A Split Ring Array Antenna for WLAN Applications using MIMO Techniques

Rajeev Mathur
Geetanjali Institute of Tech
Studies, Udaipur. India

Sunil Joshi
College of Technology and
Engineering, MPUAT, Udaipur

ABSTRACT

The paper proposes design of an array antenna with proximity coupled feeding at frequency 2.55 GHz. At first, a linearly polarised rectangular patch antenna is discussed. The basic rectangular structure is modified using proximity coupled feed to enhance the impedance bandwidth. Then, in order to introduce circular polarisation, the patch structure is further modified into Split Ring structure. An Array of these Split Rings is constructed to increase the directivity. Inter-element spacing of the array is further changed with 5mm offset and it is observed that the antenna turns in to a dual band antenna. The performance of Split Ring Array Antenna (SRAA) is investigated in terms of relevant parameters viz. impedance bandwidth, gain, axial ratio and efficiency. The SR Array antenna exhibits qualitatively better performance and can be used for wireless LAN and WAN in MIMO environment.

Keywords

Array Antenna, Split Ring Array, Antenna Array, MIMO, Wireless Local area Networks, Wide Area Network.

1. INTRODUCTION

In the last one decade the wireless networking technology has experienced tremendous growth in terms of business as well as technological advancements. The future development aims to provide videos, speech and data communications at anytime, anyplace and anywhere around the world. To achieve this, the terminal antennas must meet the requirements of enhancement of radio performance in terms of coverage and capacity. A number of different antenna solutions can be applied to improve the performance of the wireless communication system like WLAN, WAN, WiMAX, Mobile etc.

The prevalence of Multiple radio path is the biggest challenge faced by the communication system designers. The exploitation of the multipath to enhance the performance of the system conceives the idea of Multiple Input Multi Output (MIMO) solutions [2]. The main characteristic of MIMO (Multiple Input Multiple Output) systems is the use of multiple antennas at both ends of the link to improve the communication performance. If we define N as the number of transmit antennas and M as the number of receive antennas the system can be described as in Fig 1.
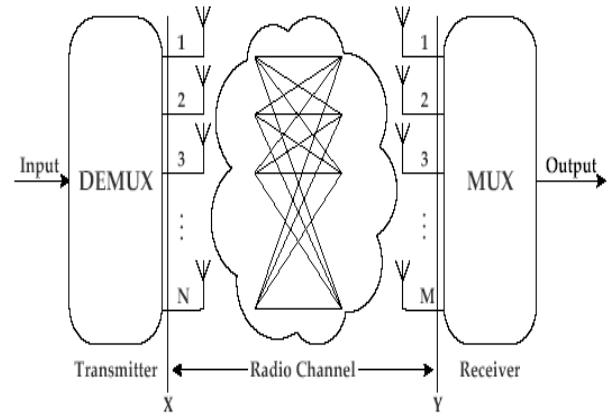

Fig. 1: MIMO system [2].

The result is reduced interference because the signal going to the desired user is increased and the signal going to other users is reduced.

Besides, Spatial Multiplexing and Transmit Diversity, Beam forming is the third dimension to the MIMO techniques. However, in order to make efficient beam former, adequate antenna design support is essential. Beam forming technique uses arrays of transmit and receive antennas to control the directionality and shape of the radiation pattern.

The proposed antenna design is a step towards this requirement in which multiple antennas and multiple signals are employed, which then shape the beam with the intent of improving transmission to the desired direction. The antenna elements have spatial separation dictated by the wavelength of transmission and are supported by sophisticated signal processing equipments and algorithms [2].

A Rectangular patch antenna is widely used in wireless communications, however, this antenna have limitations of small impedance bandwidth, gain, directivity and radiation efficiency. In fading environment it is required to have such an antenna which provides high directional gain and Radiation efficiency [2].

A split ring antenna, as shown in Fig. 4, is one such antenna which provides high gain, good impedance matching and high radiation efficiency. [4][6]. The Square Split ring a structure exhibits metamaterial property also which enhance gain of an antenna [4].

In the present paper, the authors have proposed a multiple element antenna formed with Square Split Ring (SR) Array. Proximity coupled feed is used to magnetically couple the SR array of eight elements. The designed antenna is aimed to give qualitatively better performance as compared to patch antenna such that beamforming technique could be employed for MIMO applications.

2. DESIGN OF PROPOSED ANTENNA

The resonant frequency 5 to 5.5 GHz is choosen i.e. for WLAN & WiMAX application; FR-4 substrate is selected
since it is cheaply available which have dielectric constant, loss tangent and substrate height of 4.4, 0.025 and 1.588 mm respectively. The computed values of W and L_{eff} are 128mm and 56 mm respectively. A Patch antenna desined with these dimensions is as shown in Fig 2.

The Effective length and width of the microstrip patch antenna is evaluated using following farmulae [3]:

$$W = \frac{1}{2f_r \sqrt{\mu_0 \epsilon_0}} \sqrt{\frac{2}{\epsilon_r + 1}} = \frac{\upsilon_0}{2f_r} \sqrt{\frac{2}{\epsilon_r + 1}}$$

…. 1

The actual length and effective length of patch antenna is found as [2]

$$L = \frac{1}{2f_r \sqrt{\epsilon_{reff}} \sqrt{\mu_0 \epsilon_0}} - 2\Delta L$$

…. 2

$$L_{eff} = L + 2\Delta L$$

…. 3

Where,

   fr = resonant Frequency.
   μ_0, μ_r= Free Space & Relative Permeability
   ϵ_0, ϵ_r= Free Space & Relative Permittivity
   υ_0 = Speed of light.
   Leff = Length of patch antenna
   W= Width of patch antenna.

Next we designed an antenna with proximity coupled feed to enhance the impedance bandwidth. In order to obtain circular polarisation patch structure is modified into Split Ring structure (Slots). Further, to increase gain, directivity and employ beamforming we constructed an array of Split Ring [13].

Hence to get circular polarised and large bandwidth an Array eight Square Split Ring planar structure of dimension 25 mm X 25 mm is designed and arranged in the form of array with interelement spacing of about 0.1λ to 0.25λas shown in Fig 3.

Proximity coupled feed for this antenna is designed as shown in Fig. 5. Dimension of the feed is as shown in the Fig. 5.

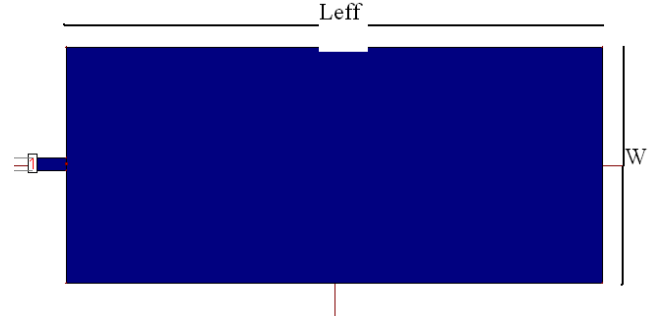**Fig. 2: Conventional Patch Antenna [1]**

Table 1: Dimension of the both Structures in mm [1]

The dimensions of both the Patch and SR Array Antenna are presented in the Table 1.

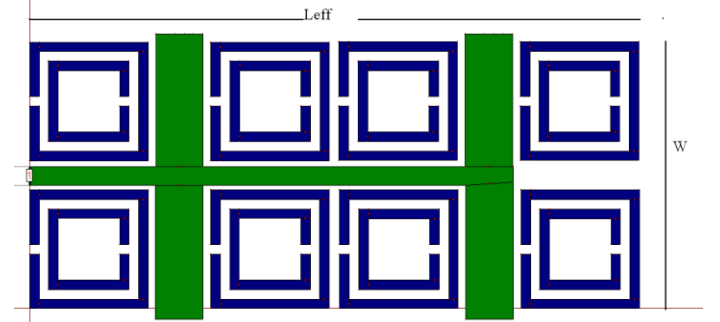| Structure	L_{eff}	W	SRR Length	SRR Width
Patch	128.7	56.3	--	--
SR Array	128.7	56.3	25	25

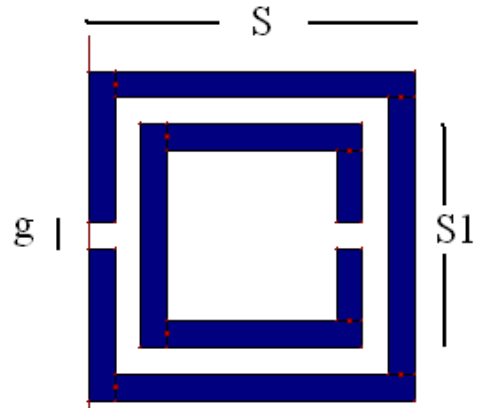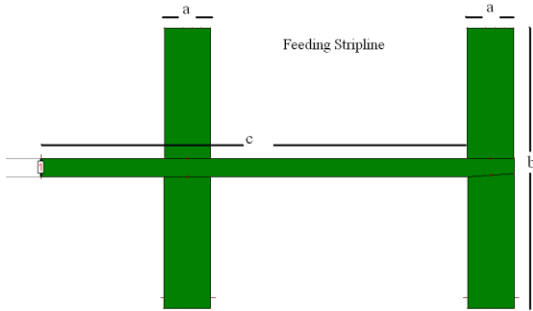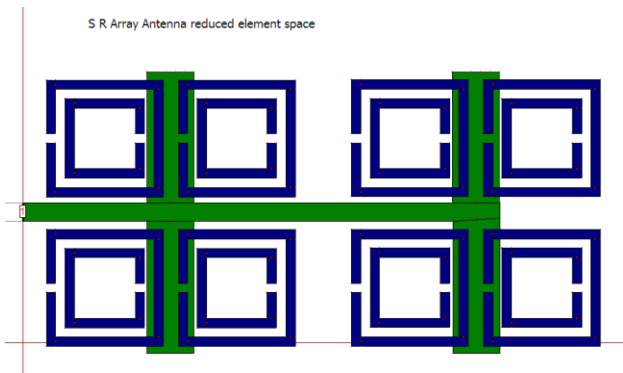**Fig. 3: SR Array Antenna with proximity feed. [1]**

Fig . 4: (a) Square Split Ring dimensions S=25mm, S1=17mm, g= 2mm; (b)Proximity coupled Strip Line dimensions: a= 10mm , b= 29mm , c= 102mm. [1]

Further we changed the inter element spacing is offset by 5mm of SR array antenna and the modified structure is as shown in the Fig. 5.


Fig. 5:SR Array Antenna with reduced interelement spacing.

3. RESULT & DISCUSSION

3.1 Return Loss

Both antenna structures SR Array & SR Array with reduced inter element spacing are simulated using IE3D simulation engine. Results are obtained on Modua. Return Loss of S R Array antenna is found well below -10 dB for frequency of 5 and 5.6 GHz (-40 dB & -38dB respectively) as shown in Fig. 6.
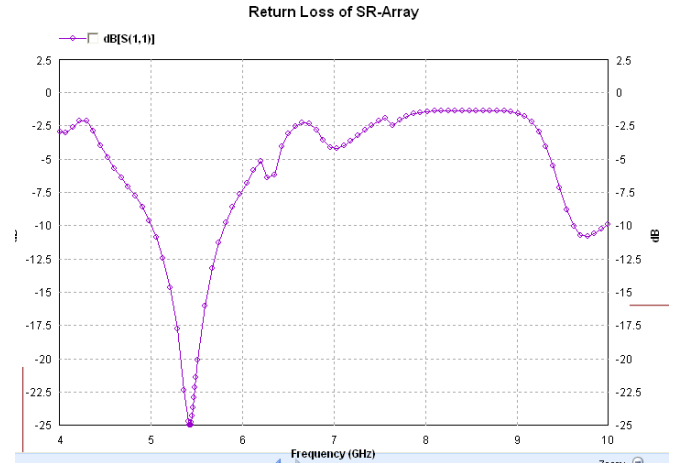
**Fig . 6: Return Loss Split Ring Array Antenna. [1]**

Return loss obtained by SR Array Antenna is well below -10 dB for the frequency range of 5.03 to 5.84 GHz. as shown in Fig. 6. The Impedance bandwidth of @ 800 MHz. By reducing inter element spacing of the S R Array Antenna This antenna also indicates to operate at frequency of 2.55G Hz. Thus, it have been observed that by modifying inter element spacing; this antenna can change its frequency of operation.
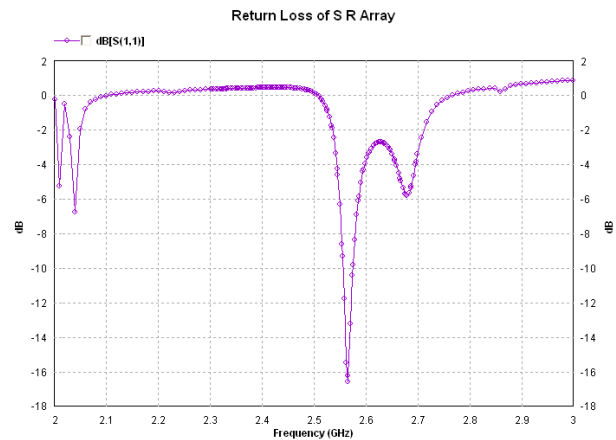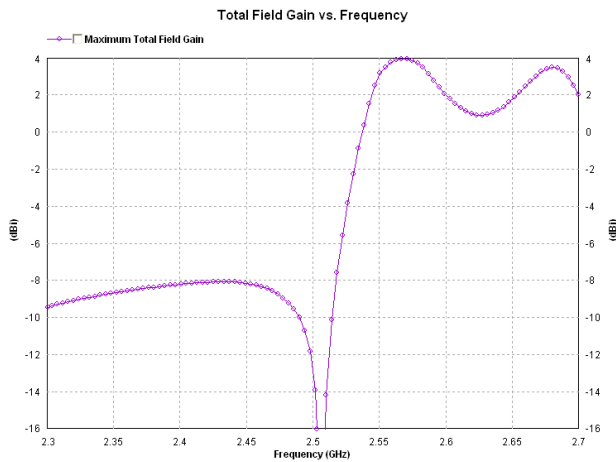

Fig. 7: Return Loss of SRR array Antenna with reduced interelement spacing.
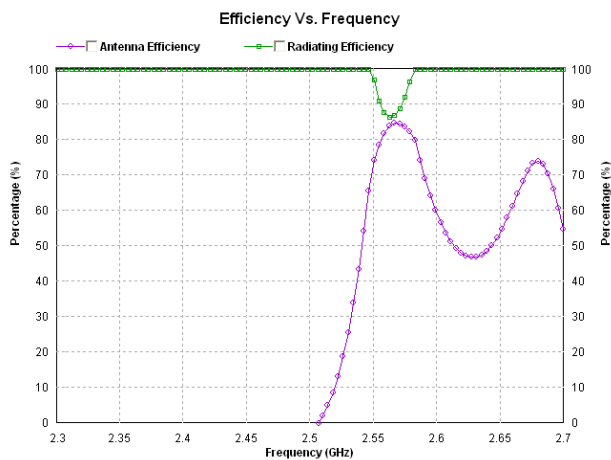
3.2 Gain & Radiation Efficiency

It was observed that in terms of gain, modified SR array antenna has good performance since gain is about 4 dBi at 2.55 GHz which is quite reasonable. Gain Vs Frequency curve for both SR Array Antenna and Modifies SR Array Antenna is shown in Fig 8 and Fig. 9.
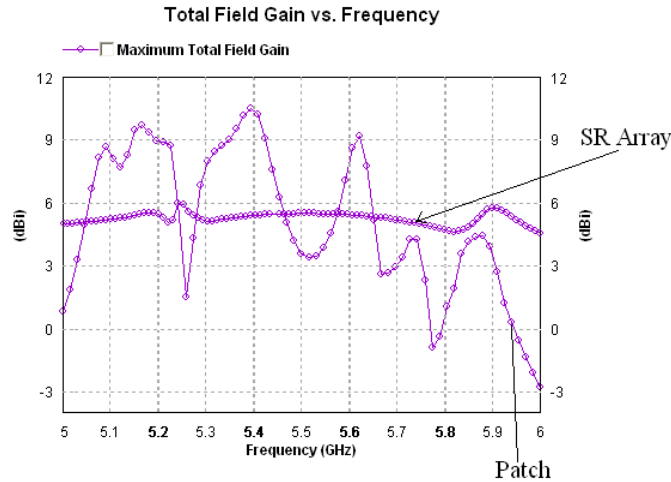
Fig. 8: Comparison of Gain between patch & SRR array Antenna [13].

Fig. 9: Gain of SRR array Antenna with reduced interelement spacing.

Fig. 9: Radiation & Antenna Efficiency of SR Array Antenna with reduced inter element spacing.

Table II: Comparison of performance parameters of antenna

Structure	Resonant Frequency	Gain	Bandwidth	Radiation Efficiency	HP Beam Width
SR Array	5- 5.81 GHz	5.8 dBi	810MHz	98%	26°
SR Array modified	2.55 GHz	4.0 dBi	10MHz	85%	35°

Fig 10. Shows the simulated radiation efficiency and antenna efficiency of the SR Array with reduced interelement spacing Both antenna efficiency and radiation efficiency is reduced by 10-13 % as compared to the SR Array antenna. To get desired frequency of operation i.e. 2.55 this efficiency may be compromised

3.3 Polarization

The important improvement in SR Array Antenna is that polarisation of SR Array Antenna is nearly circular. Since axial ratio obtained is nearly 1 For both Sr Array Antenna discussed above we have same polarisation that is circular. In Mobile and other application it is desired to have circular polarisation. Circular polarisation has been obtained due to the gaps in the split ring. Electric field components in θ, Φ direction becomes nearly equal. It is also being observed that at frequency 5.445 and 5.455 axial ratio is nearly zero indicating antenna to act as linearly polarised. We can thus summarise that SR Array antenna can be used as dual Polarised Antenna. Left-Hand Circular Field Properties are [1]:

Gain: 4.57407 dBi

Directivity: 4.58871 dBi Maximum at (35, 300) deg.

3dB Beam Width: (23.0586, 45.2311) deg. Right-Hand
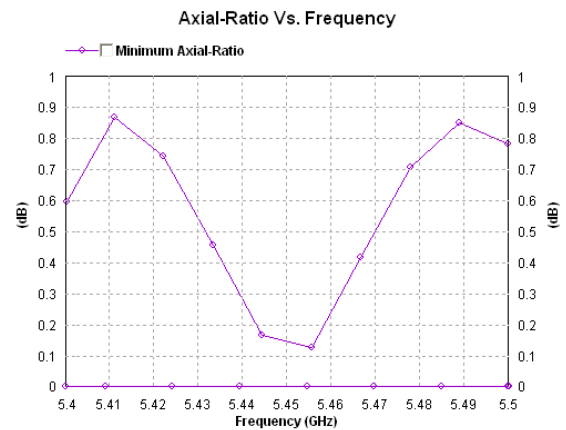
Fig. 10: Comparison of Axial Ratio of Patch Antenna & SRR array Antennas [1].

3.4 Radiation Patterns

In comparison to the radiation pattern of SR Array Antenna given by Fig. 11 Modified SR Array have also two beams in the direction 60 & 120 degrees; Due to these two beams emitted by SR Array antenna, it may also be considered to be used in MIMO application. HPBW of SR Array Antenna is increased by @ 10° . Radiation pattern of both SR Array Antenna is as shown by Fig. 11 & 12. We see that no significant change is there in both pattern except beamwidth.
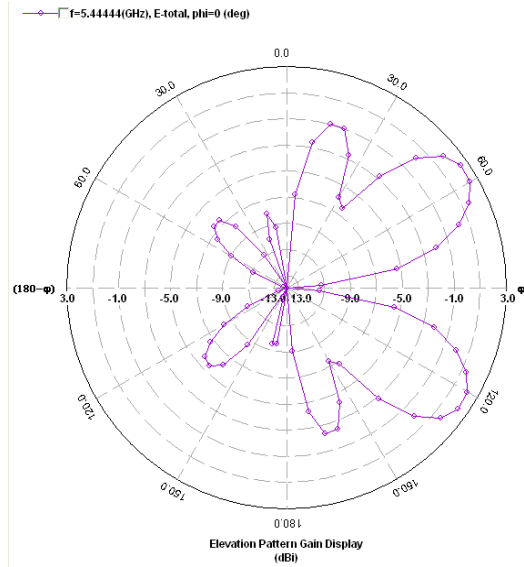
Fig.11: Radiation Pattern S R Array Antenna at f= 5.44 GHz. [1]
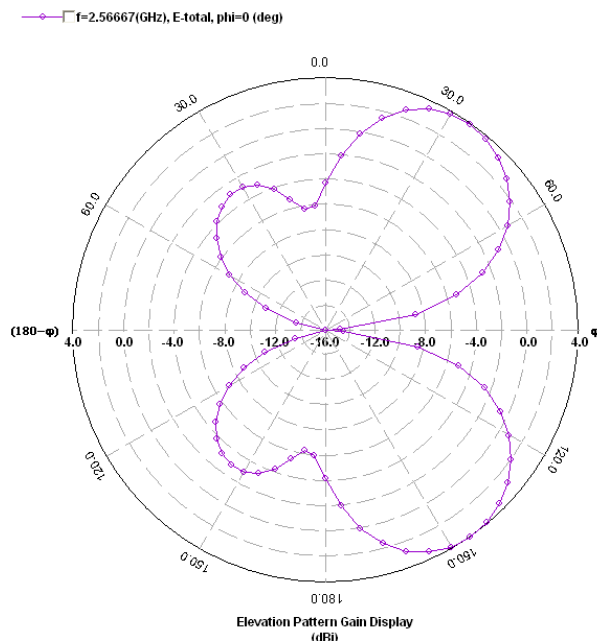
Fig.12: Radiation Pattern of SR Array Antenna with reduced inter element spacing at f = 2.55 GHz.

Also, the two beam in can be controlled with the support of sophisticated signal processing units, to give better results in MIMO technology for wireless communication. SR Array thus could be called as Multiple Antenna Array (MEA) for MIMO applications.

4. CONCLUSION

A specific application Split Ring Array Antenna is designed for wireless computer networking application is thus proposed. All the relevant parameters of antenna are suitably within the range of designed criterion. This antenna appears to be suitable for wireless LAN and WAN application, after further sensitivity test of this antenna is performed.

Proximity coupled SR Array antenna is made and it is concluded that it have good performance in terms of bandwidth, directivity. Circular Polarization of SR array antenna makes this suitable to be used in various mobile applications. Beamforming using sophisticated Signal Processing may be very well employed in to use this modified SR Array antenna for MIMO-wireless communications applications. We thus conclude that a good SR Array antenna for computer Networking application is achieved.

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