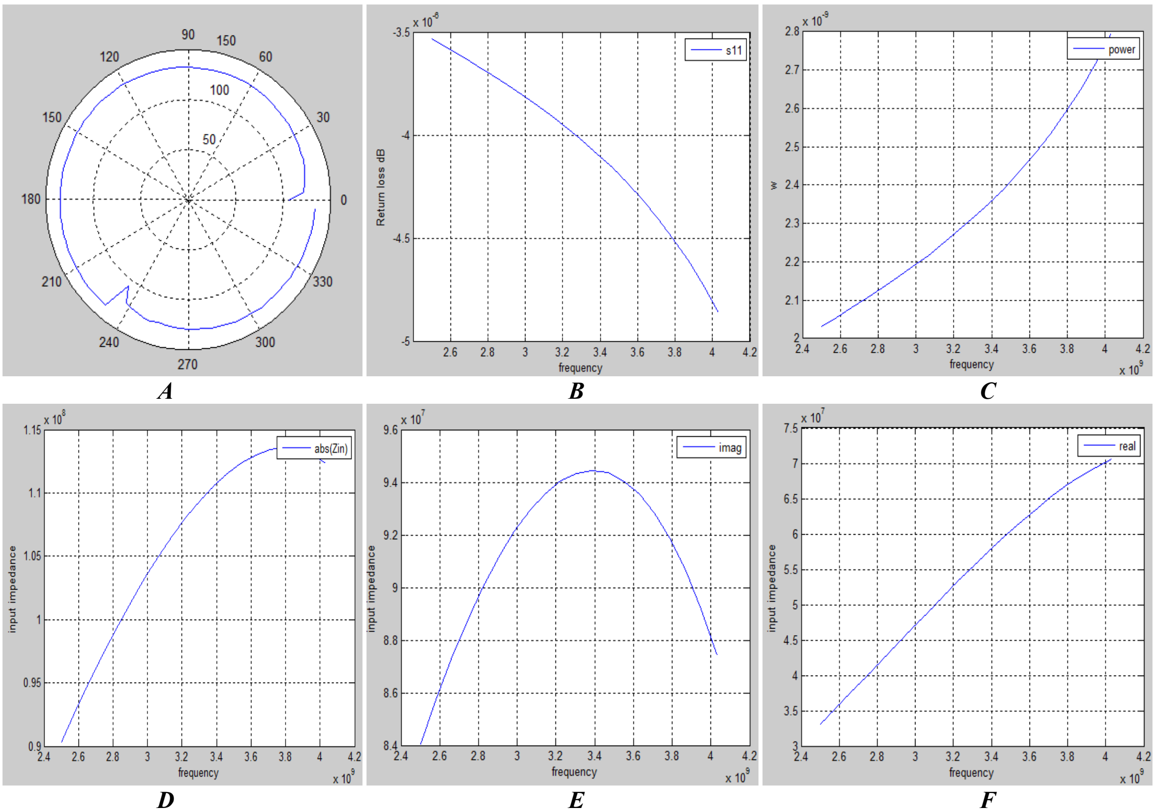
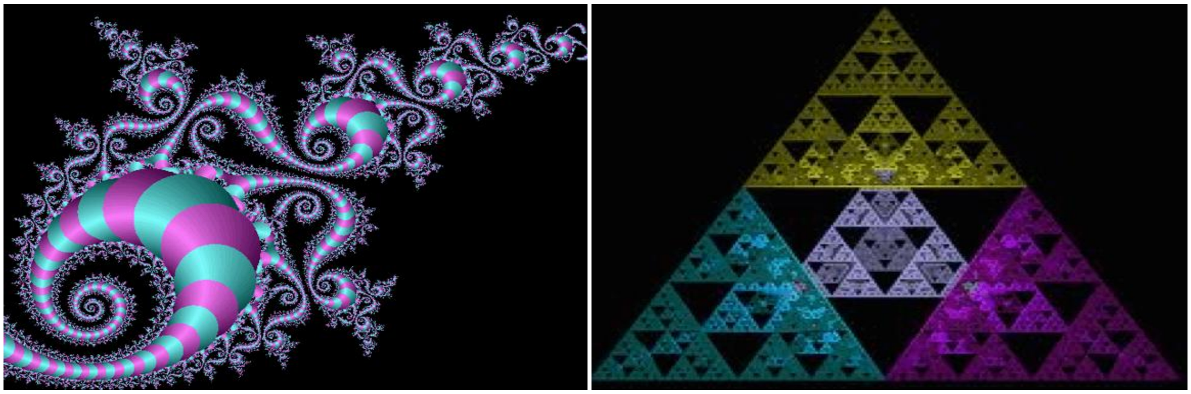


Figure 4:FOR operating frequency 2.5 GHz, A) Radiation pattern, B) Return loss in dB, C) Power gain, D) Input impedance, E) imaginary part of Z, F) Real part of Z

Compact multiband UHF Hilbert fractal antenna with wide frequency band and suitable size for installation to reduce the electromagnetic waves generated due to partial discharge method which are captured by UHF antennas. This antenna is works on the principle of Hilbert fractal antenna. This method is used to calculate the PD value and helps in examining the effects of electromagnetic wave refraction and reflection by transformer components [7].

The design of direct radiating arrays with specific operation features is done in an effective manner by using fractal antennas. These were synthesized under multi beam antenna arrays to meet the requirements of high end of coverage directivity, low side lobe level and suppressed grating lobes with minimum and maximum levels [8].
As an example for fractal antennas a snail like fractal geometry and Triangle fractal geometry were considered and the geometry of positions were shown in figure 5 A and B.
This will help in understanding the structure of fractal antennas which same in structure but varying with their sizes as they were stick together in the same structure directionality will be increased.



A B

Figure 5: A) A snail like fractal geometry, B) Triangle fractal geometry.

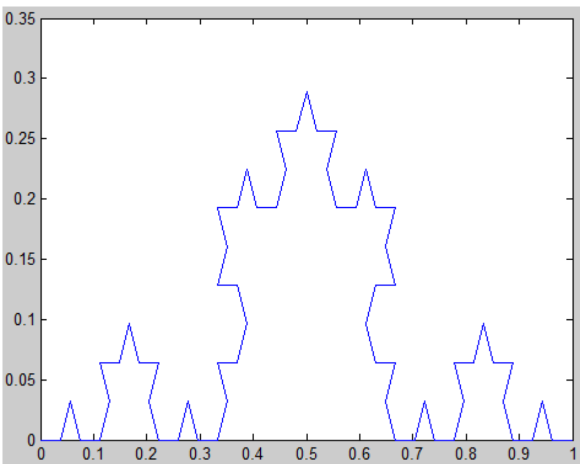


Figure 6: Existing n-array KOCH Fractal antenna

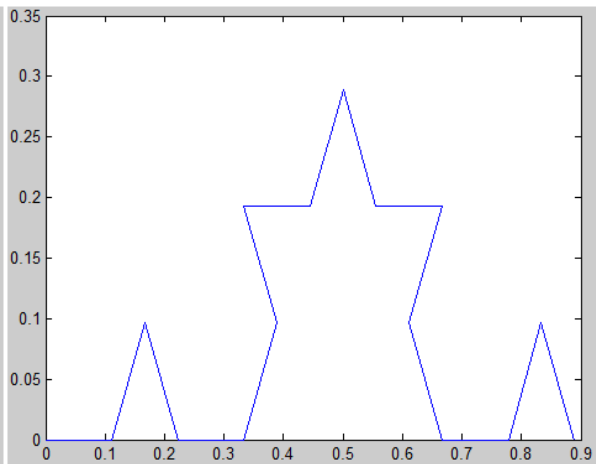
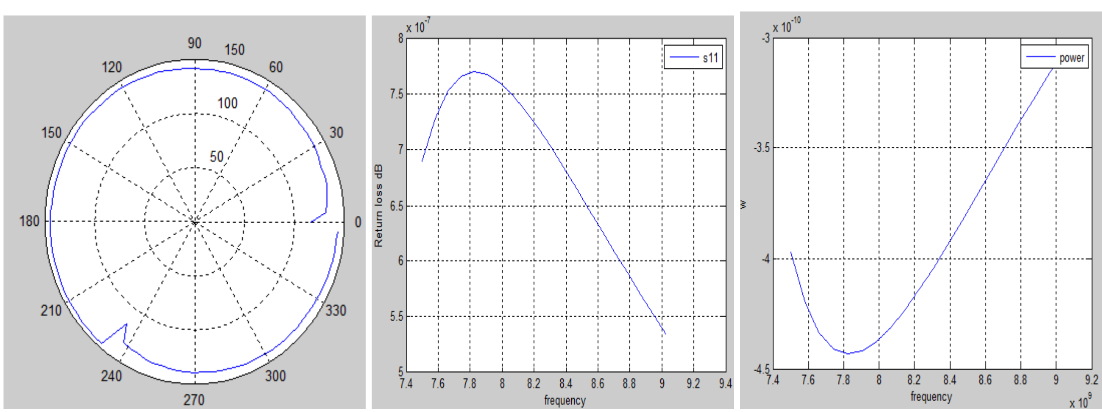
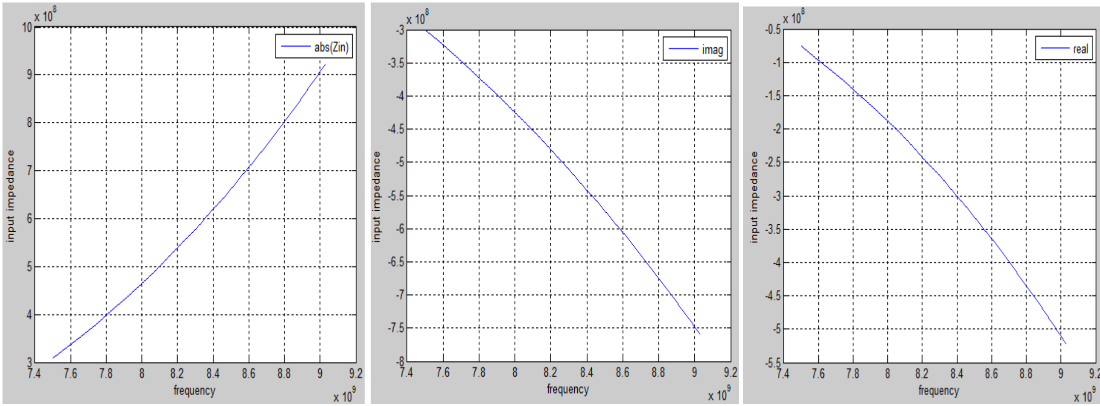


Figure 7: Modified Koch fractal n-array antenna



A B C



D E F

Figure 8: For operating frequency 7.5 GHZ, A) Radiation pattern, B) Return loss in dB, C) Power gain, D) Input impedance, E) imaginary part of Z, F) Real part of Z.

Koch fractal antenna is considered as initialised one and is modified to improve the directivity and modified with existed method is shown in the figures 6 and 7 with the titles existed Koch fractal antenna and modified Koch fractal antenna respectively.

All the graphs plotted were explained in the results column under dipole mom antenna theory. The results plotted were simulated using MATLAB. For the modified Koch fractal antenna these results were calculated.

A custom made of artificial neural networks for fractal antennas and Particle Swarm Optimization technique were used to identify or mapping the design parameters of the fractal antenna and its operational frequencies, for user defined frequencies Particle Swarm Optimization used to find the shape of the antenna. These are mainly focused on monopole antennas for effectiveness approach of obtaining simulation results [10].

A neighbourhood re-dispatch technique is used as an extension with PSO to design Ultra Wide Band (UWB) antennas. The conventional PSO algorithm with performance optimization and representing the topology problems, these antennas not only covers 3.1-10.6 GHz and 2.40-2.484 GHz or pass band of blue tooth, stop band of 5.15-5.825 GHz [11].

III. FRACTAL ANTENNA

Fractal antennas are patterns that feature geometric elements at ever smaller scale to produce self similar as well as irregular shapes. In fractal antennas the segments are of similar shapes but vary in their sizes. Mainly used for mobile communications and RADAR. These Fractal antennas imposes some exclusive properties they are

1. Reduction in the size of the antenna.
2. Multi band functionality.
3. Improvement in antenna performance such as antenna gain, power, radial distances.

It is a geometry based technology not material based, therefore these are manufactured from standard material and substrates. These are flexible, cost effective and less design complex.

IV. PARTICAL SWARM OPTIMIZATION

This method is completely based on the velocities of the particle and helps in the optimization of directivity and beam forming characteristics. The optimization process is entirely carried out using PSO and the weighted value of W will calculated using KOCH FRACTAL ANTENNA.

The proposed algorithm is based on the velocity of the particle and is explained by using the following equation. Here x indicates the particle, V indicates velocity.

$$v[x] = v[x] + c1 * rand(x) * (pbest[x] - present[x]) + c2 * rand(x) * (gbest[x] - present[x])$$

ALGORITHM: PARTICLE SWARM OPTIMIZATION

STEP1: For each particle

STEP2: Initializing particle
STEP3: END
STEP4: Do
STEP5: For each particle
STEP6: Calculating fitness value
STEP7: If the fitness value is better than the best fitness value (Best) in history
STEP8: set current value as the new Best
STEP9: End
STEP10: Choose the particle with the best fitness value of all the particles as the g_Best
STEP11: For each particle
STEP12: Calculate particle velocity
STEP13: Update particle position
STEP14: End
STEP15: While maximum iterations or minimum error criteria is not attained.

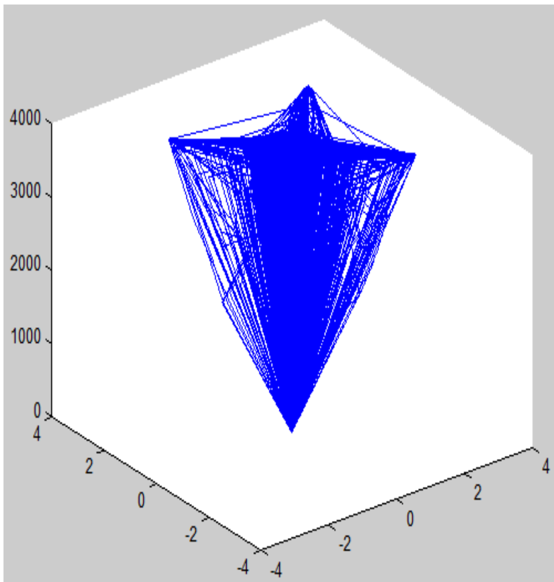


Figure 9: 3D view PSO under different velocities of the particle

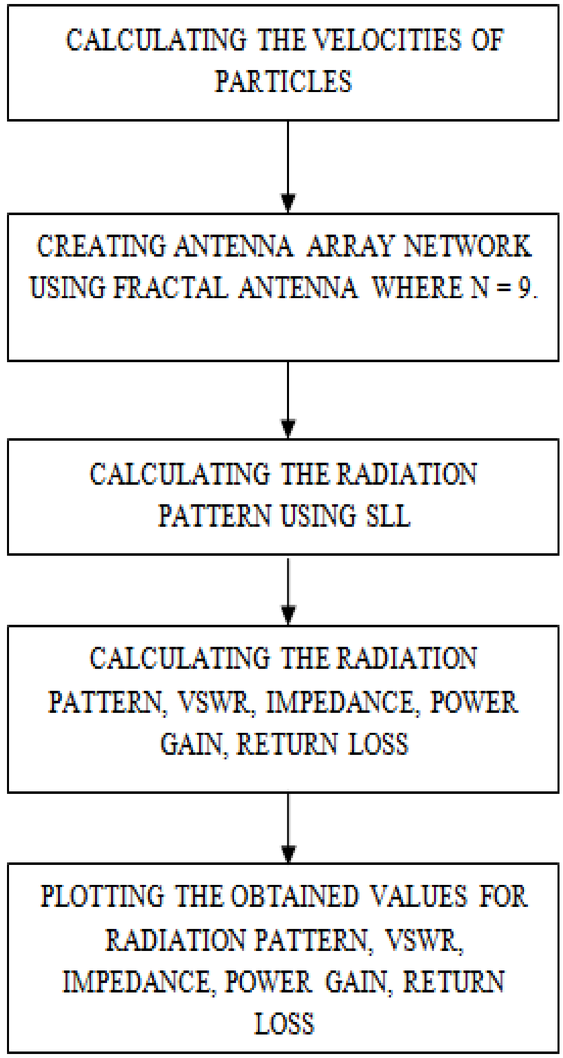
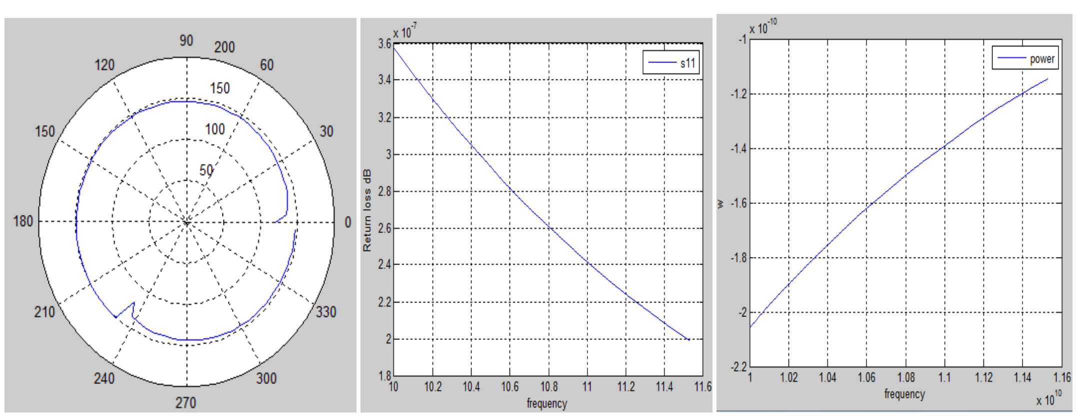
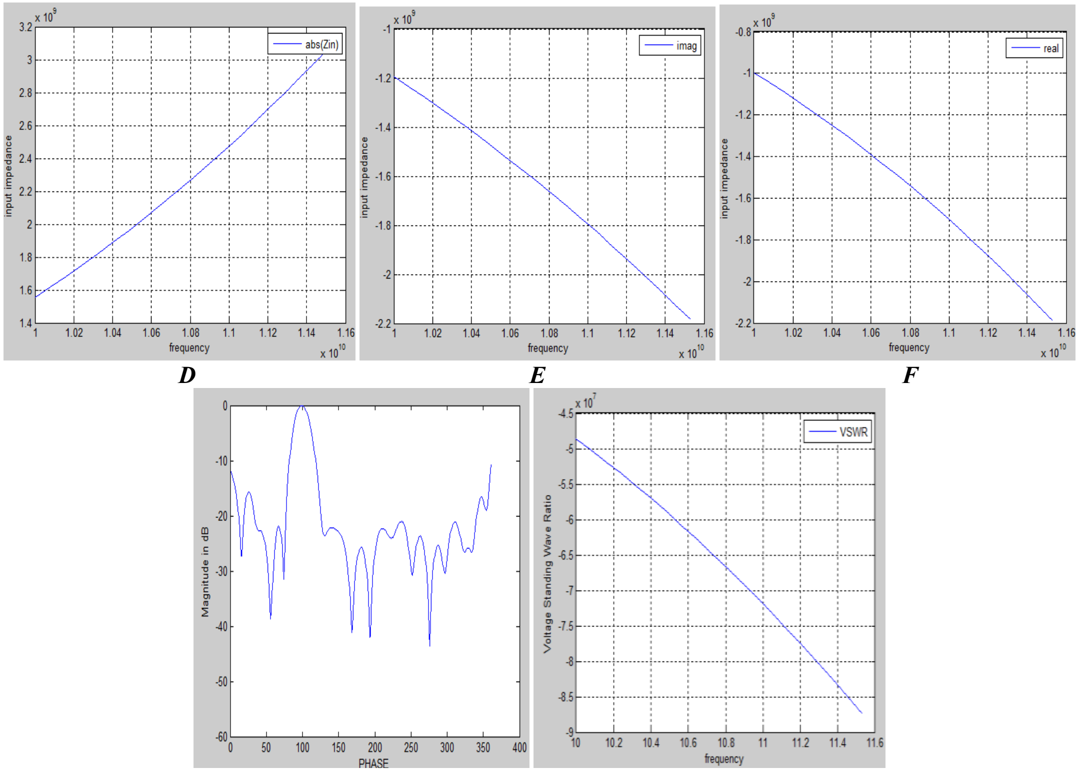


Figure 7: flowchart for proposed method

V. RESULTS



A *B* *C*



D E F G H

Figure 9: FOR OPERATING FREQUENCY 10 GHZ, A) Radiation pattern, B) Return loss in dB, C) Power gain, D) Input impedance, E) imaginary part of Z, F) Real part of Z, G) Radiation pattern with side lobes, H) VSWR.

The simulated were shown in this paper are considered on n = 9 or array of 9 antennas. VSWR, Radiation pattern, Side Lobe Level were also calculated.

VI. CONCLUSION

The comparison between PSO and GA helps in identifying to choose the best pattern of radiation using radiation pattern with side lobes. This proves from Figure 1 and Figure 2 PSO is advanced with low SLL and is suitable for UWB antennas. This is explained in the later stages with the help results plotted at different operating frequencies for VSWR, Radiation pattern, Impedance, Return loss, Power Gain and were plotted based on the modified Koch fractal antenna this improves the directivity of the antenna.

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