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RHOMBUS SHAPED RECONFIGURABLE MICROSTRIP ANTENNA FOR CDMA WIRELESS APPLICATIONS

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Abstract

Rhombus Shaped Reconfigurable microstrip antenna is designed to operate at 1.74GHz. The proposed antenna is a Rhombus shaped microstrip antenna which gives a good size reduction with good impedance bandwidth in terms of with and without capacitor. The Designed antenna is expected to reduction in size and increase in Bandwidth. The Simulation is carried out by using IE3D software and practical results are measured by Vector Network analyzer. Comparative analysis has made between with and without capacitor as a lumped element. The size reduction of Rhombus shaped Reconfigurable microstrip antenna with capacitor gives best possible size reduction of 75.95% with overall bandwidth 86MHz. Acceptable agreement is obtained between the simulated and measured antenna performance parameter.

Keywords:

Reconfigurable Microstrip Antenna, Wireless Application, Bandwidth, Reduced Size

1. 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 lightweight, 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 (MSA) suffers 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 [4]-[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.

2. LITERATURE REVIEW

T.A. Denidni and N. Hassaine [12] reported that antenna operates at the frequency band from 4.8GHz to 6.0GHz. M.R. Tayfeh Aligodaz and K. Forooraghi [13] reported that antenna can attain 72% size reduction as well as 17% impedance bandwidth. M. Ali and R. Dougal [14] reported that the antenna is designed to function in the 5GHz to 6GHz wireless band. N. Ramali and M.T. Ali [5] reported that antenna operates at the frequency band from 2.6GHz to 3.5GHz.

From the above literature review it found that most of work is carried on higher frequency band, so our designed antenna is to operate at lower frequency band and reduces its size by introducing a lumped element as capacitor.

3. 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.

3.1 DESIGN OF MICROSTRIP LINE FEEDING

The microstrip antenna is designed by using the following formula,

$$\lambda_0 = \frac{c}{f} \tag{1}$$

where, f is the resonating frequency.

Width of patch,

$$W = \frac{c}{2f_r}\left(\frac{\varepsilon_r + 1}{2}\right)^{-\frac{1}{2}} \tag{2}$$

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,

$$L = \frac{c}{2f_r\sqrt{\varepsilon_e}} - 2\Delta L \tag{3}$$

Let, Z_o = 50Ω, ε_r = 4.4; ε_r=4.4;

$$\frac{W}{d} = \frac{8e^A}{e^A - 2} \text{ for } \frac{W}{d} < 2 \tag{4}$$

where, $A = \frac{Z}{60}\sqrt{(\varepsilon_r + 1)/2} + \frac{\varepsilon_r - 1}{\varepsilon_r + 1}\left(0.23 + \frac{0.11}{\varepsilon_r}\right)$;

$$\frac{W}{d} = \frac{2}{n}\left[B - 1 - \ln(2B - 1) + \frac{\varepsilon_r - 1}{2\varepsilon_r}\left\{\ln(B - 1) + 0.39 - \frac{0.6}{\varepsilon_r}\right\}\right]$$

for $\frac{W}{d} > 2$, where $B = \frac{377\pi}{2Z_o\sqrt{\varepsilon_r}}$;

Let us assume $\frac{W}{d} > 2$,

$$R_{in} = \frac{(120\lambda_o)^2 + \left(\frac{377h}{L\sqrt{\varepsilon_r}}\right)^2 \tan^2 \beta l}{240 * l * \lambda_o\left(1 + \tan^2 \beta l\right)}$$

where, $l = \left(\frac{\theta}{\beta}\right)\left(\frac{\pi}{180}\right)$ $\beta = \frac{2\pi\sqrt{\varepsilon_r}}{\lambda_o}$; $\lambda_g = \frac{\lambda_o}{\sqrt{\varepsilon_e}}$; $L_f = \frac{\lambda_g}{4}$

The optimized geometry of proposed rhombic microstrip antenna is as shown in Fig.1. The Rhombus shaped microstrip antenna whose size is of 41mm × 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 × 77.182756)mm^2 through 50Ω 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 antennas 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; W_s = 10.27mm; L_t = 24.05mm;

W_t = 0.72mm; L_f = 15mm; W_f = 4.84mm

Capacitor used is 0.1μF.

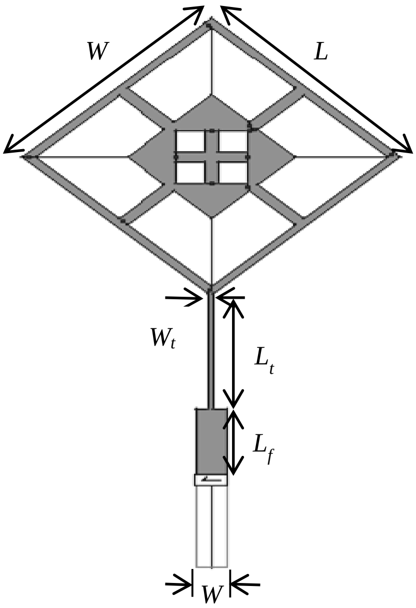

Fig.1. Rhombus shaped microstrip antenna

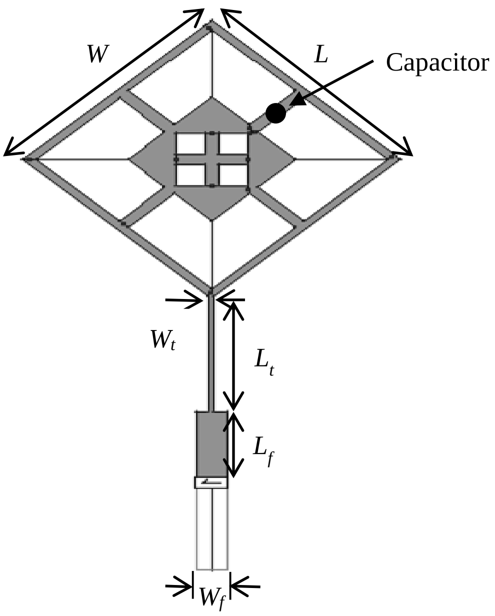

Fig.2. Rhombus shaped Reconfigurable microstrip antenna

Photograph of antenna with top and bottom view is as shown in Fig.3 and Fig.4.

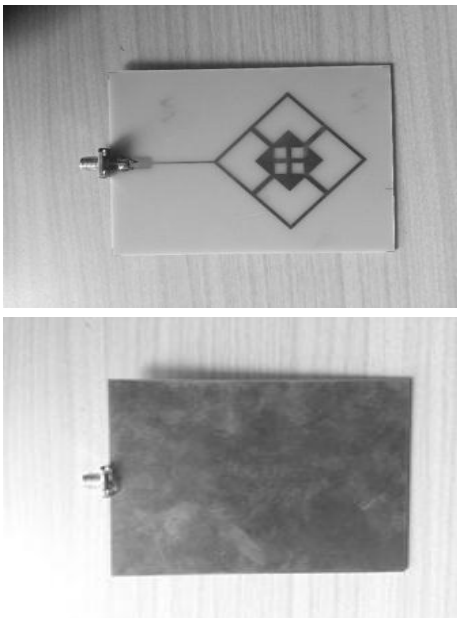

Fig.3. Front and back view of Rhombus shaped microstrip antenna without capacitor

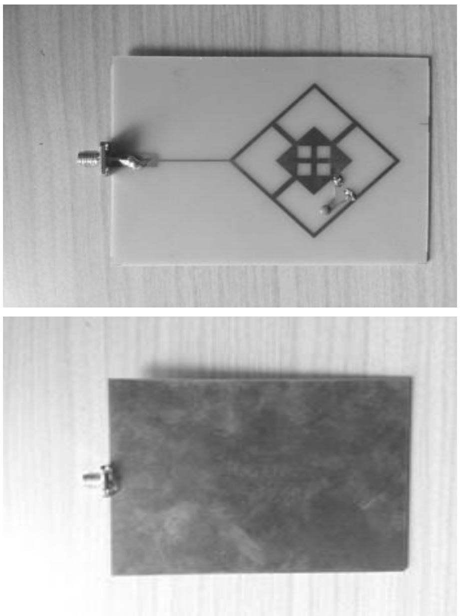

Fig.4. Front and back view of Rhombus shaped microstrip antenna with capacitor

4. RESULTS

The Fig.5 and Fig.7 show the simulated Return loss of Rhombus shaped microstrip antenna without and with capacitor. The Fig.6 and Fig.8 show the practical Return loss of Rhombus shaped microstrip antenna without and with capacitor.

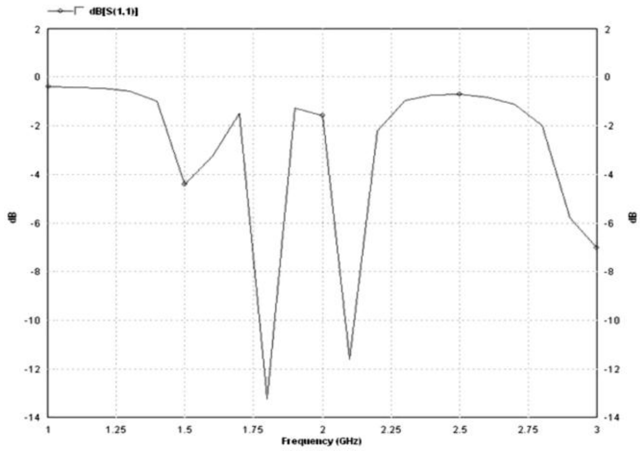

Fig.5. Return loss of Rhombus shaped microstrip antenna without capacitor

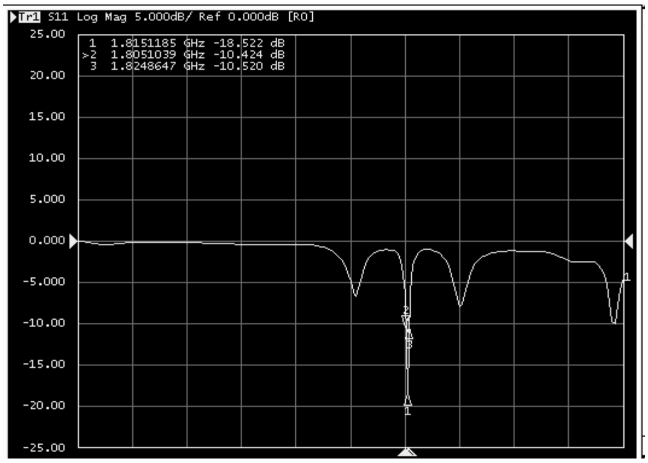

Fig.6. Practical Return loss of Rhombus shaped microstrip antenna

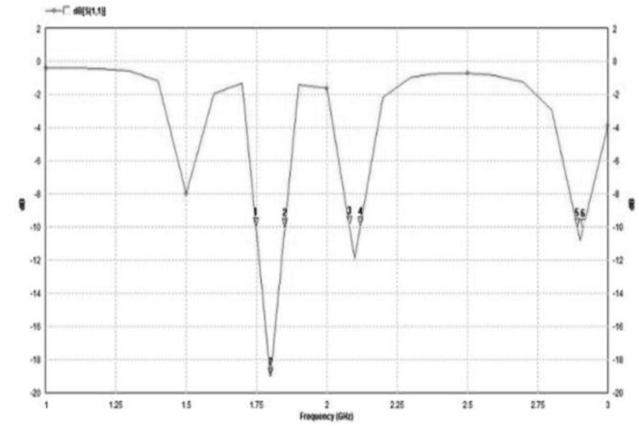

Fig.7. Return Loss of Reconfigurable shaped microstrip antenna with capacitor

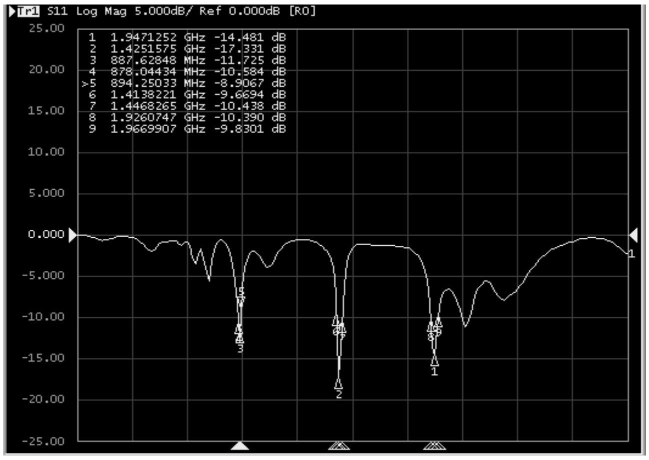

Fig.8. Practical Return Loss of Reconfigurable shaped microstrip antenna with capacitor

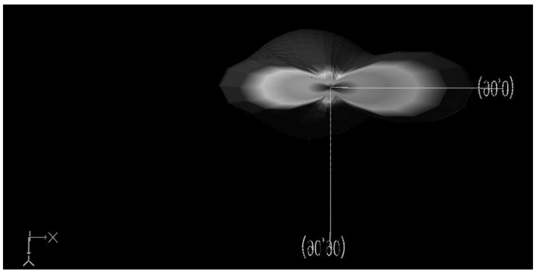

Fig.9. Radiation characterization

Table.1. Results of the proposed antenna

Sl. No.	Prototype Antenna	Resonant Frequency f_r(GHz)		Return Loss (dB)		Bandwidth (MHz)		Overall Bandwidth (MHz)	
		Sim.	Pract.	Sim.	Pract.	Sim.	Pract.	Sim.	Pract.
1	Structured Antenna without capacitor	1.8	1.8	-13.1	-18	60	20	66	20
		2.1	2.8	-11.8	-10	6	0		
2	Structured Antenna with capacitor	1.8	0.89	-11	-11	30	16	160	86
		2.09	1.4	-12	-17.3	40	30		
		2.89	1.9	-19	-14.4	90	40		

Instrument used to measure the practical return loss using vector network analyzer as shown in Fig.10.

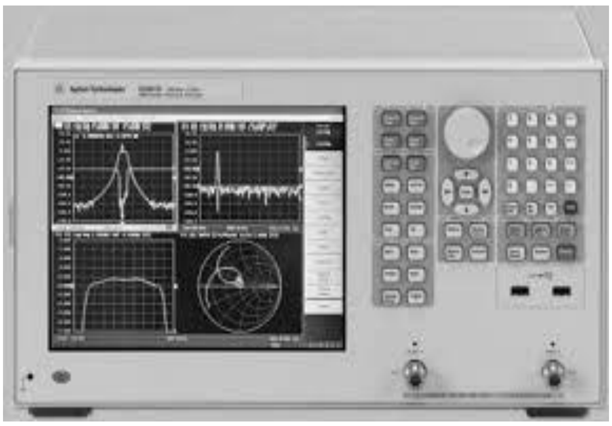

Fig.10. Vector Network Analyzer

5. CONCLUSION

Rhombus Shaped Reconfigurable microstrip antenna is designed by using a lumped element as capacitor it gives a best size reduction of 75.95% with reference to without capacitor. Overall bandwidth of 20MHz for rhombus shaped antenna without capacitor and overall bandwidth of 86MHz for rhombus shaped antenna with capacitor respectively. The overall bandwidth of rhombus shaped antenna with capacitor is 4.3 times more than the overall bandwidth of rhombus shaped antenna without capacitor. The antenna performance is suitable for handheld devices which covering the wireless communication band i.e. full coverage of CDMA application and partial coverage of DCS application.

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