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DESIGN OF RING COUPLED MICROSTRIP ANTENNA WITH U-SHAPED SLOT

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Abstract: This paper discusses the design of a ring coupled rectangular microstrip patch antenna at a design frequency of 2 GHz for wireless applications. Additionally, the effect of U-shaped slot on ring and Centre path is also studied. The microstrip patch antenna is excited using strip line feeding method. The antenna is mounted on a FR-4 glass epoxy substrate. The antennas are designed and simulated using Mentor Graphics IE3D simulation software. The antennas have been fabricated and the measured results agree with the simulated results. Highest bandwidth and sizable virtual size reduction of 12.54 and 20.53 % are obtained.

***Index Terms* - bandwidth, center patch, microstrip patch antenna, ring coupled, u slot, center patch**

I. INTRODUCTION

An antenna is defined as an electrical device used to transmit and receive electromagnetic waves. Thus antenna is regarded as a transition between free space and the system used for launching electromagnetic waves [1]. Antenna can be employed as transmitting or receiving antenna. It has directional properties. It is considered as an important component of wireless communication system [2]. Among various types of antennas microstrip antennas are finding more place in research and development, communication systems etc. Microstrip patch antennas are also called as printed antennas because they can be printed directly on a circuit board [3].

The concept of radiation Microstrip resonators was proposed about three decades ago. Since then, tremendous research and development has taken place which resulted into diverse range of applications [4]. With the increase in the role of microstrip patch antennas in various fields of science and technology, these antennas have become one of the most sought-after antennas [5]. Microstrip antennas have become the serious field of research because of their advantages like - light weight, planar structure, ease of fabrication and ease of integration with other devices [6-7]. One of the major limitations of microstrip patch antennas is they have narrow bandwidth. To enhance the impedance bandwidth of microstrip antenna slot loading technique, aperture coupled feeding technique [8] find excellent results.

A microstrip patch antenna basically consists of a sandwich of two parallel conducting layers separated by a single dielectric substrate. The patch conductors are normally of gold or copper. The lower conductor functions as a ground plane and the upper conductor is a simple patch of any desired shape [9-10]. The substrates whose dielectric constant lies between 2.2 and 12 are used for microstrip antennas. The numerous advantages associated with microstrip antennas has resulted into establishing the microstrip antenna as a separate entity in the broad field of microwave antennas. The invention of microstrip antenna is certainly a windfall to the antenna designers [11].

The rest of the paper has been organized as follows: Following microstrip patch antennas were designed to study the bandwidth and virtual size reduction of proposed antennas. Designing the conventional rectangular microstrip antenna (CRMA), proposed ring coupled rectangular microstrip antenna (PRCRMA), proposed ring coupled rectangular microstrip antenna with U-slot on ring (PRCRMAUR) and proposed ring coupled rectangular microstrip antenna with U-slot on center patch (PRCRMAUP) has been explained in Section 2. Section 3 discusses the simulated and measured results obtained through the study. Concluding remarks are given in Section 4, acknowledgement is presented in section 5 and the paper ends with references.

II. DESIGN OF MICROSTRIP ANTENNAS

The design of conventional rectangular microstrip antenna (CRMA) is carried out at the frequency of 2 GHz. The dimensions of the radiating patch are 46.5 mm × 36.2 mm. The dielectric substrate employed to design the microstrip antennas is FR-4 glass epoxy which has dielectric constant of 4.2 and loss tangent of 0.0245 respectively. The height of the substrate is 1.6mm. Fig. 1 depicts the schematic of CRMA. Table 1.1 shows the dimensions and values of different parts of CRMA.

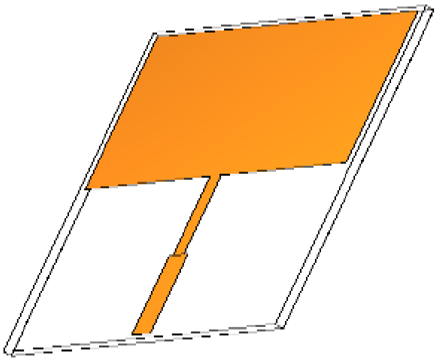

Fig. 1 Schematic of CRMA.

Table 1.1 Dimensions and values of CRMA.

Dimension	Value (mm)
Length of the patch	46.5
Width of the patch	36.2
Length of the feed	18.8
Width of the feed	3.32
Length of the quarter wave transformer	18.8
Width of the quarter wave transformer	1.278

CRMA is modified to design proposed ring coupled rectangular microstrip antenna (PRCRMA). The schematic of PRCRMA is depicted in Fig. 2.

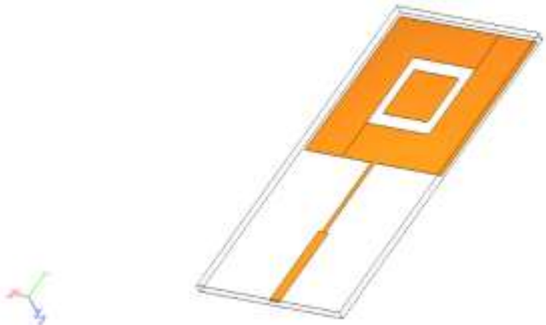

Fig. 2 Schematic of PRCRMA.

The length and width of the outer ring of PRCRMA are equal to 21.11 mm and 17.41 mm respectively. The length and width of the inner ring are equal to 15.21 and 11.41 mm respectively. The other dimensions of PRCRMA are same as that of CRMA.
PRCRMA is modified to design proposed ring coupled rectangular microstrip antenna with U-slot on centre patch (PRCRMAUP). The schematic of PRCRMAUP is shown in Fig. 3.

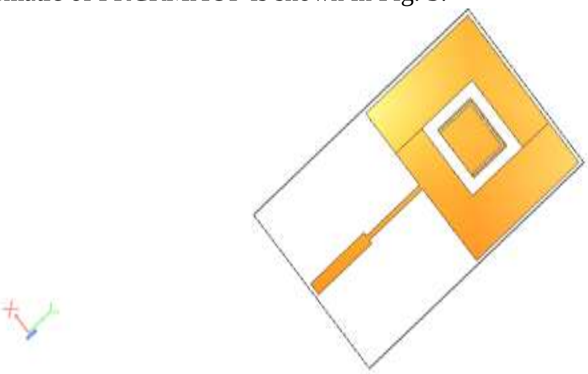

Fig. 3 Schematic of PRCRMAUP

The length and width of the left part and right part of the U-slot inside the ring of PRCRMAUP are 10.41 mm and 0.5 mm respectively. The dimensions of the centre part of the U-slot are 14.21 mm × 0.5 mm. The other dimensions of PRCRMAUP are same as that of PRCRMA and CRMA.

PRCRMAUP is modified to design proposed ring coupled rectangular microstrip antenna with U-slot on ring (PRCRMAUR). The schematic of PRCRMAUR is shown in Fig. 4.

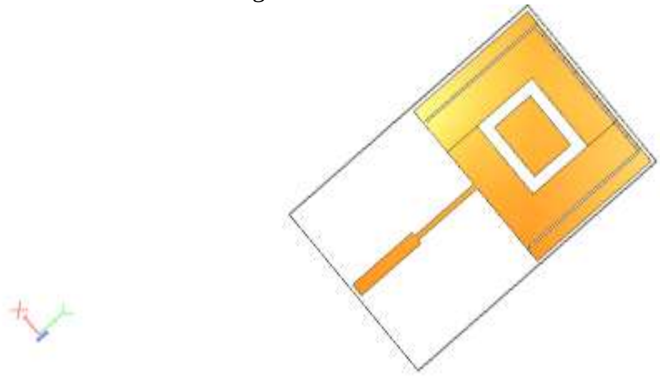

Fig. 4 Schematic of PRCRMAUR

The length and width of the left and right parts of the U-slot outside the ring of PRCRMAUR are equal to 35.2 mm and 0.5 mm respectively. The dimensions of the centre part of the U-slot are 45.2 mm × 0.5 mm. The left and right parts of the U-slot are at a distance of 3.5mm from the sides of the rectangular patch. The other dimensions of the PRCRMAUR are same as that of PRCRMAUP, PRCRMA and CRMA.

The designed antennas are fabricated and the photos of fabricated antennas are depicted in Fig. 5.

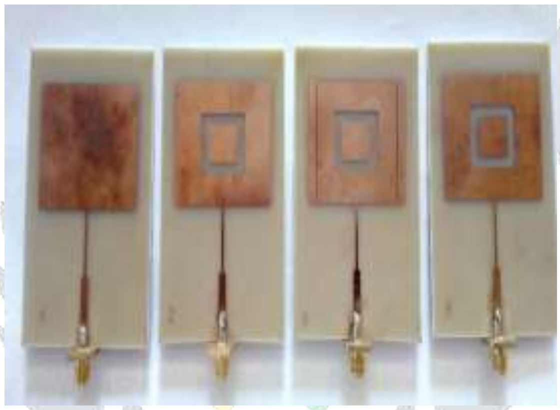

Fig. 5 Photos of fabricated antennas – CRMA, PRCRMA, PRCRMAUR and PRCRMAUP.

III. RESULTS AND DISCUSSIONS

The designed antennas are simulated using Mentor Graphics IE3D software. The simulated and measured return loss characteristics of CRMA, PRCRMA, PRCRMAUP and PRCRMAUR are depicted in Figs. 6, 7, 8 and 9. In the Figs. 6, 7, 8 and 9 the graph in red depicts the simulated results and the one in black depicts the measured results.

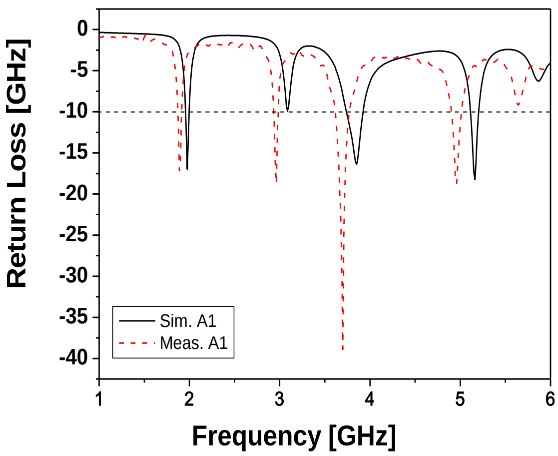

Fig. 6 Plot of return loss versus frequency of CRMA

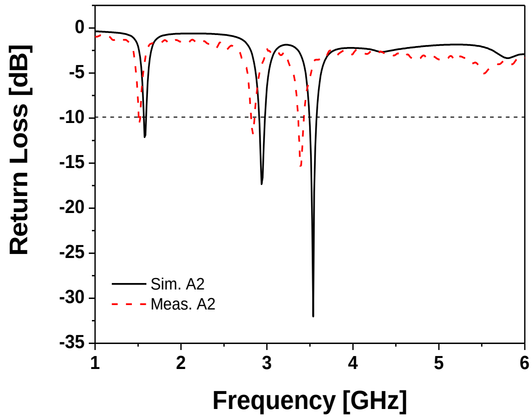

Fig. 7 Plot of return loss versus frequency of PRCRMA.

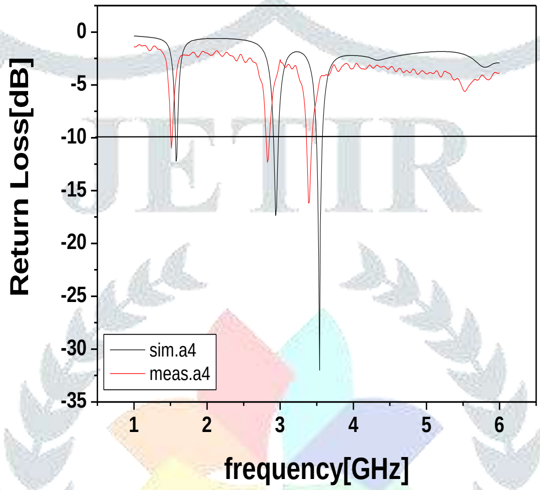

Fig. 8 Plot of return loss versus frequency of PRCRMAUP.

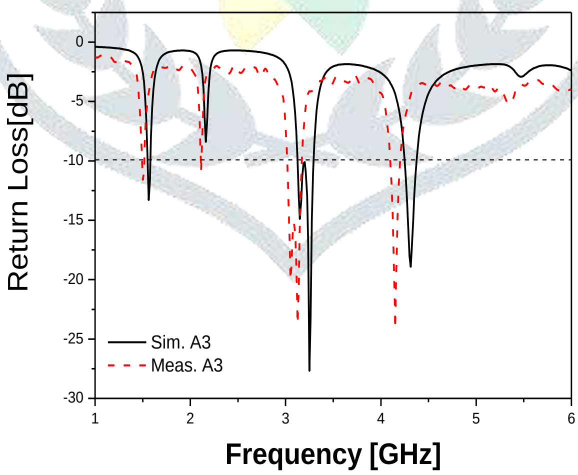

Fig. 9 Plot of return loss versus frequency of PRCRMAUR.

The performances of the four antennas are compared in terms of parameters – return loss, resonant frequency, bandwidth and virtual size reduction are studied. Resonant frequency is defined as the frequency where the antenna is producing least return loss in between the lower and upper frequencies where the return loss is equal to – 10 dB. The parameter bandwidth is determined by subtracting the lower frequency from the upper frequency where the return loss is equal to – 10 dB on either side of resonant frequency. Bandwidth (%) is calculated by using equation (1)

$$\frac{Bandwidth}{Resonant\ frequency} \times 100\% \qquad (1)$$

Among the four antennas, PRCRMAUR is producing highest measured bandwidth of 12.54 % compared to the other three antennas i.e. CRMA, PRCRMA and PRCRMAUP. The measured bandwidths produced by CRMA, PRCRMA and PRCRMAUP are equal to 4.22, 6.35 and 4.56 % respectively. The four antennas i.e. CRMA, PRCRMA, PRCRMAUP and PRCRMAUR are resonating at the measured fundamental frequencies of 1.88, 1.51, 1.51 and 1.5 GHz respectively. PRCRMAUR is producing the least resonant frequency compared to other three antennas. This contributes to virtual size reduction. Virtual size reduction (%) is calculated by using equation (2).

$$\left(\frac{f1-f2}{f1}\right)\times 100 \qquad (2)$$

In equation (2), f_1 and f_2 designate the fundamental resonant frequencies of conventional and proposed antennas. Hence the virtual size reductions produced by PRCRMA, PRCRMAUP and PRCRMAUR are equal to 19.89, 20.01 and 20.53 % respectively. Thus PRCRMAUR is producing the best virtual size reduction value of 20.53 %.

Tables 1.2 and 1.3 show the simulated and measured results of return loss, resonant frequency and bandwidth of CRMA, PRCRMA, PRCRMAUP and PRCRMAUR.

Table 1.2 Simulated results.

Antenna/ Parameter	**Resonant frequency (GHz)**	**Return loss (dB)**	**Bandwidt h (MHz)**	**Bandwidth (%)**
CRMA	1.976 2.98 3.64 4.9	-16.99 -18.11 -37.22 -19.33	48 22 70 60	4.11
PRCRMA	1.575 2.93 3.539	-12.18 -17.37 -32.16	52 92 110	9.53
PRCRMAUP	1.57 2.939 3.537	-12.08 -17.33 -31.95	32 77 91	7.21
PRCRMAUR	1.567 --- 3.248 4.31	-13.36 --- -27.72 -18.88	35 --- 180 136	10.92

Table 1.3 Measured results.

Antenna/Paramete r	**Resonant frequency (GHz)**	**Return loss (dB)**	**Bandwidth (MHz)**	**Bandwidth (%)**
CRMA	1.88 --- 3.92 5.1	-16.11 --- -17.11 -17.14	42 26 75 65	4.22
PRCRMA	1.512 2.83 3.39	-10.76 -11.74 -15.36	40 40 80	6.35
PRCRMAUP	1.51 2.82 3.38	-10.99 -12.30 -16.18	20 50 50	4.56
PRCRMAUR	1.5 2.11 3.05 4.15	-11.61 -10.95 -20.08 -24.12	40 30 170 120	12.54

Table 1.4 depicts the simulated and measured results of virtual size reduction of PRCRMA, PRCRMAUP and PRCRMAUR.

Table 1.4 Simulated and measured results

Antenna	Simulated (%)	Measured (%)
PRCRMA	19.97	19.89
PRCRMAUP	20.32	20.01
PRCRMAUR	20.77	20.53

The results clearly illustrate that PRCRMAUR is yielding the highest measured bandwidth of 12.54 % and best virtual size reduction of 20.53 % compared to other antennas. Hence PRCRMAUR is the best candidate compared to its opponents i.e. CRMA, PRCRMA and PRCRMAUP. The simulated and measured results of all the designed antennas are in good agreement.

IV. CONCLUSIONS

The antennas have been successfully designed, simulated and tested experimentally. With the introduction of U- slot on ring and patch has resulted in considerable decrease of resonant frequency of the microstrip antenna and subsequently causing virtual size reduction. Additionally, there is good improvement in bandwidth. The results obtained satisfy the requirements of wireless communications and the designed antennas can be employed in L band of microwave frequency region.

V. ACKNOWLEDGMENT

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