Performance Study of Microstrip patch Antenna for GPS Communication System

Imtiaz Ahmed, Md. Sifat Arefin, Md. Sajjad Hussain, Mir Zayed Shames

Abstract— GPS communication system is a satellite based system requiring high accuracy for its best use in the field of vehicle tracking, aircraft control etc. In order to ensure the desired accuracy, GPS antennas should have the capability of rejecting errors caused by multipath phenomena. Narrow bandwidth is one of the major disadvantages of microstrip antenna; therefore most of the research work has been focused on this factor. On the other hand, dual band antennas are widely used to minimize interference between receive and transmit modes. It may be mentioned that, in order to design miniaturized antennas with minimal increase in antenna dimension is a challenge to antenna researchers. In this paper, we had investigated the performance of microstrip patch antena using specially HFSS software for some specific design parameters such as patch width, substrate height under specific polarization condition. Our measured results include radiation pattern, S and Y parameter, effective dielectric constant etc.

Index Terms— Antenna, Dielectric constant of substrate, Effective dielectric constant, Height of dielectric substrate, Microstrip patch Antenna, Multipath, GPS

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1 INTRODUCTION

Over the last few years, the number of Global Positioning System applications requiring an augmented accuracy has increased considerably ranging from geodetic surviving to aircraft landing control and satellite attitude determination. The major source of errors limiting the accuracy of these systems is due to the multipath interference that occurs when the GPS transmitted signal is reflected or diffracted from surfaces around the antenna. Indeed, signals implying on the receiving antenna via multiple paths make a contribution with different phase's distortion. As multipath is environmental dependent and difficult to quantity, available signal processing techniques do not help to solve completely under all conditions. A more effective way to limit the deleterious interference of spurious reflection is to derive a user antenna with superior multipath rejection capability. [1], [2]

In this paper, the microstrip patch antenna will be presented. Circular polarization is achieved with a single feed easing the manufacturing of antenna and reducing its overall size. In the following, a brief account of some of the Microstrip Patch Antenna will be given and the design of the Microstrip Patch Antenna will be presented. Measured results (S parameter, Y parameter, radiation pattern (2D & 3D), radiation characteristics (RHCP & LHCP) and gain) will be presented and discussed.

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2 MICROSTRIP PATCH ANTENNA

A basic structural model of microstrip patch antenna is shown in Figure 1. The dimensions of the patch are given along with the feed network. The fabricated microstrip patch antenna is also shown as a three-dimensional radiation pattern of the fabricated antenna. [3]
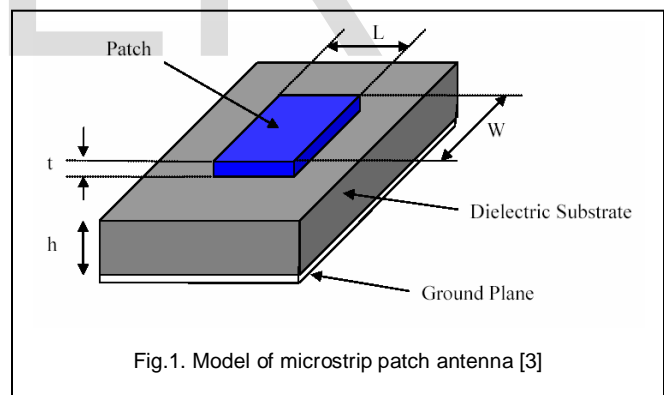

Fig.1. Model of microstrip patch antenna [3]

3 THEORY

Most of the electric field lines reside in the substrate and parts of some lines in air. As a result, this transmission line cannot support pure transverse-electric-magnetic (TEM) mode of transmission. Hence, an effective dielectric constant (ε_{eff}) must be obtained in order to account for the fringing and the wave propagation in the line. The expression for ε_{eff} [4] is given by Balanis as:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r + 1}{2} \cdot \left[1 + 12 \cdot \frac{h}{W} \right]^{-\frac{1}{2}} \tag{1}$$

Where, ε_{reff} = Effective dielectric constant

   ε_r = Dielectric constant of substrate

   h = Height of dielectric substrate

   W = Width of the patch

For efficient radiation, the width [5] is given by,

$$W = \frac{c}{2 \cdot f_0 \sqrt{\frac{\varepsilon_r + 1}{2}}} \qquad (2)$$

4 RESULTS AND DISCUSSION

Simulation results are presented by using HFSS Softwer. Following the analytical approach presented in section 3, S parameter, Y parameter, Radiation Pattern (2D), Radiation Pattern (3D), Radiation Characteristics (RHCP, LHCP) results are evaluated.

   In the following table we have summarized the values of different important parameters related to microstrip patch antenna. Here for example parameter 'dx' implies the width of patch (mentioned as 'W' in equation 1 and 2). Again, it is to be mentioned that substrate height is also denoted as 'dx' in the table (mentioned as 'h') in equation 1.

TABLE 1

PARAMETERS

| For	Starting Point (mm)	Full Length (mm)	For	Starting Point (mm)	Full Length (mm)
Patch	x = 7.025	dx = 12.45	Microstrip Line	x =10.13	dx = 2.49
	y = 8	dy = 16		y = 0	dy = 8
	z = 0	dz = 0.05		z = 0	dz = 0.05
Ground Plane	x =0	dx = 28.1	Substrate	x =0	dx = 28.1
	y = 0	dy = 32		y = 0	dy = 32
	z = 0.794	dz = 0		z = 0	dz = -0.79
Port	x =10.13	dx = 2.49	Boundary	x =-5	dx = 33.1
	y = 0	dy = 0		y = 0	dy = 37
	z = -0.794	dz = 0.794		z = -0.794	dz = 5.794

   Characteristic curve of S parameter is shown in fig. 2. From the fig, it is evident that the antenna is resonating around 7.5 GHz. More accurate results could be achieved by zooming in the simulation 7.00 GHz and 8.00 GHz.

Fig.2. **Characteristic curve of S parameter**
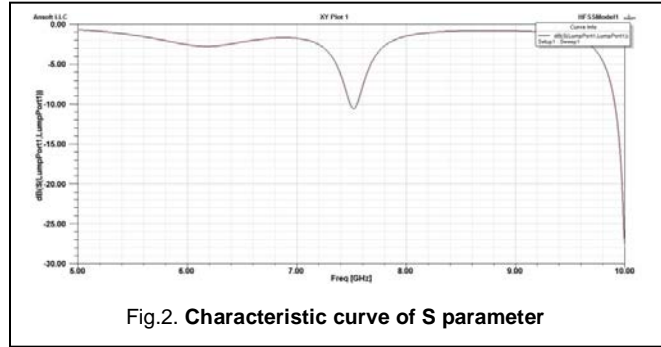
   Characteristic curve of Y parameter is shown in fig. 3. From the fig, it is evident that there are 3 maxima and 2 minima. Maximum frequency gains are -17dB, -39dB and -20dB respectively and Minimum frequency gains are -53dB and -49dB respectively.

Fig.3. **Characteristic curve of Y parameter**
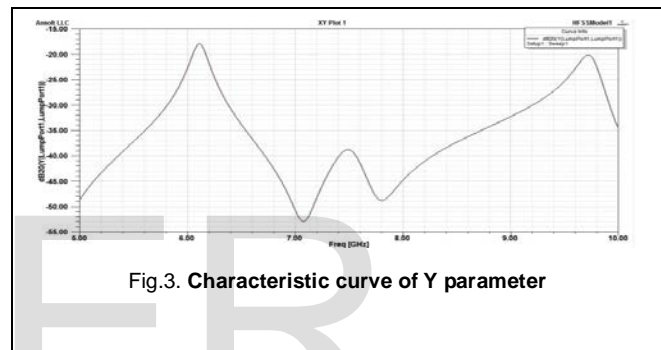
Radiation Pattern (2D) is shown in fig. 4.

Fig.4. **Radiation Pattern (2D)**
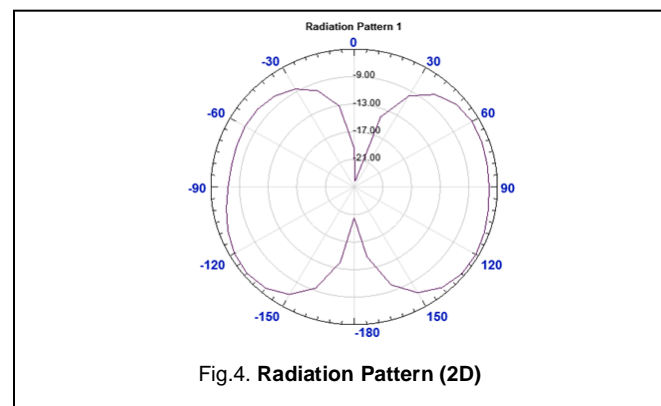
Radiation Pattern (3D) is shown in fig. 5.

   From the fig. 4 and fig. 5, it is evident that the input impendence of the patch is matched to that of the feed line. This can be achieved by creating a parameterized model of the geometry and search for the feed position which will yield a minimum value of the reflection coefficient. The beamwidth is 100 degree and Front to back ratio is -3 dB.
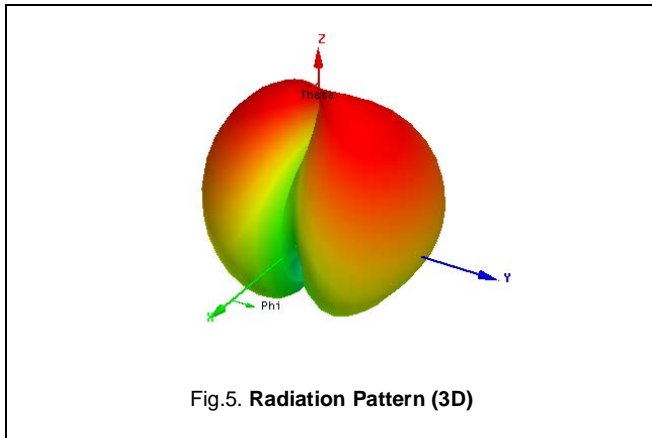
Fig.5. **Radiation Pattern (3D)**

The radiation characteristics (RHCP, LHCP) for Microstrip patch antenna is shown in fig. 7.
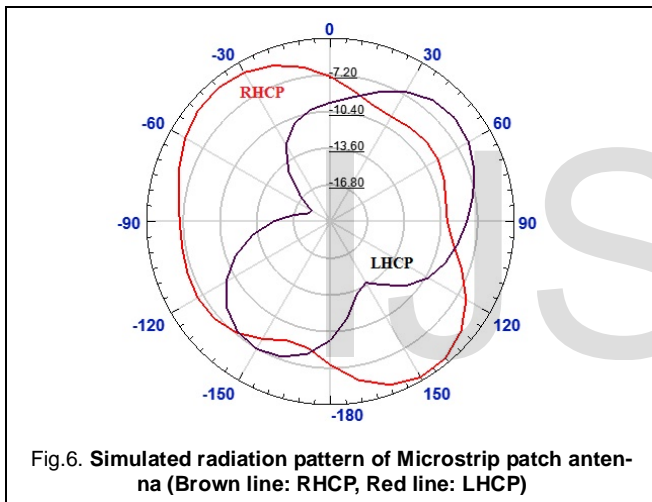

Fig.6. **Simulated radiation pattern of Microstrip patch antenna (Brown line: RHCP, Red line: LHCP)**

The gain for Microstrip patch antenna is shown in fig. 8. From the fig, it is evident that the gain is 28 dB (at 5 GHz).
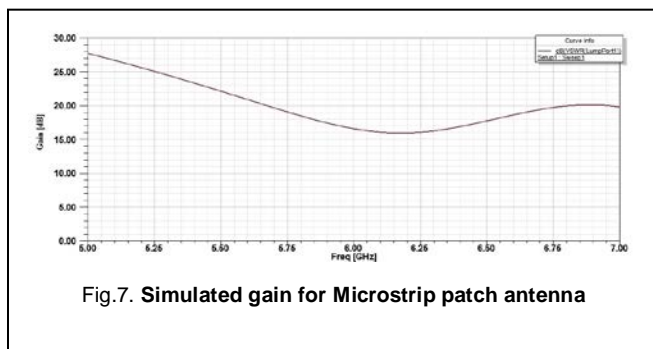

Fig.7. **Simulated gain for Microstrip patch antenna**

is suitable. S Parameter, Y Parameter, Radiation Pattern (2D), Radiation Pattern (3D), Radiation Characteristics (RHCP, LHCP) of the antenna has been successfully investigated. These fundamental parameters are modeled with the equations and estimated with HFSS software and measured the result of the antenna designing.

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4 CONCLUSION

Presented Microstrip Patch Antenna concludes that inset feed