Analysis of Coaxial Feed Rectangular Microstrip Patch Antenna

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Abstract - In this paper parametric analysis and mode analysis of rectangular microstrip patch antenna using coaxial feed was done by changing its length, width, ground plane length and ground plane width. Due excitation TM10, TM02 and TM12 modes were generated when feed location on x axis. TM01, TM02, TM03, TM21 and TM20 modes were generated when feed location on y axis.current distribution of these modes were also presented. Incorporation of slot altered the cuurnt distribution. Slot was incorporated on radiating edge of the patch. The antenna was simulated using CST, on FR-4 substrate with relative permittivity of 4.4.

Keywords—Rectangular Microstrip Patch Antenna (RMPA); Modes, CST, Dielectric Constant.

I. INTRODUCTION

Microstrip patch antenna is separate entity in microwave communication because of its several advantages like low profile, low cost, planar structure and easy integration with printed circuit board. These features make the microstrip antenna very attractive for use in high-speed vehicles, such as missiles, rockets and satellites. But it has some draw back like low gain, low impedance bandwidth and less power handling capability [1-2]. The geometry of a microstrip antenna contains conducting patch on the top of a substrate, which is backed by a ground plane. The shape of patch can be arbitrary. But in practice, regular shapes like rectangular, circular and the annular ring are used foe easier analysis. The antenna can be fed either by microstrip line or by coaxial cable. The electromagnetic Waves are guided along the coaxial line to feed the point. The energy then spread out into the region under the patch, some of which crosses the boundary of the patch and radiates into the half space above the patch. In this paper parametric study of RMPA is achieved.

II. TRANSMISSION LINE MODEL

In transmission line model the RMPA can be represented by two slots of width (W) and height (h) separated by transmission line of length (L).The width of the patch can be calculated from the following equation

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \quad (1)$$

The effective dielectric constant (ε_{eff}) is less than (ε_r) because the fringing field around the periphery of the patch is not confined to the dielectric also speared in the air also.

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}[1+12\frac{h}{W}]^{-1/2} \quad (2)$$

Because of fringing field, extension in length and width is given by empirically.

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)(W/h+0.264)}{(\varepsilon_{reff}-0.258)(W/h+0.8)} \quad (3)$$

$$\Delta W = 1.6\ln(4/\pi) \quad (4)$$

Effective length (L_e) and effective width (W_e) is given by

$$L_e = L + \Delta L \quad (5)$$

$$W_e = W + \Delta W \quad (6)$$

The length of the patch is given by

$$L = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L \quad (7)$$

Where,

c = speed of light

f_r = operating frequency

ε_{reff} = effective dielectric constant

For a rectangular Microstrip patch antenna the resonance frequency for any TM_{mn} mode is given by

$$f_{mn} = \frac{c}{2\sqrt{\varepsilon_{eff}}}\sqrt{\left[(\frac{m}{L_e})^2 + (\frac{n}{W_e})^2\right]} \quad (8)$$

The width of ground plane is given by

$$W_g = 6h + W \quad (9)$$

The length of the ground plane is given by

$$L_g = 6h + L \quad (10)$$

III.

IV. PREVIOUS WORK

I have took the idea from the paper K.V. Rop, D.B.O.Konditi, “Perforrnance Analysis of A Rectangular Microstrip Patch Antenna on Different Dielectric Substrates,” [4]. In this the effect of various dielectric constants on rectangular microstrip patch antenna’s performance is investigated by keeping the substrate

thickness constant. Simulation were carried out using MATLAB. The result shows that the dielectric constant effectively determined the performance of MSAs. In this, mode study and parameteric study have not been done which I have done in my research work.

V. PROPOSED METHODOLOGY

The configuration of proposed antenna which is designed for frequency 2.4 GHz is shown in fig. 1. The substrate used for this design is FR-4 with relative permittivity 4.4, loss tangent 0.02 and thickness h=1.6mm. Dimension of ground plane are 39mm×47.6mm. As shown in figure radiating element is rectangular patch is fed by coaxial cable. The structural parameters of the antenna are given in table 1. These physical dimensions are calculated using transmission line model.

Table-1 : Dimension for praposed antenna

Length (L)	Width (W)	Ground Plane Length	Ground Plane Width	Patch Thickness	Ground Thickness
29.5mm	38mm	39mm	47.6mm	0.035mm	0.035mm

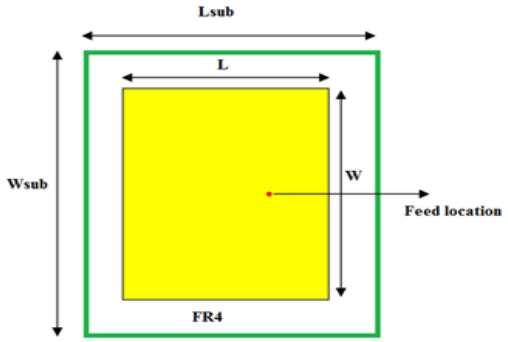

Fig.1. Configuration of proposed Antenna

VI. SIMULATION

Paramatric Analysis And Mode Analysis:

(A) Effect of feed location

It is clear from Figure 2 antenna is resonating at three frequencies. Figure 2 represents the effect of feed location. At feed location (6, 0) the return loss is -28.10dB at dominating frequency. It is because of impedance matching between antenna and coaxial feed. It is observed that return loss varies with feed location. Figure 3 shows the effect of feed location in this case feed location is chosen on y axis. It is clear from the figure antenna is resonating at five frequencies. The dominating mode frequency is 1.87 GHz. For feed location (0,6) maximum return loss is observed at frequency 1.87 GHz.

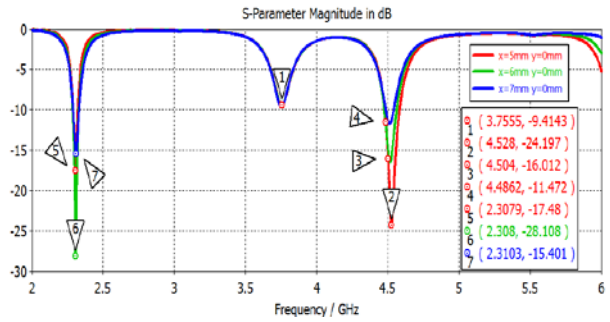

Fig.2. Return loss vs Frquency for feed location (x,0)

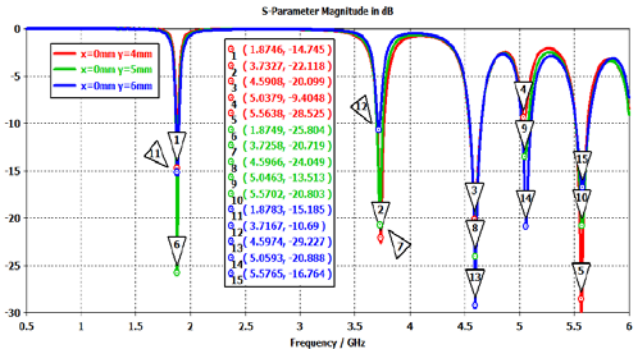

Fig.3. Return loss vs Frequency for feed location (0,y)

(B) Mode study

It is clear from the figure 4 excited modes are TM10, TM02 and TM12. Others modes are not generated even orthogonal mode is not observed figure 5(a), Figure5(b) Figure5(c) shows the current distribution of TM10, TM02 and TM12 modes respectively. For TM10 mode one half wave variations along the length of the patch and no variation along the width of the patch is observed. For TM02 mode two half wave variations are found along the width of the patch. For TM12 mode one half wave variation along length and two half wave variation along the width if observed. Figure 6 shows the modes for feed location (0, y)

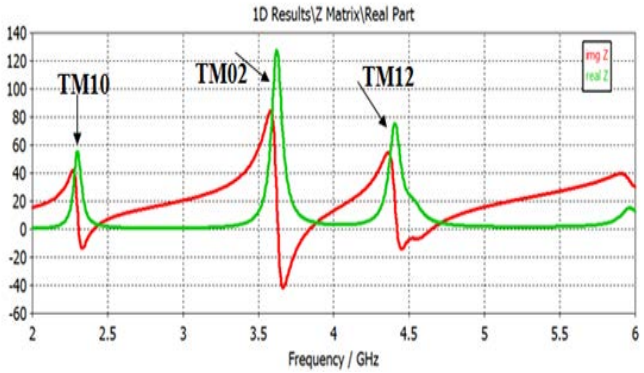

Fig.4. Resonance curve for feed location (x,0)

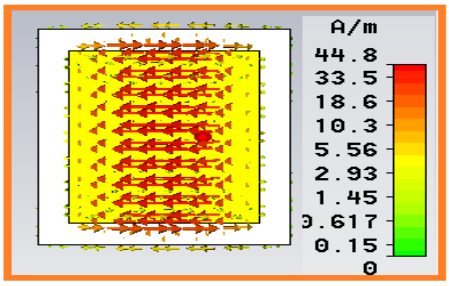

Fig.5(a). Surface current distribution for TM10 mode

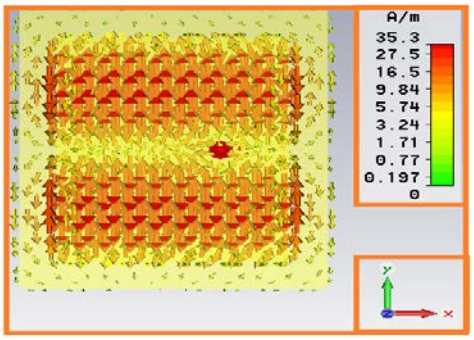

Fig.5(b). Surface current distribution for TM02 mode

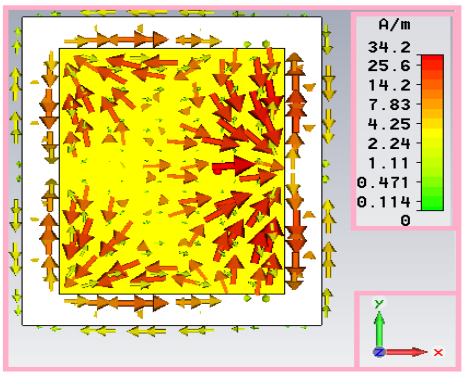

Fig.5(c). Surface current distribution for TM12 mode

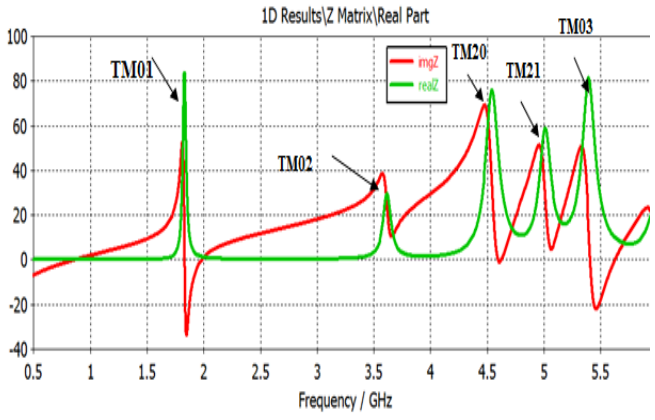

Fig.6. Resonance curve for feed location (0, y)

It is clear from figure 6 five modes are generated for feed location (0, y).These modes are TM01, TM02, TM20, TM21 and TM03. Figure7 shows the surface current distribution of these modes. For TM01 mode one half wave variation of current is observed along the width of the patch. For TM02 and TM03 two and three half wave variation of the current is found along the width of the patch. For TM20 two half wave variations is observed along the length.

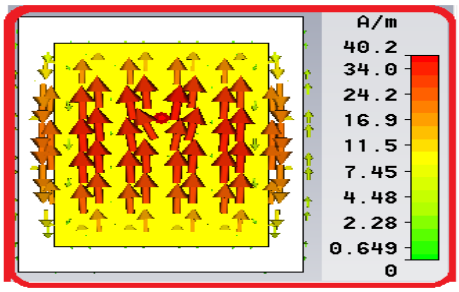

Fig.7(a). Surface current distribution for TM01 mode

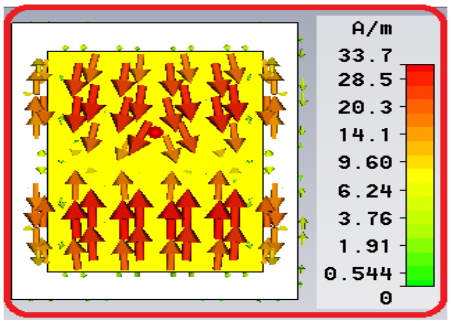

Fig.7(b). Surface current distribution for TM02 mode

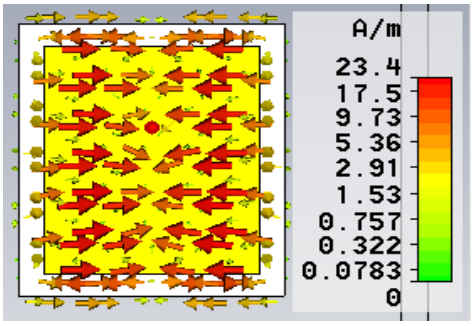

Fig.7(c). Surface current distribution for TM20 mode

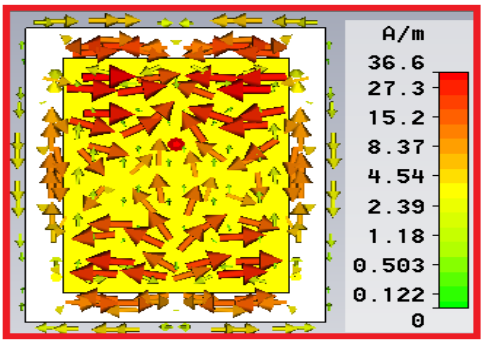

Fig.7(d). Surface current distribution for TM21 mode

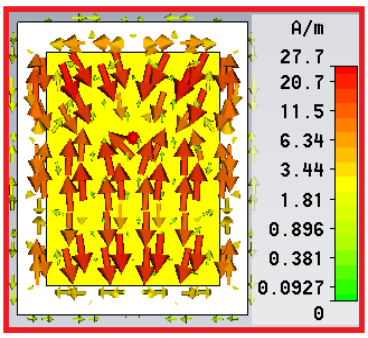

Fig.7(e). Surface current distribution for TM03 mode

(C) Effect of width

It is clear from the figure 8 antenna is resonating at three frequencies. At frequency 2.3 GHz return loss varies if width of the antenna is varied. Maximum return loss is observed for W=39mm at first resonance. It is observed that second and third resonance frequencies are shifted left if increases the width of the patch.

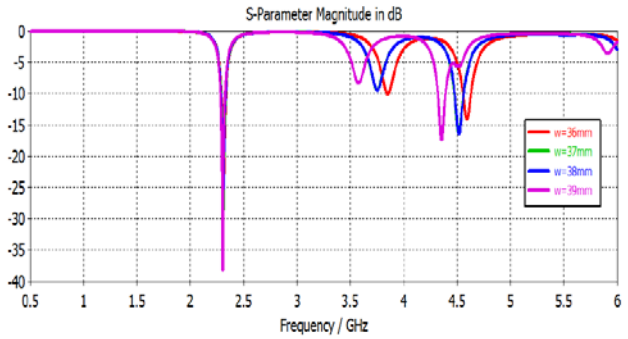

Fig.8. effect of width on return loss

(D) Effect of length

It is observed from the simulated results study that by increasing the length the first resonance frequency shifted left. It can be seen from figure 9 second and third resonance frequencies are also shifted left.

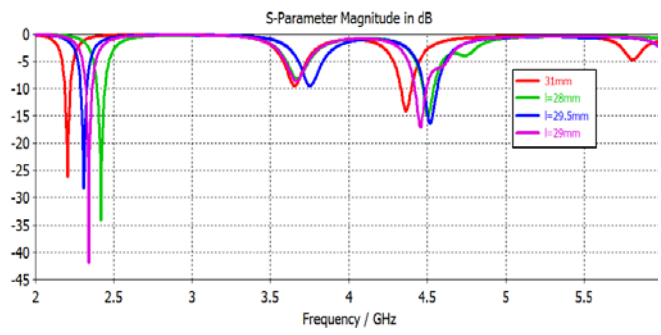

Fig.9. effect of length on return loss

(E) Effect ground plane length

Figure 10 shows the impact of ground plane length on return loss. It can be observed length of the ground plane change the impedance of antenna. Maximum return loss is found for l_g =28.1mm for FR4 based antenna at first resonance. Left shifting of resonance frequency is observed at second resonance and third resonance

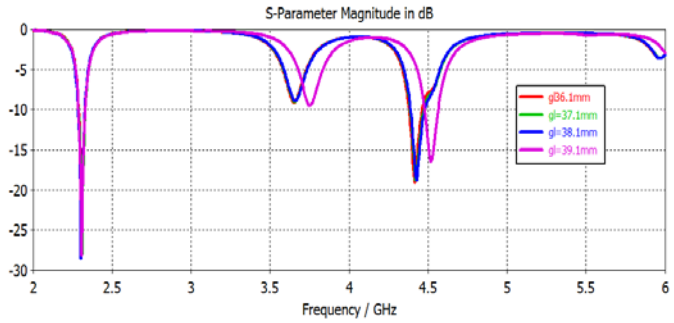

Fig.10. effect of ground plane length on return loss

Figure 11 shows the impact of ground plane width on return loss. It can be observed width of the ground plane change the impedance of antenna. Maximum return loss is found for w_g =44.6mm for FR4 based antenna at first resonance. Weft shifting of resonance frequency is observed at second resonance and third resonance

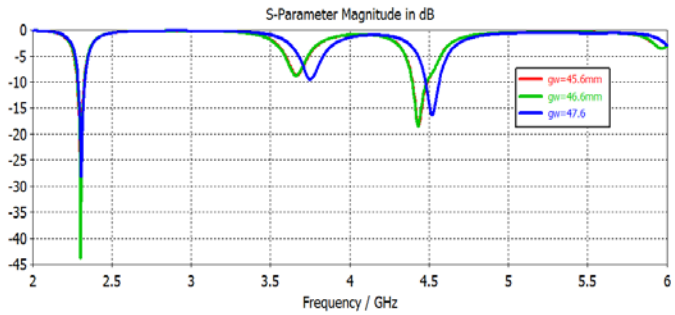

Fig.11. effect of ground plane width on return loss

(F) Effect of slot length and slot width

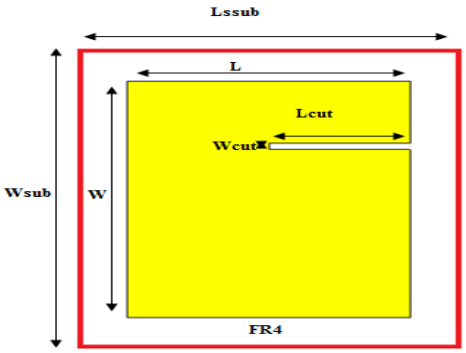

Fig.12. Configuration of proposed Antenna with slot

Figure 12 shows the geometry of proposed antenna with slot. The length of the slot l=14.75mm and width of the slot is 1mm. figure 13 shows that there is no effect on TM10 mode but the resonance frequencies of TM02 and TM12 modes are shifted left i.e. slot reduces the resonance frequency of higher order modes. It can be seen from the figure 13 no change in TM10 mode frequency but TM02mode frequency and TM12 mode frequency are shifted left as increases in slot length. Figure 14 shows the impact of slot width on mode frequencies. As slot width increases TM02 and TM12 mode frequencies are shifted right and no variation is observed in TM10 mode frequency.

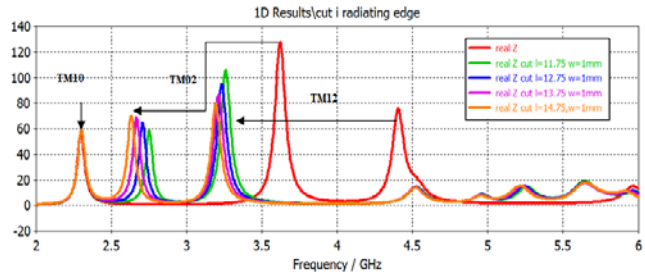

Fig.13. Effect of slot length on resonance frequencies

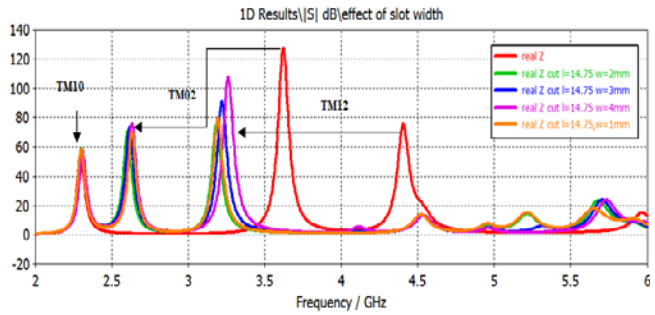

Fig.14. Effect of slot width on resonance frequencies

VII. CONCLUSION

Rectangular microstrip patch antenna has been simulated using CST software. The parametric analysis has been carried out, observed the effect on return loss and resonance frequency. It is observed that TM10, TM02 and TM12 modes are generated when feed location on x axis while TM01, TM02, TM03, TM20 and TM21 modes are generated when feed location on y axis . slot is introduced on radiating edge of the patch that alter the current distribution of the patch.

VIII. FUTURE SCOPE

Mode study has been done.we can enhance the Bandwidth of antenna by mixing two mode. It has been observed that resonance frequency of microstrip patch antenna can be reduced by introducing the slot. Whereas two modes are near then they will be mixed and bandwidth of antenna will be enhanced by incorporation of slot. Current distribution of patch will also changed.

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