ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 6, Issue 7, July 2017

Performance Analysis of Rectangular Patch Antenna for Optimized Feed-line Width

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***Abstract*—: In this research, a rectangular microstrip patch antenna is designed and the dependency of resonant frequency on the feed line width has been studied. The designed antenna has a resonating frequency of 2.4 GHz which is applicable to Wireless Local Area Network (WLAN). The antenna has made on FR-4 Epoxy as dielectric material having dielectric constant ϵr=4.4. Research shows that optimum feed width results in better return loss while reduced bandwidth.**

***Index Terms*— Micro Strip Antenna (MSA); High Frequency Structure Simulator (HFSS); WLAN; Patch; Return Loss; dielectric..**

I. Introduction

Microstrip patch antennas have found extensive application in wireless communication system owing to their advantages such as low- profile, conformability, low-cost fabrication and ease of integration with feed networks. The input impedance of these antennas depends on their geometrical shape, dimensions, the physical properties of materials involved, the feed type and location. Therefore a subset of antenna parameters can be adjusted to achieve the best geometry for matching of a particular resonance. The experimental and numerical results showed that the input impedance of a inset feed rectangular patch antenna varied as fourth power of a cosine function of the inset feed depth [1]. A more recent study shows a modified shifted square to sine form that well characterizes probe-fed patches with a notch [3]. It is found that a shifted square to cosine function works well for the inset fed patch [4] [5]. The parameters of the shifted cosine squared function depend on the notch width for a given patch and substrate geometry. Since the microwave antenna is often integrated with other microwave circuitry, a compromise has to be reached between good antenna performance and circuit design.

The basic structure of the proposed antenna, shown in Fig. 1, consists of 3 layers. The lower layer, which constitutes the ground plane, covers the rectangular shaped substrate with a side varying with dimension of patch. The middle substrate, which is made of FR4 epoxy resin, has a relative dielectric constant ϵr=4.4 and thickness 1.6 mm. The upper layer, which is the patch, covers the rectangular top surface. The rectangular patch has sides 28.5 X 32 mm that covers the middle portion of the substrate. The patch is fed by a Microstrip line with 50Ω input impedance. Simulations were performance using HFSS. Convergence was tested for a number of times. Once convergence was obtained simulations were conducted in order to obtain swept frequency response extending from 1 to 4 GHz.

II. OVERVIEW OF PATCH ANTENNA ARRAY DESIGN

Patch feeding can broadly be classified as either contacting or non-contacting. In the contacting method, either a microstrip line or coaxial cable is used to directly excite the radiating patch. This makes these techniques easy to fabricate and simple to model, especially the line fed technique. The main advantage of these techniques is that impedance matching is relatively easy since the probe or microstrip line can be placed at any desired position.

Figure 1 show the patch geometry of a line fed patch antenna which is designed on a 1.6 mm thick FR4 Epoxy dielectric substrate. Antenna dimensions are calculated using following equations, where letter W stands for the width of patch, L for length of patch, ΔL for change in length due to fringing effect.

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\epsilon_r+1}}$$

$$L = \frac{c}{2f_r\sqrt{\epsilon_{eff}+1}} - 2\Delta L$$

$$\Delta L = 0.412h\frac{\epsilon_{eff}+0.3}{\epsilon_{eff}-0.258}\left[\frac{\frac{W}{h}+0.264}{\frac{W}{h}+0.8}\right]$$

$$\epsilon_{eff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\left[1+12\frac{h}{w}\right]^{-\frac{1}{2}}$$

The dimensions of substrate are calculated accordingly to the dimension of patch. The antenna is intended to work at the center frequency (f) of 2.4GHz, hence the dimension of patch takes a rectangular shape is 28.5mm length (L) and 32mm width using above equations.

The antenna is excited using a $\lambda/4$ microstrip feeding line with the input signal obtained from a 50Ω connector to match input impedance of microstrip line. The rectangular patch and microstrip feeding line are placed on the top side of

Manuscript received Jul, 2017.

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dielectric substrate, whereas the ground plane is positioned on the bottom side.

The source for patch is at edge of patch, exited by a lump port. Since dimension of patch and the source line directly contributes to the input impedance of antenna, optimized values are essential to attain the required characteristics.

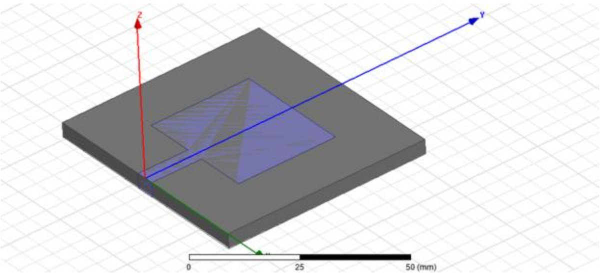

Figure 1: Structure of simple patch with line feed (units in mm)

III. DESIGN ANALYSIS

The dimension of patch was calculated for 2.4 GHz operation while the thickness is fixed at 1.6mm. Table 1 shows the variation of return loss and operating frequency corresponding to the variation in width of source line. The width was decreased from 4mm to 0.7mm and for each value characteristics of antenna including Center frequency, return loss and Bandwidth was noted down. It was observed that the return loss reaches its maximum of -34.98 db value at 1mm width. But the variation on operating frequency is negligible. The bandwidth reaches its minima of 26 MHz at 0.9 mm width. Graphical representation showing variation in return loss (in db) and bandwidth (in MHz) as a function of width of source line(w) is shown in figure 2 and 3 respectively.

Table 1: Table showing the variation of parameters with variation in width

No	Width	Fc (Ghz)	S(db)	BW(Mhz)
1	4	2.45	-4.6	312
2	3	2.44	-6.62	237
3	2	2.44	-11.09	155
4	**1**	**2.43**	**-34.98**	**37**
5	0.9	2.43	-23.88	26
6	0.8	2.43	-19.82	97
7	0.7	2.43	-16.96	230

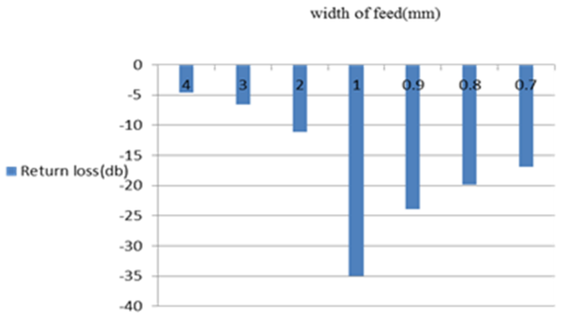

Figure 2: Variation of return loss with change in width of feed

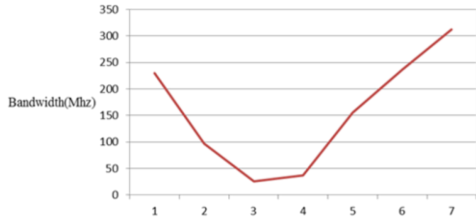

Figure 3: Variation of bandwidth with change in width of feed

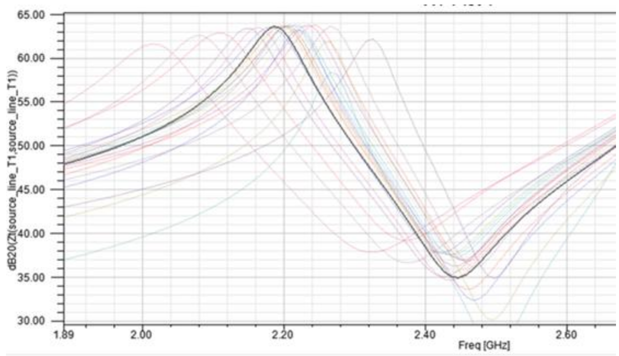

Figure 4: Variation of input impedance for resonant frequency for feed line width

IV. CONCLUSION

The microstrip line fed patch antenna, was modeled and analyzed. It was investigated how the width influence the performance especially return loss and input impedance. From the presented results it can be concluded that the width of feed line has considerable effect on performance of a simple patch antenna. Simulated results show an optimized value for source width to obtain a peak return loss of 35 db for 2.4GHz antenna. This is because of the impedance matching effect of source line and the patch. Meanwhile the bandwidth reaches its minimum value of 26 MHz at 0.9mm width. This topic certainly calls for closer attention and further work should be dedicated to the accurate analytical explanation of the input impedance for this type of the microstrip patch antennas. Proper impedance matching of a microstrip patch antenna to the feed line is paramount for efficient radiation.

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