Design, Simulation and Analysis of Multiple L-Slot Microstrip Patch Antenna

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***Abstract*— In this paper a multiple L-slot microstrip patch antenna is proposed that can be used to satisfy WLAN and WiMAX application. The proposed antenna is designed to operate with resonant frequency at 3.1 GHz for WiMAX application and by using multiple L-slot the resonance frequency is further reduced that can make possible to use it for WLAN applications also. The co-axial feeding technique is employed to feed the proposed antenna. Multiple L-slot is used on the patch to analyze the performance. The bandwidth enhancement is focused at higher operating frequencies. The simulation results such as Radiation pattern, VSWR, Gain, and Return loss are simulated using Ansoft HFSS. The simulation results of Multiple L-slot micro-strip patch antenna was obtained and the performance improvement is analyzed and presented.**

Keywords*— *Microstrip antenna; resonant frequency; , L-slot; co-axial feed; WLAN; WiMAX.

I. INTRODUCTION

In recent years, the current trend in commercial and government communication systems has been to develop low cost, minimal weight, low profile antennas that are capable of maintaining high performance over a large spectrum of frequencies. This technological trend has focused much effort into the design of micro-strip (patch) antennas. With a simple geometry, patch antennas offer many advantages not commonly exhibited in other antenna configurations.

They are extremely low profile, lightweight, simple and inexpensive to fabricate using modern day printed circuit board technology, compatible with microwave and millimeter-wave integrated circuits (MMIC) and have the ability to conform to planar and non-planar surfaces. In addition, once the shape and operating mode of the patch are selected, designs become very versatile in terms of operating frequency, polarization and impedance.

The variety in design that is possible with micro-strip antennas probably exceeds that of any other type of antenna element. With the focus on it and making use of these advantages of micro-strip antennas this paper focuses the design and simulation of Multiple L-slot Micro-strip Patch antenna that satisfy the WLAN and WiMAX applications.

II. PROPOSED ANTENNA

The proposed system is designed with Multiple L-slot micro-strip patch antenna and the antenna is fed with co-axial feed. Insertion of multiple-slots in a patch helps to overcome the problem of bandwidth limitation. The proposed antenna can be used for WLAN and WiMAX applications.

A. Microstrip Antenna

Microstrip patch antenna consists of a patch of metal that is placed on the top of a grounded dielectric substrate of thickness *h*, with relative permittivity and permeability.The metallic patch may be of various shapes, with rectangular and circular being the most common.

In this project, we used the rectangular microstrip patch antenna. The figure 1 shows the layout of microstrip patch antenna (MSA).

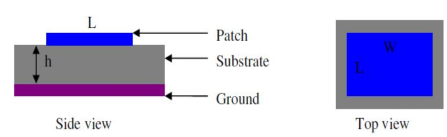

Fig.1 Layout of MSA

B. Rectangular Patch

The designed antenna consists of a radiating metallic patch situated on one side of a thin, non-conducting, substrate panel with a metallic ground plane situated on the other side of the panel. The metallic patch is made of thin copper foil or is copper-foil-plated with a corrosion resistive metal, here nickel. The patch can be designed with a variety of shapes, here it is rectangular.

C. The Substrate

The dielectric substrate is used primarily to provide proper spacing and mechanical support between the patch and its ground plane. It is also often used with high dielectric-constant material to load the patch and reduce its size. The substrate material should be low in insertion loss with a loss tangent of less than 0.005. With higher dielectric constant of the substrate material, the patch size can also be reduced due to loading effect. Certainly, with reduced antenna volume, higher dielectric constant also reduces bandwidth. There is a variety of types of substrate materials. For commercial application, cost is one of the most important criteria in determining the substrate type. For this paper purpose we used FR-4 having dielectric constant of 4.4[13]. FR-4 used as substrate to minimize insertion loss, antenna mass and material cost with increased bandwidth performance.

D. Feeding Technique

The Coaxial feed is used for feeding the designed multiple L-slot microstrip patch antenna. The inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane. The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance. This feed method is easy to fabricate and has low spurious radiation.

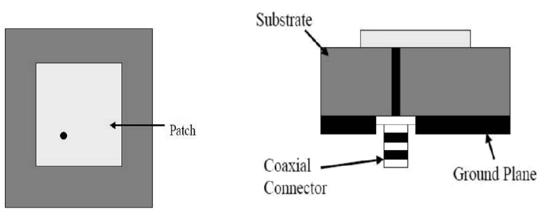

Fig. 2 Rectangular Microstrip antenna coaxial feed

III. PARAMETER STUDY

By numerical analysis the essential antenna parameters are calculated. According to [14]

Operating frequency, $f_o = (f_l+f_h)/2$ (1)

Where, f_l is the lower frequency

f_h is the higher frequency of operating band.

The guided wavelength in the substrate of the antenna, $\lambda = v_o/f_o$ Where $v_0=3\times10^8$ m/sec (2)

The thickness of Dielectric substrate,

$h \geq 0.06(\lambda / \sqrt{\varepsilon_r})$ (3)

A. Dimensions for Rectangular Microstrip Patch Antenna

Width, $W= v_o \sqrt{(2/\varepsilon_r)} / (2f_o)$ (4)

Where ε_r is the dielectric constant of the dielectric material

Effective Dielectric constant,

$\varepsilon_{reff} = [(\varepsilon_r+1)/2] + (\varepsilon_r -1) / [2 \sqrt{(1+12 h/W)}]$ (5)

Length, $L=L_{eff} -2\Delta$ (6)

Where L_{eff} is Effective Length

$L_{eff} = v_o / (2f_o \sqrt{\varepsilon_{reff}})$ (7)

ΔL is Length Extension

$\Delta L = 0.412h\ [(\varepsilon_{reff}+0.3)((W/h)+0.264)] / [(\varepsilon_{reff}-0.258)((W/h)+0.8)]$ (8)

B. Dimensions for Ground Plane

Length, $GL=6h+L$ (9)

Width, $GW=6h+W$ (10)

C. Dimensions for the Slot

Thickness, $E=F= \lambda/60$ (11)

Slot width, $D= [v_o / (f_{low} \sqrt{\varepsilon_{reff}})] - 2(L+2\Delta L-E)$ (12)

IV. GEOMETRY OF THE PROPOSED ANTENNA

The geometrical parameters of the considered antenna design are as follows. The length of rectangular patch L = 19.3mm, width of the rectangular patch W= 19.27mm, width of ground plane GW = 10.5 mm, length of ground plane GL = 16.2 mm, slot lengths L1 = 5.7 mm, L2 = 7.5 mm and width Ws = 1 mm. Length of the feeding is FL = 19.7 mm and feed width is FW = 3 mm.

The space between the rectangular patch and ground plane is G = 3 mm and vertical spacing between feed-line and ground plane is D = 1 mm.

TABLE I. DIMENSIONS OF THE PROPOSED ANTENNA

Substrate	W=26mm L=40mm t=1mm
Ground Plane	W=10.5mm, L=16.2mm
Patch	W=19.27mm L=19.3mm
For Feed	W=3mm.

For impedance matching and to reduce the return loss we employed change of feed gap and change in the substrate width.

V. STEPS TO DESIGN THE PROPOSED ANTENNA

The values obtained here are substituted in the Ansoft HFSS software design parameters and are designed. In the figure 5.2 shows the design of ground in HFSS software

A. Step 1: Creation of Ground

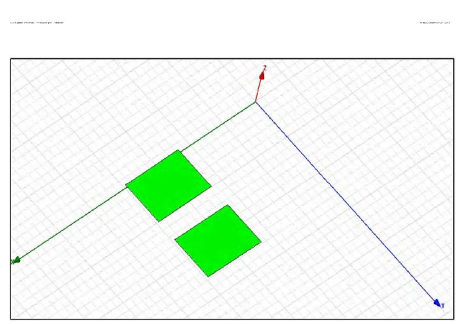

Fig. 3 Design of Ground

B. Step 2: Creation 0f Substrate

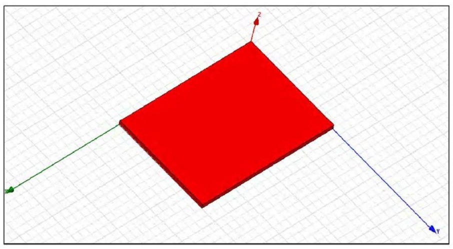

Fig. 4 Design of substrate

In the figure 4 the design of substrate in HFSS software is shown. For the substrate the material chosen plays a vital role since the antenna characteristics can gets changed according to the dielectric materials. So it plays a wider role in designing the antenna.

Using the numerical equations length and width of the substrate is 70 mm and 40 mm respectively.

C. Step 3:Creation of Single Patch

Another important parameter for designing the antenna is choosing the shape for the radiator element. Since the Multi L slot patch antenna is easy to place adjacent to each other and interference is low. The calculated width and length of the patch is 19.27 mm and 19.3 mm respectively. In the figure 5 the design of multi L slot patch antenna in HFSS software is shown.

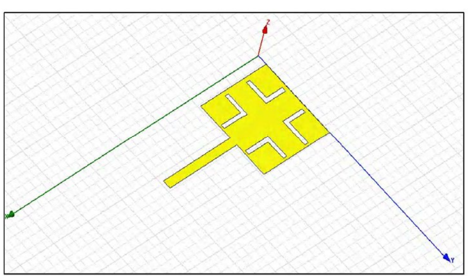

Fig. 5 Design of Multiple L-slot patch antenna

D. Step 4:Final Design

Final step is create a air box which is helpful for avoiding the radiation and give the better return loss results.Then give the validate check and analyze all.After the simulation process get the results of return loss,VSWR,mutual coupling and directivity.

Fig. 6 shows the proposed multiple L- slot patch antenna design.

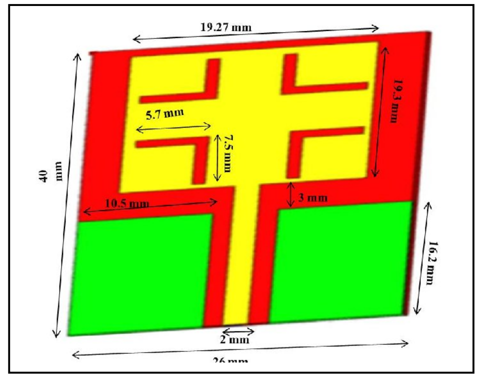

Fig. 6 Overall design of Multiple L-slot Microstrip patch antenna

VI. SIMULATION RESULTS

The antenna performance was analyzed through simulation using Ansoft HFSS software. The simulation results for antenna parameters such as the return loss, VSWR and the radiation pattern were obtained to study its performance improvement. It is usually expressed as a ratio in decibels (dB).

For a good system, this loss should be highly desirable since the power transmission will be 90% when the return loss is -10dB.

Fig. 7 shows the return loss curve of proposed antenna which is found to be -10.1822 dB in the frequency range of 3.7 GHz and -24.331dB in the frequency range of 5 GHz which is highly desirable.

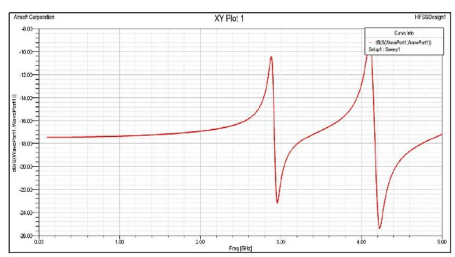

Fig. 7 Return Loss of the proposed antenna

The VSWR is a measure of how closely the source and load impedance are matched. For most antennas in WLAN, it is a measure of how close the antenna is to a perfect 50 Ohms. It can be determined through the return loss calculation.

Here the VSWR value is about 1.8971 which is calculated through the following equation:

$$VSWR = \frac{1+S_{11}}{1-S_{11}} \quad (13)$$

Fig. 8 shows the VSWR curve for the proposed antenna.

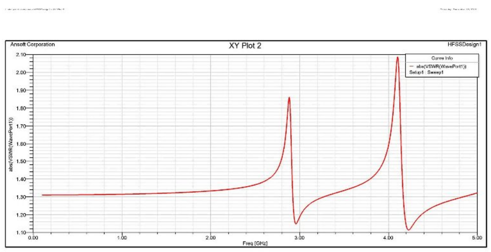

Fig. 8 VSWR of the Proposed Antenna

An antenna's directivity is a component of its gain. Directivity is an important measure because most emissions are intended to go in a particular direction or at least in a particular plane (horizontal or vertical). Emissions in other directions or planes are wasteful. Fig. 9 shows the radiation pattern of the proposed antenna.

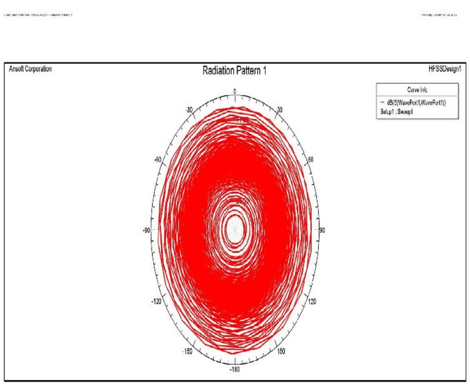

Fig. 9 Radiation pattern of the proposed antenna

VII. CONCLUSION

An electrically small multiple L-slot microstrip patch antenna operating at the 3.1 GHz was designed using HFSS software package. We applied parametric and optimization technique using genetic algorithms to achieve the antenna for the WLAN Application. The antenna provided a significant gain enhancement. Finally we compare the multiple L slot patch antenna with the antenna in different substrates. It is evident that our multi L slot patch antenna is more suitable for use due to its thickness height is much less than the antenna in [8] in addition with the enhancement gain. We conclude that by employing multiple slots on the patch, a good bandwidth and a perfect impedance match can be obtained.

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