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Rhombus Shaped Reconfigurable Microstrip Antenna for wireless Applications

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Abstract—Rhombus Shaped Reconfigurable microstrip antenna is designed to operate at lower frequency i.e 1.74GHz. The Designed antenna increase Bandwidth as well reduction in size. Comparative analysis has made with reference to without and with capacitor as a lumped element. Design analysis and Simulation is carried out by using IE3D software and practical results are measured by Vector Network analyzer. The size reduction of Rhombus shaped Reconfigurable microstrip antenna gives best possible size reduction of 75.95% with overall bandwidth 86MHz.

Keywords—Reconfigurable microstrip antenna, wireless application, multiple frequencies

I. INTRODUCTION

Microstrip antennas [1] are the most rapidly developing field in the last twenty years. Currently these antennas have a large application in mobile radio systems, integrated antennas, satellite navigation receivers, satellite communications, direct broadcast radio and television, etc. The considerable interest in microstrip antennas is due to their advantages compared to conventional microwave antennas as a light weight, low volume, conformability, and ease of manufacture. One of the most serious disadvantages of microstrip antennas is their limited bandwidth.

Microstrip antenna (MSA) [2] has several advantages compared to the conventional microwave antennas. Some of advantages of Microstrip antennas discussed by [3] are listed as follows:

- Light weight and low volume.
- Low profile planar configuration which can be easily made conformal to host surface.
- Low fabrication cost, hence can be manufactured in large quantities.
- Supports both, linear as well as circular polarization.
- Can be easily integrated with microwave integrated circuits (MICs).
- Capable of dual and triple frequency operations.
- Mechanically robust when mounted on rigid surfaces.

However Microstrip antenna (MSAs) suffer from many disadvantages compared to conventional antennas. Some of them are as follows:

- Narrow bandwidth
- Quite large size for lower microwave frequencies
- Low efficiency
- Low Gain
- Extraneous radiation from feeds and junctions
- Poor end fire radiator except tapered slot antennas
- Low power handling capacity

However, there are ways of substantially diminishing the effects of these disadvantages. The techniques to overcome the first two limitations are discussed extensively in this paper. The limitation of MSA can overcome by using a Reconfigurable concept with microstrip antenna.

Reconfigurable antenna has a significant Potential in the modern wireless communication. This is as a result of the reduction in antenna size and cost, and convenience for certain applications to operate with a single antenna than multiple Antennas [5].Moreover, these reconfigurable antennas have interesting characteristics as they can provide various features in different operating frequencies [6]-[7], polarizations [8], [9], and radiation patterns [10], [11] by changing the current distribution over the volume of the antennas.

II. ANTENNA DESIGN

Rhombus shaped Microstrip patch antenna are designed with three essential parameters are:
i) Frequency of operation (f_0): The resonant frequency of the antenna must be selected appropriately which is able to operate under desired frequency range. The frequency of operation in this design is 1.8GHz.
ii) Dielectric constant of the substrate (ε_r): The dielectric material selected for design is glass epoxy which has a dielectric constant 4.4.

iii) Height of dielectric substrate (h): For the Microstrip patch antenna to be used in cellular phones, it is connected that the antenna should not be bulky. Hence, the height of the dielectric substrate is selected as 1.6mm.

Design of Microstrip line feeding:

$\lambda o = \frac{C}{f}$ where f is the resonating frequency

Width of patch $W=\frac{C}{2fr}\left(\frac{\varepsilon r+1}{2}\right)^{-1/2}$; Effective length$\Delta L = 0.412h * \frac{(\varepsilon_e+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_e-0.258)\left(\frac{W}{h}+0.8\right)}$,

Where $\varepsilon_e=\frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{w}\right]^{-\frac{1}{2}}$; Length of Patch $L=\frac{c}{2f_r\sqrt{\varepsilon_e}}-2\Delta L$

Let Zo=50Ω ε_r=4.4 ; $\frac{W}{d}=\frac{8e^A}{e^A-2}$ for $\frac{W}{d}<2$,

Where $A=\frac{z}{60}\sqrt{(\varepsilon r+1)/2}+\frac{\varepsilon r-1}{\varepsilon r+1}\left(0.23+\frac{0.11}{\varepsilon r}\right)$;

$\frac{W}{d}=\frac{2}{\pi}\left[B-1-\ln(2B-1)+\frac{\varepsilon r-1}{2\varepsilon r}\left\{\ln(B-1)+0.39-\frac{0.6}{\varepsilon r}\right\}\right]$ for $\frac{W}{d}>2$, Where $B=\frac{377\pi}{2Zo\sqrt{\varepsilon_r}}$;

Let us assume w/d < 2

$R_{in}=\frac{(120\lambda o)^2+\left(\frac{377h}{L\sqrt{\varepsilon r}}\right)^2\tan^2\beta l}{240*l*\lambda_0(1+\tan^2\beta l)}$; where $l=\left(\frac{\theta}{\beta}\right)\left(\frac{\pi}{180}\right)$ $\beta=\frac{2\pi\sqrt{\varepsilon_r}}{\lambda_0}$; $\lambda_g=\frac{\lambda_0}{\sqrt{\varepsilon_e}}$; $L_f=\frac{\lambda_g}{4}$

The optimized geometry of proposed rhombic Microstrip antenna is as shown in Fig.1 The Rhombus shaped microstrip antenna whose size is of 41mm x 41mm is printed on a dielectric substrate of thickness 1.6mm. The material used in glass epoxy with dielectric permittivity of ε_r=4.4 which is designed to operate at 1.8GHz.This antenna is fed by microstrip line of dimension (L_f50,W_f50)=15mm,4.84mm through quarter wave transformer having (L_t50,W_t50)=24.05mm, 0.72mm. They are mounted on ground plane of dimension (106.225 x 77.182756) mm^2 through 50 ohm SMA connector. The rhombic shape of zeroth iteration is a conventional square. In zeroth iteration, this curve begins as a straight line imposed upon the sides of the square. Next,another square of side length each side of the square is removed. The antenna are initially simulated using IE3D software and all the parameters are optimized and they are as follows:

h=1.6mm, L=41.08mm, W=41.08mm, L_s=10.27mm, Ws=10.27mm, L_t=24.05mm, Wt=0.72mm, L_f=15mm, W_f=4.84mm.

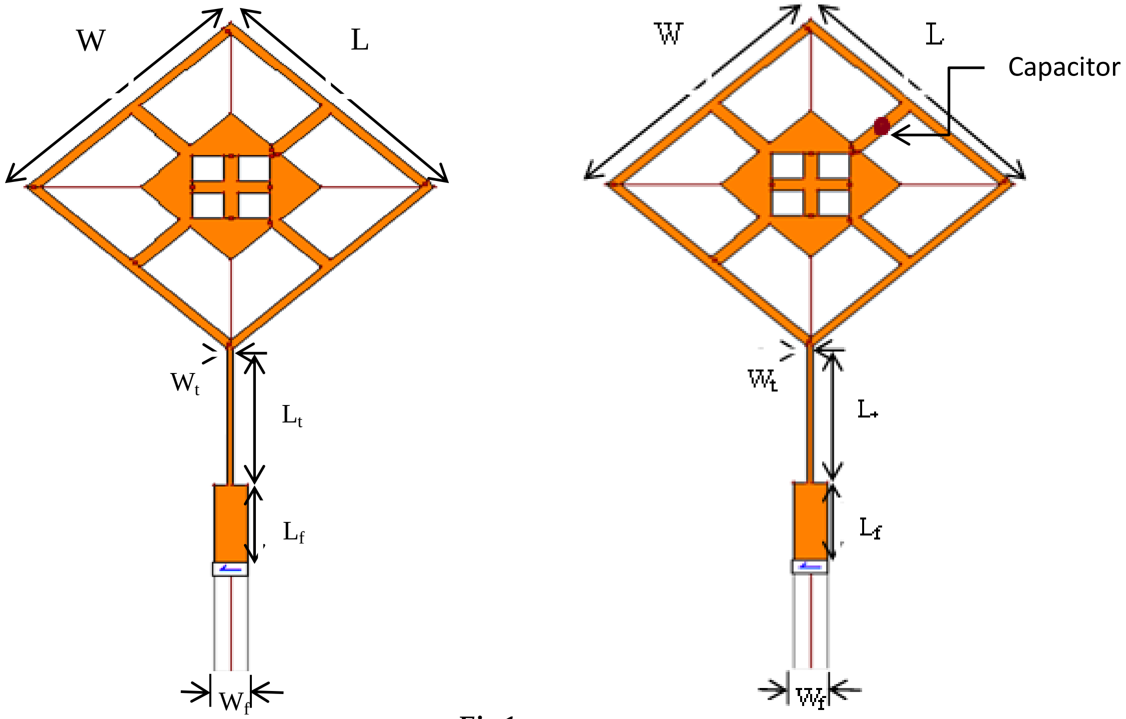

Fig 1

Photograph of antenna with top and bottom view is as shown in Fig.2 & Fig 3.

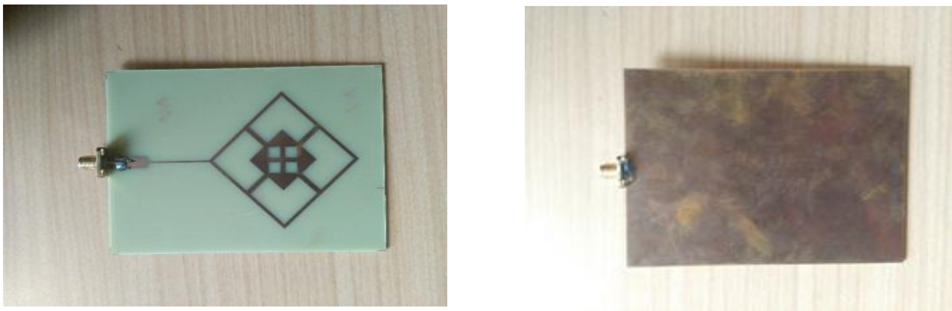

Fig 2 Front and back view of Rhombus shaped Microstrip antenna without capacitor

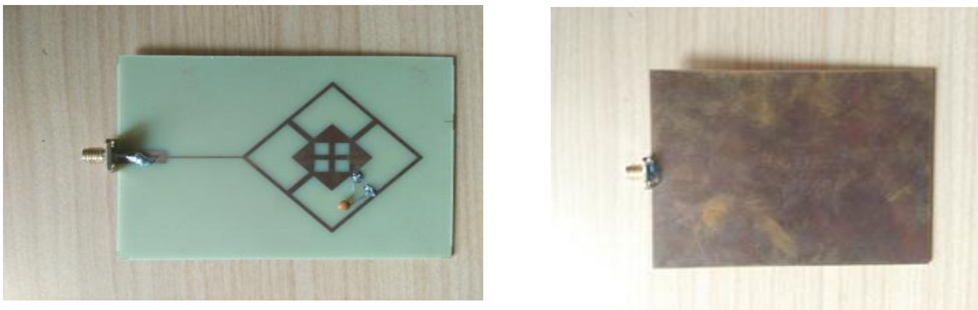

Fig 3 Front and back view of Rhombus shaped Reconfigurable Microstrip antenna with capacitor

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III. RESULT AND DISCUSSION

Simulation & Practical Results: Fig 4 & Fig 6 shows the simulated Return loss of Rhombus shaped Microstrip antenna without and with Capacitor & Fig 5 & Fig 7 shows the practical Return loss of Rhombus shaped Microstrip antenna without and with Capacitor

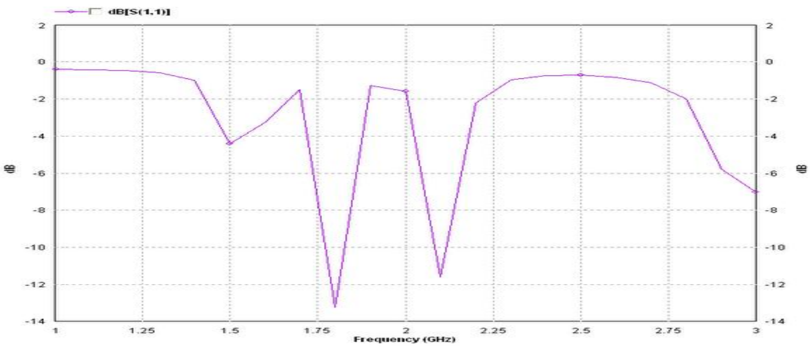

Fig 4 Return loss of Rhombus shaped Microstrip antenna without Capacitor

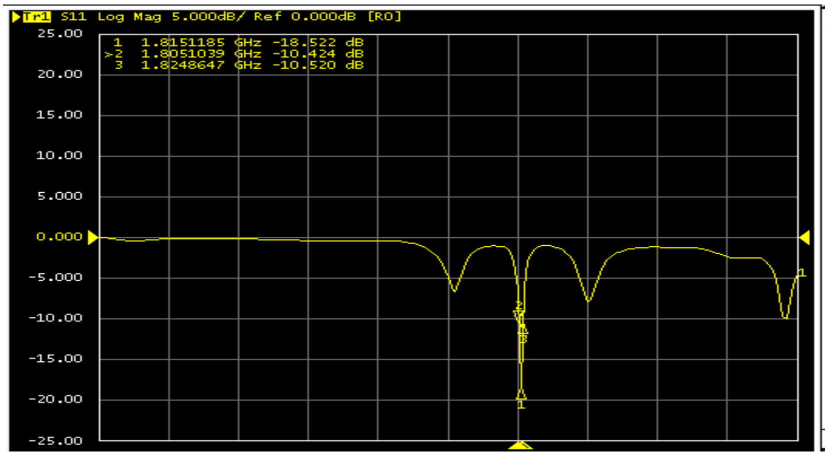

Fig 5 Practical return loss of Rhombus shaped Microstrip antenna

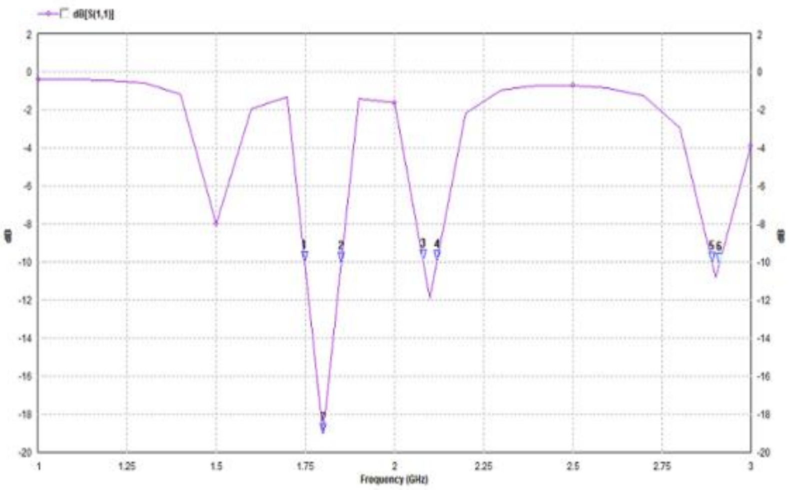

Fig 6 Return Loss of Reconfigurable shaped Microstrip antenna with capacitor

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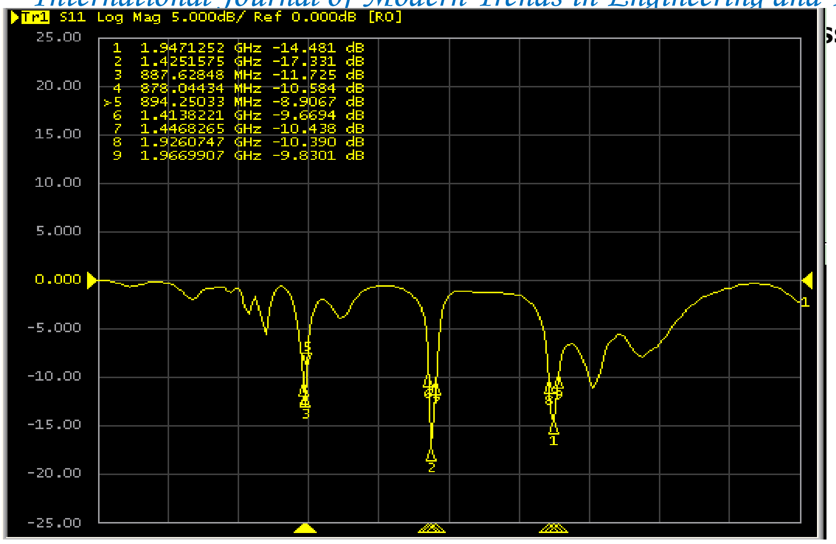

Fig 7 Practical return loss of Rhombus shaped Reconfigurable Microstrip antenna with capacitor

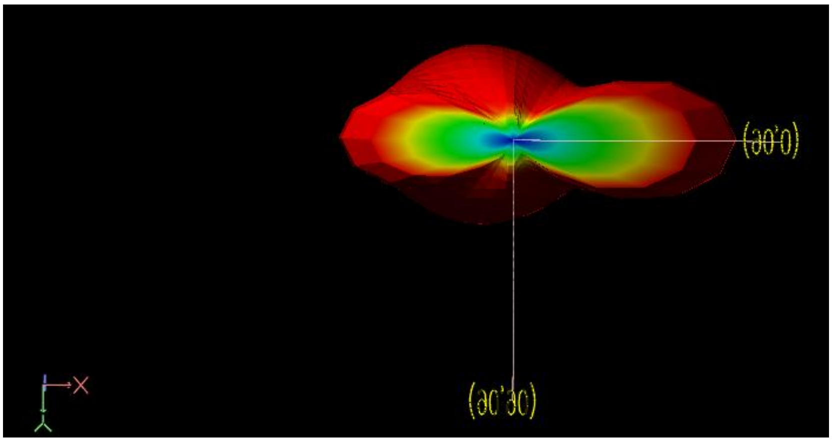

Fig 8 Radiation characterization

Sl No	Prototype Antenna	Resonant frequency f_r(GHz)		Return loss (db)		Bandwidth (MHz)		Over all Bandwidth (MHz)	
		Sim	Pract	Sim	Pract	Sim	Pract	Sim	Pract
1	Structured Antenna without Capacitor	1.8	1.81	-13.1	-18	60	20	66	20
		2.154	2.8	-11.8	-10	6	0		
2	Structured Antenna with Capacitor	1.8	0.89	-11	-11	30	16	160	86
		2.09	1.42	-12	-17.33	40	30		
		2.89	1.94	-19	-14.48	90	40		

Table 1: Results of the proposed antenna

Instrument used to measure various parameter like Return loss using vector network analyzer as shown in fig 9.

Fig 9 Vector Network Analyzer

IV. CONCLUSION

Rhombus Shaped Reconfigurable microstrip antenna gives a best size reduction of 75.95% with reference to without and with capacitor as a lumped element and its equivalent bandwidth obtained are 20MHz and 86MHz respectively.

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