

Rectangular Microstrip Patch Antenna Using Air as Substrate for S-Band Communication

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ABSTRACT

A Rectangular Microstrip Patch Antenna model is proposed using air as a substrate to study the characteristics of designed antenna. The dimensions of designed antenna are 17 mm × 16.66 mm with substrate at frequency 3.525 GHz. In this paper, the simulation is performed by using software Computer Simulation Technology (CST) Microwave studio based on finite difference time domain technique. The characterization of the designed antenna was analyzed in terms of return loss, bandwidth, directivity, gain, radiation pattern, VSWR.

KEYWORDS

Rectangular Microstrip Patch Antenna; Air Substrate; Directivity

1. Introduction

Due to attractive and unique properties (e.g. low profile, conformal nature, and high speed), microstrip antennas are finding many applications in various fields like Microwave Engineering, Mobile Communication, Satellite Communication and aircraft systems. As a result, in recent years a considerable attention has been paid by many antenna designers to enhance the characteristics of these antennas. Microstrip patch antenna is special class of microstrip antennas. It consists of a patch on one side of a dielectric substrate and ground plane on the other side of the substrate [1]. The patch may be of any geometry like circular, triangular, rectangular, elliptical, square, and ring.

To meet the requirement of low profiling, conformal nature there are numerous materials used as a substrate like RT Duriod 5880, FR4, Alumina, Honeycomb, etc. [2].

Chandra *et al.* [3] proposed rectangular patch antenna using air as substrate for X-band. They used Agilent's E8363B network analyzer to obtain simulation results; from simulation results they observed 2 - 3 dB improvement in peak gain. Recently Ali *et al.* [4] designed the microstrip antenna using the same above substrate at 5.8

GHz frequency; results obtained by them strongly match with Chandra *et al.* [3].

In this paper a sincere attempt is made to design, model, optimize, and analysis rectangular microstrip patch antenna taking air as a substrate at 3.525 GHz with the help of CST microwave [5] electromagnetic simulator.

2. Antenna Design

The selected dielectric materials for the antenna is air which has a dielectric constant of 1 (ϵ_r) and the height of dielectric substrate is 1.5 mm (h). We use CST microwave studio for design, modeling of proposed antenna. Microstrip feed line of 50 is used to feed the antenna.

The physical dimensions of the patch are based on the following formulae.

$$L = \frac{v_0}{2f_r \sqrt{\epsilon_r}} \quad (1)$$

$$W = \frac{v_0}{2f_r \sqrt{\frac{2}{\epsilon_r + 1}}} \quad (2)$$

where L is the length, W is the width and f_r is fre-

quency of the proposed antenna. v_0 is the space speed of light and ϵ_r is relative permittivity of substrate. The physical dimensions of the ground plane are based on the following formulae.

$$Lg = 6h + L \quad (3)$$

$$Wg = 6h + W. \quad (4)$$

where Lg and Wg are the length and width of the ground plane and h is the thickness of substrate. The geometry of proposed antenna is shown in **Figure 1**. The dimension is taken in millimeters (mm) and numbers of used mesh cells are 28,899.

3. Optimized Antenna Design

The dimensions of the metallic patch were slightly changed in order to improve the antenna performance parameters. A systematic study of thickness of the substrate is optimized from 0.2 mm to 4.4 mm in 0.1 mm increments. Finally the dimension of ground plane is mm and dimension of the patch is 17 mm \times 16.66 mm.

4. Simulation Results

The measured and simulated results obtained for proposed antenna are presented graphically and numerically. CST microwave studio [5] electromagnetic simulator has been used to obtain these results.

4.1. Return Loss

Return Loss is a measurement from which we can judge

how much amount of power is reflected back by the antenna.

The numerical value of the S_{11} parameter from the **Figure 2** is -40.9638 dB. There is one sharp narrow deep at 3.525 GHz which shows that proposed antenna is a single band antenna. The bandwidth of the proposed antenna is found to be 140.6 MHz from **Figure 2**.

4.2. Radiation Pattern

It is a graphical representation of the radiation properties of the antenna as a function of space coordinates [2]. Here the radiation pattern is determined in the far field region.

In this paper we only discuss two radiation properties namely directivity and polarization. **Figures 3(a)-(d)**, are the 3D, 2D, polar and Cartesian graphs of the radiation pattern respectively. **Figure 3(a)** shows that the directivity of the proposed antenna is 6.68 dBi, radiation efficiency is -25.33% and total efficiency is -25.33% . It is also observed that maximum radiation is emitting from the center of the top the patch. This shows that the proposed antenna is feasible for S-band communication. From **Figure3(c)** an angular width (3dB) of antenna is 71.0 deg.

4.3. VSWR

VSWR is the way to see how much system is matched. It is the ratio between the maximum voltage and minimum voltage in the transmission line. For the best value of antenna it should be equal to 1.

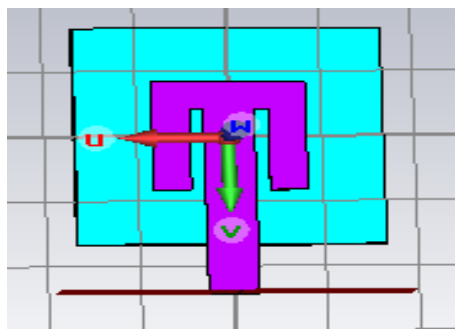


Figure 1. Geometry of proposed antenna operating at 3.525 GHz.

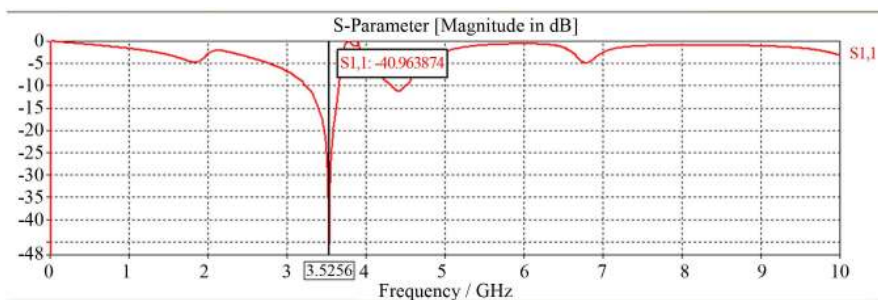
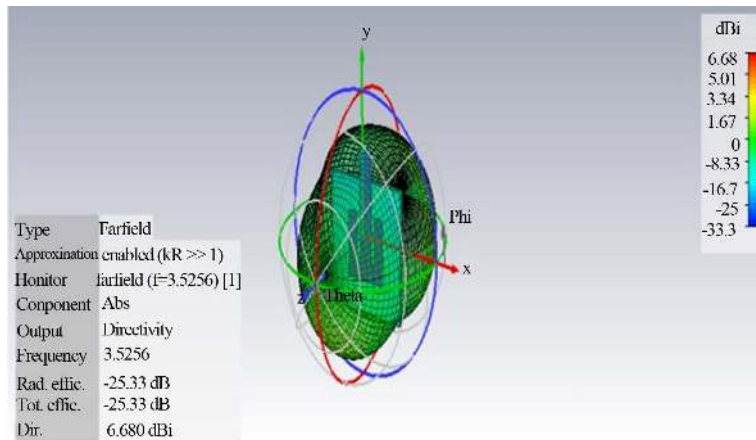
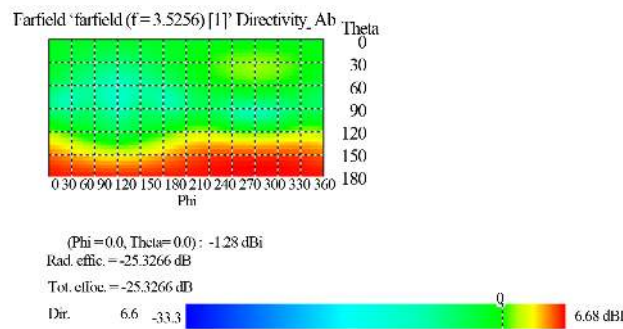


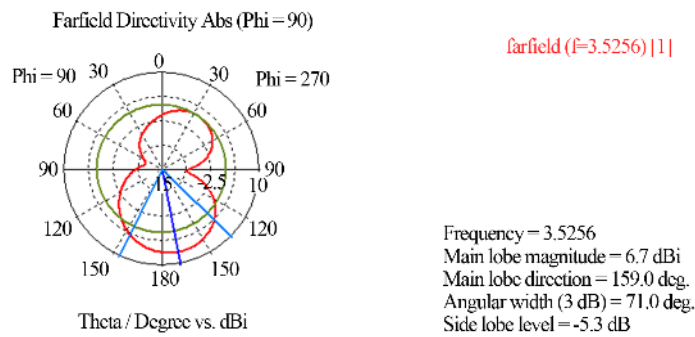
Figure 2. Return loss of proposed antenna at 3.525 GHz.



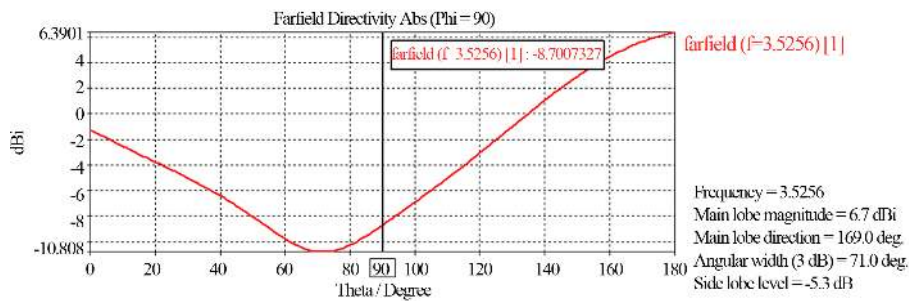
(a)



(b)



(c)



(d)

Figure 3. (a) 3D-Radiation pattern of proposed antenna at 3.525 GHz. (b) 2D-Radiation pattern of proposed antenna at 3.525 GHz. (c) Polar plot of proposed antenna operating at 3.525 GHz. (d) Cartesian plot of proposed antenna operating at 3.525 GHz .

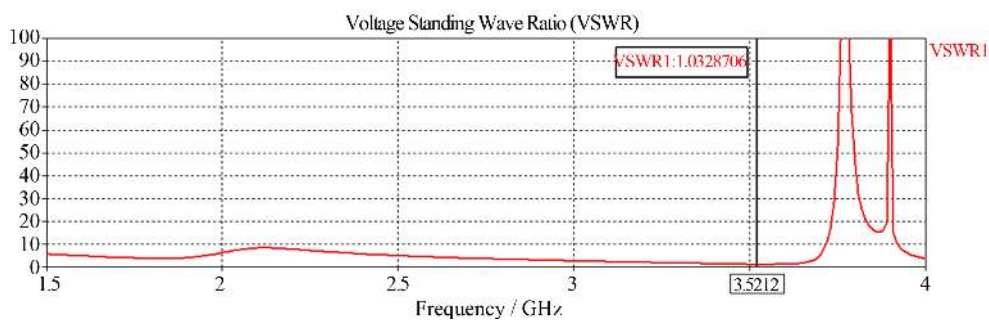


Figure 4. VSWR plot of proposed antenna operating at 3.52 GHz.

Looking at **Figure 4**, it can be observed that the measured value of VSWR is 1.0328.

5. Conclusion

This paper has successfully designed a rectangular patch antenna operating at 3.525 GHz. It is found that using air as a substrate has been an improvement in return loss of -40.965 dB. The antenna also is capable of functioning at 3.525 GHz with a gain of 6.68 dBi. This antenna has a big potential for a Microwave application.

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