International Journal on Recent and Innovation Trends in Computing and Communication
Volume: 3 Issue: 3

ISSN: 2321-8169
1507 - 1509

Bandwidth Enhancement in Microstrip Patch Antenna Using Rhombus Shape Slot

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Abstract—The Microstrip antennas are the low profile radiators. It is so because of their numerous features such as low volume, compactness, low fabrication cost and mechanical robustness. Numerous techniques have been suggested to improve the Microstrip patch antenna characteristics. In this paper we discuss the slot coupled patch antenna, one with a rectangular patch and other one with a rhombus shaped patch. And study the antenna characteristics of both the antenna such as bandwidth, radiation loss and gain. The results indicate the impact of changing patch on the antenna performance. To excite the structure the microstrip line is placed below the slot. The slot is made between the feed line and the radiating patch substrate. Fields from the microstrip line will be coupled to the patch through this narrow slot.
ANSYS HFSS is used to carry out the procedure

Keywords—slot antenna, rectangular slot patch, rhombus slot patch, bandwidth, radiation pattern

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I. Introduction

All manuscripts must be in English. Advancements in printed circuit fabrication bought a revolutionary change in the way antennas were fabricated. It's now possible to fabricate extremely useful low profile antennas; such antennas are either called as printed circuit antennas or simple the microstrip antennas. Microstrip antenna has two parallel conductors and a dielectric substrate sandwiched between the two. The lower conductor serves as ground plane and the upper conductor as a patch. This is how microstrip antennas got the name patch antennas. The patch can be of any shape, circular, square, rectangular, triangular, elliptical , dipole etc. in this paper we discuss two different patch antennas, first a rectangular slot patch antenna and second a rhombus slot patch antenna.[1-6]

The various advantages of patch antennas prompted us to carry out research in this field. The advantages of patch antennas are Ease of fabrication, compactness, high reliability, low initial costs and light weight. Applications where high performances, size, low installation cost, cheap and integral antennas are required, patch antennas are always the first choice. The field of application are very wide-ranging from satellites, spacecrafts, missiles and wireless communication. The wireless communication demands for high capacity and small size. Thus small sized antenna were required as the devices became small themselves. This need led to development in patch antennas [8].The patch antennas also compensate for the coupling effects due to various nearby objects acting as scatters.

But Microstrip antennas suffer from some disadvantages also. They lack polarization clarity, low power, less efficient, low scanning ability, narrow bandwidth, and spurious feed radiation. But these disadvantages can be overcome using various techniques, including feeding techniques, stack configuration, changing height of substrate and using different patch.

In the present work we compare two slot coupled antennas having different patches. Various performance metrics are studies such as radiation loss, gain and bandwidth. This would help us to enhance the antenna performance. Slot couple patch antennas are designed to achieve the higher bandwidth with better radiation efficiency and less return losses so that said disadvantages can be eliminated [7].

II. RESEARCH METHODOLOGY

In this section we discuss the antenna design. The antennas are fed using coax probe feed. First antenna has a rectangular patch whereas the second antenna under study has a rhombus shaped patch.

The antennas have a narrow slot located on the ground plane, sandwiched between the feed line and radiating patch substrate. The structure would be excited from the Microstrip line present at the bottom. Fields would be coupled from microstrip line to the patch via the narrow slot. Both the structures are designed and simulations are done using ansoft HFFS antenna design kit. HFSS employs the Finite Element Method (FEM), adaptive meshing, and vivid Graphics to 3D EM problems.

III. ANTENNA DESIGN:

While designing the Microstrip antennas, fringing fields need to be considered. It is so because due to fringing effect Electrical length of the patch of the Microstrip antenna appears to be much larger than it physically is. The dimension gets increased on both sides, the increase denoted by a distance ΔL. ΔL is called the normalized extension and is realised using the relation

$$\frac{\Delta L}{h} = \left\{0.412\left\{\left(\in_{eff}+0.3\right)\left[\left(\frac{W}{h}\right)+0.264\right]\Big/\left[\left(\frac{W}{h}+0.246\right)\right]\right\}\right. \quad [1]$$

Here ϵ_{eff} : the effective dielectric constant

$\frac{W}{h}$: The width to height ratio

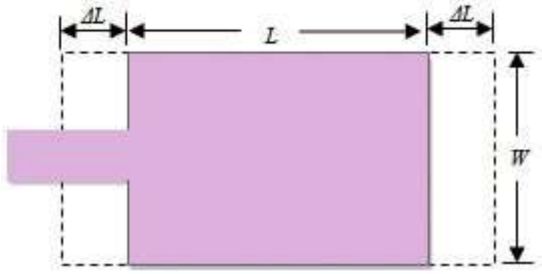

Fig 1.1 Physical and effective lengths of rectangular Microstrip patch

Now taking into account the effective length which needs to be modified too as the length of the patch became extended. The effective length becomes L=λ/2. As shown in fig 1.1

Therefore the relation obtained is

$$L_{eff} = L + 2\Delta L_{eff} \quad [2]$$

Design Equations:

- To determine the width at which the structure would radiate efficiently, the following relation is used

$$W = \left(1\big/2f_r\sqrt{\varepsilon_o\mu_o}\right) = \left(\vartheta_o\big/2f_r\right)\sqrt{\frac{2}{\varepsilon_r}}$$

[3] Here ϑ_o is the free-space velocity of light.

- Next step is to ascertain the effective dielectric constant of the antenna.
- If w is calculated / known we can calculate the ΔL
- The length of the antenna now can be determined by using the following relation:

$$L = \frac{1}{2f\sqrt{\varepsilon_{reff}\sqrt{\mu_o\varepsilon_o}}} - 2\Delta L \quad [4]$$

IV STRUCTURE OF ANTENNA

The structures of antennas are discussed in this section. Fig1 shows an antenna structure with a rectangular patch and fig.2 shows an antenna structure with rhombus shaped patch, which are excited using two slots on the ground plane. The dielectric between patch and slot is of thickness 0.16cm and dielectric between slot and feed is also of the same thickness, i.e. 0.16 cm. The material used is Rogers RT/Duroid 5880(tm) having a relative permittivity of 2.2. Feed line of 50 is divided into two 100 feed lines but having different lengths.

V. Figures and Tables (RESULT)

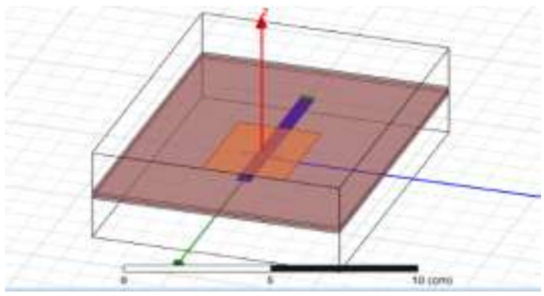

Fig. 2 Rectangular patch

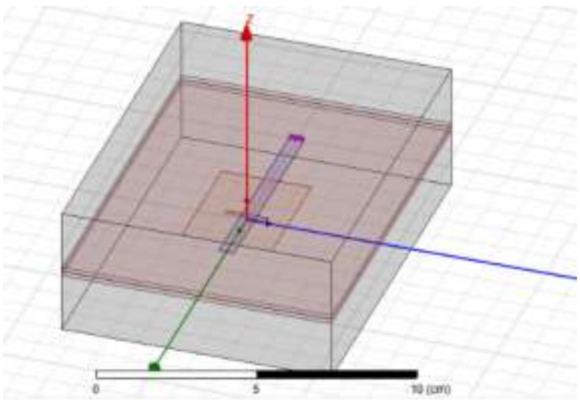

Fig. 3 rhombus patch

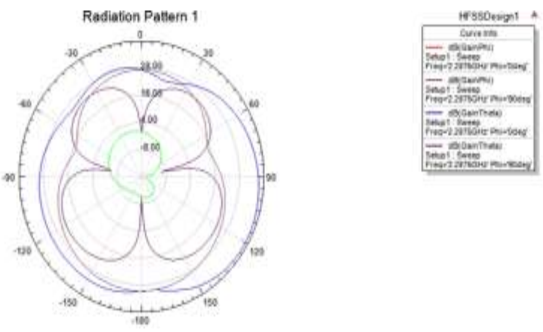

Fig 3.1 radiation pattern

ISSN: 2321-8169
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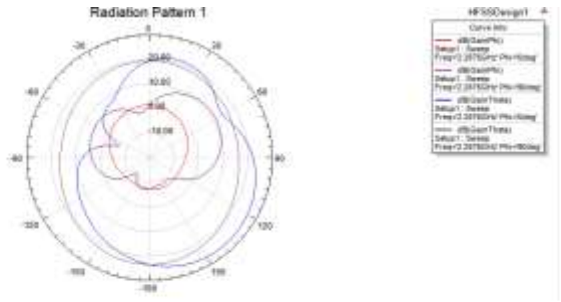

Fig 2.1 radiation pattern

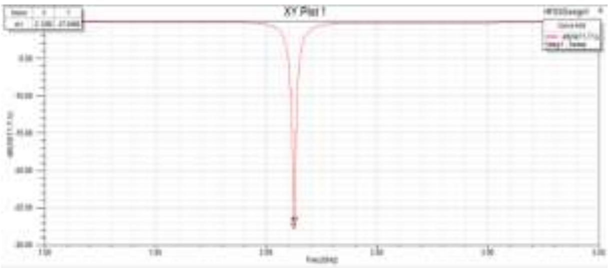

Fig 2.2 XY plot

TABLE I

Antenna type/ Properties	Rectangular slot	Rhombus slot
bandwidth	1.2%	1.3%
gain	1.58	2.27
Resonant frequency	2.25 GHz	2.25 GHz

Conclusion:

Two aspects of microstrip antennas have been studied. The main concern is to study the bandwidth improvement of the microstrip antenna. Antenna design is done by using High Frequency Structure Simulator (HFSS). This paper presents two slot coupled patch antennas having different patches but constructed with same material and operating at same frequency of 2.25 GHz. The figs represent the two antenna structures and their radiation plots.

This paper presents a slot coupled patch antenna simulated at frequencies 2.25 shown in figures 2.1, 2.2, 3.1 and 3.2 where fig 2.1-fig 3.1 represents the radiation pattern .Fig 2.2 and fig 3.2 represents return loss characteristics.

The patch and the ground plane are separated by a material with low dielectric constant Rogers RT/Duroid 5880 and an air gap.

There is a trade-off between frequency of operation and increase in bandwidth and radiation loss. The bandwidth achieved at higher frequencies is high but the problem is that the radiation loss is also high at higher frequencies.

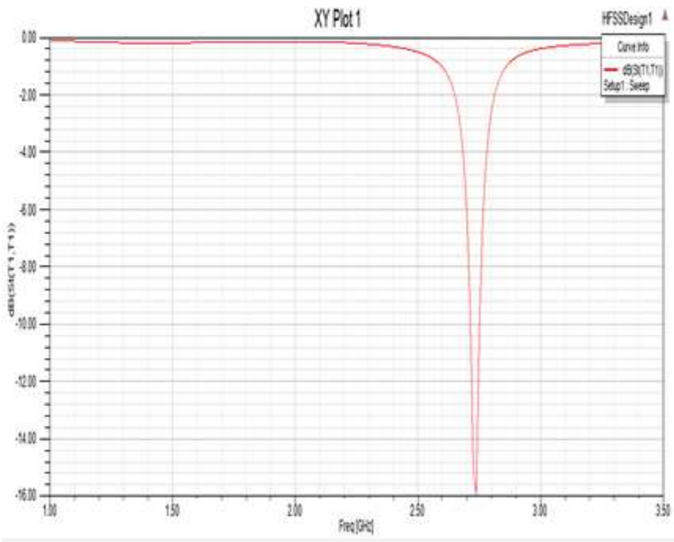

Fig 3.2 XY plot

Therefore appropriate operating frequency was selected and simulations were carried out.

Results have been summarised in the table I. as it can be seen better gain and bandwidth performance were achieved using rhombus slot, also the return loss also decreased.

Hence from table1 I would like to conclude that the rhombus slot patch antenna offers better bandwidth characteristics.

Acknowledgment

The author would like to thank GITAM University and TEQIP for their support during this research work

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