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Design of Microstrip Stacked Square Patch Antenna

Naresh Kumar Joshi, Manisha Uttamrao Birare, Neeraj Nahata

Abstract**—*****many applications need very broad band antenna, but the narrow bandwidth of a microstrip antenna is one of the most important features that restrict its wide usage. So to enhance the bandwidth and overcome this difficulty we have used microstrip patch antenna fed by a coaxial feed to increase the bandwidth by changing substrate and its thickness. Here we proposed the microstrip square patch antenna with improved bandwidth at centre frequency of 2.4GHz. The measured results demonstrate that this structure exhibits an enhance bandwidth, which is over 15% for $|S_{11}|$ ≤10 dB ranging from 2.314 to 2.677GHz. From the analysis of simulated results it can be verified that the antenna is best suitable for s-band frequency operations and wireless communication.***

Index Terms— **Bandwidth, Gain, Microstrip Antenna, Square Patch, Stacked layer..**

I. INTRODUCTION

In the recent years, there has been rapid growth in wireless communication. Day by day users are increasing, but limited bandwidth is available and operators are trying hard to optimize their network for larger capacity and improved quality coverage. This surge has led the field of antenna engineering to accommodate the need for broadband, low-cost, miniaturized and easily integrated antennas [1]. A widely used antenna structure with above characteristics is microstrip patch antenna. Microstrip patch antennas are a superior selection for wireless communication systems due to their attractive characteristics of small size, low cost and weight, conformability, and ease of manufacturing, so these antennas have been developed in the last decades increasingly. In many applications, the main barrier to use microstrip patch antennas is their limitation of bandwidth. Many techniques have been employed to increase the bandwidth as in [2]-[5]. In this paper authors presented microstrip square patch antenna using a thick dielectric substrate having a low dielectric constant which provides better efficiency, larger bandwidth and better radiation at centre frequency 2.4GHz. From the measured results, the obtained impedance bandwidth (determined from 10 dB reflection coefficient) of the proposed antenna can operate from 2.314GHz to 2.677GHz covering the 2.4GHz s-band. Simple patch is designed and compared with stacked square patch antenna.

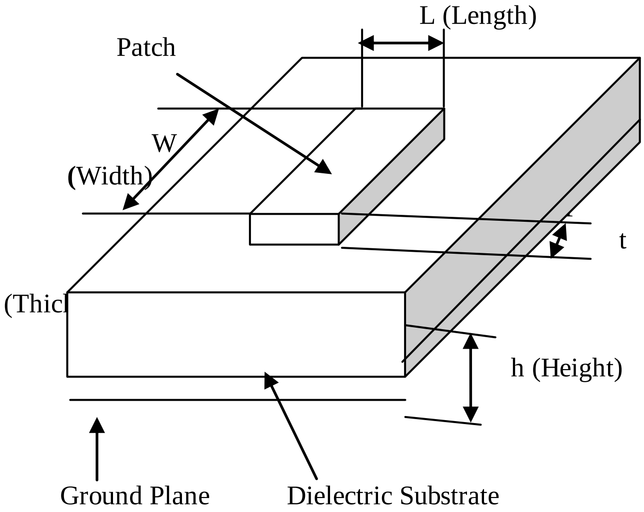

Fig.1. Microstrip Patch Antenna

II. MICROSTRIP PATCH ANTENNA

Microstrip patch antennas consist of a very thin radiating patch (t << λ where λ_o is the free space wavelength) on one side of a dielectric substrate which has a ground plane on the other side as shown in Fig.1. The patch is generally made of conducting material such as copper or gold and can take any possible shape. A metallic strip (patch) is placed in a small fraction of a wavelength (h << λ_o usually 0.003 $\lambda_o \leq h \leq 0.05 \lambda_o$) above a ground plane. The dielectric constant of the substrate (ε_r) is typically in the range of $2.2 \leq \varepsilon_r \leq 12$ as in [6], [7]. The micro strip patch antenna radiate primarily because of the fringing field between the patch edge and the ground plane. For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation [6].

III. DESIGN OF MICROSTRIP STACKED SQUARE PATCH ANTENNA

The geometry of the proposed microstrip square patch antenna is illustrated in Fig.1. The proposed antenna has a simple configuration, consisting of square patch and coaxial feeding is used for excitation. This multilayer antenna composes three layers each of thickness4mm. The ground plane size of 100mm × 100 mm is chosen. The first layer, above the ground is consist of foam of dielectric constant 1.07

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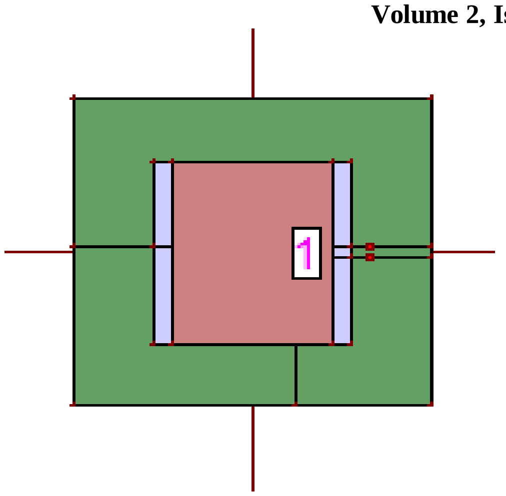

Fig.2. Designed Stacked Square Patch Antenna

With height of 4mm and patch size of 54.5mm × 60mm is implemented on this layer. It is fed by coaxial feeding at position (15.7, 0).The middle layer is air gap positioned between bottom layer and top layer. The top layer also consist of foam of dielectric constant of 1.07 with height of 4mm, beneath this layer another patch size of 40mm × 60 mm is implemented. The antenna is designed and simulated using IE3D software version 14 is shown in Fig.2. Design of micro strip patch antenna depends mainly upon three parameters, namely substrate and its dielectric constant, height of the substrate and resonant frequency. In this paper, selected three parameters are: Resonant Frequency (fr) = 2.4 GHz, Dielectric constant (ε_r) = 1.07, Height of the dielectric substrate (h) = 4mm. The designed microstrip stacked square patch antenna is shown in figure 2.

A. *Calculation of the width (W)*

The width of the Microstrip patch antenna is given by as in [6],

$$W = \frac{c}{2f\sqrt{\frac{(\varepsilon_r+1)}{2}}} \qquad (1)$$

The width of proposed patch antenna was calculated by using (1) is W=61.43mm, where c is the speed of light.

B. *Calculation Of Effective Dielectric Constant (E_{reff})*

The effective dielectric constant is given by as in [6],

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-1/2} \qquad (2)$$

The effective dielectric constant was calculated by using (2) is ε_{reff} = 1.067.

C. *Calculation of the Length Extension (ΔL)*

The extended length of the patch is given by as in [7],

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)} \qquad (3)$$

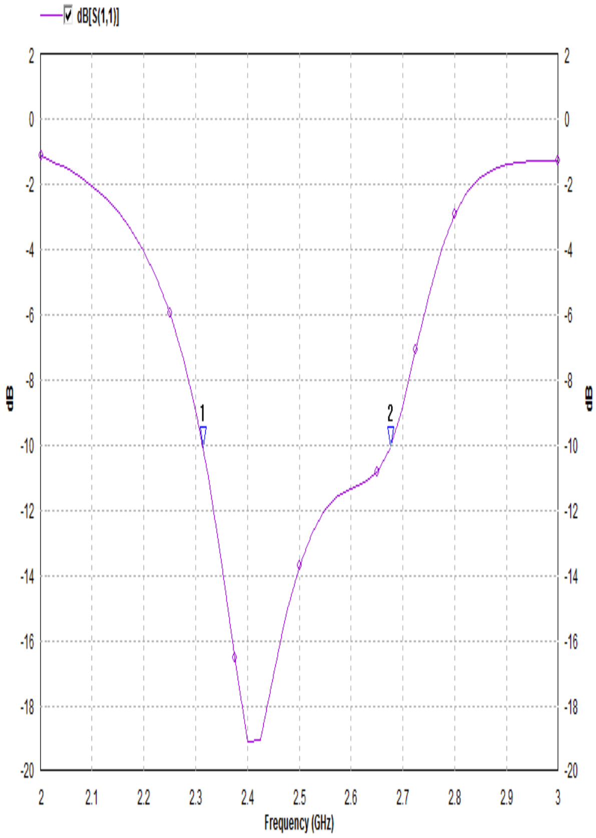

Fig.3. Return loss of antenna

The extended length of patch was calculated by using (3) is ΔL = 2.692mm

D. *Calculation of the Effective length (L_{eff})*

The effective length of patch is given by as in [6],

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}} \qquad (4)$$

The effective length of patch was calculated by using (4) is L_{eff} = 60.506mm

E. *Calculation Of The Resonant Length Of Patch (L)*

The actual length of the patch is given by [7]

$$L = L_{eff} - 2\,\Delta L \qquad (5)$$

This comes out to be 55.122mm

Finally we have selected optimize dimension for patch i.e. length L = 54.5mm and W = 60mm.

IV. RESULT & DISCUSSION

The simulated result of S_{11} scattering parameter (return loss) of microstrip square patch antenna is presented in Fig.3. As in Fig.4 the value of VSWR is within 1 to 2 in the operating range at 2.4GHz.

Table I. Comparison of Results

Sr. No.	Parameter	Simple Patch Antenna	Stacked Square Patch Antenna
1	Bandwidth	100MHz	363 MHz
2	VSWR	1.03	1.25
3	Directivity	9.52dBi	9.314dBi
4	Gain	9.39dBi	9.15dBi

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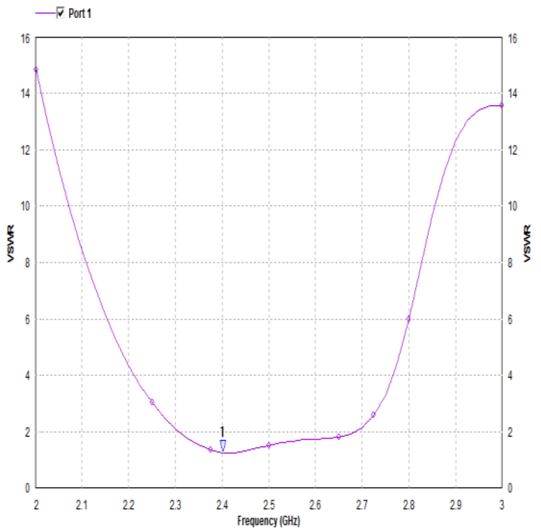

Fig.4.VSWR of Antenna

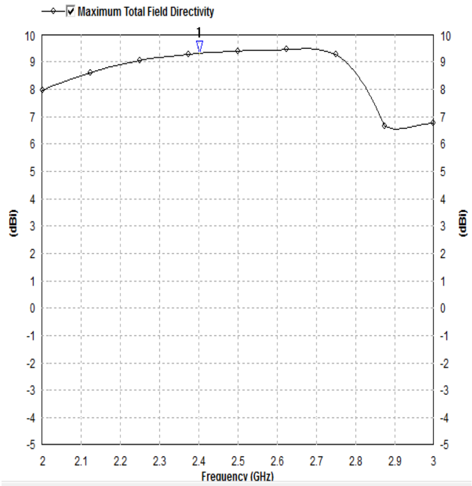

Fig.5. Directivity of Antenna

The design antenna exhibits a good impedance matching of about 50 Ohms at the center frequency. The directivity of antenna is 9.314dBi as shown in Fig.5. The maximum gain of antenna is 9.15dBi as shown in Fig.6; it is more than 90% which leads good antenna performance. The results of microstrip stacked square patch antenna are compared with simple patch antenna by simulation are present in Table I. After comparison it seem that the microstrip square patch have good enhance bandwidth but directivity and gain are few percentage decreases, it much not effect antenna efficiency because it is more than 90%. The enhance bandwidth of this antenna is best suitable for wireless communication.

V. CONCLUSION

A novel technique for enhancing bandwidth of a microstrip patch antenna has been proposed. Three substrate layers are used in the microstrip stacked square patch antennas which enhance the bandwidth. The antenna is successfully designed and it attains a bandwidth of 363MHz using IE3D software.

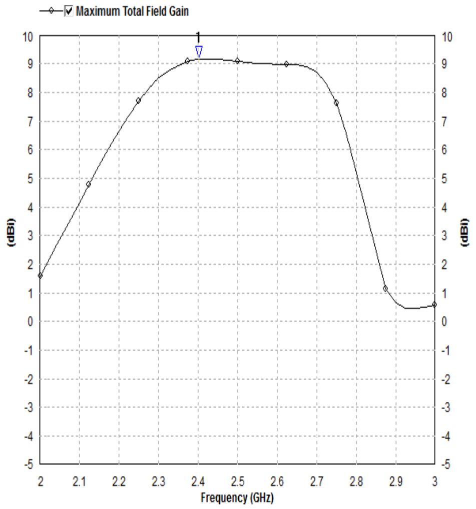

Fig.6. Gain of antenna

The design antenna exhibits a good impedance matching of about 50 Ohms at the center frequency. The microstrip stacked square patch antenna produced higher bandwidth (about 15%) in comparison to simple patch antenna (4%). From the analysis of simulated results it can be verified that the antenna is best suitable for s band frequency operations. This antenna is applicable to modern wireless communication frequencies operating at 2.4GHz.

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