DESIGN AND ANALYSIS OF RECTANGULAR PATCH WITH SQUARE SLOTS

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ABSTRACT

This paper presents the comparison of results of micro-strip patch antenna by cutting different slots. In this paper a rectangular patch (29.443 x 38.036 x 1.6mm) is taken over which slots are cutting to analyze the response of this antenna. Three different shapes of slots have been taken for result analysis. Rectangular slot with rotation, Rectangular slot with rotation and Symmetrical Y shaped slot shaped slot results are compared in this paper. Epoxy Raisin () of height of 1.6mm has been taken. The antennas were simulated for purpose the application of 3G communications for resonance frequency 2.4 GHz (S-Band).The results are calculated and analyzed keeping fringing field in mind. The results are carried using coaxial field. The results are being simulated using IE3D software.

KEYWORDS- *Micro-strip Antenna, Radiation Pattern, Bandwidth enhancement techniques*

I. INTRODUCTION

A micro-strip antenna generally consists of a dielectric substrate sandwiched between a radiating patch on the top and a ground plane on the other side. The patch is generally made of conducting material such as copper or gold and can take any possible shape. Micro-strip Patch antennas are fascinated because of their low cost, low profile, light weight, mechanically robust, easy to fabricate and analyze[1]. As we know that the surface of rectangular patch starts radiating the EM-waves and the return loss having one resonant is observed. If the slot is cut onto a patch then there will be two radiating surfaces and resonant band is observed. The slots can have different shapes, there are number of shapes available but this paper includes three basic shapes. In this paper patch of rectangle shape was taken under consideration. This feeding technique gives best impedance matching at 50Ω.The techniques used to enhance bandwidth are to choose a thick substrate with low dielectric constant and slotted patch. Another important parameter that must be taken while designing a micro-strip antenna is it fringing field. Fringing field is a function of effective dielectric constant. The fringing fields along the width can be modeled as radiating slots increasing electrical length of patch than physical length.

II. SOFTWARE USED

IE3D is an integrated full-wave electromagnetic simulation and optimization package for the analysis and design of 3D and planar microwave circuits, MMIC, RFIC, RFID, antennas, digital circuits and high-speed printed circuit boards (PCB). Since its formal introduction in 1993 IEEE International Microwave Symposium (IEEE IMS 1993), the IE3D has been adopted as an industrial standard in planar and 3D electromagnetic simulation. Much improvement has been achieved in the IE3D since then. TheIE3D has become the most versatile, easy to use, efficient and accurate electromagnetic simulation tool.

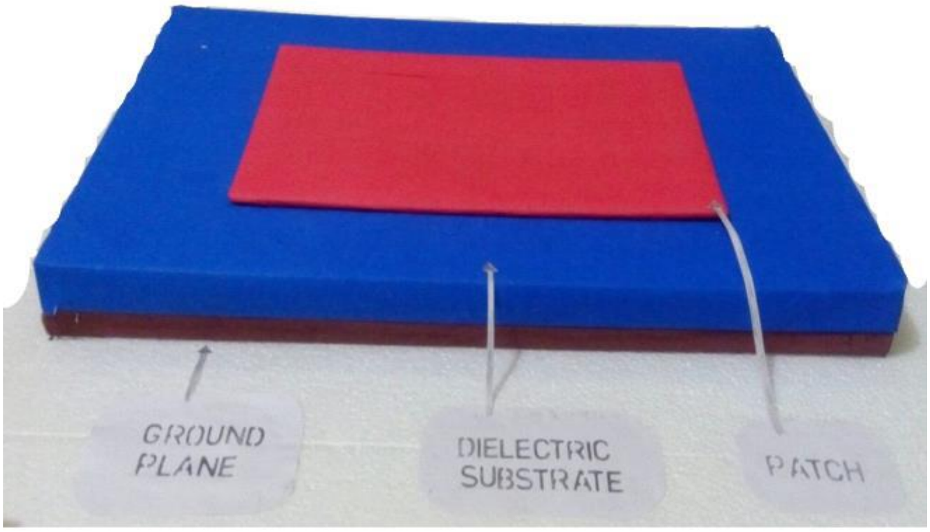

Fig-1 Structure of Microstrip Patch Antenna

III. IMPORTANT PARAMETERS

A. Radiation Pattern

The term radiation pattern simply gives information about the power radiated by the antenna in all direction. It also explains about the antenna beam width, side lobes and antenna resolution.

B. Return Loss

The amount of radiated power that is being reflected back due to the insertion of any other device in transmission media is termed as return loss. The return loss is given by,

$$RL\ (dB) = 10 \log\ (P_r / P_i)$$

Where P_r is the power reflected and P_i is the power supplied by the source.

C. VSWR

The ratio of maximum voltage to minimum voltage is termed as VSWR.

$$\text{VSWR} = V_{max} / V_{min}$$

Where V_{max} is the maximum voltage and V_{min} is the minimum voltage.

IV. ENHANCEMENT IN BANDWIDTH

A. Height of Dielectric Constant

On increasing the height of the substrate there is an increment in the resonant frequency but the height of the substrate cannot be increased beyond the limit because then there will be requirement of increased length of probe feed which will then introduces increase in the inductance. So on increasing the height of the substrate the antenna will suffer from large inductance. As substrate height increases, surface wave and spurious feed radiation increases (which is undesired radiation and may couple to other components) which limit the bandwidth.

B. Increasing the value of Dielectric Constant

The dielectric constant plays a major role in the overall performance of the antenna. It affects both the width, in turn the characteristic impedance and the length resulting in an altered resonant frequency and reduced transmission efficiency. Also dielectric constant controls the fringing field which is the main cause of radiation in microstrip patch antenna. The lower will be dielectric constant the wider will be the fringes which in turns results into the better radiation and also increased bandwidth and efficiency. By increasing the dielectric constant of the substrate material the bandwidth and gain values decreases, whereas a high value of dielectric constant results in compact dimensions of antenna.

C. Concept of slot cutting

When the patch of comparative length and width have been taken under consideration then the edges of patch starts radiating and resonant are observed .From here the concept of slot arrived that if there will be two radiating surfaces then there will be resonant band for which the antenna will work. Different shapes of slots are cut over the different shapes of patches to determine the broader bandwidth. Generally rectangular, triangular, circular, letter shaped slots are cut to enhance the bandwidth.

V. Designing Procedure

In starting a rectangular patch of 29*38 mm is taking on FR4 substrate material. This is shown in figure 2. After simulating this patch using IE3D, maximum return loss occur at 2.38 GHz. Now for increasing the number of resonance multi slot cut at the corner of main radiating patch. This slot is approximately one third of the main patch.

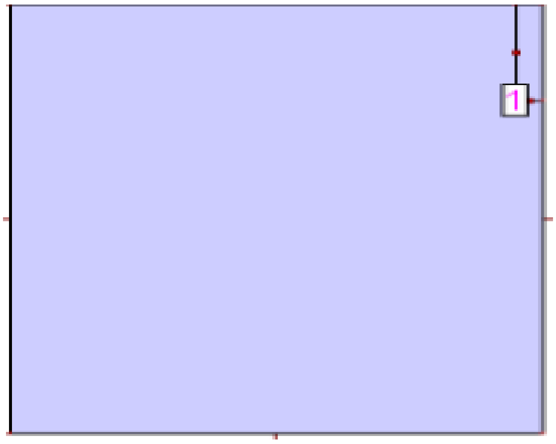

Fig.2 Rectangular Patch without Slots

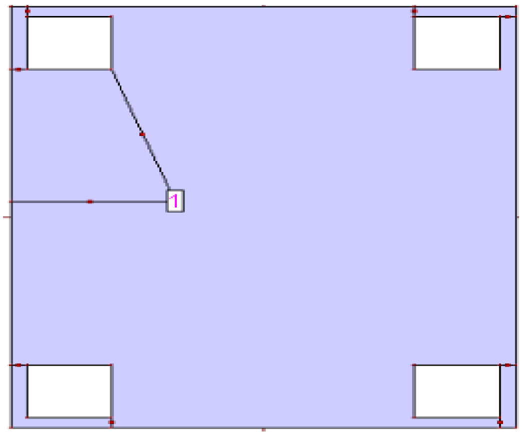

Fig. 3 Rectangular Patch with Square Slots

TABLE-1: Design Parameters

Design Parameters	Rectangular Patch without Slot	Rectangular Patch with Square Slots
Dielectric Constant	4.4	4.4
Loss Tangent	0.0016	0.0016
Patch Dimensions (mm)	(29.443 x38.036 x1.6)	(29.443 x38.036 x1.6)
Slot Dimensions (mm)	-	(10 x10)

VI. Results

The simulation results for all the antennas have been tabulated in Table 2. As discussed previously, corner cut microstrip patch antenna having square slots with coaxial (probe) feed is presented here. Different design parameters with their effects are studied. For the operational frequency of 2.35 GHz (2330-2400MHz) and 3.51 GHz (3507-3658MHz) VSWR nearly 1.06 and maximum return loss up to -30.574 dB has been obtained.

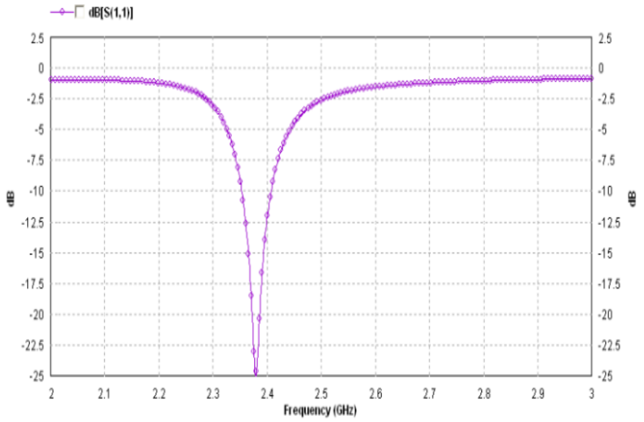

Fig.4 Return Loss for Rectangular Patch without Slots

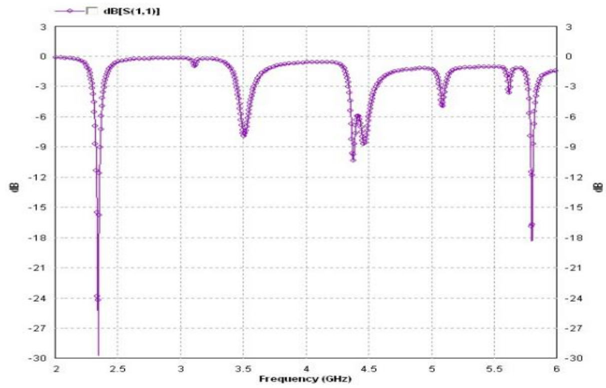

Fig.5 Return Loss for Rectangular Patch with Square Slots

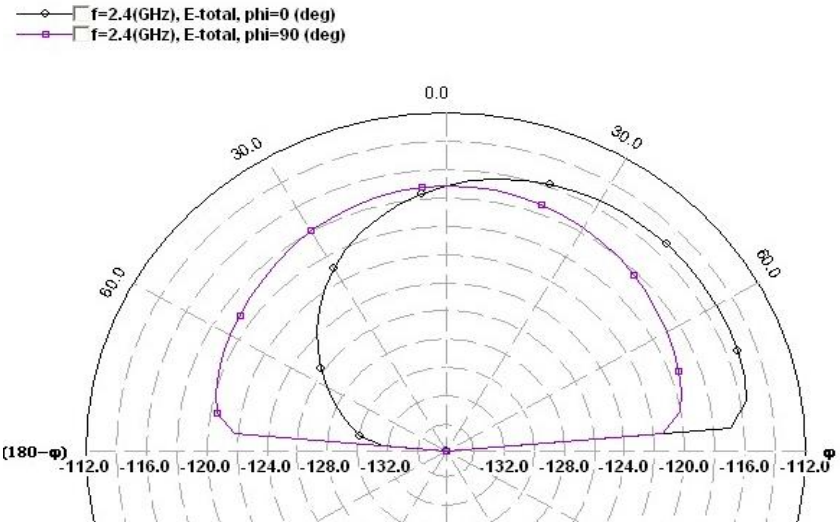

Fig.6 Radiation Pattern for Rectangular Patch without Slots

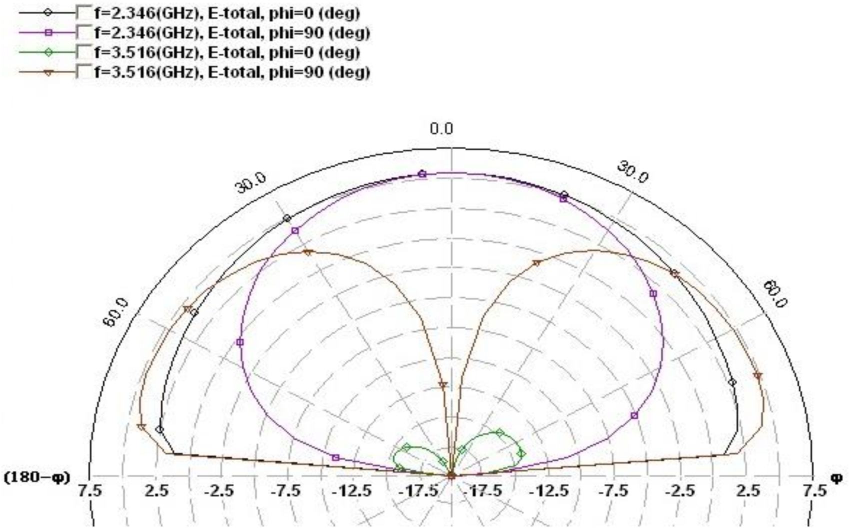

Fig.7 Radiation Pattern for Rectangular Patch with Square Slots

TABLE-2: Comparison of Performance Parameters

Performance Parameters	Rectangular Patch without Slots	Rectangular Patch with Square Slots
Feeding Point Location	(3.625 , -17.85 ,1.6)	(-5.3, 1.5 ,1.6)
Resonance Frequency (Ghz)	2.38	2.346 , 3.51
Bandwidth	8.1%	25.8%
Gain (dBi)	3.57	5.40
VSWR	1.35	1.06
Reflection Coefficient (dB)	-25.01	-30.574

VII. CONCLUSION

The measured results indicate that the antenna exhibits a good input return loss at the designed frequency and other multiband frequency. From measurement and simulation the multiband frequency occur at 2 different resonance frequency with a return loss more than 10 dB. The radiation pattern shows this antenna can perform similar with a dipole antenna. This type of antenna is the best candidate for future broadband wireless communications.

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