EFFECT OF SLOTS ON PERFORMANCE OF THE MICROSTRIP PATCH ANTENNA

Sumit Srivastava[1], Sweta Agarwal[2], Priya Agarwal[3], Sweta Srivastava[4]

[1], Assistant Professor, M.J.P.Rohilkhand University (India)

[2]Assistant Professor, [3,4] M.Tech. Student, Invertis University,Bareilly,(India)

ABSTRACT

In this paper, a microstrip patch antenna with different slots has been proposed. The impact of the slots on the antenna characteristics such as return loss, VSWR is shown. The antenna uses coaxial feeding technique. Using of slots increases the bandwidth of antenna. The design can be used in communication and GPS applications. Microstrip antenna is simulated by IE3D software.

***Keywords:* Microstrip antenna, Return loss (S_{11}), IE3D.**

I. INTRODUCTION

Microstrip antennas are widely employed in communication systems, radar, imaging due to their attractive features, such as low profile, conformability, low cost and light weight. The microstrip patch antenna consists of conducting patch on a ground plane separated by dielectric substrate. With the help of slots, the size of microstrip patch antenna has been reduced. This effect has been done by changing the path of the current. When the slots are cut on the patch the path of the current is changed. Current travels extra path as compare to the without slot of microstrip antenna. With this concept the size of the antenna is reduced i.e. small size antenna has been used at lower frequency. The operation principal of the antenna is investigated using the coaxial feeding technique. The conducting patch can be taking any shape but rectangular shape configurations are the most length of the antenna is nearly half wavelength in the dielectric, which governs the resonant frequency of the antenna. There is no hard and fast rule to find the width of the patch. A new class of printed slots antennas with high efficiency is presented in this paper.

II. PROPOSED ANTENNA AND SIMULATION

2.1 Basic Rectangular Patch Antenna

The rectangular patch antenna is shown in figure1. The length and width of the antenna is 25mm and 25mm respectively. The antenna is printed on a substrate of thickness 1.6mm and relative permittivity(ε_r) 4.4. The printed antenna is etched on ground substrate. The dimension of the rectangular antenna can be roughly determined by

$$f_{mnp} = \frac{k_{mnp}\, c}{2\pi \sqrt{\varepsilon_r}}$$

Where m,n,p= { 0,1,2,3……………} are respectively , number of half –cycle field variation along the x,y,z directions; k_{nmp} is wave number .

$$k_{mnp} = \sqrt{\left(\frac{m\pi}{W}\right)^2 + \left(\frac{n\pi}{L}\right)^2 + \left(\frac{p\pi}{h}\right)^2}$$

Where c is the speed of light in air, ε_r is the effective permittivity and L is the length of the antenna.

A microstrip patch antenna is designed for the resonant frequency 2.79GHz. Simple Rectangular Microstrip Patch Antenna fed by coaxial feed technique is shown in figure1. The proposed antenna has dimension of L =25cm& W=25cm and is printed on a substrate. On the upper side of PCB we design the patch of giving dimensions and on the lower side of PCB copper plate acts as the ground .

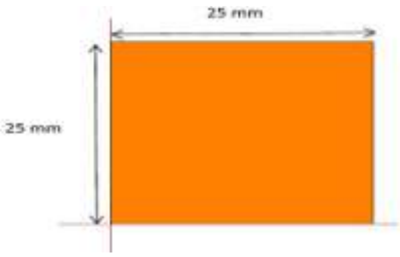

Figure1. Geometry of Basic of Rectangular Patch Antenna

The whole geometry is simulated and raised practically using a FR4 dielectric substrate of height 1.6mm and having a dimension constant 4.4. Loss tangent of the material is 0.01. Coaxial feeding technique is used for providing the feed to the antenna.

Return loss of rectangular microstrip patch antenna is shown in figure 2. The value of return loss is -13.605 dB at frequency of 2.7928 GHz

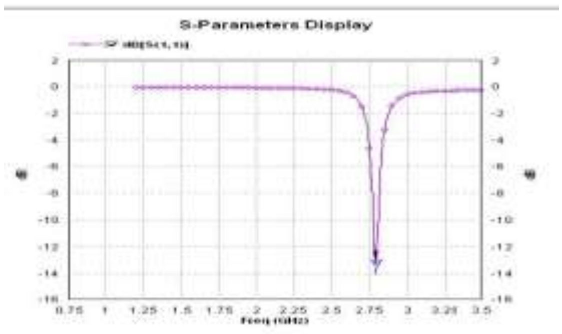

Figure2. Simulated Return Loss of Microstrip Patch Antenna

The VSWR of rectangular microstrip antenna without slot is shown in figure3. The value of VSWR is 1.5318 at 2.7928GHz

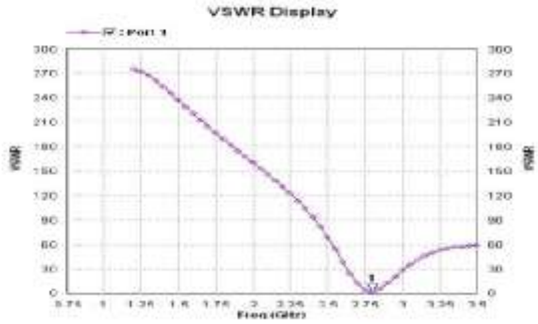

Figure3. VSWR v/s Frequency Plot of Rectangular Microstrip Patch Antenna

2.2 Rectangular Patch Antenna with Single Slot.

The proposed first geometry of rectangular patch antenna with single slot is shown in figure 4.

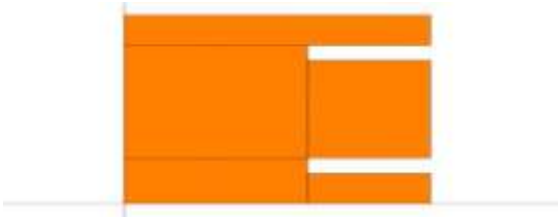

Figure4. Single Slot Shape Rectangular Microstrip patch antenna

The operating frequency of rectangular patch antenna with single E slots is 2.268GHz. The length of slot (L_1, L_2) is 10mm. The spacing between two slots are 13mm. The whole geometry is simulated and realized practically using a dielectric substrate of height 1.6mm and having a dielectric constant 4.4mm. Loss tangent of the material is 0.01. Coaxial feeding technique is used to providing the feed to the antenna.

Return loss of rectangular microstrip antenna with single E slot is shown in figure 5. The value of return loss is -16.0471 dB at frequency of 2.268 GHz.

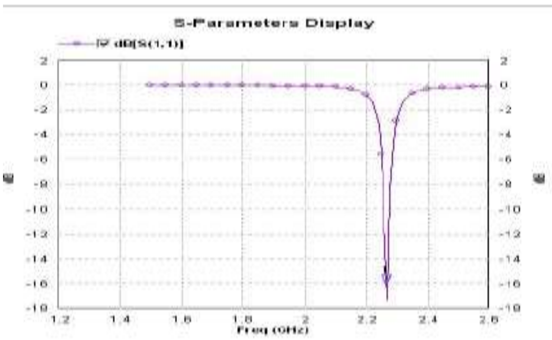

Figure5. Simulated Return Loss of Rectangular Patch Antenna with Single Slot.

The VSWR of rectangular microstrip antenna with single slot is shown in figure 6. The value of VSWR is 1.4122 at 2.268GHz.

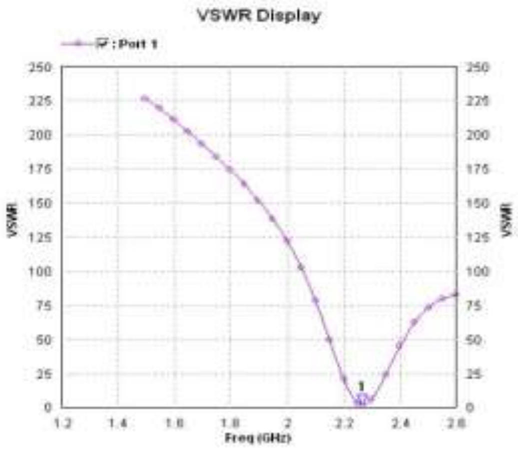

Figure6. VSWR v/s Frequency Plot of Rectangular Patch with Single Slot

2.3 Rectangular Patch Antenna with Dual Slots.

The proposed geometries of rectangular with single slot is shown in figure7. Patch Antenna.

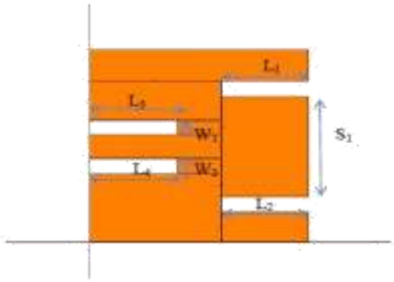

Figure7. Rectangular Microstrip Patch Antenna

The dual E slots operating frequency is 1.7897GHz. The length of the slot (L_1, L_2, L_3, L_4) is 10mm and the width of the slot (W_1, W_2, W_3, W_4) is 2mm. The spacing between two slots (S_1) is 13mm and the spacing between two slots (S_3) is 3mm.The whole geometry is simulated and realized practically using a dielectric substrate of height 1.6mm and having a dielectric constant 4.4mm. Loss tangent of the material is 0.01. Coaxial feeding technique is used to providing the feed to the antenna.

Return loss of rectangular microstrip antenna with double slot is shown in figure 8. The value of return loss is -27.4496dB at frequency of 1.7897GHz.

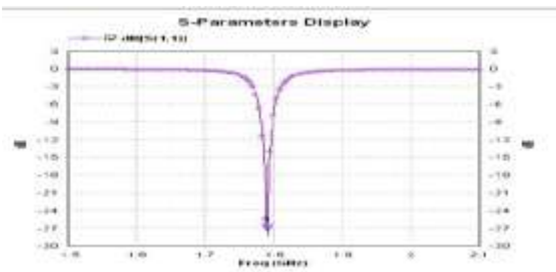

Figure8. Simulated Return Loss of Rectangular Patch Antenna with Dual Slots.

The VSWR of rectangular microstrip antenna with dual slot is shown in figure 9. The value of VSWR is 1.0896 at 1.7897GHz.

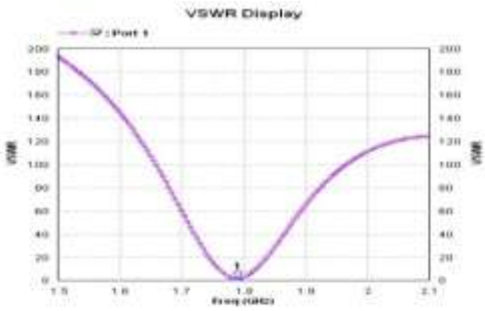

Figure9. VSWR v/s Frequency Plot of rectangular Patch with Double Slots

Methodology

(i) Width of metallic patch (W)

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r+1}} = \frac{C}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}}$$

Where,

C = free space velocity of light.

$\varepsilon_r =$ Dielectric constant of substrate.

(ii) Length Extension

$$\Delta L_n = 0.412h\frac{(\varepsilon_r+0.3)\left(\frac{W_n}{h}+0.264\right)}{(\varepsilon_r-0.258)\left(\frac{W_n}{h}+0.813\right)}$$

(iii) VSWR (Voltage Standing Wave Ratio)

$$VSWR = \frac{V_{max}}{V_{min}} = \frac{1+|\Gamma|}{1-|\Gamma|}$$

(iv) Return Loss

$$RL = -20\log|\Gamma|$$

III. RESULT

IE3D software has been used to simulate the rectangular patch antenna. The simulation is based on method of moment. Coaxial feeding technique is used for feeding purpose. For finding the feeding point hit and trial method is used. Various parameters such as return loss, VSWR, input impedance, radiation pattern etc. are observed by the simulator.

When compare the all plots, a result comes out. With increment of slots frequency reduced that is size is reduced; return loss is improved as shown in figure 10.

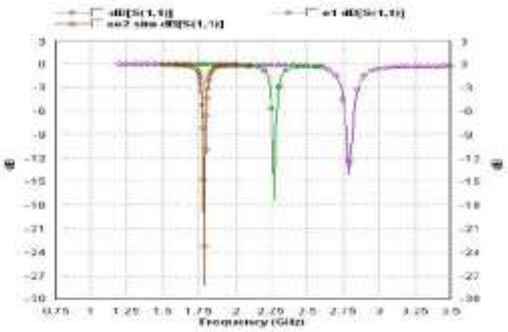

Figure 10. Comparatively Graph for Return Loss of Rectangular Patch Antenna

To obtain perfect matching between the feeding system and the antenna, Γ = 0 is required and therefore, from equation (a), RL = infinity. In such a case no power is reflected back. Similarly at Γ = 1, RL = 0 dB and VSWR= infinity, form point (iii&iv) implies that all incident power is reflected.

For practical applications, a VSWR of 2 is acceptable and this corresponds to a return loss of 9.54 dB. Usually return losses ranging from 10 dB to 12 dB are acceptable.

3.1 Comparative Chart of the Microstrip Antenna with Different Slots.

	Properties	Without slot	With Single E slot	With Dual E slot
1	**Resonant Frequency**	2.792 GHz	2.268GHz	1.7897 GHz
2	**Return loss**	-13.605 dB	-16.047dB	-27.449dB
3	**VSWR**	1.53	1.41	1.08

This comparable table shows the effects of slots on the performance of microstrip antenna. When the slots are cut on the patch resonant frequency is decreases, return loss increases, and VSWR is decreases.

IV. CONCLUSION

In this paper, the design of proposed Microstrip Patch Antenna using Different Slots have been calculated mathematically, Simulated on the IE3D Software. Reduction of return loss as well as increase of bandwidth significantly. This had also been proven that dual slots have low return loss and VSWR at low operating frequency as compare to single slot & having no slot.

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