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Micro strip Patch Antenna for Satellite Communication

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Abstract—Microstrip antennas are increased due to its use in high frequency, high speed data communication applications. Microstrip antennas are becoming very widespread within the mobile phone market. A microstrip patch antenna for satellite application is proposed. The Bandwidth of the Antenna is 0.3 GHz and it has return loss of -27.533 dB. The antenna has a planar rectangular geometry with inset feed and symmetric slots. The basic theory and design of the antenna is analyzed, simulated and optimised using HFSS. This antenna has favourable characteristics for 6.7-7.2 GHz which is used for satellite application. The antenna has been analysed for various dimensions of slots and slits.

Keywords—HFSS,Microstrip, Satellite Communication, X band.

I. INTRODUCTION

Microstrip antennas were developed and the demand for their application is continuously on the rise, especially in the last decade. Microstrip antennas are best form of antennas because they are light weight, low profile, low cost, ease to analyze, fabricate and are compatible with the integrated circuits Antenna is one of the critical component in any wireless communication system. The growth of this technology has boosted with the rapid rise of wireless communication technologies. They have found huge applications in the domains of defence and satellite communication. During the last decade, the cost to develop and manufacture the microstrip antenna has reduced significantly, because of the huge advancement of its technology and increasing investment in this sector commercially. Moreover, the current satellite communication applications are benefited hugely by the small size and low profile of the microstrip antenna.

These antennas are also considered to have relatively high value of return losses. Research shows that cutting slots and slits in radiating patch and ground plane shift the operating frequency and increase resonating frequencies. Most of the antennas that were proposed before had narrow slots etched on the ground place. The slots leak electromagnetic waves which deteriorate the radiation patterns of the antenna.

On similar lines this paper proposes an antenna for satellite communication using equally spaced slots and slits. A small-size rectangular patch antenna is made using a square slot surrounded by rectangular slots.

Rectangular Polarization is achieved without the need of external coupler or polarizer. X band in communication engineering is defined from 7 to 11.2 GHz and the antenna’s optimum working range lies within this range. This antenna has a frequency bandwidth of 0.3 GHz centered at 7GHz with a return loss of -27.5dB.

The name HFSS stands for High Frequency Structure Simulator. HFSS is a high-performance full-wave electromagnetic (EM) field simulator for arbitrary 3D volumetric passive device modelling that takes advantage of the familiar Microsoft Windows graphical user interface. It integrates simulation, visualization, solid modelling, and automation in an easy-to-learn environment where solutions to your 3D EM problems are quickly and accurately obtained. Ansoft HFSS employs the Finite Element Method (FEM), adaptive meshing, and brilliant graphics to give you unparalleled

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performance and insight to all of your 3D EM problems. Ansoft HFSS can be used to calculate parameters such as S Parameters, Resonant Frequency and Fields.

II.GEOMETRY AND STRUCTURE OF PROPOSED ANTENNA

The proposed antenna design is illustrated in Fig.1. It is printed on FR-4 substrate having relative permittivity of 4.4, loss tangent of 0.021 and thickness of h=1.6 mm. It consists of a inset microstrip-fed rectangular patch antennas based on the port through which the input is given has an input impedance of 50 . The rectangular patch has two slits cut from its sides. The dimensions of the microstrip patch and the substrate are shown in Table I. added in inverted L configuration on the top right. The square slot at the centre has been added to shift the smaller insignificant resonating frequencies to the left. The antenna gives the best performance in the X band region for a frequency of 7 GHz and a return loss of -27.533 dB.

The removal of extra significant frequencies has been achieved by a bit of compromise on the return loss, making the antenna optimum to work at X band region for satellite communication. The radiation pattern for far field for all the slot configuration at a solution frequency of 7 GHz is depicted in Fig. 3, from where it is clearly evident that the radiation bands in the operation region are stable. Fig. 4 and Fig. 5 show the electric field and magnetic field magnitude respectively when the antenna is excited at 50 ohm input impedance via a wave port. Cross Polarization has been achieved through linearly polarising the antenna 45 degrees to the vertical as mentioned in Fig. 6.

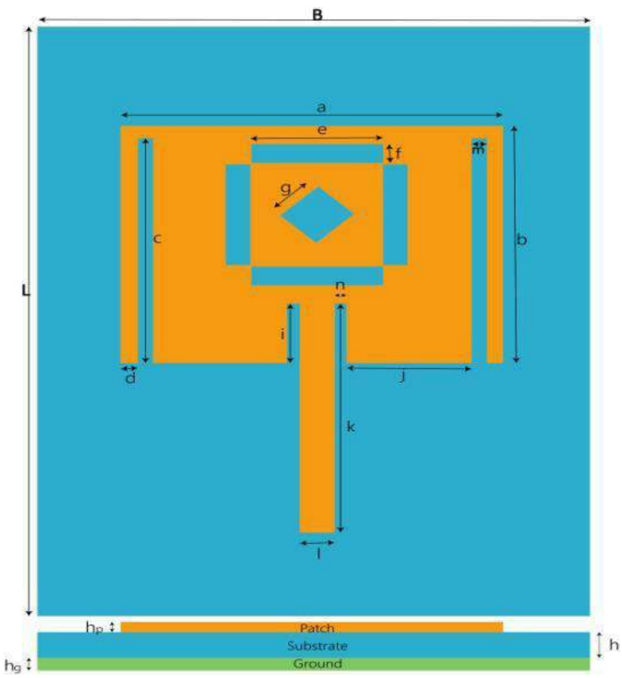

Fig. 1: Antenna Design

Table 1 Dimension of Patch

Parameter	Values	Parameter	Values
L	123.39 mm	B	83.6 mm
H	1.6 mm	hg	35 um
A	49.41 mm	b	41.36 mm
C	40.36 mm	d	1 mm
E	18 mm	f	2.5 mm
G	7 mm	i	12.633 mm
J	17.853 mm	k	50.708 mm
L	4.852 mm	m	1 mm
N	2.426 mm	hp	35 um

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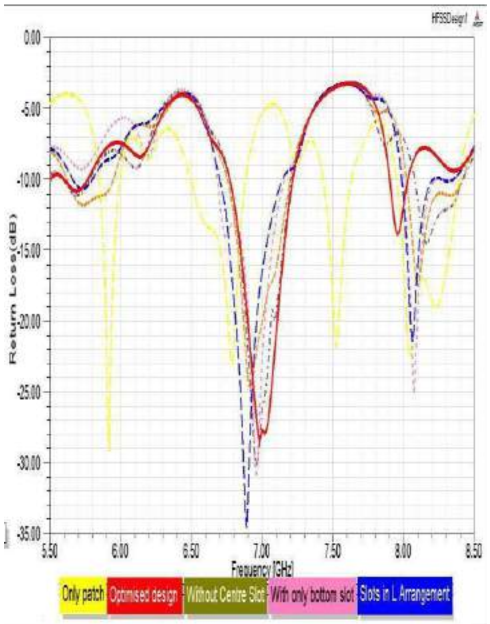

Fig. 2: Return Loss of Proposed Antenna with varying slot configurations

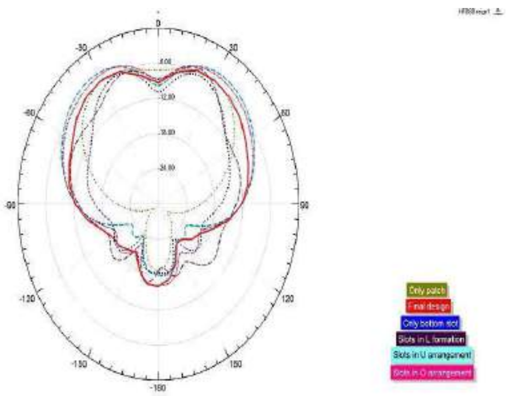

Fig. 3: Radiation Pattern

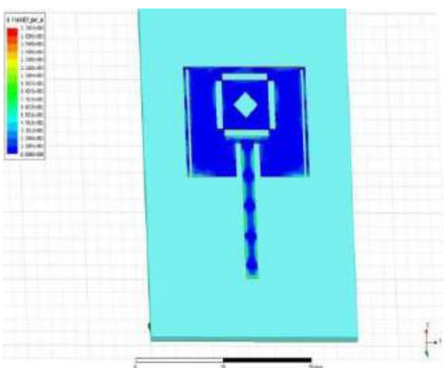

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Fig .4: Electric field pattern

III PATTERN DEFINITION

3.1 Radiation Pattern:

An antenna radiation pattern or antenna pattern is defined as a mathematical function or a graphical representation of the radiation properties of the antenna as a function of space coordinates.
Radiation patterns are conveniently represented in spherical coordinates.
Pattern: $E(\theta,\varphi)$. $dA = r^2 \sin\theta d\theta d\varphi$.

3.2 Components in the Amplitude Pattern

- There would be, in general, three electric-field components (E_r ,E_θ,E_φ) at each observation point on the surface of a sphere of constant radius.
- In the far field, the radial E_r component for all antennas is zero or vanishingly small.
- Some antennas, depending on their geometry and also observation distance, may have only one, two, or all three components.

In general, the magnitude of the total electric field would be
$|E| = q\ |E_r|\ 2 + |E_\theta|\ 2 + |E_\varphi|$

3.2.1Isotropic Radiator:

A hypothetical lossless antenna having equal radiation in all directions.

3.2.2Omni directional Radiator:

An antenna having an essentially no directional pattern in a given plane (e.g., in azimuth) and a directional pattern in any orthogonal plane.

3.2.3Directional Radiator:

An antenna having the property of radiating or receiving more effectively in some directions than in others. Usually the maximum directivity is significantly greater than that of a half-wave dipole.

IV. RESULTS AND DISCUSSION

The rectangular patch antenna has been analysed with HFSS. Fig. 2 shows the return loss curve properties of the antenna, with varying slots. From the figure it is clear that the addition of slots to the antenna design improved the performance of the antenna. The antenna is specified to work in X band for satellite communication at 7 GHz. Two slits have been cut from the sides to ensure enhanced directivity and gain. Rectangular slots are designed on the patch to improve performance.

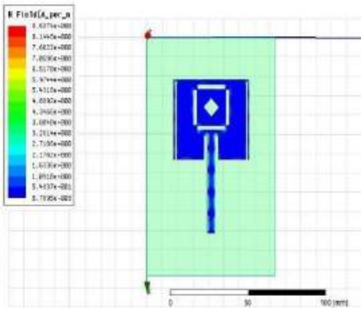

Fig. 5: Magnetic Field Pattern

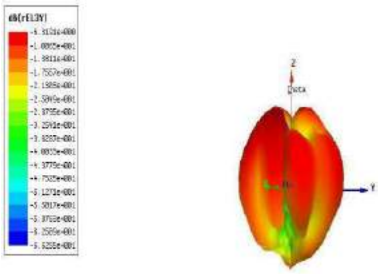

Fig. 6: Cross polarization

IV. CONCLUSION

In this paper, a rectangular microstrip patch antenna with-out the need of an external coupler or polarizer, has been discussed. The designated X Band antenna has a bandwidth from 6.85 GHz to 7.15 GHz. Slits have been introduced on the sides of the patch to improve return loss and decrease solution frequency. The return loss and radiation pattern for far field have been illustrated in the paper. The simulation results show that the X Band antenna achieves a high return loss beyond 27 dB.

This antenna can therefore meet the various requirements for satellite communication applications. The isolation and return loss improvement technology will be studied further to obtain high gain and relatively small size with larger packing efficiency onboard satellite devices.

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