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A Printed Microstrip Antenna for RADAR Communication

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Abstract : *A single layer, single feed compact slotted patch antenna is thoroughly simulated in this paper. Resonant frequency has been reduced drastically by cutting two different slots. The first one is the combinations of two triangular and another rectangular slot at the upper right corner and rest is bilateral triangle at the lower left corner from the conventional microstrip patch antenna. Simulated antenna size has been reduced by 48.11% with an increased frequency ratio when compared to a Conventional microstrip patch antenna.*
Keywords— *Bandwidth, Compact, Patch, Resonant frequency, Slot*

I. INTRODUCTION

Modern wireless devices are required to provide a myriad of services, leading to increased Demands for microwave communications that support multiple applications. In addition to this multi-functionality, users expect compactness of their gadgets, in which the antennas and batteries are the most restrictive components that hinder the accomplishment of size requirements. In recent years demand, a small and light weight compact multi-resonant microstrip antenna which supports the high mobility, necessity for a wireless telecommunication device and for high resolution mapping, for radar communication [1-6]. Due to many reasons, mainly because there are various wireless communication systems and many telecommunication operators using various frequencies, multiband characteristic is more desirable than having one antenna for each frequency band. Most effective technique is cutting slot in proper position on the microstrip patch. In this paper includes cutting two different slots on which the first one is the combinations of two triangular and another rectangular slot at the upper right corner and rest is bilateral triangle at the lower left corner from the conventional microstrip patch antenna, to increase the return loss and gain-bandwidth performance of the simulated antenna (Fig 2). To reduce the size of the antenna substrates are chosen with higher value of dielectric constant [7-10]. Our aim is to reduce the size of the antenna as well as increase the operating bandwidth. The proposed antenna (substrate with ε_r = 4.4) has a gain of 3.98 dBi and presents a size reduction of 48.11% when compared to a conventional microstrip patch (10mm X 6mm). The simulation has been carried out by IE3D [11] software which uses the MOM method. Due to the small size, low cost and low weight this antenna is a good entrant for the application of X-Band microwave communication and Ku-Band RADAR communication.

The X band and Ku-Band defined by an IEEE standard for radio waves and radar engineering with frequencies that ranges from 8.0 to 12.0 GHz and 12.0 to 18.0 GHz respectively. The X band is used for short range tracking, missile guidance, marine, radar and airbone intercept. Especially it is used for radar communication ranges roughly from 8.29 GHz to 11.4 GHz. The Ku band is used for high resolution mapping and satellite altimetry. Especially, Ku Band is used for tracking the satellite within the ranges roughly from 12.87 GHz to 14.43 GHz.

II. ANTENNA DESIGN

The configuration of the conventional printed antenna is shown in Figure 1 with L=6 mm, W=10 mm, substrate (PTFE) thickness h = 1.6 mm, dielectric constant ε_r = 4.4. Coaxial probe-feed (radius=0.5mm) is located at W/2 and L/3. Assuming practical patch width W= 10 mm for efficient radiation and using the equation [6],

$$f_r = \frac{c}{2W} \times \sqrt{\frac{2}{(1+\varepsilon_r)}} \qquad \text{..... (1)}$$

Where, c = velocity of light in free space. Using the following equation [9] we determined the practical length L (=6mm).

$$L = L_{eff} - 2\Delta L \qquad \text{..... (2)}$$

where, $\frac{\Delta L}{h} = \left[0.412 \times \frac{(\varepsilon_{reff} + 0.3)\times(W/h + 0.264)}{(\varepsilon_{reff} - 0.258)\times(W/h + 0.8)}\right]$ ..... (3)

$$\varepsilon_{reff} = \left[\left(\frac{\varepsilon_r + 1}{2}\right) + \frac{\varepsilon_r - 1}{\left(2\times\sqrt{\left(1 + 12\times\frac{h}{W}\right)}\right)}\right] \quad ..... (4)$$

And $L_{eff} = \left[\frac{c}{2 \times f_r \times \sqrt{\epsilon_{eff}}}\right]$ .....(5)

Where, L_{eff} = Effective length of the patch, $\Delta L/h$ =Normalized extension of the patch length, ε_{reff} = Effective Dielectric constant.

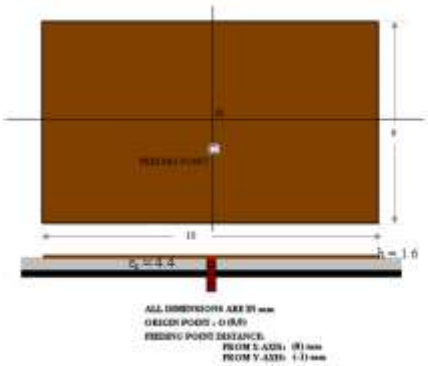

Figure 1: Conventional Antenna configuration

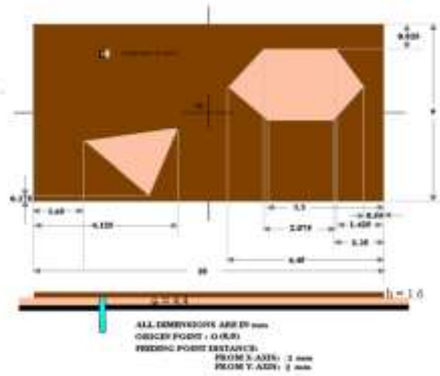

Figure 2: Simulated Antenna configuration

Figure 2 shows the configuration of simulated printed antenna designed with similar PTFE substrate. Cutting two different slots on which the first one is the combinations of two triangular and another rectangular slot at the upper right corner and rest is bilateral triangle at the lower left corner and the location of coaxial probe-feed (radius=0.5 mm) are shown in the figure 2.

III. RESULTS AND DISCUSSION

Simulated (using IE3D [11]) results of return loss in conventional and simulated antenna structures are shown in Figure 3-4. A significant improvement of frequency reduction is achieved in simulated antenna with respect to the conventional antenna structure.

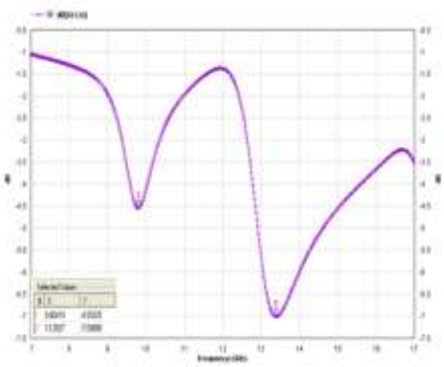

Figure 3: Return Loss vs. Frequency (Conventional Antenna)

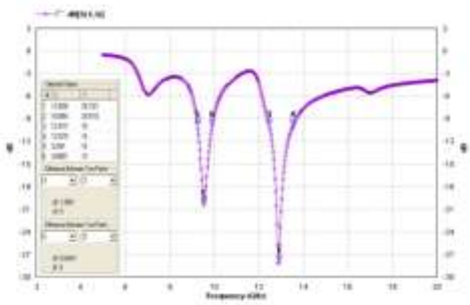

Figure 4: Return Loss vs. Frequency (Slotted Antenna)

In the conventional antenna return loss of about -7.01 dB is obtained at 13.39 GHz. Comparing fig.3 and fig.4 it may be observed that for the conventional antenna (fig.3), there is practically no resonant frequency at around 9.54 GHz with a return loss of around -6 dB. For the simulated antenna there is a resonant frequency at around 9.54 GHz where the return loss is as high as -20.51 dB.

Due to the presence of slots in simulated antenna resonant frequency operation is obtained with large values of frequency ratio. The first and second resonant frequency is obtained at f_1= 9.54 GHz with return loss of about -20.51 dB and at f_2 = 12.90 GHz with return losses -28.13 dB respectively.
Corresponding 10dB band width obtained for Antenna 2 at f1, f2 are 642.41 MHz and 1.05 GHz respectively. The simulated E plane and H-plane radiation patterns are shown in fig 5-12. The simulated 2D E plane radiation pattern of simulated antenna for 9.54GHz is shown in figure 5.

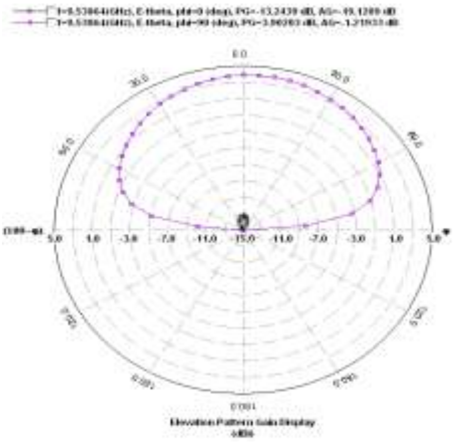

Figure 5: E-Plane (2D View) Radiation Pattern for slotted Antenna at9.54 GHz

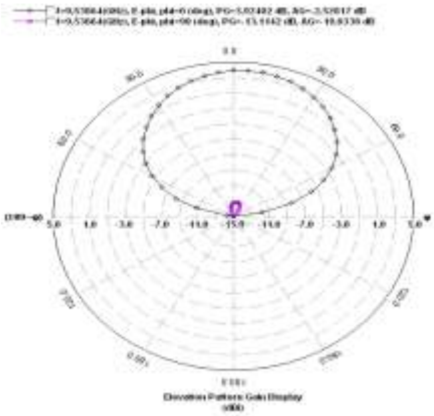

Figure 6: H-Plane (2D View) diation Pattern for slotted Antenna at 9.54 GHz

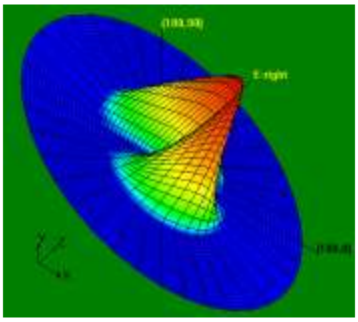

Figure 7: E-Plane (3D View) Radiation Pattern for slotted antenna at 9.54 GHz

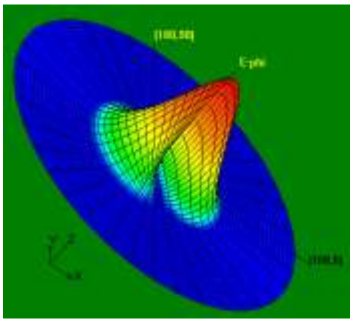

Figure 8: H-Plane (3D View) Radiation Pattern for slotted antenna at 9.54GHz

The simulated 2D H plane radiation pattern of simulated antenna for 9.54 GHz is shown in fig 6. The simulated E plane radiation pattern (3D-view) of Slotted Antenna for 9.54 GHz is shown in fig 7. The simulated H plane radiation pattern (3D-view) of Slotted Antenna for 9.54 GHz is shown in figure 8.

The simulated E plane radiation pattern of slotted antenna for 12.90 GHz is shown in figure 9. The simulated H plane radiation pattern of slotted antenna for 12.90 GHz is shown in fig10.

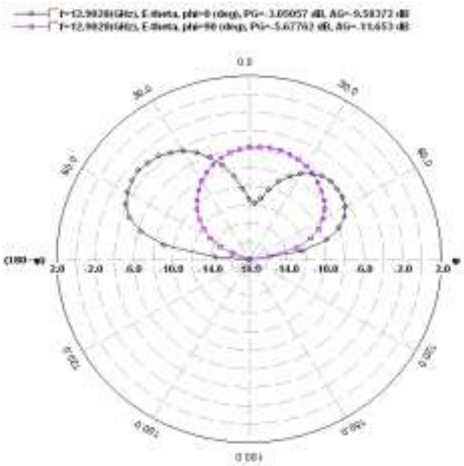

Figure 9: E-Plane (2D View) Radiation Pattern for slotted antenna at 12.90 GHz

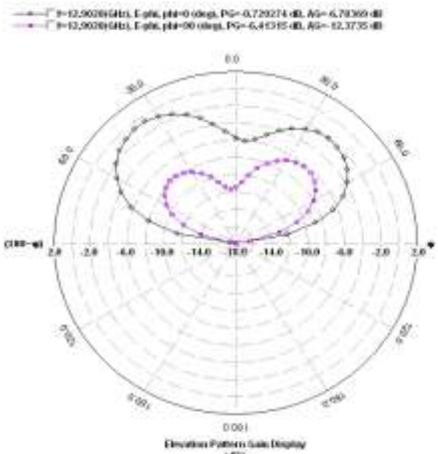

Figure 10: H-Plane (2D View) Radiation Pattern for slotted antenna at 12.90 GHz

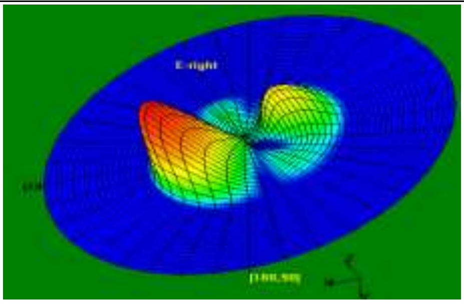

Figure 11: E-Plane (3D View) Radiation Pattern for slotted antenna at 12.90 GHz

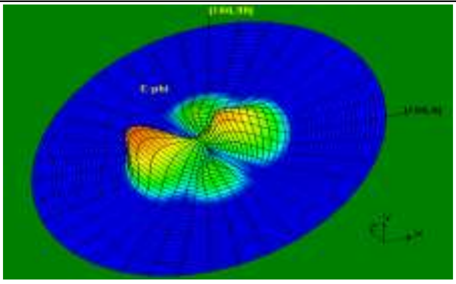

Figure 12: H-Plane (3D) Radiation Pattern for slotted antenna at 12.90 GHz

The simulated E plane radiation pattern (3D-view) of Slotted Antenna for 12.90 GHz is shown in fig 11. The simulated H plane radiation pattern (3D-view) of Slotted Antenna for 12.90 GHz is shown in fig 12.

All the simulated results are summarized in the following Table1 and Table2.

TABLE I:
SIMULATED RESULTS FOR ANTENNA 1 AND 2

ANTENNA STRUCTURE	RESONANT FREQUENCY (GH_Z)	FREQUENCY RATIO	3 DB BEAM-WIDTH (^{0})	ABSOLUTE GAIN (DBI)
Conventional	f_1= 13.39		NA	NA
Slotted	f_1= 9.54	f_2/ f_1=1.352	165.47^0	3.980
	f_2= 12.90		144.27^0	1.140

TABLE II:
SIMULATED RESULTS FOR ANTENNA 1 AND 2

ANTENNA STRUCTURE	RESONANT FREQUENCY (GH_Z)	RETURN LOSS (DB)	10 DB BANDWIDTH (GH_Z)
Conventional	f_1= 13.39	-7.01	NA
Slotted	f_1= 9.54	-20.51	0.6424
	f_2= 12.90	-28.13	1.0541

IV. CONCLUSION

Theoretical investigations of the single layer single feed multi-resonant microstrip printed antennas have been carried out using Method of Moment based software IE3D. Introducing slots at the edge of the patch size reduction of about 48.11% has been achieved. The 3dB beam-width of the radiation pattern 165.47° (for f_1) and 144.27° (for f_2) which is sufficiently broad beam for the applications for which it is intended. The resonant frequency of slotted antenna presented in the paper for a particular location of feed point (-3 mm, 2 mm) considering the centre as the origin was quite large as is evident from table1. Alteration of the location of the feed point results in narrower 10dB bandwidth and less sharp resonances.

V. Acknowledgements

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