ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 5, Issue 6, June 2016

Microstrip Patch Antenna Design for Aeronautical Radio Navigation, Mobile Fixed Satellite and Radio Astronomy Applications

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Abstract— **In this paper, reduced ground rectangular microstrip patch antenna has been proposed. The antenna has been designed using substrate of FR4 material having dielectric constant of 4.4 with radiating patch and a ground plane. The ground plane has been partially reduced to improve the antenna performance. The antenna has a feed line which is connected to patch of width 9.22 mm. The feed line has to be of suitable width so as to match the antenna impedance with the port impedance (50 ohm).The feed line thickness is same as that of the patch thickness. The antenna performance has been analyzed in terms of various antenna parameters such as return loss (dB), impedance bandwidth (GHz), gain (dB), directivity (dBi), HPBW and VSWR. The proposed antenna has return loss (S_{11}) of -36.16 dB at resonant frequency of 4.39 GHz .The antenna has gain of 6.718 dB, directivity of 6.530 dBi and percentage bandwidth of 24.214 percent at resonant frequency of 4.39 GHz. The antenna has been designed and simulated using CST Microwave Studio (2010).The designed MPA is suitable to be used for Mobile Fixed Satellite (4.4 GHz – 4.99 GHz), Fixed Satellite (4.5 GHz – 4.8 GHz), Radio Astronomy(4.99 GHz – 5 GHz) and Aeronautical Radio Navigation(5 GHz – 5.15 GHz) applications. The antenna has a bandwidth of 1.063 GHz and VSWR is less than 2.**

***Index Terms*— Aeronautical Radio Navigation; HPBW; Mobile Fixed Satellite; Radio Astronomy; VSWR**

Manuscript received June, 2016.

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I. INTRODUCTION

With the advancement in the modern communication technology, the use of microstrip patch antenna has increased because of its low cost, low weight and small size [1]. The microstrip patch antenna also termed as patch antenna, is usually fabricated on a dielectric substrate which acts as an intermediate between a ground plane at the bottom side of substrate and a radiating patch on the top of substrate [2]. The patch can be designed in many shapes like rectangular, circular, triangular, elliptical, ring, square etc. Microstrip patch antennas are inexpensive to manufacture on printed circuit board of specific characteristics and dimensions [3]. However, the microstrip patch antenna (MPA) suffers from major limitation of narrow bandwidth. The selection of substrate is the most important parameter while designing an antenna. The size of an antenna is dependent on the dielectric constant of a substrate. The size of antenna is inversely proportional to dielectric constant i.e. higher is the dielectric constant, lower is the size of antenna [4]. The feeding can be defined as a means to transfer the power from the feed line to the patch, which itself acts as a radiator. The microstrip feed line is commonly used in MPA design because it is relatively simple to fabricate [4]. The bandwidth of MPA can be improved by either using a slotted patch [5][6] or by using reduce ground plane [7]. . The most unique technique used to enhance the bandwidth and reduce the size of patch is to defect the ground [8]. Defected ground structure is realized by etching periodic or non-periodic defect in the ground plane [9]. Defected Ground Structure changes shielded current distribution in the ground plane which depends upon shape and dimensions of the defect. The impedance value and surface current of antenna is also influenced due to defected ground structure. The defected ground structure generally controls the excitation and electromagnetic waves propagated through the substrate [10] [11] [12].

Section II (Antenna Geometry) describes the geometry of the proposed antenna including side view, top view and bottom view of antenna illustrating the dimensions of patch, substrate and ground plane.

Section III (Theoretical Results) describes the competency of designed antenna in terms of return loss (S_{11}), bandwidth, gain, directivity, VSWR and impedance.

Section IV (conclusion) compares the simulated and practically designed antenna. It also proposes the suitability of designed antenna for various wireless applications

I. ANTENNA GEOMETRY

The rectangular shaped wide band antenna is designed and simulated using CST Microwave studio 2014. Flame Retardant (FR4) having dielectric constant of 4.4 and thickness of 2 mm is used as substrate which is sandwiched between radiating patch and ground plane. The copper of thickness 0.1 mm is used both for radiating patch and ground. The ground surface is reduced in order to enhance the antenna performance in terms of return loss and bandwidth. The feed line has to be of suitable width (9.22 mm) so as to match the antenna impedance with the port impedance for maximum power transfer from port to the antenna. The size of antenna is 101.18 x 47.16 mm^2.

The Fig.1 (a) represents the side view of the proposed microstrip patch antenna. The Fig. 1(b) shows the geometry of the rectangular radiating patch at the top surface of the substrate 1. As shown in Fig.1 (b), the shape of patch is rectangle. The Fig.1 (c) depicts the ground at the bottom surface of the substrate. The antenna dimensions are listed in Table I.

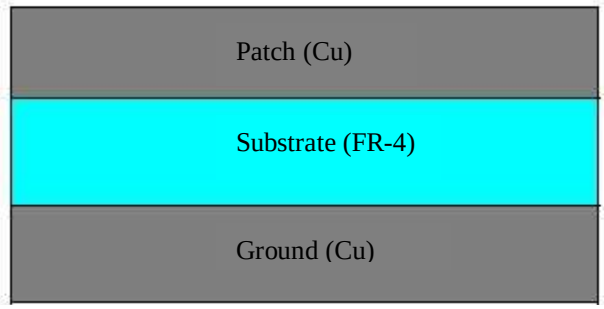


Fig.1 (a).Side view of the proposed antenna

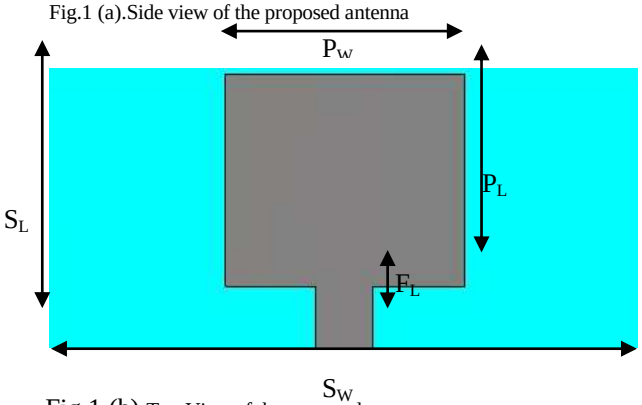


Fig.1 (b).Top View of the proposed antenna

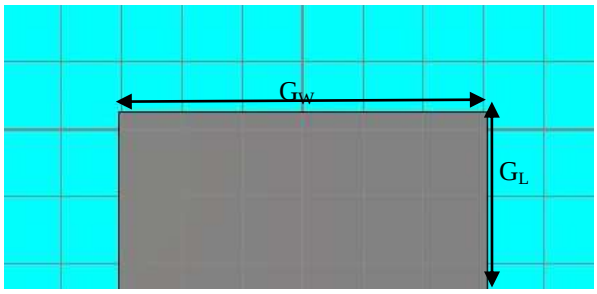


Fig.1 (c).Geometry of reduced ground of the proposed antenna

TABLE I. ANTENNA DIMENSIONS

S.No.	Parameters	Value (mm)
1.	Width of patch, P_W	39.18
2.	Length of patch, P_L	34.46
3.	Length of feedline, F_L	10.6
4.	Width of ground, G_W	61.18
5.	Length of ground, G_L	29.16
6.	Width of substrate, S_W	101.18
7.	Length of substrate, S_L	47.16

III. THEORETICAL RESULTS

The proposed antenna has been simulated using CST Microwave Studio 2014.The analysis of proposed antenna design has been done in terms of return loss (dB), Bandwidth, directivity (dBi), gain (dB), impedance (Ω), HPBW (deg.) and VSWR as shown in Fig.2, Fig.3, Fig.4, Fig.5, Fig.6, Fig.7 and Fig.8, respectively. It has been observed that the return loss is -36.16 dB at the resonant frequency of 4.39 GHz. The simulated bandwidth of proposed antenna is 1.06 GHz (4.165 GHz – 5.229 GHz). The Smith Chart plot indicates the variation of impedance of the antenna with frequency. The value of impedance should lie near 50 ohms in order to perfectly match the port impedance with the antenna impedance for maximum transfer of power to antenna. The antenna impedance for the proposed antenna is 50.04 Ω. The proposed antenna has gain of 6.718 dB and directivity

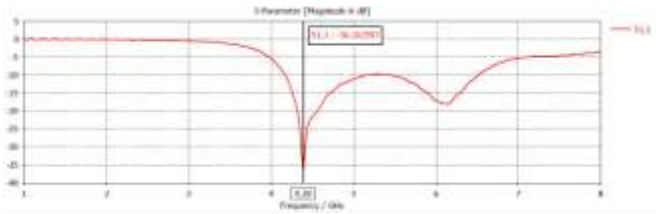


Fig.2.Return Loss plot of the proposed antenna

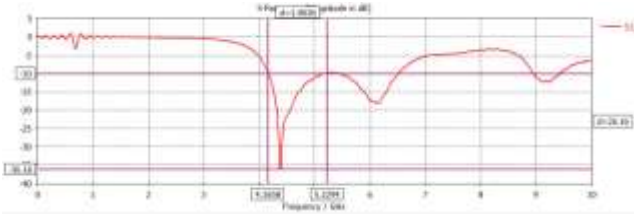


Fig.3.Bandwidth plot of the proposed antenna

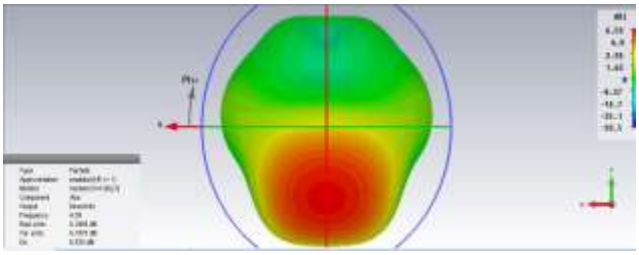


Fig.4.3D plot of directivity for the proposed antenna

with operating frequency range of 11.801 GHz – 11.906 GHz and return loss (S11) of -39.571 dB at resonant frequency of 13.49 GHz. It has been observed that the proposed antenna has gain of 8.874 dB, directivity of 8.995 dBi and percentage

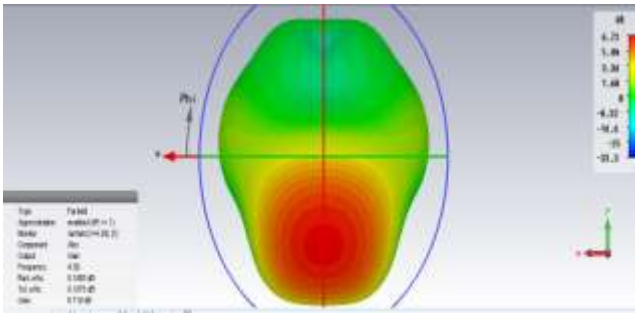


Fig.5.3D plot of gain for the proposed antenna

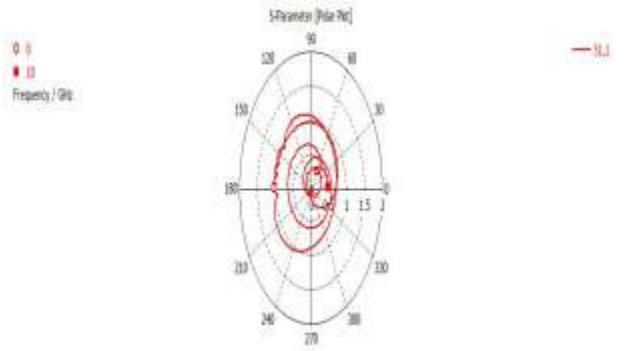


Fig.6.Smith chart plot of the proposed antenna

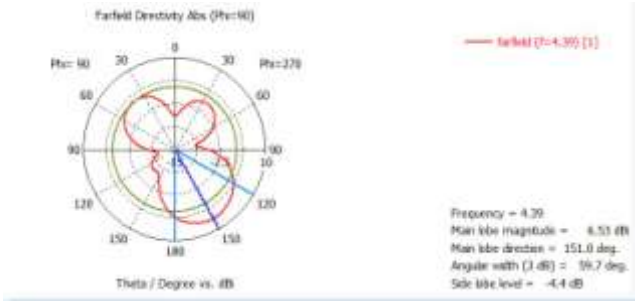
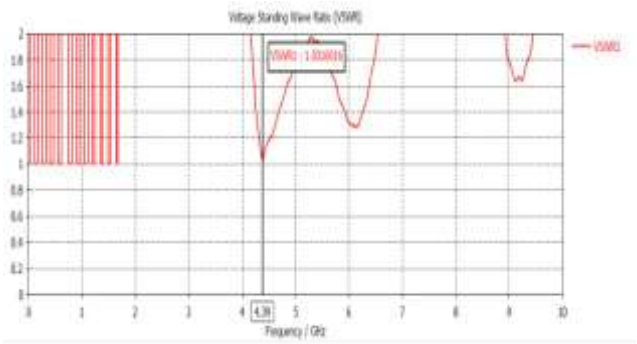


Fig.7.HPBW plot of the proposed antenna



S.N0.	Parameter	Magnitude
1.	Input Impedance	50.04 Ω
2.	Return loss (S_{11})	36.16 dB
3.	Percentage Bandwidth	24.14 %
4.	Gain	6.718 dB
5.	Directivity	6.53 dBi
6.	VSWR	Less than 2
7.	HPBW	59.7 deg.

TABLE II. SIMULATED RESULTS OF PROPOSED ANTENNA

IV. CONCLUSION

The rectangular shaped microstrip patch antenna has been designed and simulated using CST Microwave Studio 2014. The proposed antenna design has substrate of FR4 material having reduced ground on the lower side of substrate and rectangular patch on the upper side of substrate. It has been observed that the proposed antenna has impedance bandwidth of 1.06 GHz with operating frequency range of 4.165 GHz – 5.229 GHz and return loss (S_{11}) of -36.16 dB at resonant frequency of 4.39 GHz. It has been observed that the proposed antenna has gain of 6.718 dB, directivity of 6.53 dBi and percentage bandwidth of 24.14 percent. The proposed antenna has VSWR of 1.03 and HPBW of 59.7 deg. The proposed antenna can be suitably used for Mobile Fixed Satellite (4.4 GHz – 4.99 GHz), Fixed Satellite (4.5 GHz – 4.8 GHz), Radio Astronomy (4.99 GHz – 5 GHz) and Aeronautical Radio Navigation (5 GHz – 5.15 GHz) applications in the frequency range of 4.165 – 5.229 GHz.

ACKNOWLEDGMENT

We would like to express our gratitude towards our Prof. Ekambir Sidhu, Assistant Professor, Department of Electronics and Communication Engineering, Punjabi University, Patiala for his guidance and supervision for the successful completion of this research work. We would also like to thank God for providing us the opportunity to work and complete the project. We would also like to thank our parents for providing the motivation and timely support for the completion of this research project.

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