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Optimization of Geometry of Microstrip Patch Antenna for Broadband Applications

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ABSTRACT: The purpose of the paper is to design wideband rectangular patch antenna printed on FR-4 substrate. Higher bandwidth can be achieved by unsymmetrical feed and a reduction in ground plane with proper gap distance. The rectangular patch antenna works from 1.4-4GHz at 95% bandwidth with a 2.1 mm wide microstrip line feed.

Key words: Microstrip patch antenna, Bandwidth, Return loss, Optimization.

I. INTRODUCTION

Microstrip antennas are well known for its advantages such as light weight, low fabrication cost, mechanically robust and capability of dual and triple band frequency operation. These antennas are used in many modern communications systems such as personal communication systems, satellite and other wireless applications. However, narrow bandwidth is major disadvantage for this antenna [1]. Higher bandwidth is desired in various applications like remote sensing, biomedical, mobile radio, satellite communications etc. In order to improve the bandwidth, intensive research has been carried out and proposed several techniques. These techniques include the implementation of thick substrate with a low dielectric constant [2] and employing stacking or parasitic patches [3].Stacked patches result an improvement of 10% - 20%, but this design has drawback of additional complexity in fabrication.

The use of U-slot and L-probe in the design of small size microstrip antennas has been presented [4-6]. Different techniques like utilizing a microwave substrate material, addition of a shorting pin. A compound technique [7] include adjusting the displacement of patches, setting two pairs of conducting bars around the lower patch as parasitic radiator and loading a capacitive disk on the top of probe and the bandwidth has been remarkably improved. Various broad banding methods are proposed in [8]. All the above mentioned methods are based on the modification of surface current distribution to improve the bandwidth. This paper uses the modification of ground plane dimensions and feed line position for wideband antenna design.

II. ANTENNA DESIGN

The basic design considerations for a rectangular patch were considered for the design. 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 $t << \lambda_o$ (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 $2.2 \leq \varepsilon_r \leq 12$. Formulas used for the patch design is explained in [9].

$$\text{Patch width} = w = \frac{c}{2f\sqrt{\frac{(\epsilon_r+1}{2}}} \quad (1)$$

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Patch length= $L = L_{eff} - 2dL$ (2)

Where $L_{eff} = \frac{c}{2f\sqrt{\varepsilon_{reff}}}$ (3)

$$dL = 0.412h\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)} \quad (4)$$

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}(1+12\frac{h}{W})^{-\frac{1}{2}} \quad (5)$$

Ground length, $L_g = 6h + L$ (6)

Ground Width, $W_g = 6h + W$ (7)

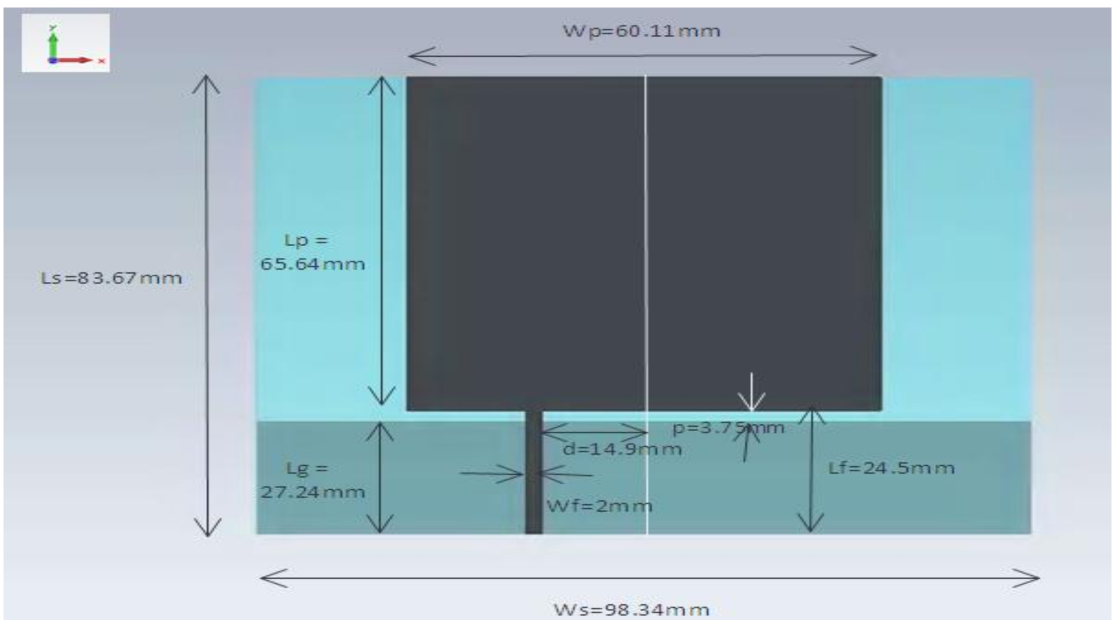

Fig.1. Geometry of the designed antenna.

A rectangular patch antenna dimensions are optimized using CST Microwave studio to operate them for biotelemetry applications as shown in fig.1. The antenna are printed on a FR-4 substrate having the thickness h = 1.6 mm and permittivity ε_r = 4.4 and fed by a 50Ω microstrip line which is located at a distance P from the central axis for better impedance

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matching. The shape of the patch, position and width of feed line and ground plane dimensions are obtained to achieve -10dB impedance bandwidth. The optimized parameters obtained for both the antenna are listed in table 1

Table1. Dimensions of proposed antenna

Parameter	Lp	Wp	Ls	Ws	Lg	Lf	Wf	d	p
Value(mm)	65.64	60.11	83.67	98.34	27.24	24.5	2	14.9	3.75

III. RESULTS

For better impedance matching, parametric study is performed on gap distance p, which is responsible for lower limit of the frequency band as plotted in fig-2. The ideal value obtained is p = 4mm. The bandwidth obtained for optimum value of p = 4mm is 2.6GHz and is shown in fig-3. The radiation pattern is shown in fig.4.

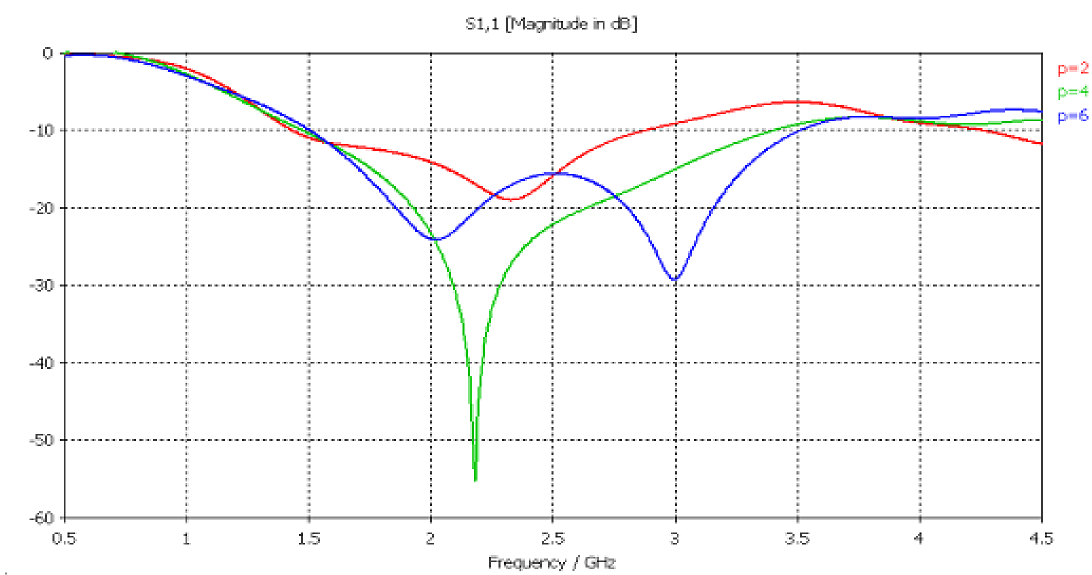

Fig.2 Return loss plot for different values of ‘p’

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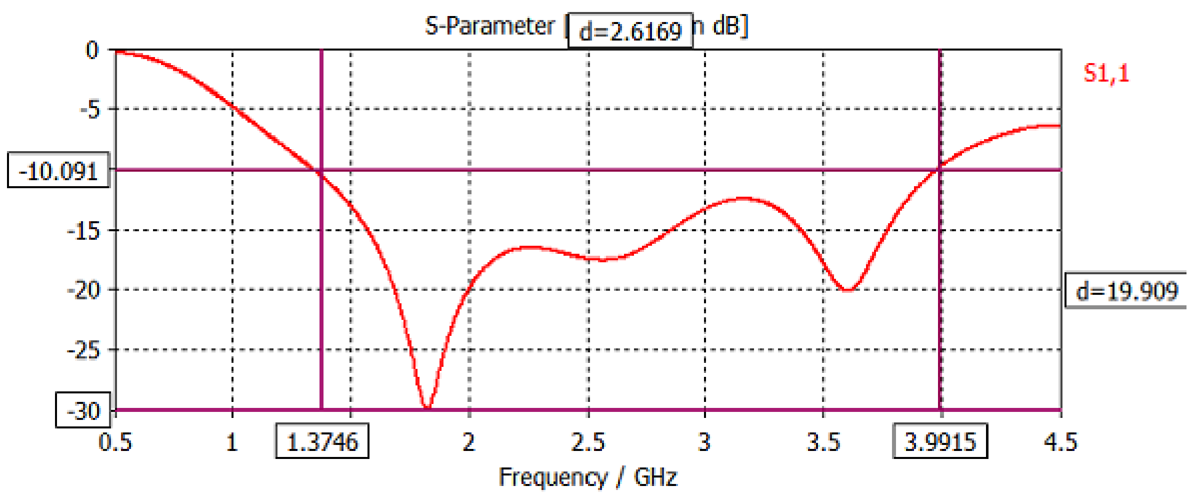

Fig.3 Return loss plot at p=4

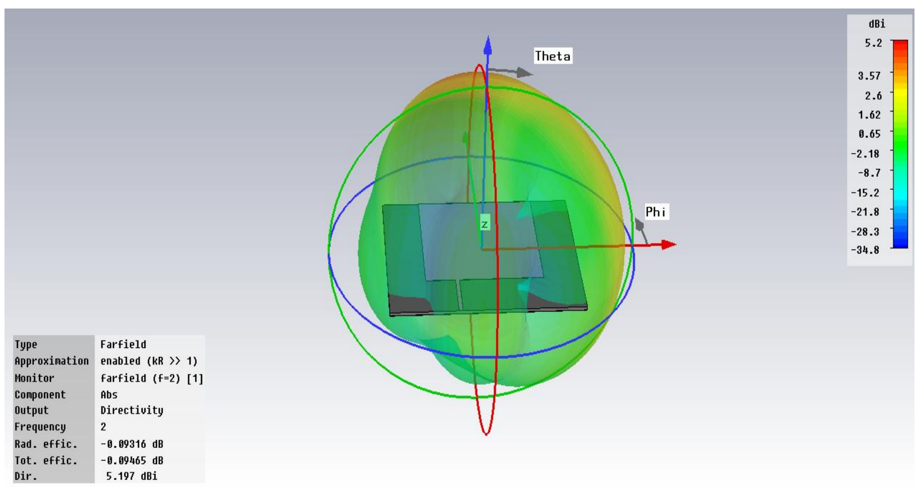

Fig.4 Radiation pattern of the patch antenna

IV. CONCLUSION

The paper presents the optimized design of wideband rectangular patch antennas for several wireless applications especially for biotelemetry. A compact size as well as broadband behavior was achieved mainly by using asymmetrical feed and a reduced ground plane. The Gap distance shows influence on impedance matching and the typical value is 4 mm. Its bandwidth ranges from 1.56 GHz to 3.5 GHz with an impedance matching around 76.7 % for S11 ≤ -10 dB. The best impedance Matching was obtained at 2.02 GHz (S11 = -24.3 dB) and 3.13GHz (S11 = -24.4 dB), which matches quite well with simulation results.

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