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An Aperture Feed Inverted Swastika DRA MIMO Antenna for Wireless Applications

Mukh Ram[1], Amit Srivastava[2], Amit Yadav[3], Abhishek Yadav[4], Adarsh Shukla[5] and Pramod Kumar[6]

[1,2,3,4,5,6]Department of Electronics and Communication, Inderprastha Engineering College, Ghaziabad, 201010, U.P. India
E-mail: [1]mram2679@yahoo.co.in, [2]ameetsrivastav786@gmail.com, [3]yadavamit2896@gmail.com
[4]abhishek997.mgs@gmail.com, [5]adarshshukla.gkp@gmail.com, [6]er.pramodkumar@gmail.com

Abstract—*A single -element, single-frequency band, and multiple-input–multiple-output (MIMO) antenna system is proposed. Rectangular dielectric resonator antennas (RDRAs) were used as the radiating elements in the MIMO antenna system. For compactness and printed circuit board integration such that the complete antenna system occupies a volume of 70 mm×70 mm×8mm. The simulated bandwidths (BWs) were at least 1.15 GHz for the single band of operation. A study provided in terms of the impedance matching, isolation, BW, and envelope correlation coefficient (ECC). Moreover, the antenna successfully achieved mutual coupling minimization of* $\leq -20dB$*, eventually resulting in enhancement of radiation efficiency.*

Keywords*: MIMO, RDRA, ECC, diversity gain.*

1. INTRODUCTION

For achieving high capacity and high-speed wireless communication concentration, the researchers have focused on the multiple-input- multiple-output (MIMO) antenna [1]. MIMO requires several transmitter and receiver antennas that function simultaneously. The development of the MIMO antenna helps to overcome multipath propagation with non-line-of-sight (NLOS), eventually resulting in the attainment of more accurate data. Moreover, the MIMO antenna enhances channel capacity (bits/Hz) by increasing the spectrum efficiency of the channel using Equation (1) [2].

$$C_{MIMO} = \log\left[\det\left(I_{M_R} + \frac{SINR}{M_T} HH^H\right)\right] \quad (1)$$

$M_T$and $M_R$are the numbers of transmitters and receivers, respectively. While $I_{MR}$is the identity matrix, $M_R \times M_R$, and$H$ is a $M_T \times M_T$matrix. Referring to Equation (1), the capacity of MIMO can be increased because of the increase in transmitter and receiver antenna.

Multiple-input–multiple-output (MIMO) technology is currently used in most wireless standards. It will be used in future technologies as well because of the advantages it provides in increasing the system throughput compared. with single antenna/channel communications [3]

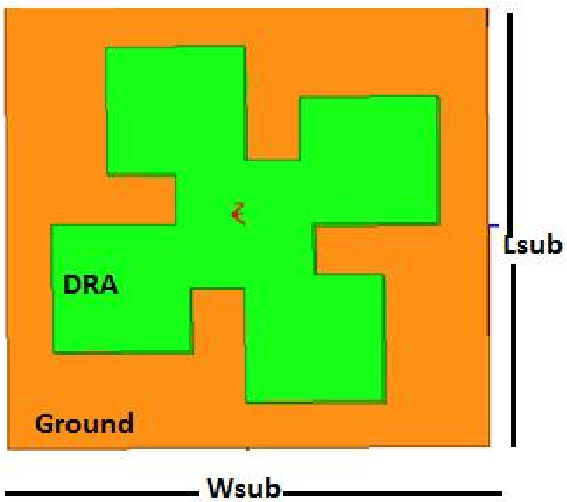
Currently in 802.11n WLAN standards MIMO technology employed for wireless access points. These antenna configurations are generally occupy a large volume around the access points [4]. More planar topologies are generally preferred and some multi-band MIMO antennas can also been found in the literature [5-8]. However, one major drawback with these types of multi-band metallic-based printed MIMO antennas is their relatively low efficiency (not exceeding 65%) when using commercial substrates. On the other hand, dielectric resonator antennas (DRAs) are known to offer high radiation efficiencies and ease of integration with other electronics when placed on a common substrate. Operation over a wide range of frequencies is also possible by altering the size of the element or scaling the value of the employed dielectric constant [9]. These antennas use an involved probe feed, complicated fabrication processes, and require different material types making them expensive and complex to manufacture. Not to mention that the obtained efficiency at the various bands is not equal and the antennas can have difficulty with polarization purity. Several other feeding mechanisms have been investigated in the literature such as a microstrip-fed, aperture coupled slot beneath the DRAs [10].

This research proposes a compact MIMO antenna with four port symmetrical radiating elements on the same substrate. The antenna's radiating element excited with a 50Ω micro strip line feed. For this design, the partial ground plane function as tuning circuit for the antenna's matching network.

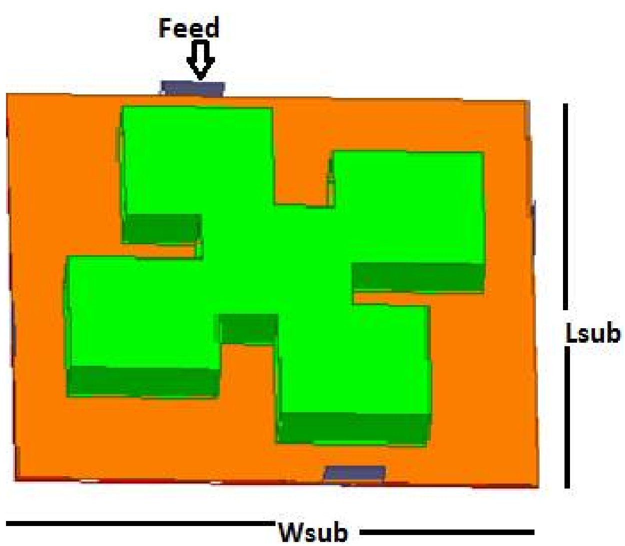
To the authors' knowledge, the MIMO antenna's reflection coefficient, mutual coupling, and correlation coefficient need to be analyzed collectively as they are intimately related to each other. The author focuses on the minimization of the mutual coupling and correlation coefficient to increase radiation efficiency and improves antenna diversity.

2. DESIGN OF THE PROPOSED ANTENNA

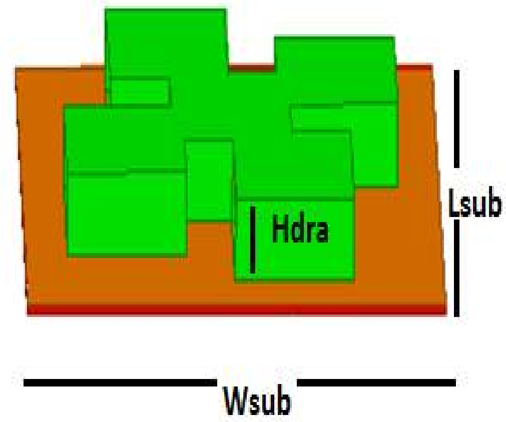
The configuration of the proposed low-profile, single frequency, and RDRA-based MIMO antenna system is shown in Figures. The length (Ldra), width (Wdra) and height of DRAs 1–4 are 20mm and 20mm and *h*= 8mm, whereas the substrate length(Lsub) and width (Wsub)70mm×70mm respectively. All RDRA types has same material TMM10i(tm) with ϵr = 9.8. Themicrostrip feed with w=1.524mm has been wised for 50Ω impedance. The dimensions are shown in Fig1a-d



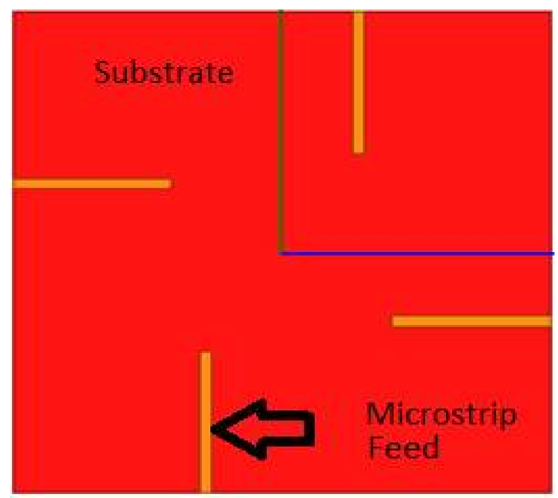
(a) Front View



(b) Top View



(a) Side view



(b) Back View

Fig. 1: Diagram of the RDRA dual-frequency MIMO antenna system

Here four basic RDRA Structure is shown in figure 1(a),1(b),1 (c),1(d). The material used for the substrate is FR4 epoxy.

The material used for the antenna is Rogers TMM having dielectric constant 9.8.

The basic shape of antenna is Inverted Swastika having aperture feed for providing the signal.

3. RESULT AND DISCUSSION

Whenever antennas are being designed, impedance matching is the most demanding feature. A study of the input reflection coefficient is performed between the frequency range 3.5GHz to 5GHz as shown in Fig.2 the lower and upper frequency below -10dB are 3.55GHz to 4.71GHz with bandwidth(BW) about 1.16GHz is suitable for WMAX, WLAN and ISM band applications.

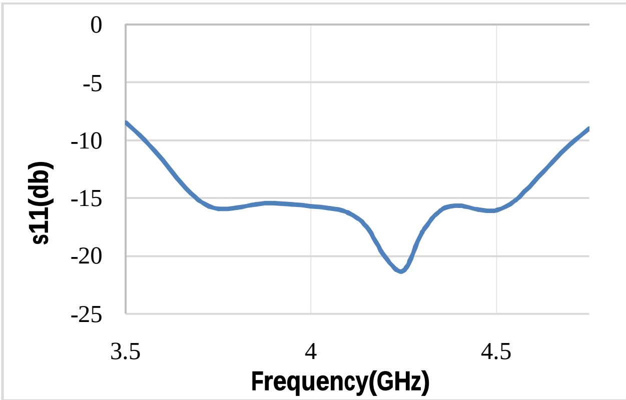


Fig. 2: Return Loss vs. Frequency in the frequency range 3.5GHz – 5GHz

In MIMO applications, the signals transmitted by multiple antenna elements are generally supposed to be uncorrelated. For MIMO applications, the mutual coupling should be minimized to as low value as possible. The mutual coupling for S12, S13 and S14 is less than $\leq -10dB$ as shown in fig.3

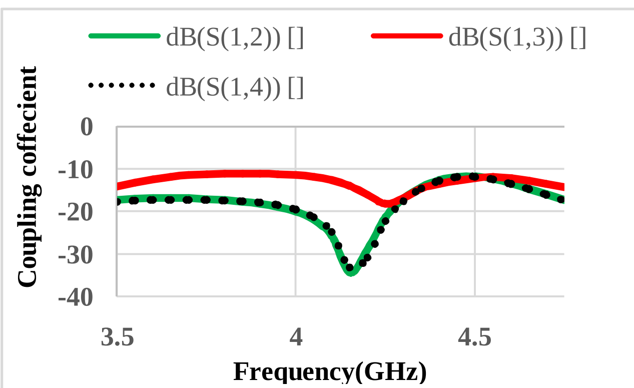


Fig. 3: The coupling coefficient between ports in frequency range 3.5GHz – 5GHz

The degree of correlation between two antenna elements where diversity is exploited in the systems, for instance in MIMO systems. The minimization of the correlation is required to evaluate the diversity performance of the systems because of the inverse relationship between the correlation and diversity gain. The correlation (ρ) can be written mathematically from s parameters [11] as in equation (2)

$$\rho = \frac{\left|S_{11} * S_{12} + S_{21} * S_{22}\right|^2}{\left(1-\left(\left|S_{11}\right|^2+\left|S_{22}\right|^2\right)\right)\left(1-\left(\left|S_{22}\right|^2+\left|S_{12}\right|^2\right)\right)} \quad (2)$$

Correlation coefficient and diversity gain are closely interrelated. The lower is the correlation value; the better is the diversity gain. The relationship between them can be expressedmathematically [12] as in Equation (3)

$$G_{app} = 10 * \sqrt{1-|\rho|^2} \quad (3)$$

The lower correlation coefficient reflects higher antenna diversity. Inthe MIMO system, the minimum value of correlation is significant in determining antenna diversity performance. The correlation $\leq -6dB$ isdesirable. It is plotted in fig 4 which show $\leq -20dB$. The diversity gain plot is given in Fig.5 with value20dB

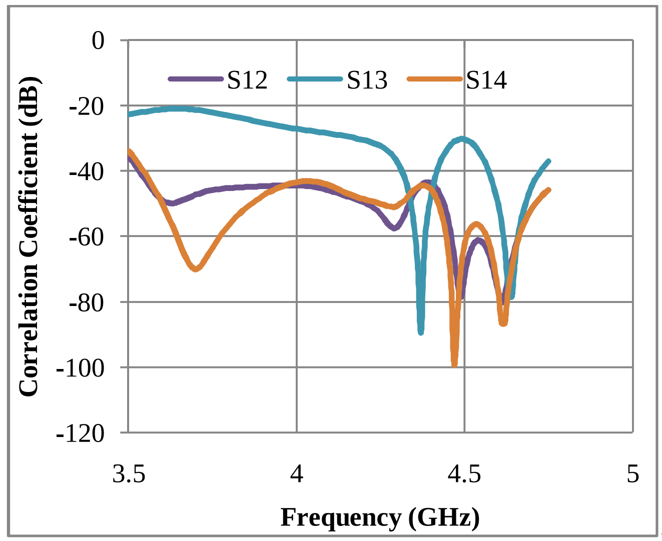


Fig. 4: Simulated MIMO antenna's Envelope correlation coefficient (ECC)

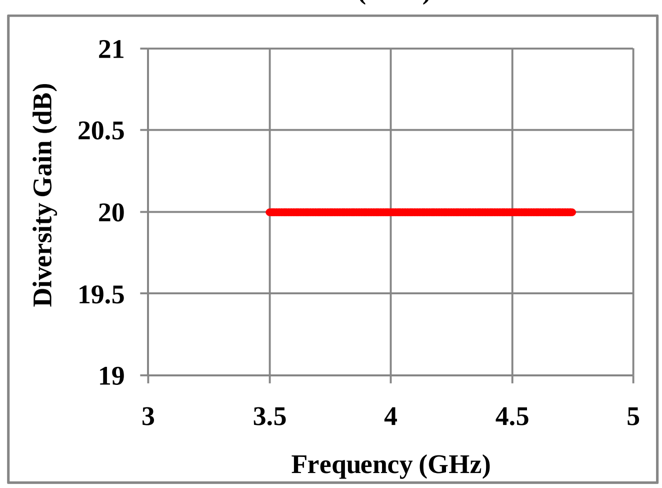
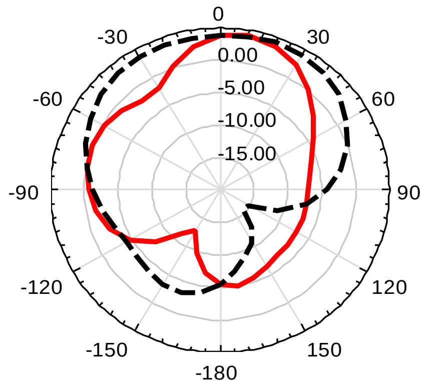
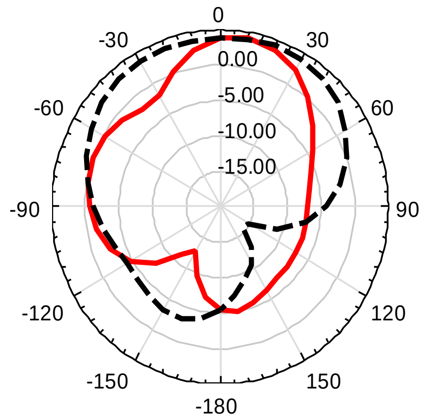


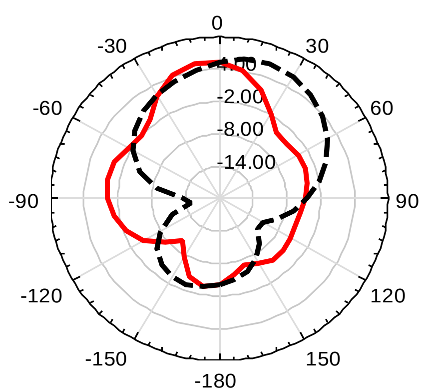
Fig. 5: Simulated MIMO antenna's diversity gain



(a) $f = 3.8GHz$



(b) $f = 4.2GHz$



(c) $f = 4.4GHz$

Fig. 6 Two-dimensional radiation pattern for E and H filed (red line is E-field and black is H fields pattern)

4. CONCLUSION

A low-profile, single-band, DRA-based MIMO antenna system for wireless access points was presented. The overall size of the proposed MIMO antenna system was 70 mm×70mm×8 mm. We discuss the MIMO antenna's characteristics of reflection coefficient, mutual coupling, correlation coefficient, gain, and radiation pattern, and analyze the antenna's novel design, which gives the antenna optimum functionality

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