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RESEARCH ARTICLE

Design of Microstrip Antenna for Wireless Local Area Network

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Abstract— Modern wireless and mobile communication systems requires antenna which should have light weight, low profile, low cost, and easy to be integrated with RF devices. This demand is completed by microstrip antennas. This paper presents rectangular microstrip patch antenna for WLAN applications designed using IE3D software. The microstrip antenna is designed with dielectric substrate as Rogers RT/duroid 5880(tm) with ε_r = 2.2. This antenna will work on IEEE 802.11 WLAN 2.4 GHz band. The antenna is optimized to improve the performance measures like gain, return loss and efficiency. The IE3D result shows this antenna is suitable for WLAN applications.

Keywords— Microstrip, Antenna, WLAN, IE3D

I. INTRODUCTION

The microstrip patch antennas are widely used in WLAN applications because of its features like low-profile, compactness and high efficiency [1, 5]. A microstrip patch antenna is most often a 1/2 wavelength structure although it can also be made as a 1/4 wave element [1]. The patch antennas are printed on the top surface a 2-layer PCB, although sheet metal patches over a ground plane with an air-dielectric are also in wide use. Patch antennas are considered directional antennas with a primary lobe of radiation over an approximately 70 x 70 degree sector (in the direction away from the ground plane). Because of the directional nature patch antenna may be an excellent choice for a fixed-mount device on the side of building where the radiation from an omnidirectional antenna [4] would be wasted in the direction of the building.

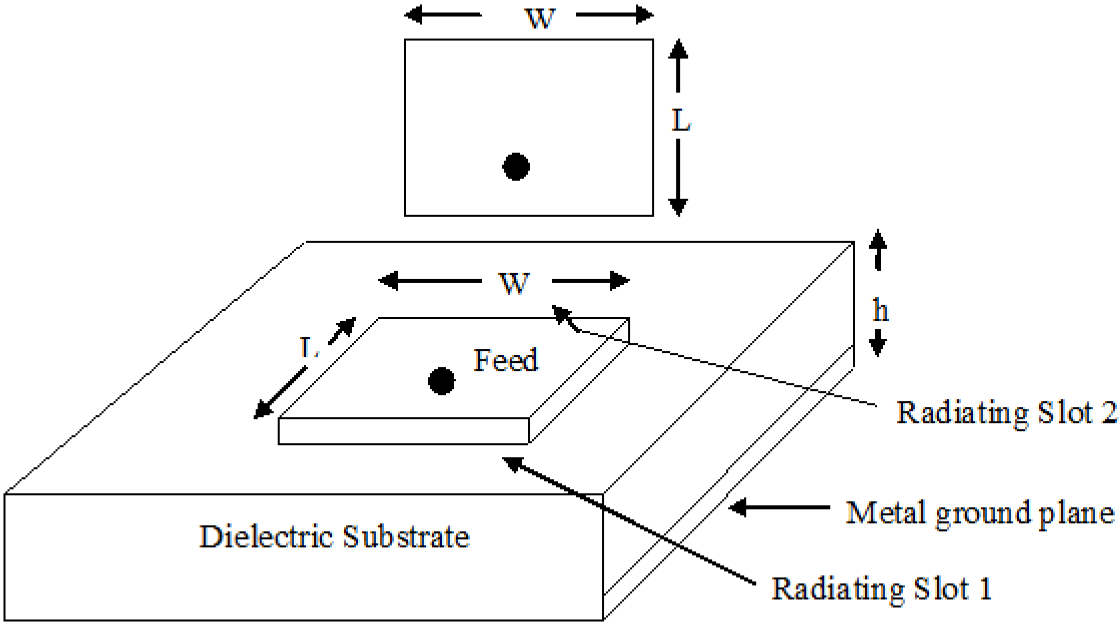

Fig. 1 Structure of Microstrip Antenna

II. ANTENNA PERFORMANCE MEASUREMENTS

To successfully design an antenna a number of measurements must be made to quantify the antenna performance [4]. Below are the various antenna performance measurements.

A. Impedance and Antenna Bandwidth

Antenna impedance is typically measured as return loss or VSWR [4]. The equipment used to measure this parameter is a Network Analyzer. The impedance (and the bandwidth over which the impedance is acceptable) must be measured with the antenna installed in the device with all components installed. The impedance measurement often requires special fixtures and assemblies to allow access to the antenna terminals. It is not uncommon that the antenna requires some small tuning adjustments when the device is finally fully assembled. At this stage, if the initial design was well done, most embedded antennas are often quite easily tuned with small changes to the PCB layout or sheet metal part, and/or with the addition of passive components on the antenna or the radio PCB.

B. Gain and Radiation Patterns

Calibrated measurements of antenna gain and radiation patterns are made in an Anechoic Chamber. The anechoic environment eliminates all reflections and allows precise and repeatable measurements to be made. The device under test is typically rotated 360 degrees in multiple orientations to determine the shape of the radiation pattern from many different directions. Reference antennas are used as calibrated gain standards. As with impedance measurements, gain and radiation patterns should be measured using a complete product.

C. Efficiency Measurements

As mentioned earlier, efficiency may be the single most important parameter to be measured, especially for an embedded antenna which can have degraded efficiency due to its tight integration with the device. Efficiency can be calculated from the calibrated gain and radiation pattern measurement but this can be a time-consuming effort.

III.MICROSTRIP ANTENNA CALCULATIONS

The rectangular microstrip antennas are made up of a rectangular patch with dimensions width (W) and length (L) over a ground plane with a substrate thickness (h) having dielectric constant (ε_r). There are numerous substrates that can be used for the design of microstrip antennas, having their dielectric constants usually in the range of $2.2 \leq \varepsilon_r \leq 12$. The ones that are most desirable for antenna performance are thick substrates whose dielectric constant is in the lower end of the range because they provide better efficiency; larger bandwidth loosely bound fields for radiation into space, but at the expense of larger element size [2]. The design of microstrip patch antenna assumes that the specified information includes dielectric constant of substrate (ε_r), height of substrate (h) and resonant frequency (f_r) [3]. After specifying ε_r, f_r and h determine the values of Width (W) and Length (L). Different dimensions of rectangular microstrip antenna [1] are calculated as follows:

For good radiation efficiency the width is calculated as [11]

$$W = \frac{1}{2 f_r \sqrt{\mu_0 \varepsilon_0}} \sqrt{\frac{2}{\varepsilon_r + 1}} = \frac{\nu_0}{2 f_r} \sqrt{\frac{2}{\varepsilon_r + 1}}$$

Where ν_0 is the free-space velocity of light.

The effective dielectric constant of microstrip antenna given in [6] as

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

Expression of extension of length as in [7] is given by

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

Then actual length of patch can be calculated

$$L = \frac{1}{2 f_r \sqrt{\varepsilon_{reff}} \sqrt{\mu_0 \varepsilon_0}} - 2\Delta L$$

IV. DESIGN OF ANTENNA

Figure 2 and 3 shows the Initial shape of rectangular microstrip antenna and its Optimized structure respectively. The geometrical dimensions for design of antenna are length = 48.6 mm and width= 41.54 mm. The height of Rogers RT/duroid 5880(tm) substrate h=1.58 mm and dielectric constant is 2.2. The effective dielectric constant (ε_{eff}) = 2.1101 and xtension of lenght (ΔL) is 0.8329 mm. This patch antenna uses a coaxial line feed at distance of 26.2 mm with thickness of 5 mm. The resonant frequency is 2.4 GHz at which antenna will work.

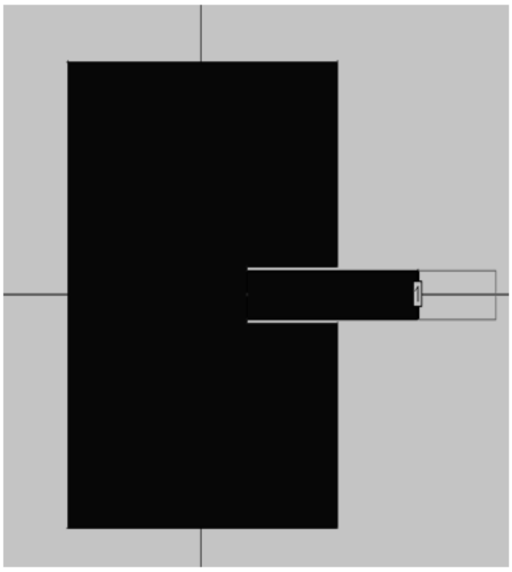

Fig. 2 Rectangular Microstrip Antenna

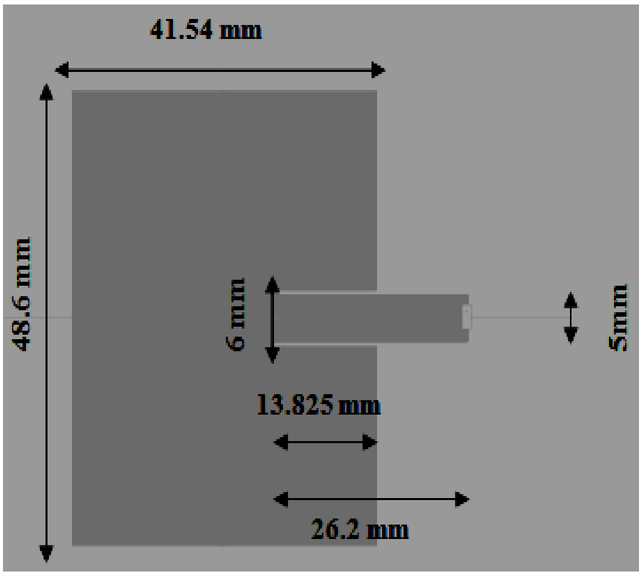

Fig. 3 Optimized Structure of Rectangular Microstrip Antenna

V. SIMULATION RESULTS

IE3D simulator [12] is used for simulation and various results of rectangular microstrip antenna are presented in figure 4 to 9.

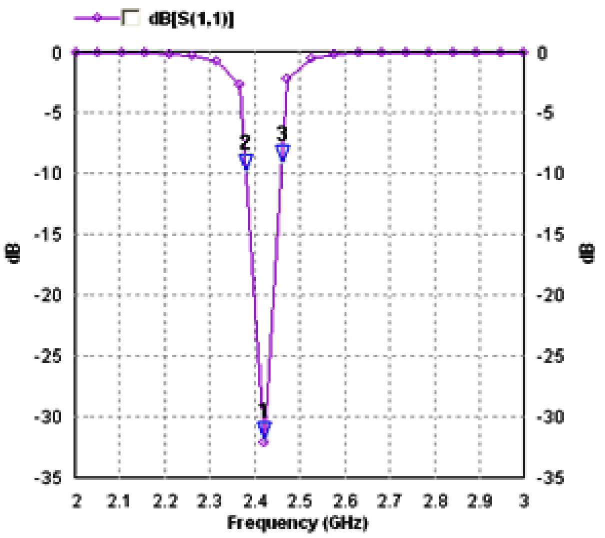

Fig. 4 Return Loss versus Frequency plot

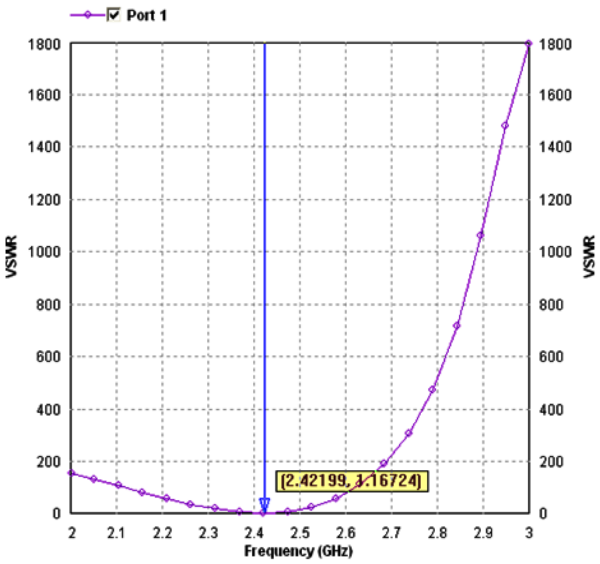

Fig. 5 VSWR versus Frequency plot

Figure 4 plots the Return Loss results of the antenna. The Return loss is -31.9 at 2.42 GHz frequency with lower and higher cut off frequencies are 2.38GHz and 2.46 GHz respectively. Figure 5 plots the VSWR (Voltage standing wave ratio) result. The VSWR versus frequency curve shows its value 1.16 at 2.42 GHz.

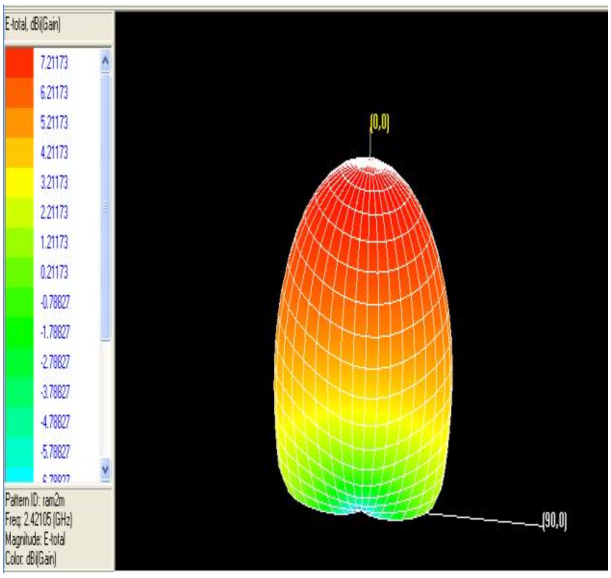

Fig. 6 3D Radiation Pattern

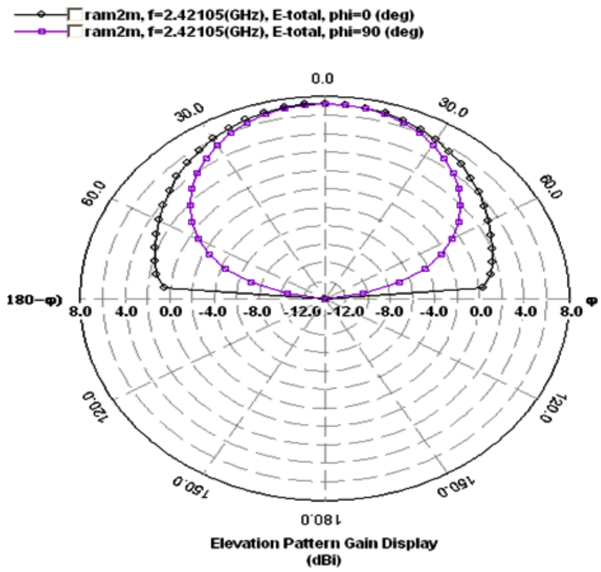

Fig. 7 2D Elevation Pattern Gain Display

Figure 6 and 7 plots the Antenna gain. Figure 6 shows the 3D radiation pattern and figure 7 shows 2D elevation pattern gain display. Result shows rectangular microstrip antenna gain is 7.2db at frequency 2.42GHz. The maximum gain of antenna in one direction is shown as directivity is 7.6db as shown in figure 8.

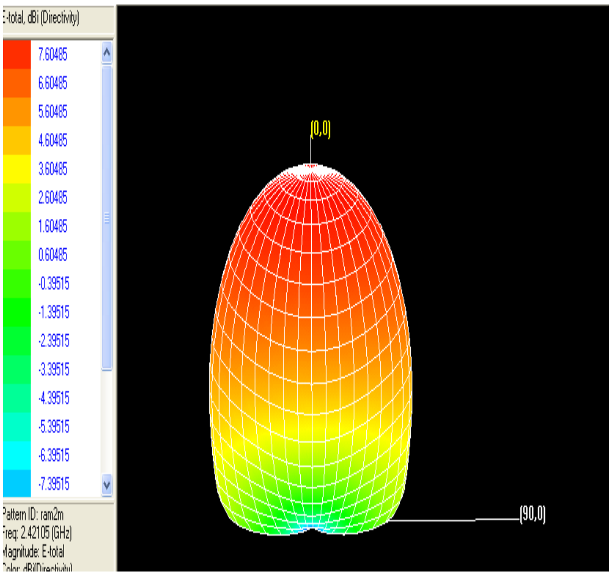

Fig. 8 3D Directivity

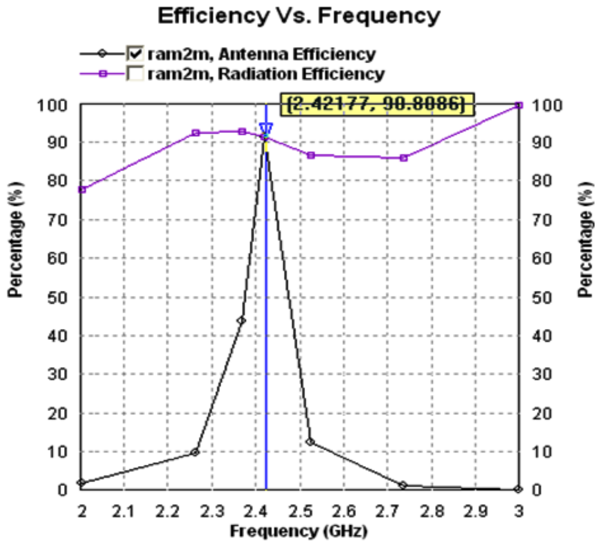

Fig. 9 Antenna Efficiency plot

Figure 9 shows the Efficiency versus Frequency graph. This graph plots Antenna efficiency and Radiation efficiency. Result shows the 90%, 91% antenna efficiency and radiation efficiency at frequency 2.42 GHz respectively. This shows the antenna gives good performance at 2.4 GHz band.

VI. CONCLUSION AND FUTURE WORK

In this paper we design a rectangular microstrip antenna for WLAN application. The frequency band used for antenna is IEEE 802.11 WLAN 2.4 GHz. Simulation is done with IE3D and results shows good performance with antenna efficiency is 90%. The antenna achieves gain of 7.2db at 2.42GHz and its maximum gain in one direction is 7.6db. The return loss result shows -31.9 at 2.42 GHz. All these performance measure results make this antenna suitable for the WLAN applications. In future we can design an antenna array by joining number of antennas to increase the gain in all directions.

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