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Design and Development of Inverted U-Slot Rectangular Ring Coupled Monopole Microstrip Antenna for Quad Band Operation

Premavani[1], C. Kalpana[2], S. N. Mulgi[3]
[1]*Department of Electronics, Govt. First Grade College, Krishnarajapura, Bangalore, Karnataka, India*
[2]*Department of E and CE, BKIT, Bhalki, Karntataka, India*
[3]*Department of PG Studies and Research in Applied Electronics, Gulbarga University, Kalaburagi, Karnataka, India*

Abstract:** This paper present a novel design and development of inverted U-slot rectangular ring coupled monopole microstrip antenna (IURCMMA) for quad band operation. The monopole microstrip antennas are commonly designed for wide band operation. However, by placing the optimum ring slots in the form of slits on the radiating patch, the antenna can be made to operate at different frequency bands. The proposed antenna operates in the frequency range of 1.5 to 10 GHz with a peak gain of 8.69 dB and gives omni directional radiation pattern in both E and H planes. The measured and simulated results of return loss are in good agreement with each other. With these features the proposed antenna may find many applications at microwave frequency range.
***Keywords:** Monopole, Rectangular, Bandwidth, Quad band , Gain.*

I. INTRODUCTION

The microstrip antennas have become more popular in the recent years due their light weight, low cost, ease of fabrication, planar and compact.

These antennas are more useful at microwave frequency range usually 1 to 100 GHz. Many researchers have designed microstrip antennas for single, dual, triple and multiband operations at different microwave frequencies. Attempts are made to enhance bandwidth, gain, radiation efficiency etc [1-8]. Notch band microstrip antennas were also designed to avoid unwanted range of frequency in order to stop electromagnetic interference. The researchers have used different geometry, size, materials, techniques to achieve the desired parameters of an antnenna. In this paper a simple method has been used by placing optimum slots in the form of ring slits on the radiating patch, with this the antenna can be made to operate at different frequency bands. This type of study is found to be rare in the literature.

II. GEOMETRY OF IURCMMA

The top and side view geometry of IURCMMA is as shown in Fig 1. The antenna consists of a radiating patch of width Wp and length Lp. A rectangular ring of dimension W2 xL2 is placed at the center of the patch. An inverted U shape coupled ring slot is placed on the patch with a gap of 0.5mm as shown in the figure. The surround patch strip and inner patch acting as parasitic elements to the driven patch.

The antenna is fed using a single 50Ω microstripline feed which is connected to 50 Ω SMA connector for excitation. The length of feed is L_f and width is W_f. A partial copper ground plane of height Lg is placed below the microstrip line feed on the bottom layer of the substrate.

The gap between the partial ground plane and radiating patch is g. The antennas is fabricated on low cost glass epoxy dielectric substrate material with a thickness of h and size Ws x Ls having relative permittivity (εr) 4.2 and loss tangent (δ) 0.05. The antenna design model and dimensions have been optimized to achieve quad bands by using ANSYS HFSS simulation software. The optimized design dimensions of IURCMMA are given in Table 1. The photograph of fabricated antenna is as shown in Fig. 2.

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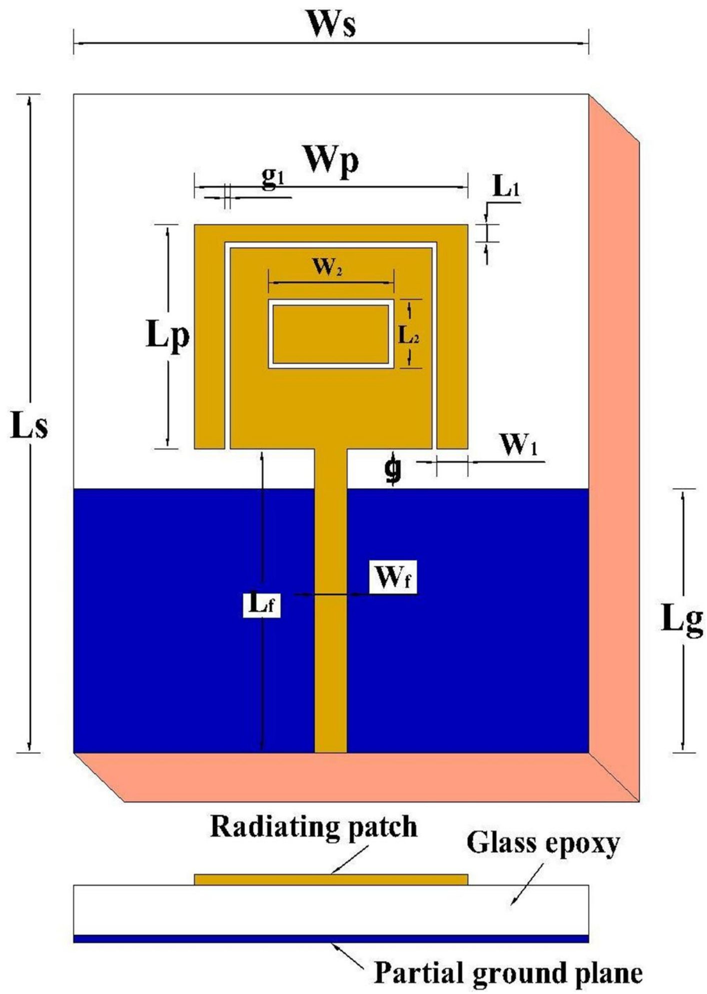
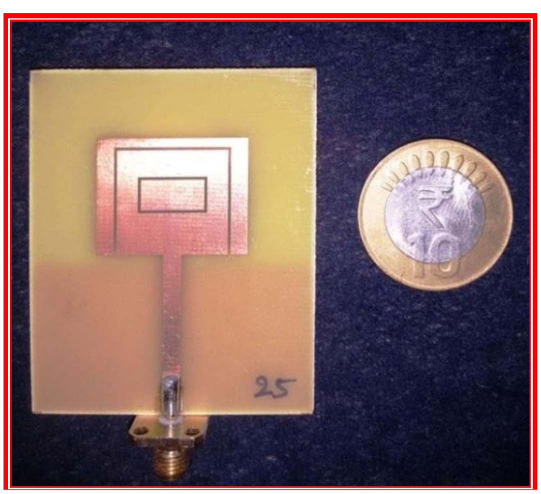
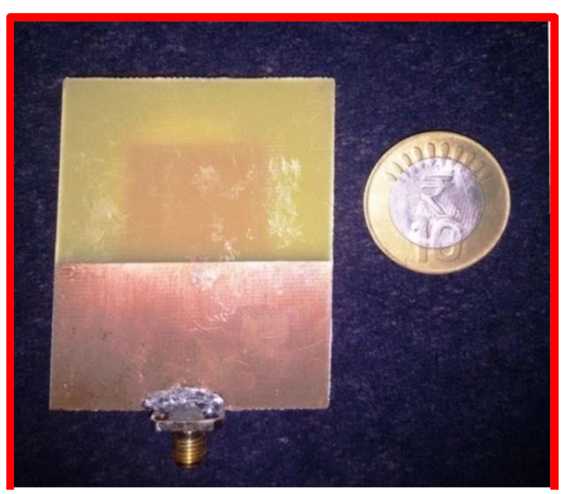


Fig. 1: Top view geometry of IURCMMA.



(a) Top view



(b) Bottom view

Fig. 2: Photograph of fabricated IURCMMA (a) Top view and (b) Bottom view.

Table 1: Optimized design dimensions of IURCMMA.

Antenna parameter	Dimensions (in mm)
Width of substrate (Ws)	50
Length of substrate (Ls)	60
Width of patch (Wp)	26.6
Length of patch (Lp)	20.4
Width of feed line(W_f)	3.2
Length of feed line(L_f)	27.7
Gap between the radiating patch and ground plane (g)	1.7
Substrate thickness (h)	1.6
Length of the ground plane (Lg)	26
Width W_1	3
Length L_1	1.6
Width W_2	11
Length L_2	5.3
Gap g_1	0.5

III. RESULTS AND DISCUSSIONS

The Fig 3 shows the variation of return loss versus frequency of IURCMMA. From this figure, it is observed that, the antenna resonates for four bands of frequencies found at fr_1 (2.49GHz), fr_2 (4.46GHz), fr_3 (6.62GHz) and at fr_4 (9.55GHz) having minimum return loss of -13.16dB, -30.08dB,-19.87dB and -14.02 dB respectively. The magnitude of bandwidth of each operating band is BW_1=35.91% (2.01GHz-2.89GHz), BW_2=18.43% (3.94GHz-4.74GHz), BW_3=7.77% (6.31Hz- 6.82GHz) and BW_4=6.25% (9.30GHz-9.90GHz) with a peak gain of 8.69dB found in its operating band. The experimental variation of return loss versus frequency graph of IURCMMA is in good agreement with simulated graph. The patch and coupled slots make the antenna resonate repetitively due to coupling effect.

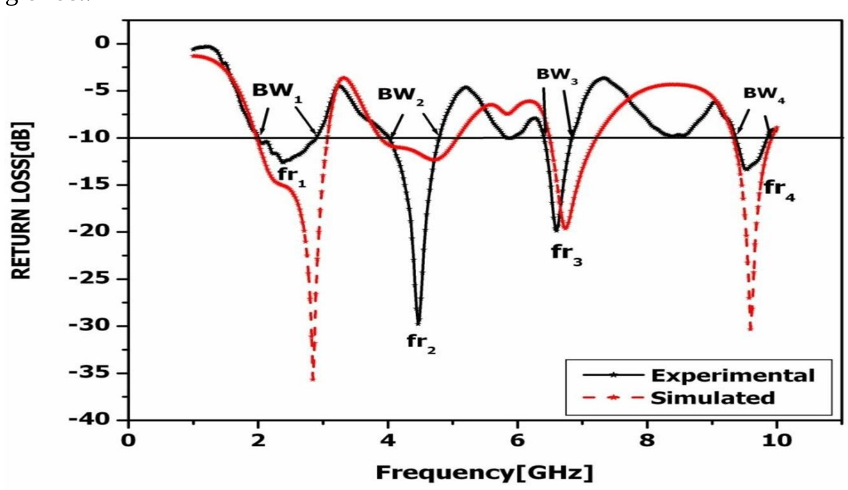


Fig. 3: Variation of return loss verses frequency plot of IURCMMA.

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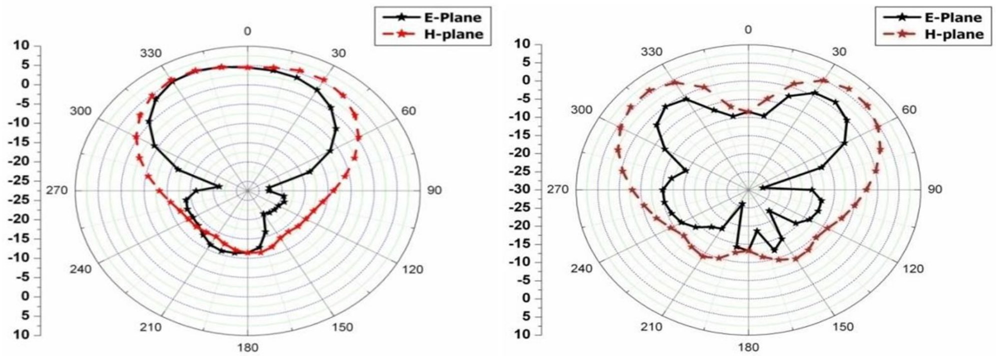
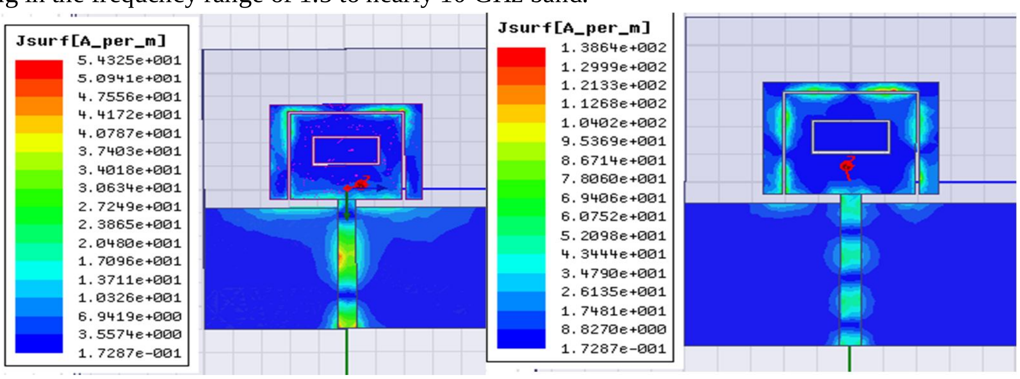
A typical 2D and 3D E and H-plane radiation patterns of IURCMMA measured at their resonant frequencies is as shown in Fig. 4. From this figure it is observed that, the radiation patterns are nearly omni directional in both E and H plane.



(a) (b)

Fig. 4: Typical 2D and 3D radiation pattern of IURCMMA measured at (a) 4.46 and (b) 6.62 GHz.

Figure 5 shows the simulated surface current distributions of IURCMMA measured at 4.46GHz and 6.62 GHz. From these figures it is seen that, the surface current distribution is observed towards the edge point of the microstrip line feed, at the gap, on the patch and current distribution is also observed at the ground plane surface of the antenna. The antenna may find different applications working in the frequency range of 1.5 to nearly 10 GHz band.



(a) (b)

Fig.5: Surface current distribution of IURCMMA measured at (a) 3.0 and (b) 6.13 GHz.

IV. CONCLUSION

From the detailed experimental and simulation study it is conclude that, the proposed antenna is quite capable for operating four band of frequency in the range of 1.5 to 10 GHz with a peak gain of 8.69 dB. In each operating band the antenna gives nearly omni directional radiation patterns in both E and H plane. The experimental and simulation results of return loss verses frequency is in good agreement with each other. The proposed antenna is simple in its structure and easy to fabricate and use low cost substrate material. With these features the proposed antenna may find many applications at microwave frequencies.

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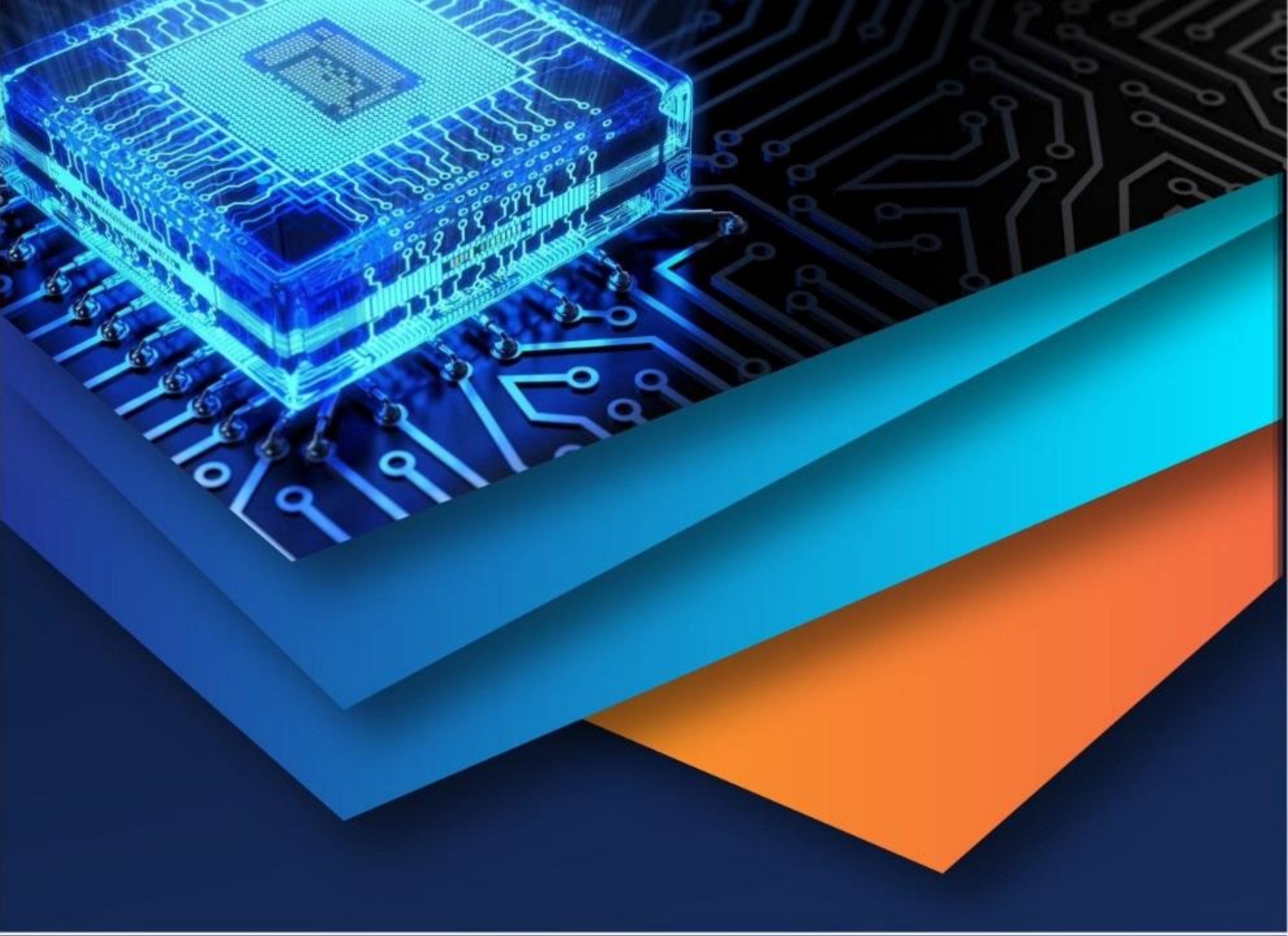

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