Optimized Antenna for 5.2GHz Applications

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ABSTRACT

Most of the communications in the century is accomplished through the wireless medium. There are various standards for simultaneous running of different applications. WLAN (Wireless Local Area Network) is a common wireless communication standard. Among the five bands announced by IEEE in 802.11 standards for wireless LAN, two most common bands are 2.4 GHz and 5.2 GHz. In this paper, an antenna is designed for 5.2 GHz WLAN applications. To remove the problem of mismatching at coaxial feeding, an approach of improving the matching performance is studied. The requirement of impedance matching, gain and bandwidth are studied and performance of the proposed antenna is analysed on the HFSS (High Field Structural Simulator). The proposed antenna has the bandwidth of 223 MHz (5.100-5.323 GHz) at -10 dB reflection coefficient and the maximum gain achievable is 5.1719dB. Soft-computing technique is used to optimize the best impedance match at 5.2 GHz.

Keywords Wimax, WLAN, Co-axial feed, E-shape antenna, Microstrip antenna, soft-computing, Genetic Algorithm, HFSS, Impedance matching.

1. INTRODUCTION

In 21th century wireless portable devices are interacting with every person. Demand of wireless and portable devices are booming for the wireless applications like WLAN, WiMAX, Wi-Fi, Bluetooth etc. These standards are used in cell-phone, modems, i-pods, laptops etc. The performance of any wireless system much depends on the high performance antenna. So, there is a need of 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. There are different antenna designs for 2.4 and 5.2 GHz band [1-3]. So, the design of a high performance antenna which provides high gain, wide band and small in size is era's demand and challenge to the designer. But to solve the problem of calibration in portable devices and issue of designing the planar structure antenna with low profile, microstrip antenna is the choice to fulfil the need. Mocrostrip antenna provides more privileges like low cost, easy designing, multi-band characteristics, support both linear and circular polarization also. But microstrip antenna has some drawback like low power handling capacity, low gain and less bandwidth etc. There is availability of different methods to enhance the bandwidth of an antenna like meta-material, LC parameter variation,stacking, thick substrate, slotting etc.
General structure of microstrip antenna is the rectangular patch antenna. But the disadvantage of low bandwidth of the rectangular patch makes it unsuitable for different applications. One of the methods discussed above can be used for bandwidth enhancement. Also various structures are investigated in literature such as C-shape, E-shape and U-shape [4-6]. Comparison shows that E-shape antenna is better than the other two in terms of bandwidth. Figure.1 of E-shape is shown below

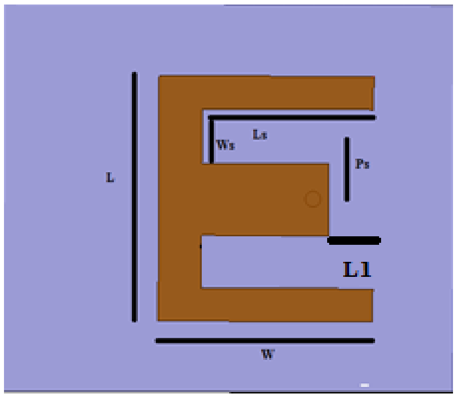

Figure.1 Co-axial probe feed E-shape antenna

But C-shape antenna is more compact than E-shape. So optimization of E-shape antenna is needed. Many optimization algorithms have been applied over 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]. The IWO optimization algorithm optimizes the antenna markedly than other but the genetic algorithm is much easier to model [9].

2. GENETIC ALGORITHM

Soft-computing is an innovative approach in constructing computationally intelligent systems. Soft computing is a term used in programming refers to problems in engineering whose solutions are unpredictable, uncertain. Many conventional mathematical models are both challenging and precise while soft computing deals with imprecision, uncertainty, partial truth and approximation to achieve practicability robustness and low solution.
In the field of artificial intelligence, genetic algorithm is a heuristic search. This heuristic mimics the process of natural selection and is used to generate satisfactory solution to optimization and search problems. Genetic algorithm has a wide variety of applications in engineering, economics, manufacturing, bio-informatics, mathematics, computer

science etc. The algorithm begins by creating a random initial population. Then algorithm creates a sequence of new populations. At each step, the algorithm uses the individuals in the current generation to create the next population. To create the new population, the algorithm performs the following steps:

1. Scores each member of the current population by computing its fitness value.
2. Scales the raw fitness scores to convert them into a more usable range of values.
3. Selects members, called parents, based on their fitness.
4. Some of the individuals in the current population that have lower fitness are chosen as *elite*. These elite individuals are passed to the next population.
5. Produces children from the parents. Children are produced either by making random changes to a single parent — *mutation* — or by combining the vector entries of a pair of parents — *crossover*.
6. Replaces the current population with the children to form the next generation.
7. The algorithm stops when one of the stopping criteria is met.

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.

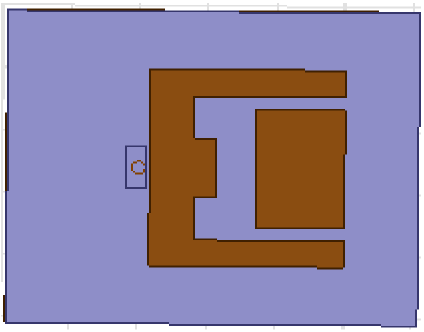

Figure.2 Geometry of Proposed Antenna

Co-axial probe of the 50 ohm characteristic impedance is used for the feeding. As discussed many optimization has applied to this antenna and IWO optimizes antenna markedly [9] and the genetic algorithm is applied for the best impedance match at 5.2 GHz on the this antenna. Antenna is designed over the Rogers/duroid 5880 (tm) substrate of 30X25 mm^2 and thickness 3.2mm. Values of the dimensions of E-shape are shown in Table.1.

Table.1 Dimensions of initially taken E-shape Antenna

Parameter	**Value**
L	15.75
W	14.25
Ls	11.4
Ws	3.39
Ps	4.06
L1	0

Large thickness introduces large inductance, which is compensated by the capacitive feeding as shown in Figure.3.This feeding technique is basically indirect feeding to the patch and variation of LC parameter. This feeding provides the better matching characteristics by introducing the capacitance. This capacitance compensates the inductance of coaxial probe and increases the return losses. Important parameters for the capacitive feeding are the length, width and distance of the feeding patch from the radiating patch [14].

Length of feeding patch = 1.5 mm.
Width of the feeding patch = 3.43 mm.
Distance of the feeding patch from radiating patch = .25 mm.

A. Curve Fitting

Length of the central branch is the variable parameter to control the resonate frequency of the antenna at 5.2 GHz. To generate the relationship equation between length 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 value of L1 is 0 and resonate frequency was 5.8 GHz. By applying the values to Graphmatica (curve fitting software), the following equation is obtained.

$$fr = 0.0000077*L1^4 - 0.0004*L1^3 - 0.0002*L1^2 + 0.1518*L1 + 4.0621 \quad \text{...... (1)}$$

B. Optimization by Genetic Algorithm

Fitness function is the Root Mean Squared Error (RMSE) between the calculated values fr from above expression and the desired resonance frequency 5.2 GHz 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 1.989 mm. The final dimensions of the antenna are same as given in Table.1 except the length of central branch.

C. Parasitic Element

In radio antenna, a passive radiator or coplanar parasitic patch is used as a conductive element. It is not electrically connected to anything else. The purpose of the parasitic element is to modify the radiation pattern and increase the gain. Parasitic element does this by acting as passive resonator and absorbing the radio waves from the nearby driven element and re-radiating them again. Dimension of parasitic patch are

Parasitic Patch Length = 6.5 mm
Parasitic Patch Width = 9.51 mm

4. SIMULATION

High Frequency Structural Simulator (HFSS) is used for the simulation of the proposed antenna. The reflection coefficient S_{11} versus frequency curve is shown in Figure.3. The maximum value of S_{11} shown by the curve is -31.549 dB and bandwidth is 223 MHz (5.100 to 5.323 GHz).

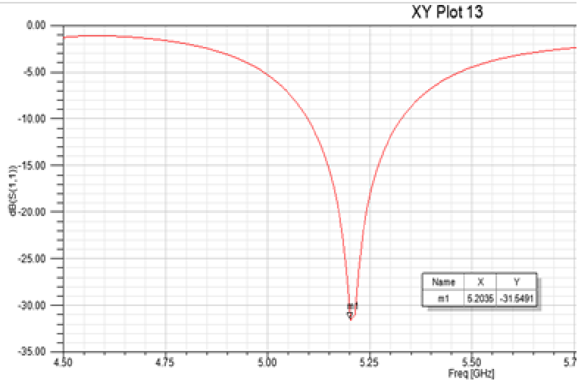

Figure.3 S_{11} Parameter of Proposed Antenna

Figure.4 shows the gain Vs frequency curve. The maximum gain achieved at resonance frequency is 5.1719 dB.

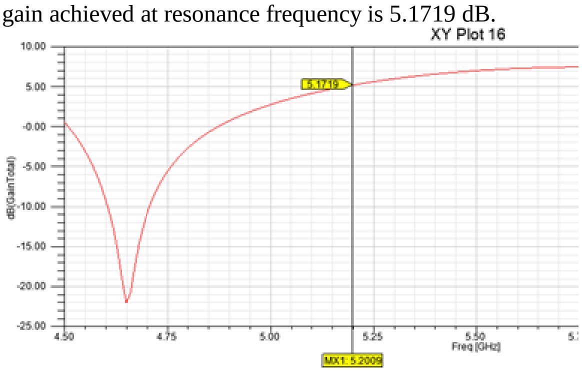

Figure.4 Gain Vs Frequency of Proposed Antenna

Figure.5 shows the 3-D polar plot of radiation pattern.

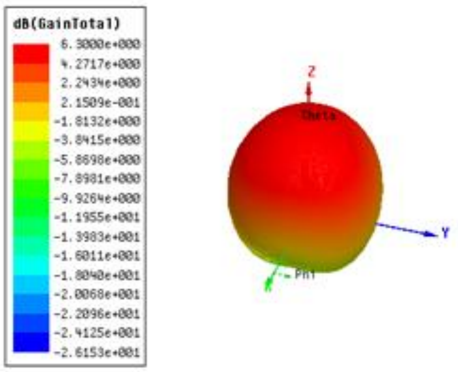

Figure.5 3-D Radiation Pattern of Proposed Antenna

The proposed antenna provides the satisfactory performance in terms of the return loss, gain and bandwidth.

5. COMPARISON

Proposed antenna dimension is 25X30X3.2 mm^3. It provides 223 MHz bandwidth and gain of 5.1719 dB. Return loss of simulated antenna is -31.549dB. The dimension of rectangular patch antenna designed to resonate at 5.2 GHz is 27X31 mm2. Rectangular patch designed for WLAN will provide the return loss bandwidth of 219.2 MHz. 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}.

6. CONCLUSION

In this paper, an antenna is presented for the WLAN application at 5.2 GHz. Genetic algorithm (Soft computing) and curve fitting is used to resonate at 5.2 GHz. The proposed antenna is resonating at 5.203 GHz. Coaxial feed of 50 ohm characteristic impedance is used for the feeding. This antenna shows the good agreement with the desired return loss, bandwidth and gain. The proposed antenna exhibits a return loss bandwidth of 223 MHz (5.100- 5.323 GHz), which is in the desired frequency range. Also it provides the maximum gain value of 5.1719 dB with the reflection coefficient S_{11} of -31.549 dB. Hence the proposed antenna satisfies all the requirements for the WLAN application.

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