ENHANCEMENT OF DIRECTIONAL PARAMETERS OF A MICROSTRIP PATCH ANTENNA RESONATING AT 2.4 GHZ

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Abstract—This paper is focused on the design and simulation of patch antenna (which is widely used in cell phones today) with an emphasis on optimization of a 2.4 GHz rectangular patch antenna considering directivity and gain as the parameters. In proposed technique for designing of a microstrip patch antenna for 2.4 GHz resonating frequency, as the length of patch is decreasing the resonating frequency shift to the desired resonating frequency. This technique also improves the gain and directivity of designed antenna. The proposed antenna is analyzed and designed using CST-MWS. The optimized simulated results show that the main lobe level is increased from 6.8 db to 7 db and side lobe level reduced from -11.2 db to -12.1 db.

Index Terms— Directivity, Main lobe, Rectangular microstrip patch antenna, Resonating frequency, Side lobe.

I. INTRODUCTION

As communication devices become smaller due to greater integration of electronics, the antenna becomes a significantly larger part of the overall package volume. This results in a demand for similar reductions in antenna size. In addition to this, low profile antenna designs are also important for fixed wireless application. A patch antenna (also known as a rectangular micro strip antenna) is a type of radio antenna with a low profile, which can be constructed on a flat surface. It consists of a flat rectangular metallic sheet or "patch" of metal, mounted over a larger metallic sheet called a ground plane. Commonly made micro strip antenna shapes are square, rectangular, circular and elliptical, but any continuous shape is possible and can be created. [1]

Feed line is used for excite to radiate by direct or indirect contact. Microstrip patch antennas can be fed in a variety of ways. Microstrip line feed is one of the easier methods to fabricate as it is a just conducting strip connecting to the patch and therefore can be consider as extension of patch. It is simple to model and easy to match by controlling the inset position. [2]

II. ANTENNA DESIGN

For a rectangular patch, the length L of the patch is usually $0.3333\lambda_o < L < 0.5\lambda_o$, where λ_o is the free space wavelength. The patch is selected to be very thin such that $t \ll \lambda_o$ (where t is the patch thickness). The height h of the dielectric substrate is usually $0.003\ \lambda_o \leq h \leq 0.05\ \lambda_o$. The dielectric constant of the substrate (ε_r) is typically in the range $2.2 \leq \varepsilon_r \leq 12$. The most popular models for the analysis of microstrip patch antennas are the transmission line model, cavity model and full wave model. The transmission line model is the simplest of all and it gives good physical insight but it is less accurate. [3]

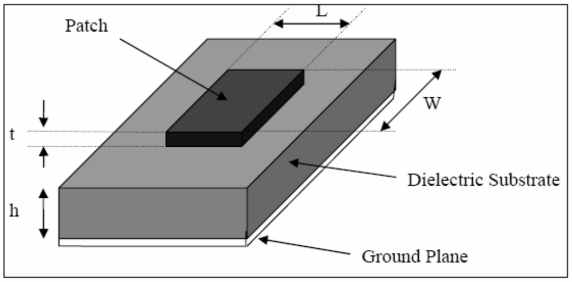


Figure -1 – A Typical Microstrip Patch Antenna [7]

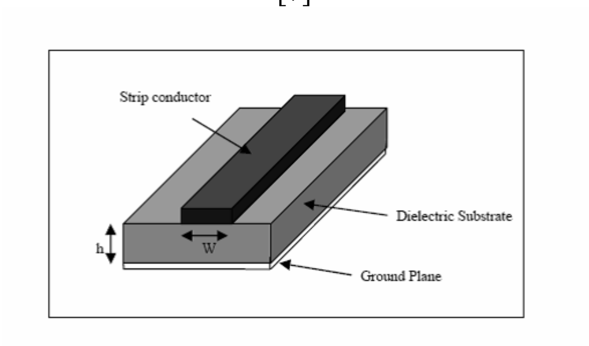


Figure -2 – Microstrip Transmission line feed [7]

The width of the microstrip patch antenna was computed with the following equation: [4][7]

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

Where c is the speed of light (3x108 m/s), fr is the operating frequency of 2.4 GHz and Er is the dielectric permittivity of 4.3. The length of microstrip patch antenna is given by the following equations:

$$E_{reff} = \frac{E_r+1}{2} + \frac{E_r-1}{2}\left(1 + 12 \times \frac{h}{W}\right)^{-\frac{1}{2}}$$

Where Ereff is the effective dielectric constant and h is the thickness of the dielectric substrate.

$$L_{eff}(eff.length) = \frac{c}{2 \times f_r \times \sqrt{E_{reff}}}$$

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

,

In the equation above ΔL stands for length extension. Therefore, the actual length of the microstrip patch antenna is given by:

$$L = L_{eff} - 2 \times \Delta L$$

Calculation of impedance of patch by given formula

$$Zo = \frac{90}{\varepsilon r - 1}\left[\frac{\varepsilon r\, L}{W}\right]^2$$

Calculation of inset feed distance (Yo) for 50 ohm value

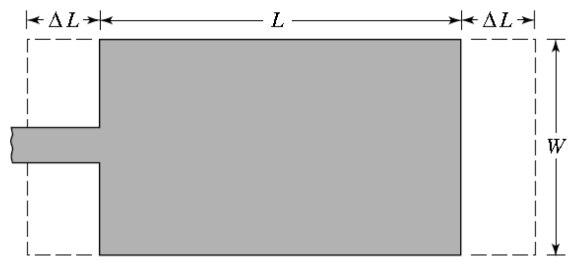
$$50 = Zo\left[\cos\left(\frac{\pi Yo}{L}\right)\right]^2$$

Calculation of effective impedance of microstrip line so that impedance can be matched at inset point at a distance Yo from edge of patch for 50 ohm value. The impedance of microstrip line is more than 50 ohm because of mutual coupling between patch and line and is given by

$$Z = \sqrt{50 * Zo}$$

Calculation of ratio of width of microstrip line to height of substrate as we know the effective impedance of the line Z, by given formula

$$Zo = \frac{87}{\sqrt{\varepsilon r + 1}} ln\left[\frac{5.98\, h}{.8Wo + t}\right]$$



(a) Top view

Figure 3: Top view of antenna [7]

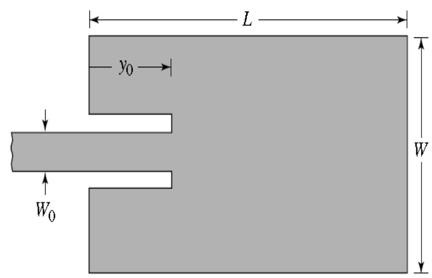


Figure 4: Distance Yo from edge of patch so that patch impedance at this point is 50 ohm[7]

III. Proposed Design And Simulation Results

The resonant properties of the designed microstrip patch antenna are studied by adjusting the different values of parameters using CST-MWS. The S11 parameter calculated. The effects of variation of patch length (L) of designed antenna also studied. From calculated patch length i.e. L = 29.849 mm, the return loss parameter obtained is shown in figure 5. Here return loss parameter is not minimum at resonant frequency 2.4 GHz as the approximate formula for calculation of parameters of antenna structure is used.

Table 1 gives the dimensions of proposed patch antenna for 2.4 GHz Resonating frequency

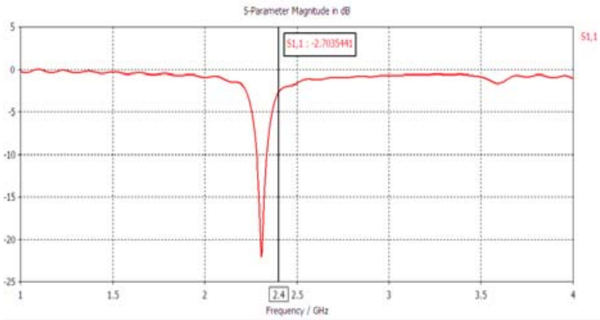


Figure 5: Return loss parameter for 2.4GHz resonating antenna with L = 29.849 mm

Table 1- Dimensions of calculated and proposed patch antenna for 2.4 GHz Resonating frequency

1	Resonating frequency	2.4 GHz
2	Substrate	$\varepsilon_r = 4.3$
3	Thickness of ground plane	.3mm
4	Thickness of substrate	1.4mm
5	Width of patch, W	38.39mm
6	Length of patch,L (Optimized)	28.67mm
7	Width of substrate (generally double of patch)	80mm
8	Length of substrate (generally double of patch)	60mm
9	Thickness of patch, t	.07mm
10	Inset feed distance , Yo	10.96mm
11	Width of microstrip feed line,Wo	.26mm

Keep Yo fixed and reduce the length of patch in step size then this minima will shift towards resonant frequency and we can obtain the minimum of return loss parameter at specified resonant frequency and can be seen from figure 6.

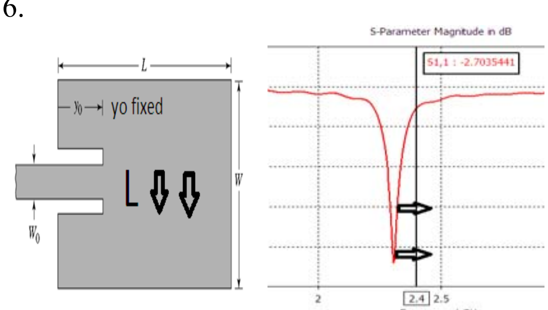


Figure 6: L is decreasing keeping yo fixed return loss minima approaches resonant frequency

As decreasing from L = 29.849 mm to L = 28.67mm the resonating frequency shifted from 2.308 GHz to 2.4 GHz. Also return loss minimum is -28.27 db which was -23.8 db, result shown in figure 7

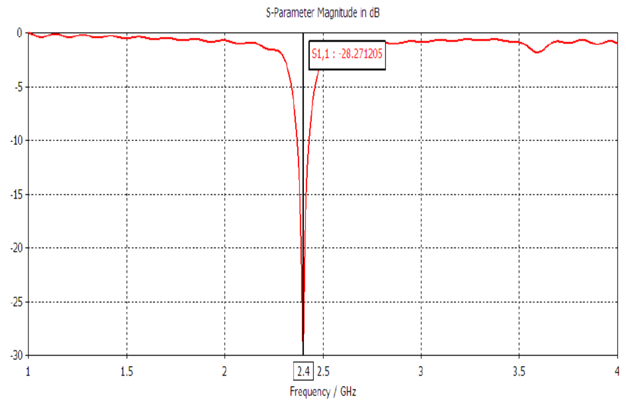


Figure 7: Return loss parameter for 2.4GHz resonating antenna with L = 28.67 mm

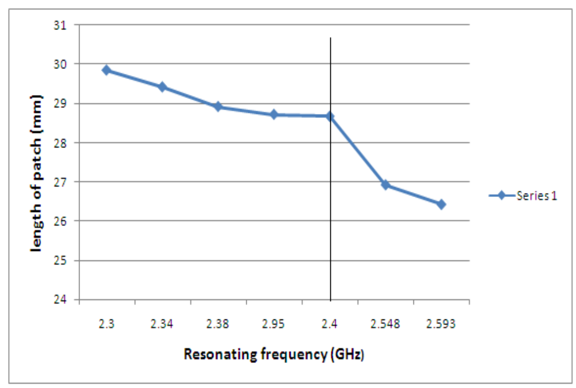


Figure 8: Effect of variation of patch length on resonating frequency

The 2-D radiation pattern observed for the values of patch length L = 29.849mm and L = 28.67mm shown in figure 9 and figure 10 respectively

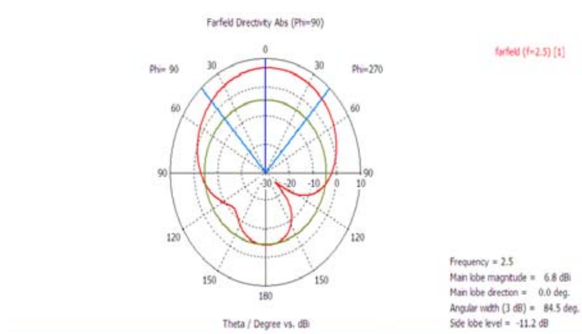


Figure 9: 2-D Radiation pattern for 2.4GHz resonating antenna with L = 29.849mm (**Main**

lobe is 6.8 dBi, Side lobe magnitude is -11.2 dBi)

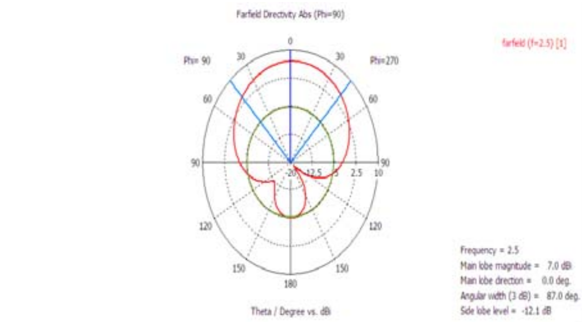


Figure 10: 2-D Radiation pattern for 2.4GHz resonating antenna with L = 28.67mm (**Main lobe is 7.0 dBi, Side lobe magnitude is -12.1 dBi**)

IV. CONCLUSION

Now a day's various wireless systems such as Bluetooth, WLANs, and GPS have been highly integrated into the mobile equipments, and in order to fulfill the RF system requirements using the different frequency band, antenna technology is required to wideband characteristics. The proposed square patch antenna is designed by considering strip line feeding and their output parameters are presented in this paper. The directional parameters like main lobe level, side lobe level and directivity of proposed antenna in this paper are 7.0 dBi, -12.1dBi and 7.006dBi respectively. As length of the patch is decreasing from 29.849 mm to 28.67 mm, many of the parameters of our antenna got optimized values. Antenna efficiency parameters can also be observed from the 3-D radiation pattern for the proposed antenna resonating at 2.4GHz.

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