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Design of Slotted Microstrip Patch Antenna for WLAN Application

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***Abstract*— A simple microstrip patch antenna consists of metallic patch and ground between which is a dielectric medium called the substrate. Microstrip patch antennas are used for communication purposes especially in military and civil applications. In this paper a simple microstrip patch antenna is designed and evaluated using HFSS software at a resonant frequency of 2.4 GHz . The proposed slotted microstrip patch antenna designed at C-band microwave frequency consist of air filled substrate with coaxial feed requiring very low power dissipation. Recently printed antennas have played a major role in development of antenna at different frequency. The proposed antenna is done on fr4(fr substrate with dielectric permittivity ε_0 and the thickness h_0 will provide with good omnidirectional radiation pattern. It has advantage in simple design, Compact in size and easy in fabrication.**

***Keywords*— Slotted Microstrip patch antenna, fr4(frame resistive) substrate , Stripline feeding, HFSS software.**

I. INTRODUCTION

Antenna is a transducer designed to transmit or receive electromagnetic waves. Microstrip antennas have several advantages over conventional microwave antenna and therefore are widely used in many practical applications. Microstrip antennas in its simplest configuration are shown in Fig1. It consists of a radiating patch on one side of dielectric substrate (Єr≤10), which has a ground plane on other side. Microsrtip antennas are used for number of wireless applications such as WLAN, Wi-Fi, Bluetooth and many other applications. A simple microstrip patch antenna consists of a conducting patch and ground plane between them is a dielectric medium called the substrate having a particular value of dielectric constant. The dimensions of a patch are smaller as compared to the substrate and ground. Dimensions of a microstrip patch antenna depend on the resonant frequency and value of the dielectric constant. Microstrip antenna is a printed type antenna consisting of a dielectric substrate sandwiched in between a ground plane and a patch.

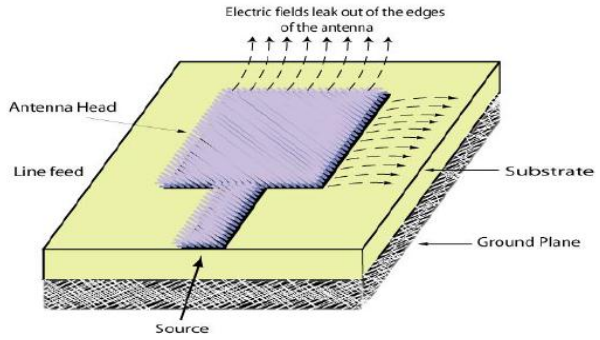

Figure 1. Microstrip antenna configuration

1.1 Microstrip Patch Antenna

Nowadays, in mobile communication systems, the requirement of small sized antenna for miniaturization purpose of mobile units has been increased. Hence, reduced size and enhanced bandwidth are the major considerations in microstrip antennas for practical applications. Therefore, study regarding small size and enhanced bandwidth of microstrip antenna has been greatly increased. In the past few years, great progress in the design of small sized microstrip antenna with broadband and gain enhanced performance has been reported hence we select the microstrip patch antenna for WLAN application.

These include cutting slots in the radiating patch, in recent times many novel planar antennas have been designed to satisfy the requirements of mobile cellular communication systems. Some Microstrip antennas are also very good choice for applications in communication devices. In this paper, Slotted Microstrip patch antenna has been proposed which operates for 2.4GHz band for WLAN application. Radiating patch and a partial ground. The proposed antenna has compact size which is added advantage to use it.

II. ANALYSIS OF MICROSTRIP PATCH ANTENNA

For designing of a microstrip patch antenna, we have to select the resonant frequency and a dielectric medium for which antenna is to be designed. The parameters to be calculated are as under.

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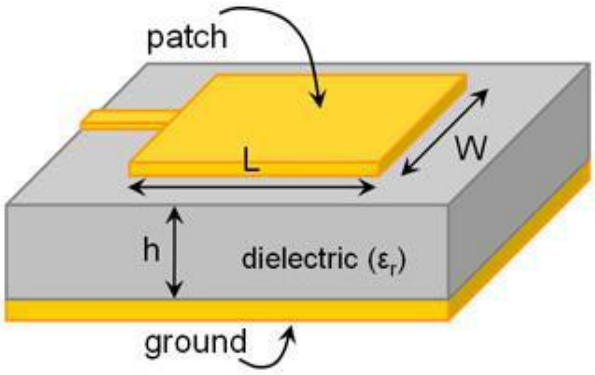

Figure2. Structure of a Microstrip Patch Antenna

Width (W): The patch Antenna width can be calculated using the following equation

$$W = \frac{C_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

Where, W = Width of the patch

C_0= Speed of light

ε_r= value of the dielectric substrate

Effective refractive index: The substrate and air have different dielectric values. It is an important parameter while design the microstrip patch antenna. The radiations traveling from the patch towards the ground pass through air and some through the substrate (called as fringing). The effective dielectric constant (ε_r) is calculated using the following equation:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2}, W/h > 1$$

Length: Due to fringing, electrically the size of the antenna is increased by an amount of (ΔL). Therefore, the actual increase in length (ΔL) of the patch is to be calculated using the following equation:

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

Where 'h'= height of the substrate.

The length (L) of the patch is now to be calculated using the below mentioned equation:

$$L = \frac{C_0}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L$$

Length (L_g) and width (W_g) of ground plane: Now the dimensions of a patch are known. The length and width of a substrate is equal to that of the ground plane. The length of a ground plane (L_g) and the width of a ground plane (W_g) are calculated using the following equations:

$$L_g = 6h + L$$
$$W_g = 6h + W$$

III. Designed Antenna And Its Parameters

After an exhaustive literature review of the papers ranging from the year 1996-2014, there have been different types of approaches for making the small size antenna which are used only for WLAN applications. For WLAN technology there are various antennas used at 2.4GHZ frequency, like Micro strip patch antenna or PCB antenna, Chip antenna, Helical Wound Stub antenna, Low Profile Dome antenna, Dipole antenna with flying lead etc.

In this paper several parameters of Slotted Microstrip patch Antenna resonating at frequency 2.4GHZ have been investigated using HFSS software. The geometry of patch antenna is shown in figure-1.

The design specifications for patch antenna are:

- Substrate permittivity (ξr) = 4.2
- Substrate thickness (h) = 1.6 mm.
- Length of patch (L) = 50.12 mm.
- Width of patch (W) = 50.12 mm.
- Slot Length(L) = 20.24mm
- Slot Width(W) = 20.24mm

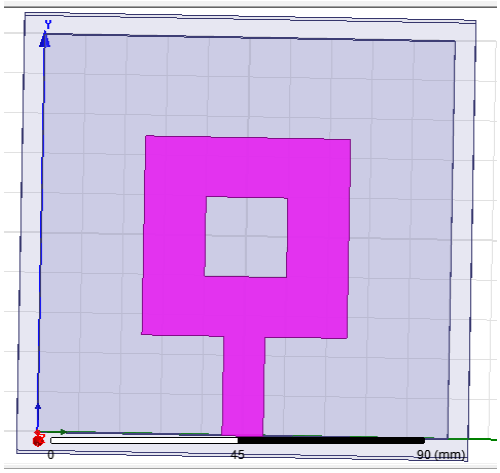

Figure 3. Rectangular microstrip patch antenna resonating at 2.4 GHZ.

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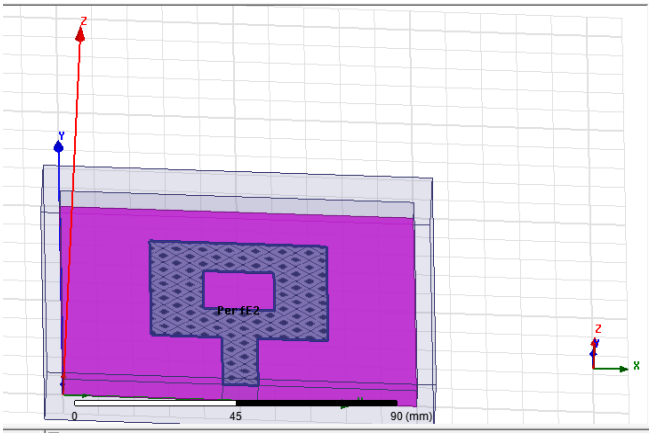

IV. Simulation Result Discussion

HFSS simulation software was chosen to simulate the structures shown in the Figures. The VSWR and Radiation was obtained from simulation. The simulated result of Slotted Microstrip Patch Antenna are shown below.

The figure-4 below shows the Voltage Standing Wave Ratio (VSWR) versus frequency graph of the designed antenna. The VSWR is minimum (equal to 1.886031) at 2.4 GHz

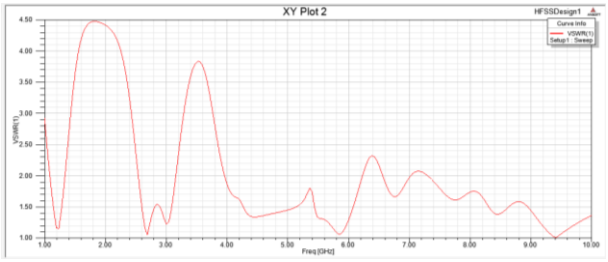

Figure 4. VSWR

The following figure-5 shows the 2D Radiation pattern of the antenna.

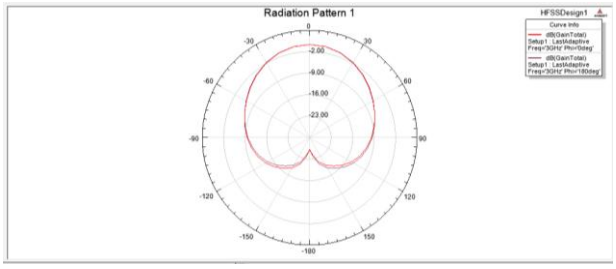

Figure 5. 2D Radiation pattern

The following figure-6 shows the gain pattern of the antenna in the farfield. The direction of the maximum gain of the antenna is above the patch (i-e, in the direction of theta), while minor lobes are on the opposite side

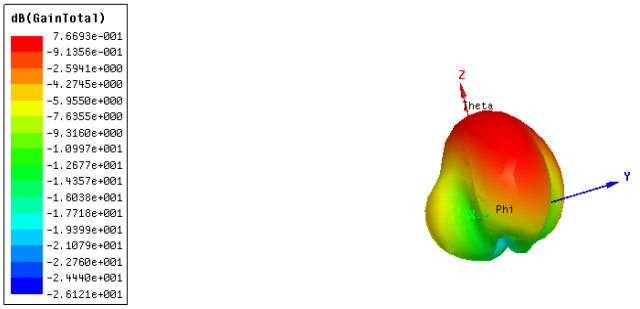

Figure 6. 3D Radiation Pattern

V. Conclusion

The research motivation of this project is to design slotted Microstrip patch antenna for WLAN application which operates in S-band at 2.4 GHz. HFSS simulator is used for design and simulation of patch Antenna. The Slotted patch antenna with 50ohms line feed has been designed. The VSWR of the designed antenna is 1.88, the radiation Efficiency at 2.4 GHz is achieved. The gain and bandwidth of single element patch shows the path of further experiments with arrays of antennas and in the case of dual polarization. Results & analysis of this antenna indicates that it is applicable in miniature devices, simple design & compact size as added advantage, which can easily be used in embedded wireless system applications.

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