Development of Optimized Antenna for WLAN Application

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ABSTRACT

WLAN(Wireless Local Area Network) is a popular wireless communication standard. It is designed to provide 60 Mbps data rate. Most of the planar antenna design for the WLAN application is of 2.4 GHz and 5.2 GHz band. In this paper, an antenna is designed for 5.2 GHzWLAN applications. The impedance matching, bandwidth and gain of proposed antenna are studied and analysed on the HFSS (High Field Structural Simulator). The proposed antenna based on the co-axial probe feed configuration has the bandwidth of 254 MHz (5.098-5.352 GHz)at -10 dB reflection coefficient and the maximum gain achievable is 6.073dB. Genetic algorithm is practice to optimize the best impedance match at 5.2 GHz.

Keywords*WiMAX, WLAN, E-shape antenna, Microstrip antenna, Genetic Algorithm, HFSS, Impedance matching, Co-axial feed.*

1. INTRODUCTION

As the demand of wireless and portable devices are going to increase for the wireless application like WLAN, WiMAX, Wi-Fi, Bluetooth etc. It is must to design the broadband, high gain antenna. WLAN is a wireless standard which was designed to provide the 60 Mbps data rate, attracts the user to satisfy their speed demand. IEEE 802.11 standard announces the five bands for WLAN applications, these are 2.4 GHz, 3.6 GHz, 4.9 GHz, 5.2 GHz and 5.9 GHz.There are different antenna designs for 2.4 and 5.2 GHz band [1-3]. So the design of a high gain, wide band and small in size is era’s demand and challenge to the designer. Whenever the issue of designing the low profile, planar structure antenna comes into account then microstrip antenna is the choice to fulfil the need. Mocrostrip antenna provides more privileges like multi-band characteristics, low cost, support both linear and circular polarization also. But microstrip antenna has some drawback like narrow bandwidth, less gain, low power handling capacity etc. There is availability of different method to enhance the bandwidth of an antenna like slots, meta-material, stacking, LC parameter variation etc.

Basic structure of microstrip antenna is the rectangular patch antenna. But the bandwidth of the rectangular patch is very narrow. One of the methods discussed above can be used for bandwidth enhancement. Also various structures for bandwidth enhancement are investigated in literature like- C-shape, E-shape, U-shape [4-6]. Result comparison shows that E-shape antenna is better than the other two in terms of bandwidth. Figure.1 of E-shape is shown below

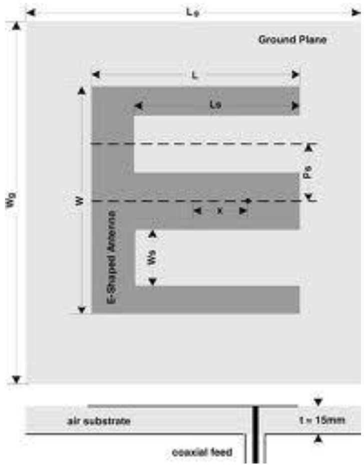

Figure.1 Co-axial probe feed E-shape antenna

So many optimization algorithms are applied to optimize the E-shape antenna. These algorithms are Particle Swarm Optimization and its variant, Genetic Algorithm, Differential Evolution, Self Adaptive Differential Evolution, Central Force Optimization and Invasive Weed Optimization (IWO)[6-13]. Comparison shows that the IWO optimizes the antenna markedly than other but the genetic algorithm is much easier to model [9].

2. GENETIC ALGORITHM

In the field of artificial intelligence genetic algorithm is a heuristic search that mimics the process of natural selection. This heuristic is used to generate satisfactory solution to optimization and search problems. Genetic algorithm has a wide variety of applications in computer science, economics, engineering, manufacturing, mathematics, bio-informatics etc. The evolution usually starts from a population of randomly generated individuals and happens in generation. In each generation, the fitness of every individual in population is evaluated. Multiple individuals are selected from the current generation based on their fitness. Then modification is applied to create the new population. There are several selection methods like uniform, roulette, Tournament, custom etc. Also some individual who have better fitness can be mutate to the next generation, some mutation process are constraint dependent, uniform, Gaussian, adaptive feasible, custom etc. Finally, the evolution stop on either target achieved i.e. required fitness achieved or stopping criteria like time or generation.

3. ANTENNA DESIGN

Figure.2 shows the geometry of the proposed antenna for 5.2 GHz, single band operation for WLAN application.

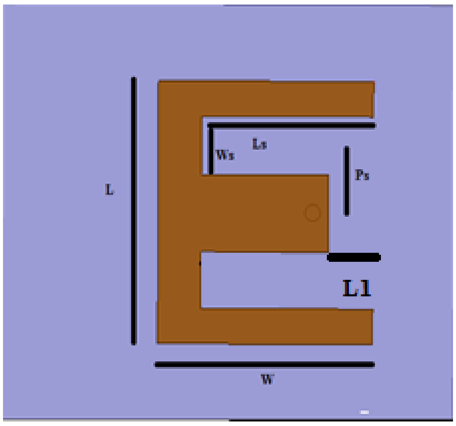

Figure.2 Geometry of Proposed Antenna

Antenna is feed by co-axial probe of the 50 ohm characteristic impedance. As discussed many optimization has applied to this antenna, so the IWO optimized antenna [9] and apply the genetic algorithm for the best impedance match at 5.2 GHz. Antenna is designed over the Rogers/duroid 5880 (tm) substrate of 30X25 mm^2.Values of the dimensions of E-shape are shown in Table.1.

Table.1 dimensions of E-shape Antenna

Parameter	**Value**
L	15.75
W	14.25
Ls	11.4
Ws	3.39
Ps	3.31

The goal of the optimization is to resonate the antenna at 5.2 GHz and length of the central branch is the variable parameter to control the resonate frequency.

A. CURVE FITTING

To generate the relationship equation betweenlength L1 and resonate frequency fr, length L1 is varied, while keeping the other parameter constant. For each value of L1, antenna is designed in HFSS and calculate it's resonate frequency fr. Both the value of L1 and fr are recorded for each design. The initial length of central branch was 11.4 mm and resonate frequency was 5.8GHz. By applying the values to Graphmatica (curve fitting software), the following equation is obtained.

$$fr = 0.019*x^4 - 0.0307*x^3 - 0.2156*x^2 + 0.0642*x + 6.2738 \quad \text{...... (1)}$$

B. OPTIMIZATION BY GENETIC ALGORITHM

Fitness function is the Root Mean Squared Error (RMSE) between the calculated values fr from equation1 and the desired resonance frequency for each generated value. Stochastic uniform selection, adaptive feasible mutation and scattered crossover operators are used for the genetic algorithm. The optimize value of the central branch length is 8.394 mm. The final dimensions of the antenna are same as given in Table.1 except the length of central branch.

4. SIMULATION

Simulation of proposed antenna is carried out on High Frequency Structural Simulator (HFSS). Figure.3 shows the value of the reflection coefficient S_{11} versus frequency curve. The maximum value of S_{11} shown by the curve is -16.53 dB and bandwidth is 254 MHz (5.0710 to 5.3248 GHz).

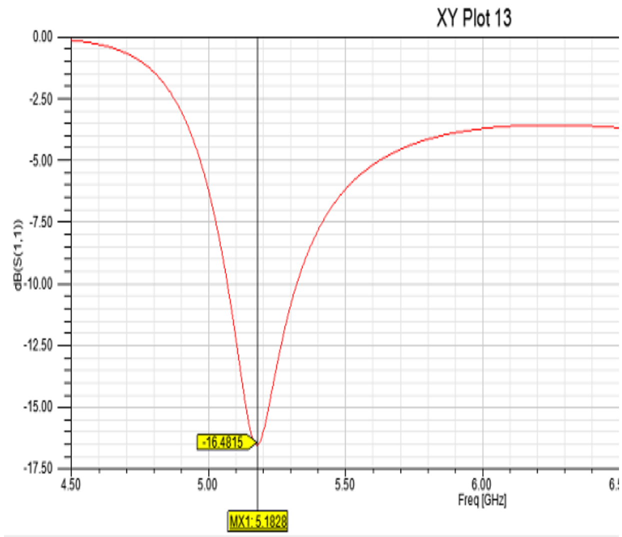

Figure.3 S_{11} Parameter of Proposed Antenna

Figure.4 shows the gain Vs frequency curve.The maximum gain achieved at resonance frequency is 6.0583 dB.

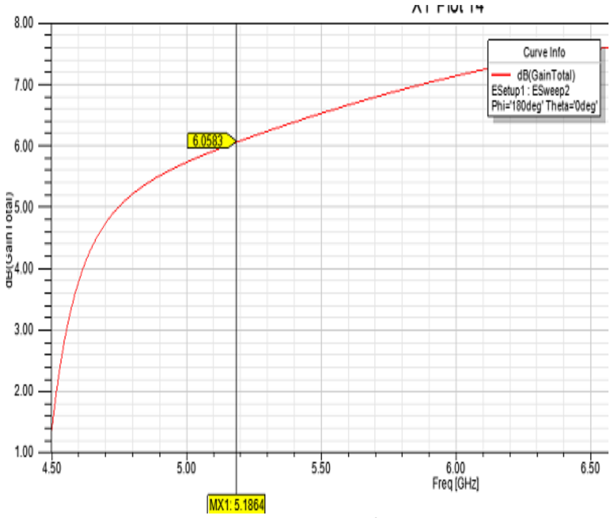

Figure.4 Gain Vs Frequency of Proposed Antenna

Figure.5 shows the 3-D polar plot of radiation pattern.The proposed antenna provides the satisfactory performance in terms of the return loss, gain and bandwidth.

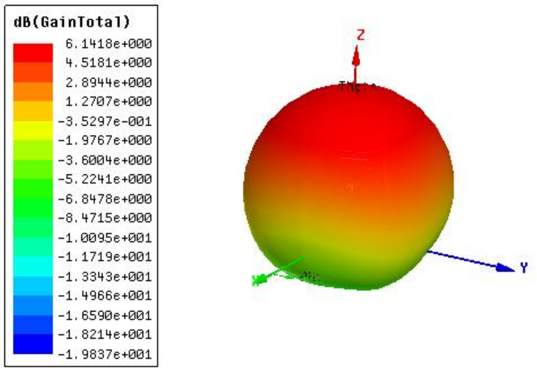

Figure.5 3-D Radiation Pattern of Proposed Antenna

5. RESULT

Proposed antenna design is of size 25X30 mm^2. It provides 254 MHz bandwidth and gain of 6.0583 dB. Hence the proposed antenna is in good agreement in both of the parameter and size also.

6. COMPARISON AND DISCUSSION

The simple rectangular patch antenna designed for 5.2 GHz simulated on CST microwave tool has presented [3]. Rectangular patch antenna designed is of 27X31 $mm^{2.}$ Rectangular patch designed for 5.2 GHz for WLAN will provide the return loss bandwidth of 219.2 MHz and maximum gain achieved is 5.208 dB. The desired bandwidth for the 5.2 GHz WLAN is 5.15-5.35 GHz. Hence the proposed antenna is in good agreement in all four parameters size, bandwidth, gain and S_{11}.

7. CONCLUSION

In this paper, an antenna is presented for the WLAN application at 5.2 GHz. The antenna is E-shape antenna. Coaxial feed of 50 ohm characteristic impedance is used for the feeding. Soft computing (genetic algorithm) and curve fitting is used to resonate at 5.2 GHz. The proposed antenna is resonating at 5.182 GHz.This antenna shows the good agreement with the desired return loss bandwidth and gain. The proposed antenna exhibits a return loss bandwidth of 254 MHz (5.071- 5.324 GHz), which is in the desired frequency range. Also it provides the maximum gain value of 6.058 dB with the reflection coefficient S_{11} of -16.48 dB. Hence the proposed antenna satisfies all the requirements for the WLAN application.

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