Design and fabrication of 2.4GHz rectangular patch antenna for Wi-fi application

Sumathi A[*] Priyadarshini K Desai[**]
[*] Associate Professor, Dept of ECE, BNMIT, Bangalore, Karnataka, India
[**] Assistant Professor, Dept of ECE, BNMIT, Bangalore, Karnataka, India
[1] sumathi.ayn@gmail.com, [2] priyadarshini.p.r@gmail.com

Abstract: *In the last few decades, the development of wireless and mobile communication has influenced the social and economic development. Billions of devices demand wireless connection which runs on data, voice and other applications. Antenna is an integral part in any wireless communication system. From the deign perspective, antenna must be compact, easy to manufacture and cost effective. This paper presents a design of rectangular patch antenna, operating at 2.4GHz. The antenna is initially simulated on CST, required parametric sweep is carried out in term of length and width of patch, to resonate at 2.4GHz. The simulated antenna is then printed using PCB printing machine, PCB Prototyping System, Eleven Lab. The printed antenna was tested using Keysight's PNA-LN-5232A (Vector Network Analyzer). The measurements/ variation in the reflection coefficient were observed /noted within the vicinity of human body and gold metal plus human body, at different position. Near the ear. The simulation results and measured results are in good match. Designed antenna is suitable for the Wi-fi, WLAN, communication application.*

Keywords: Patch Antenna, wireless communication, WLAN.

1. Introduction

In recent years wireless communication has grown tremendously, to meet the user requirement in terms of data transfer, connectivity and mobility. For the wireless communication application, the antenna design plays an important role. Design of compact, efficient and cost-effective antenna is very important. Printed antenna is more suitable for the next generation wireless communication system. An attempt has been done to design and fabricate a rectangular patch antenna with a microstrip line feed technique. The fabricated antenna is suitable for any ISM band application. The paper contains the following sections: Part I: Working and design of rectangular patch. Part2: Simulation of the designed Patch antenna, Part 3: Fabrication of the rectangular patch Part 4: Results and Discussion, Part 5: Conclusion.

2. Working and Design of Patch

The Micro strip Patch antenna consists of dielectric substrate sandwiched between two metallic surfaces, in which one surface operates as ground and the other is the radiating patch. When the excitation signal is applied to a patch through proper feed line the waves generated within the dielectric undergo reflections and energy is radiated from the edges of the metal patch. There are different feed techniques to excite the radiating patch. The micro-strip feed line is the simplest among all the feeding technique. The rectangular patch is excited through a 50Ω ohm micro-strip line.
The design equation for the radiating patch is as shown.

$$Wp = \frac{c}{2f_0\sqrt{\frac{\epsilon_r+1}{2}}} \quad (1)$$

$$L = L_{eff} - 2\Delta L \quad (2)$$

$$\Delta L = 0.412h \frac{(\epsilon_{eff}+0.3)(\frac{W}{h}+0.264)}{(\epsilon_{eff}-0.258)(\frac{W}{h}+0.8)} \quad (3)$$

$$L_{eff} = \frac{c}{2f_0\sqrt{\epsilon_{eff}}} \quad (4)$$

$$\epsilon_{eff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}[1 + 12\frac{h}{W}]^{-1/2} \quad (5)$$

The parameters of the patch, substrate, ground plane and feeding line are summarized in table I:
All printed material, including text, illustrations, and charts, must be kept within the parameters of the 8 15/16-inch (53.75 picas) column length and 5 15/16-inch (36 picas) column width. Please do not write or

print outside of the column parameters. Margins are 3.3cm on the left side, 3.65cm on the right, 2.03cm on the top, and 3.05cm on the bottom.

Antenna Part	Parameter (Symbol)	Value (mm)
Ground Plane	Width (Wg)	60
	Length (Lg)	60
	Thickness (t)	.03
Substrate	Width (Ws)	60
	Length (Ls)	60
	Height (h)	1.53
Patch	Width (W)	38.4
	Length (L)	29.8
	Thickness (t)	.03

Table 1. Antenna Parameter specifications

3. Simulation of Designed Patch Antenna

Microstrip Patch antenna shown in fig 1 was simulated using CST Microwave studio. The antenna was fed by a microstrip line. In the simulated microstrip patch antenna , the ground, patch antenna and the feedlines were of high conductivity metal (typically copper). The substrate (FR 4) had a thickness of 1.53 mm with permittivity εr =4.2. The designed antenna was simulated to check S11 parameter. When the patch with dimension mentioned in the above table was simulated the S11 parameter was -14.1 dB.

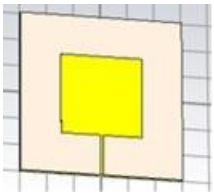

Fig. 1. Simulation of the designed Patch

The simulation was carried by varying the width of the patch for optimization. For a square patch of 30mm the S11 parameter was observed to be -26.863 dB. The graph of frequency vs magnitude in dB is as shown in figure 2 and variation of VSWR with frequency is as shown in figure 3 which is near to 1 for frequency of 2.3 GHz.

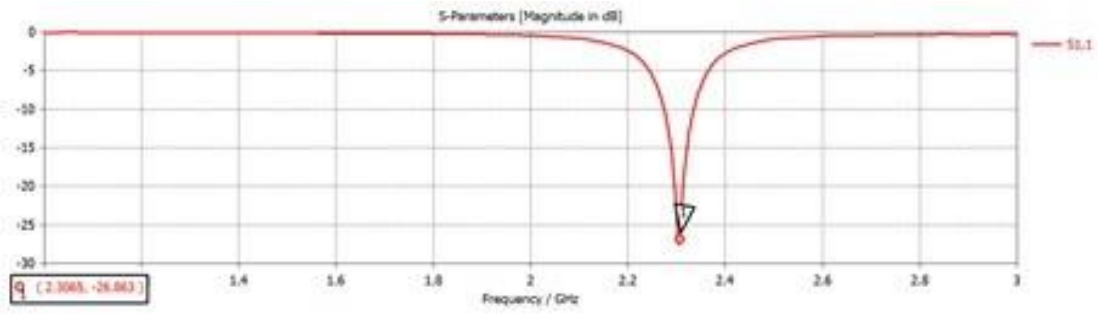

Figure. 2. S-parameter for square patch.

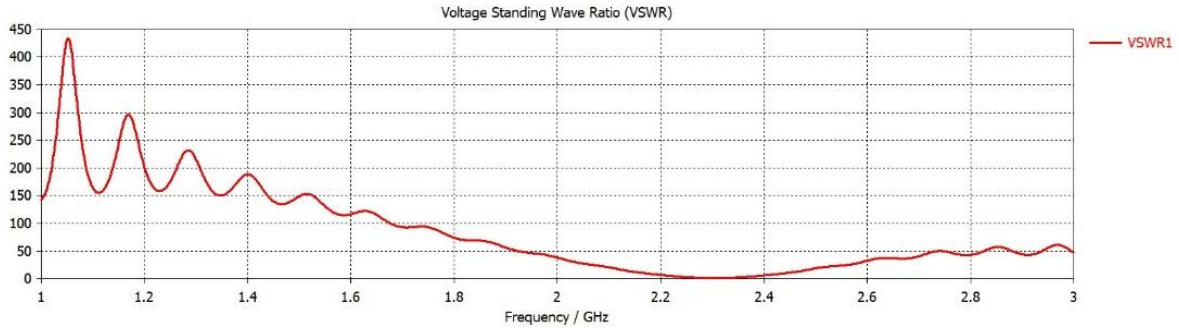

Figure 3. VSWR for square patch

The patch width was changed from 38mm to 35mm and to 30mm to optimize the S11 parameter. The graph of S-Parameter with different patch width is as shown in figure 4.

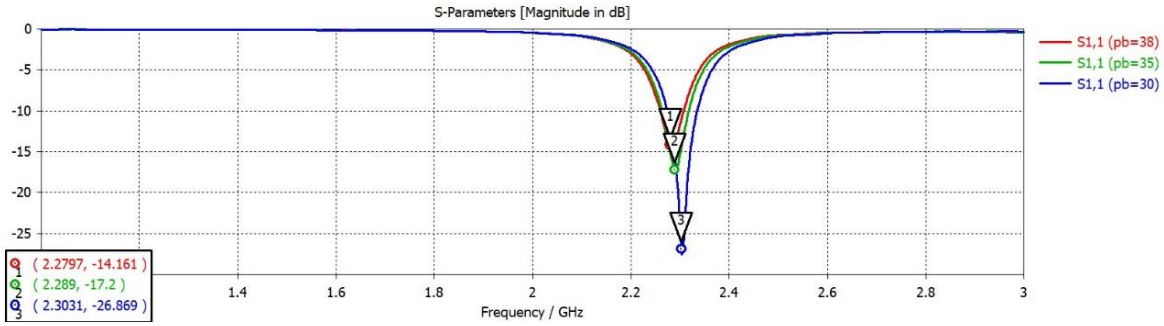

Figure 4. S-parameter for varied patch width.

4. Fabrication and Measurement of Designed Patch Antenna

The fabrication of antenna was done using PCB Prototyping System of MITS Electronics. The .cst files were converted into Gerber files to suit the input format of MITS Eleven Lab. The fabricated antenna is then used for practical testing by soldering 50Ω SME connector. The antenna was fabricated on FR-4 Substrate with dielectric constant of 4.2. The fabricated antenna is shown in figure 5 (b)

(a) (b)

Figure. 5. (a) PCB Prototyping System, Eleven Lab (b) Fabricated Microstrip Antenna

To validate the patch antenna designed in CST, the antenna fabricated on FR4 di-electric substrate having an overall area of 60 x 60 mm2 and thickness 1.59 mm was practically tested using Vector Network Analyzer. The testing of antenna hardware was performed on Keysight's PNA-LN-5232A (Vector Network Analyzer) The return loss plot obtained after measurement is presented in figure 6

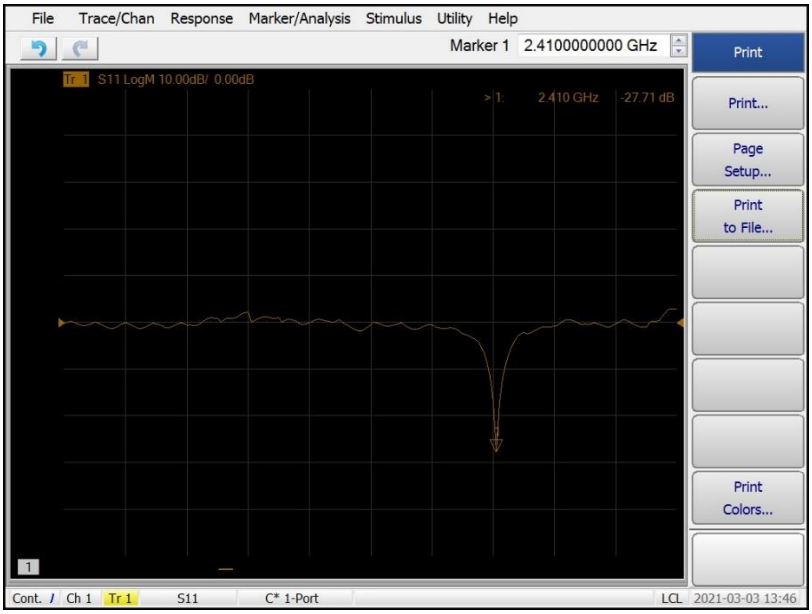

Figure. 6. Return loss measured for square patch using VNA

5. Results and Discussion

The simulation results showed that antenna resonates at the required frequency of 2.306 GHz and the reflection coefficient obtained was -26.863 dB. When the measurement was done practically the antenna resonated at 2.4 GHz and reflection coefficient measured -27.71dB. As the patch width was varied from 38mm to 30mm the results showed better reflection coefficient from -14.161 to -26.863.

6. Conclusion

A rectangular patch antenna was simulated using CST Microwave studio showed good agreement with the fabricated antenna. The simulation results showed that antenna resonates at the required frequency of 2.306 GHz and the reflection coefficient obtained was -26.863 dB. Whereas the fabricated antenna resonated at 2.4 GHz and reflection coefficient measured -27.71dB. The antenna configurations showed quite good results on perspectives of re-turn loss, VSWR. The results exhibited significant shift in S11 parameter of the antenna when the width of the antenna was varied

7. References

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