Optimization Of Microstrip Patch Antenna Using Genetic Algorithm

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Abstract- *This project gives a fresh approach of optimization of inset-fed patch antennas using genetic algorithm. HFSS can be used to simulate the patch antenna and thereby results can be verified by the resonating frequency in opposition to desired frequency, and the radiation pattern. Then the antenna can be optimized in respect with many kinds of necessity and situations, with respect to less arithmetic complication assets usage. This optimization is done through Genetic Algorithm on MATLAB. The simulation is done using HFSS and optimized using Genetic Algorithm on MATLAB ,finally the patch is fabricated using FR4 substrate.*

Keywords- Optimization, Return loss, Bandwidth.

I. INTRODUCTION

This paper characterize the antenna as "a part of a transmitting or receiving system that is designed to radiate or receive electromagnetic waves". Micro-strip antennas (MSA) are considered as better kind of one printed antennas. Now a days wireless communication system cannot be thought without these antennas. MSA is said as the most important part and parcel for wireless communication system since they not only eliminate feed radiation but are also compact, robust ,easy to make and appliance. They are capable of giving a good performance in different conditions, considering compact frequency selection, custom-built radiation pattern

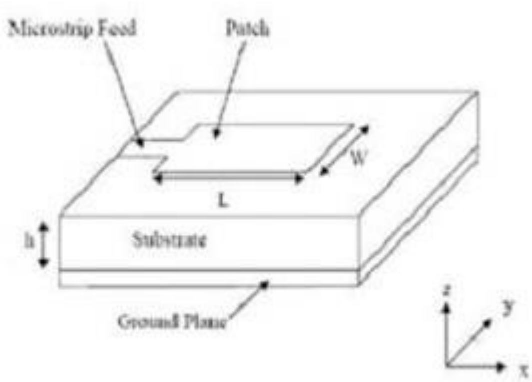

Fig. 1: Front view of microstrip patch antenna.

And less Loss conditions. However, narrow bandwidth, low gain and efficiency often limit their use. Therefore, the designing of these antennas with respect to various scenes is a difficult challenge, thus we use genetic algorithms for the same.

Genetic Algorithms(GAs) that belong to the larger part of evolutionary algorithms which is modifying heuristic search algorithm . These algorithms are established upon the theory of natural selection and genetics. That uses the input data from the user to learn the required solution domain such that the algorithm itself learns the user and what they require to better the performance of the system. They are commonlyused to generate high-quality solutions for large and complex data sets. Genetic algorithms can be easily distinguished with the other traditional optimization methods since they work with a coding variable. The algorithms requires design area to be changed to a genetic area. The main advantage of coding in GA is that, it can convert a continuous search area or space into discrete space. GA uses multiple point approach with respect to the traditional optimization of one point method for a given population of points i.e. it can exercise on a number of single point designs simultaneously. Basically a GA takes use of combination of random operator that makes the search space better in flexible manner. Between the Genetic Algorithm optimization, encoding of factors of every existence of population is done to convert into string of bits that is chromosomes. The starting set of chromosomes(individuals) which are termed as generations is generated inconstantly. The fitness for every member of group is obtained by using cost function. The process of cohabit finds out new generation. The best chromosomes are elected then gets more chances for reduplicate. Crossover and mutation both of these are recycled for the generation of cost function. The better of all chromosomes or individual are send without any modification for next generation. The repeating method forms consecutive generations til a finish or stop position is obtained. In other words, it is survival of the fittest.

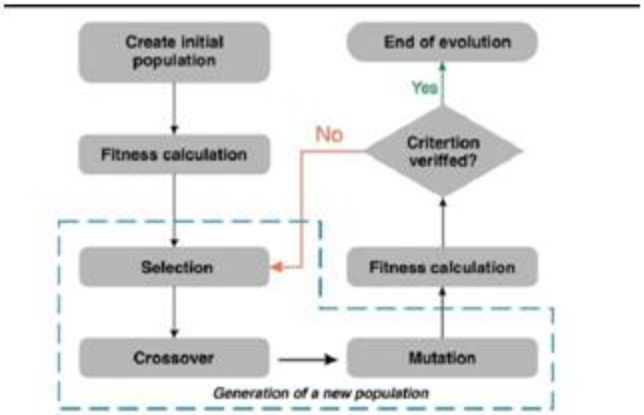

Fig. 2: Flow chart of genetic algorithm optimization.

Currently, many methods is proposed for optimizing microstrip patch antennas like that of usage of dielectric substrate of high permittivity, and many types of already present optimization algorithms for example particle swarm optimization (PSO) and genetic algorithm (GA).

This is one of the globaloptimized algorithms that is usedfor optimization of antennas. It is a powerful, stochastic based search method, which can handle optimization problems that cannot be handled by conventional methods. The concept of this algorithm is to divide any regular square microstrip patch antenna to a grid of symmetrical squares and then use genetic algorithm to selectively remove smaller metallic grid squares from the patch, and then, novel non-intuitive shapes can be formed. This method is also used to make dual-band antennas because of several current paths on the patch, wide-band antennas, and longer meandering current paths on the patch which leads to miniature performance of patch antennas. In this project, genetic algorithm is used to design the antenna, in order to optimize bandwidth of the antenna. The analysis and working of the patch antennas is done using MATLAB and HFSS. The design is implemented on a microstrip patch antenna using FR4 substrate. FR stands for flame retardant,. FR-4 was developed by the NEMA in 1968.FR-4 glass epoxy is a popular and versatile high-pressure thermoset plastic laminate grade with good strength to weight ratios. It has very less water absorption, FR-4 is mostly used as an electrical insulator possessing considerable mechanical strength. The material is famous to retain its high mechanical values and electrical insulating qualities in both of the dry and humid conditions. It has good fabrication characteristics, these properties make FR-4 suitable for a wide variety of electrical and mechanicalapplications.

II. METHODOLOGY

A. Unoptimized Methodology :

- The unoptimized Microstrip patch antenna is simulated using HFSS.
- Ansys HFSS is a 3D electromagnetic (EM) simulation software for designing and simulating high-frequency electronic products such as antennas, antenna arrays, RF or microwave components, high-speed interconnects, filters, connectors, IC packages and printed circuit boards.
- In order to obtain the desired frequency which is 7.75GHz, many trails were made.
- The parameters and range of parameters used for the design used is shown.

Table 1. Parameters taken for antenna design.

Patch		Substrate		Feedline		Ground Plane	
Lp	Wp	Ls	Ws	Lf	Wf	Lg	Wg
4 bits	4 bits	4 bits	4 bits	3 bits	3 bits	4 bits	4 bits
5-20 m m	5-20 mm	30-45 mm	30-45 mm	2-9 m m	1-4 mm	4-19 m m	15-30 mm

The range for the parameters were decided based on the given formulae:

- Patch width $= \frac{c}{2f}\sqrt{\frac{2}{\varepsilon_r+1}}$
- Patch length = $L_{eff} - 2\Delta L$
- where, $L_{eff} = \frac{c}{2f\sqrt{\varepsilon_r}}$
- $\varepsilon_r = \frac{\varepsilon_r+1}{2}\frac{+\varepsilon_r-1}{2}\left[1+12\frac{h}{w}\right]^{-\frac{1}{2}}$
- Substrate length =L + 6h
- Substrate width = W + 6h
- Length of the feedline = $\frac{\lambda_g}{4}$

Table 2. Proposed antenna geometry.

Parameter	Value
Substrate Length	16mm
Substrate Width	20mm
Patch Length	9mm
Patch Width	12mm
Feedline Length	9mm
Feedline Width	3mm
Ground plane Length	16mm
Ground plane Width	20mm

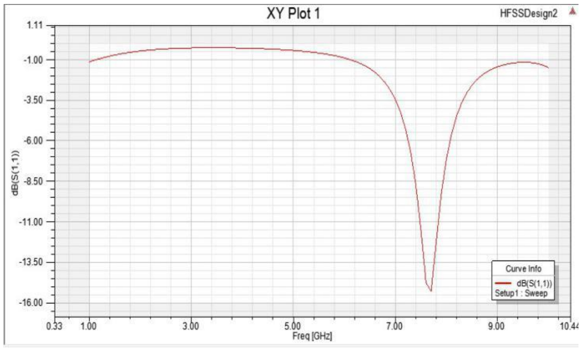

Fig. 3. Measured Return loss for unoptimized antenna.

Table 3. GA parameters for antenna design.

GA parameters	Values
Population type	Double vector
Population size	200
Crossover	Single point
Fraction of crossover	0.8
Mutation	Adaptive feasible
Migration	Forward
Generations(total)	200

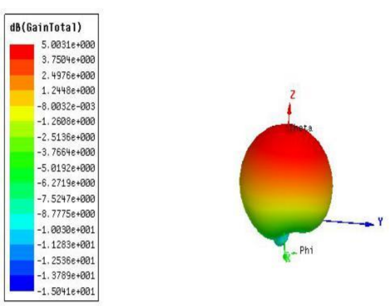

Fig. 4. Polar Plot for unoptimized antenna.

B. Optimized Methodology:

In order to obtain the optimized results, Genetic Algorithm(GA) is developed on MATLAB.

- GA features a smart ability to create a global search and explore the search areaby the means of various kinds of crossover techniques. They provide globality of search and have a good convergence rate.
- GA search from a population of discrete points, and use payoff(objective function) rather than searching for a single point and the derivatives..
- GA has the tendency to make use of probabilistic transition rules and supports multi-objective optimization, and not deterministic rules.

The cost function used for GA is:

ereff= (4.4+1.0)/2.0+(4.4-1)/(2.0*sqrt(1.0+12.0*(1.6/x(1))))
dl=0.412*1.6*((ereff+0.3)*((x(1)/1.6)+0.264))/((ereff-.258)*((x(1)/1.6)+0.8))
Leff = 3.0/(2.0*70*sqrt(ereff))

y(1) = 3*10^8/2*10^9*(sqrt(0.37))-x(1) ,
Where, x(1) = width of the patch .
y(2) = Leff - 2*dl -x(2) ,
Where, x(2) = length of the patch.
y(3) = x(1)+6*1.6- x(3)
Where, x(3) = width of the substrate.
y(4) = x(1)+6*1.6- x(4)
Where, x(4) = length of the substrate.
y(5) = (0.04/4*sqrt(ereff)) - x(5)
Where, x(5) = length of the feedline.

- The output of GA is obtained at 115^{th} iteration.

Table 4. Proposed geometry for optimized antenna.

Parameter	Value
Substrate Length	45mm
Substrate Width	45mm
Patch Length	20mm
Patch Width	8.19mm
Feedline Length	9mm
Feedline Width	3mm
Length of Ground plane	6mm
Width of Ground plane	44mm

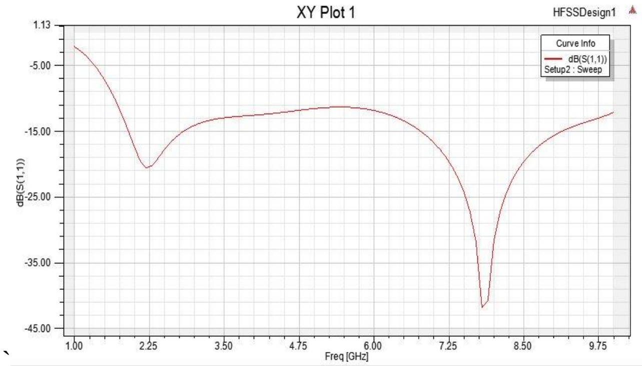

Fig 5. Measured return loss for optimized antenna.

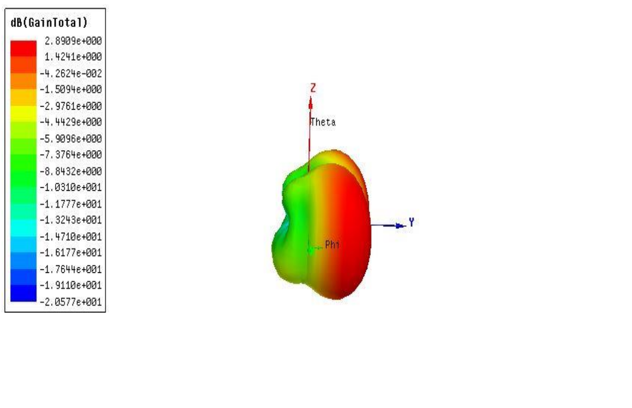

Fig. 6. Polar Plot for optimized antenna.

III. RELATION TO PREVIOUS WORK

The below table shows a comparison between a couple of recently designed wide-band antennas and the proposed antenna design. The proposed antenna demonstrated a wider bandwidth and improvements in the return loss (S11 parameter) at 7.75 GHz.

Antenna	BW	Antenna size	substrate	Return loss	frequency
This work	2.62 GHz	45*45*1.6 mm²	FR-4	43 dB	7.8 GHz
[9]	500MHz	70*70*70 mm²	FR-4	20 dB	5.51 GHz
[10]	2.26 MHz	38.92*45*1.6 mm²	FR-4	20.5 dB	8.92 GHz
[11]	470 MHz	47*10*5 mm²	FR-4	36 dB	1.92 GHz
[12]	1.5 MHz	96*72*1.6 mm²	FR-4	35 dB	5.7 GHz
[13]	730 MHz	38*10*1.6 mm²	FR-4	21 dB	5.36 GHz

IV. CONCLUSION

This paper presents the simulation and optimization of Microstrip Patch antenna, designed by HFSS and GA. The motivation of this work is to improve the return loss (s11) and radiation efficiency of the antenna. The proposed antenna is compact is size and displays radiation pattern throughout it's operating range. Based on these qualities, the proposed antenna is appropriate for wide-band applications.

REFERENCES

[1] Raj Gaurav Mishra,Ranjan Mishra, "Analysis of Microstrip Patch antenna designed using Genetic Algorithm based optimization for wideband Applications", International journal of Pune and applied mathematics, vol 118 no. 11 2018,841-849.

[2] Priyanka Jain, Vikas Maheshwari, Vandana Vikas Thakre, "Microstrip Patch antenna Optimization using Genetic Algorithm", International journal of engineering applied sciences and technology,2016 vol.2, ISSUE 2,ISSN no.2455-2143,pages 30-33.

[3] Susmit Bhattacharya and Souti Chattopadhyay, "Optimization of Inset-fed Microstrip Patch antenna using Genetic Algorithm",2015.

[4] Chandran, P.P and Viswasam, S(2014). "Gain and bandwidth optimization of Microstrip Patch antenna." 2014 Forth International Conference on advances in communication.

[5] Jayasinghe, J.M.J.W And Uduwawala , D.N(2010). "Design of Patch antennas using Genetic Algorithm optimization" 2010.5th International conference on industrial and information systems.

[6] S. Ashok Kumar et al., "Design and development of CPW fed monopole antenna at 2.45 GHz and 5.5 GHz for wireless applications", Alexandria Engineering Journal, 2017.

[7] Narinder Sharma, Vipul Sharma, "A design of Microstrip Patch Antenna using hybrid fractal slot for wideband applications", Ain Shams Engineering Journal, ISSN 2090-4479, 2017.

[8] C.L. Liu, Y.F. Lin, C.M. Liang, S.C. Pan, H.M. Chen, "Miniature internal penta-band Monopole antenna for mobile phones", IEEE Trans Antennas Propag, 58 (3), pp. 1008-1011, 2010.

[9] A. Mehdipour, I.D. Rosca, A.R. Sebak, "Full composite fractal antenna using carbon nano-tubes for multiband wireless applications", IEEE Antenna Wirel Propag Lett, 9, pp. 891-894, 2010.

[10] Jamil A, Yusoff MZ, Yahya N, Zakariya MA, "A compact multiband hybrid Meander-Koch fractal antenna for WLAN USB dongle", 2011 IEEE Conference on

Open Systems (ICOS2011), pp. 290-293. Langkawi, Malaysia, 2011.
[11] Anennas, John D.Krauss, lll (SEI) edition ,McGraw-Hill International edition.
[12] Antenna and wave propagation- Harish And Sachidananda : Oxford Press.
[13] Genetic Algorithm in search, Optimization and Machine Learning ,Goldberg David E.