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Analysis and Design of Rectangular Microstrip Patch Antenna AT 2.4Ghz WLAN Applications

Ogunlade Michael Adegoke, Ismael Saad Eltoum
Department of Electronics Engineering
Tianjin University of Technology and Education
Tianjin, China

ABSRACT- **In this paper, a rectangular microstrip patch antenna is designed. The proposed antenna operates at 2.4GHz resonant frequency for wireless local area network [WLAN]. There are different shapes of an antenna but our focus is on rectangular shape antenna design, and this antenna is designed in such a way to support the above resonant frequency. This choice of frequency has made the antenna a perfect choice for use in the wireless Local Area Network [WLAN]. In order to make the proposed antenna more accurate and efficient, High Frequency Structure Simulator software HFSS's optometric is used for the optimization of the antenna design. The microstrip line model method is used and been simulated by using HFSS software. A rectangular Patch design equations are introduced and validated by well simulated results. This antenna is implemented on FR4 Epoxy dielectric substrate with relative permittivity of $\in_r$=4.4, thickness h= 1.60mm and input impedance of 50 ohms. The simple configuration and low profile attributes of the proposed antenna made it easy fabrication and suitable for the application in the WLAN applications.**

Keywords: Frequency, Micro strip, Patch, VSWR, Return loss, WLAN.

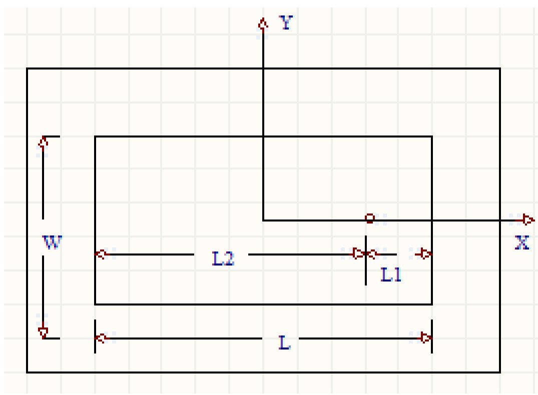
1. INTRODUCTION

Because of micro strip patch antenna's many unique and attractive properties, there seems to be little doubt that it will continue to find many applications in the future. It's properties includes, light weight ,low profile, easy fabrication, compact and conformability to mounting structure.

In this design, we are concentrating on rectangular microstrip patch antenna which consists of rectangular patch of length [L0] and width [W0] of the patch. All these were calculated by using rectangular patch design equations. All the dimensions are in mm. The operating bands are evaluated by using the software called HFSS with a return loss S11 of -29.69dB and VSWR of 1.20 which is less than two. The simulated radiation patterns of the design frequency are well acceptable. The wireless local area network requires this band of frequency 2.4GHz (2400-2484MHz) which is based on IEEE802.11b for WLAN applications. With reference to the simulation results, we can see that the multiband antenna achieve good results once we make comparison with the IEEE 802.11bfor the verification. The choice of chosen a relative permeability of $\in_r$ =4.4, gives better efficiency and larger bandwidths.

2. PROPOSED ANTENNA GEOMETRY

Shown below in figure 1, is the geometry of the rectangular microstrip patch antenna. This consists of rectangular patch with dimension $L_0, W_0, W_2, W_1, L_1, L_2$, respectively. The rectangular patch is separated from ground plane with FR4 Epoxy dielectric substrate with relative permittivity of $\in_r$=4.4,and thickness of 1.6mm. The details dimensions are given in the table below all of which are calculated using rectangular Patch design equations.



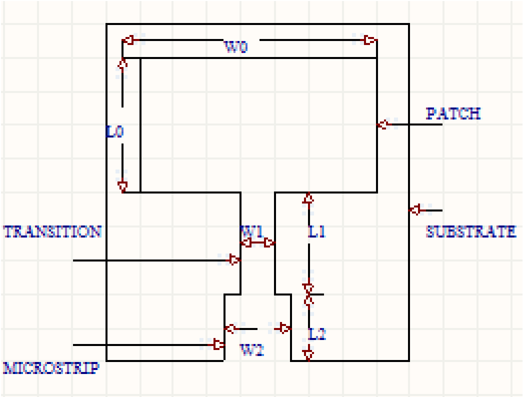


Figure1:Antenna Geometry

Table1. Design Parameters of the rectangular microstrip patch Antenna.

Parameters	Values[mm]
H	1.60
L0	28.00
W0	37.26
L1	17.45
W1	1.10
L2	15.0
W2	2.98
ϵ_{eff}	4.10
ΔL	0.738
L_{eff}	30.86

3. ANALYSIS AND DESIGN EQUATIONS

These equations are basically meant for predicting the resonant frequency, width, Patch thickness, and dielectric constant. The width of the rectangular microstrip patch antenna is given as;

$$W = \frac{C}{2F\sqrt{\left(\frac{\epsilon_r+1}{2}\right)}} , \qquad (1)$$

Where, C is the speed of light, F is the resonant frequency, ϵ_r is Relative dielectric constant of the substrate. By substituting the values of F=2.4GHz, C= 3×10^8m/s, Hence, the Width W= 37.26mm.The proposed antenna consists of the patch, the substrate, ground plane and microstrip line for impedance matching. The bottom layer is the ground plane that covers the rectangular shape substrate with a side of 31.14mm× 37.26mm. The middle layer constitutes the substrate which is made up of FR4-Epoxy dielectric substrate with a relative permittivity of ϵ_r=4.4 and height of 1.60mm. The rectangular patch covers the middle portion of the substrate and the patch is fed by a microstrip line method with 50Ohms input impedance respectively.

The effective dielectric constant ϵ_{eff}, is given as:

$$\epsilon_{eff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2} \frac{1}{\sqrt{\left(1+\frac{12h}{w}\right)}} , \qquad (2)$$

Hence, h is the height, W is the width, ϵ_r is the dielectric constant of the substrate. Dielectric constant is a function of frequency. As the operation frequency increases, the effective dielectric constant approaches the value of the dielectric constant of the substrate as shown in the design calculation. By substituting the values of h, W, and ϵ_r, the value of the effective dielectric constant obtained is ϵ_{eff}=4.10.

The effective length L_{eff} is calculated to be :

$$L_{eff} = \frac{C}{2F\sqrt{\epsilon_{eff}}} , \qquad (3)$$

By substituting the values of C and ϵ_{eff} above, the effective length L_{eff}=30.86mm.

The difference in length ΔL, which is a function of the effective dielectric constant and the ratio of width to height is given as;

$$\Delta L = 0.412h \frac{(\epsilon_e+0.3)}{(\epsilon_e-0.258)} \frac{(w/h)+0.264)}{(w/h+0.8)} \qquad (4)$$

Hence, Substitutes all the values to this equation, the difference in length ΔL,= 0.738mm.

The actual length of the patch which is given as , L_{eff} = L+2ΔL.

L = 31.14mm.

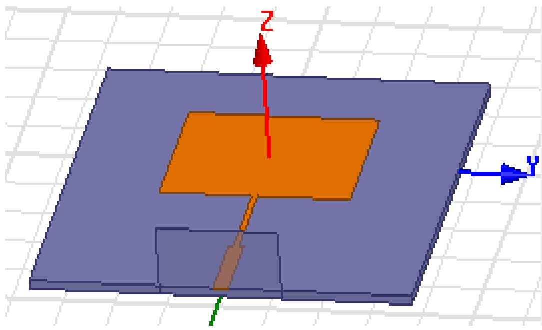


Figure 2. Proposed rectangular micro strip patch Antenna using HFSS Software.

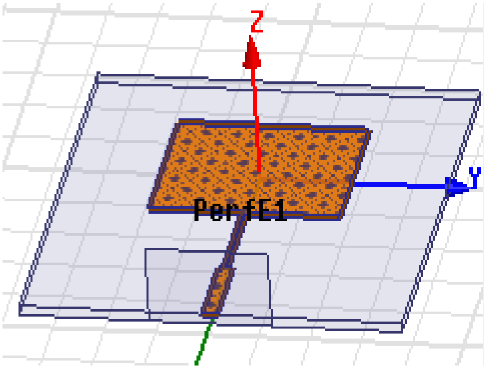


Figure 3. Proposed rectangular microstrip Patch Antenna Showing perfect E1-Plane.

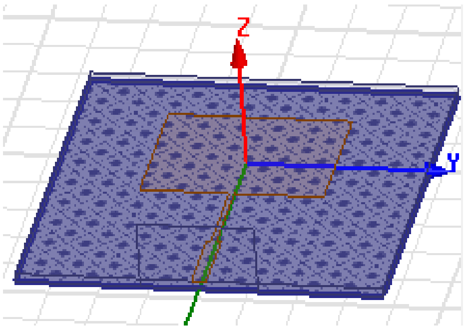


Figure 4. Proposed rectangular microstrip Patch Antenna Showing perfect E2-Plane.

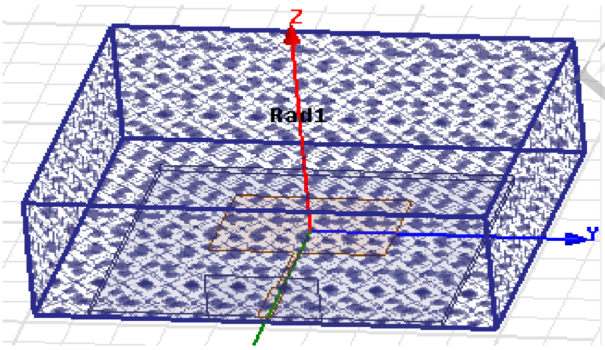


Figure 5. Rectangular micro strip patch antenna design enclosed inside radiation Air-Box.

4. SIMULATED RESULT OF THE ANTENNA

When the designed antenna is simulated by using HFSS the return loss and the VSWR are shown below. From the results obtained, we could observed that the designed antenna is having a band frequency operation of 2.4GHz with -29.69dB return loss. The voltage VSWR standing wave ratio is 1.2. This indicates the impedance matching between the field and the load and ,the value should be equal to 1 in an ideal situation but not realizable practically. In other words, practically it should be less than 2 but greater than 1 for good operation of the antenna. This antenna has been able to achieved the desired value of the VSWR of 1.2. Simulated results of 3D, EH plane pattern are shown in figure5.The proposed antenna can cover WLAN applications.

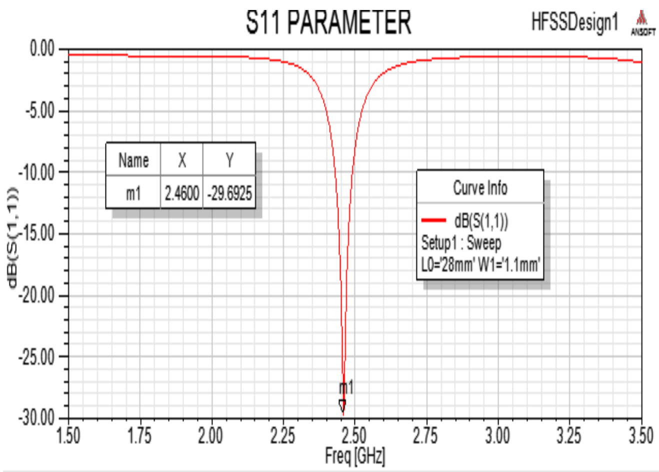


Figure 6. The return Loss

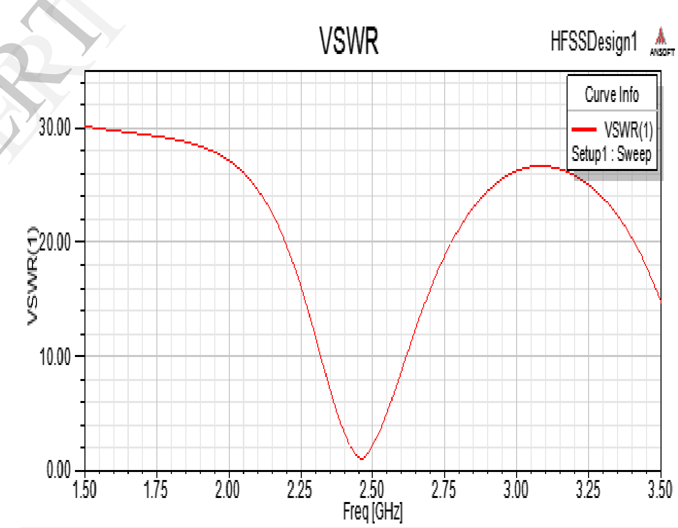


Figure 7. The VSWR of studied antenna.

The figure 8,9 shows the simulated E- and H- field radiation patterns of the proposed antenna at a frequency of 2.4GHz. Radiation pattern refers to the direction of the electromagnetic waves radiates away from the antenna. It is a graphical representation of radiation properties of the rectangular micristrip patch antenna as the function of space co-ordinate. From the simulated analysis of the solution set up of HFSS, the solution frequency was set to 2.45GHz for maximum number of 20 adaptive solutions with maximum delta S of 0.02 .In addition there are two types of fields namely, far and near field but, in this antenna design we only focusing on the far fields. By setting the EH Plane, the far field radiation sphere setup values of Phi start from 0 and stop at 90, with step size of 90.Similarly, the values of theta start from -180 and stop at 180 with a step size of 1. The values of phi and theta are good from the simulation results as shown in the radiation pattern 1 below. In actual fact, a microstrip patch antenna radiates normally to its patch surface. The radiation patterns of the antenna is omnidirectional and with this, this antenna can be use for WLAN.

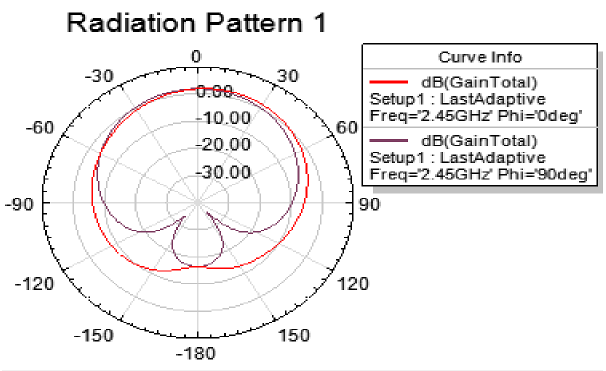


Figure8. Radiation Pattern

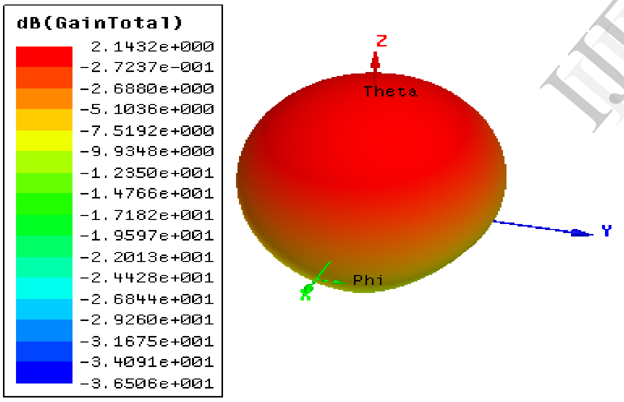


Figure 9. 3D-Gain Total

5. CONCLUSION

The antenna is having return loss of-29.6925 dB at 2.4GHz .This designed antenna is simulated on HFSS software. For this antenna, a sufficient band-width was achieved by utilizing microstrip line technique, the desired frequency of 2.4GHz is achieved, likewise the VSWR value of 1.2 is achieveable. The designed microstrip antenna is optimized to cover WLAN . The proposed antenna is very compact, very easy to fabricate, and is fed by a 50Ω microstrip line which makes it very attractive for current and future WLAN applications.

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