High Gain Double Cross Monopole Array Antenna With CSRR

B Madhavi, M V Siva Prasad

Abstract: A high gain double cross monopole antenna array is modelled, and its analytical study is presented in this article. The proposed antenna model consisting of FR4 as substrate material with overall dimension of 42X36X1.6 mm. Complementary split ring resonators are loaded in the ground plane to enhance the gain and radiation characteristics in the modelled antenna along with array setup. Antenna is operating in the quad band with application bands at 4.5, 7.8, 10.5 and 12 GHz respectively. The prototyped antenna is providing good radiation parameters with the value of gain more than 12 dB in the prescribed working band. The fabricated antenna model measurement results is exhibiting good similarity with simulation.

Index Terms: Array Antenna, Bandwidth, CSRR, Double Cross, High Gain, Monopole, Radiation pattern

1 INTRODUCTION

The demand of high gain antennas in the communication applications are increasing day by day with respect to the need of high-speed data rates. Researchers designed several antennas to cater the needs of modern communication applications for different fields [1-4]. The antenna array is the set of 2 or more antennas connected in linear or planar structure. The signals from the antenna are combined to achieve the greater performance over the single element. In the array structure each individual antenna is used for transceiver for the radio waves [5-12]. The antenna connected in such a way that their individual currents are specified in the specified phase relation and amplitude. By arranging the antennas in such a way helps the array to act like a single element. Usually in the arrays the improved characteristics are observed such as improved gain in the antenna. The size of the array may not be suitable for certain applications where high gain compact dimensions are required. The compact antenna model with reasonably good performance characteristics will survive the purpose in various communication applications. Literature is available for such [13-18]. The design of the microstrip antenna arrays is done because of the some of the limitations in single element microstrip antennas because they have low gain. To overcome this draw back array concept is used [19-22]. By reducing the feed network losses in the microstrip antennas the efficiency of array antennas can be improved. The microstrip antennas has several disadvantages like there is a significance increases in the power consumption, dimensions and weight. The advantage of the microstrip antenna arrays is simple construction of array, as the elements are etched along with feed structure as an integration which leads to have very small and minimum cost effective design. Conductor, radiation and dielectric losses are the major components of losses in microstrip array antennas [23-26].

- *Research Scholar, Department of ECE, Acharya Nagarjuna University, AP, India*
- *Professor, Department of ECE, RVR & JC College of Engineering, AP, India*

2 ANTENNA GEOMETRY

Double cross monopole antenna with single radiating structure is shown in Fig 1. The dimensional characteristics as per the antenna design parameters can be observed here.

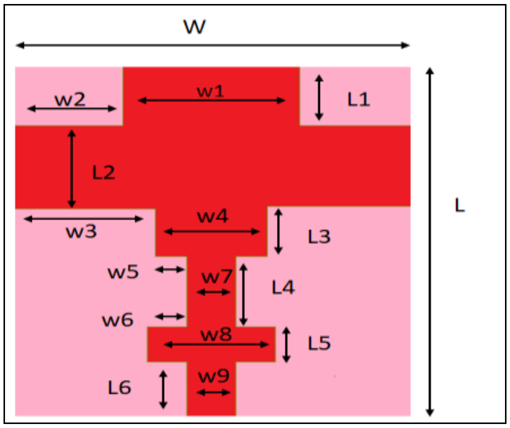


***Fig 1**. Dimensional view of the single element antenna*

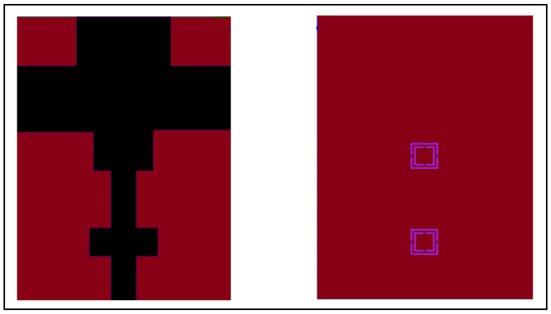


***Fig 2**. CSRR loaded double cross monopole*

SRR and complementary SRR are used in the design of the antenna in the ground plane to bring the metamaterial orientation. Fig 2 shows the CSRR loaded structure in lower plane of the proposed antenna. An equivalent circuits for SRR and CSRR are presented in Fig 3 and 4.

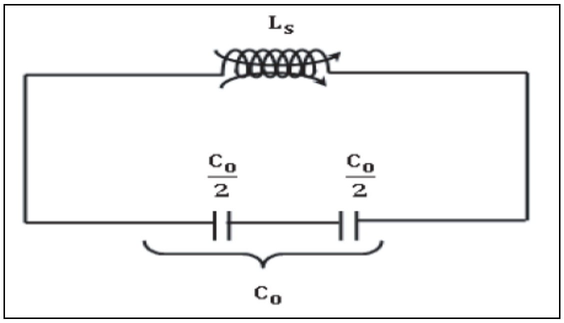


***Fig 3**. SRR Equivalent Circuit*

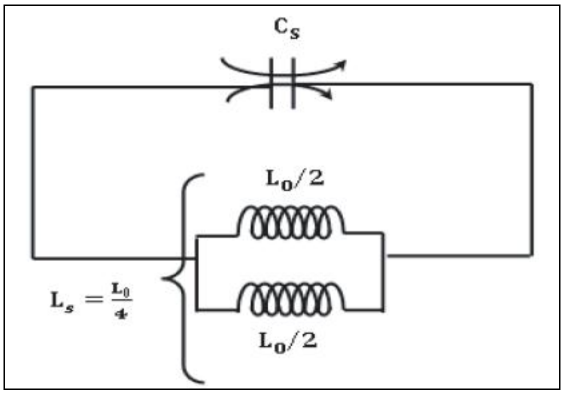


***Fig 4.** CSRR Equivalent Circuit*

The magnetic response of the SRR is presented in Fig 5. The negative permittivity between 2 to 3 GHz can be observed from Fig 5.

3 RESULT AND ANALYSIS

The magnetic response of the CSRR is presented in Fig 6. The negative permittivity between 3 to 4 GHz witnessed in Fig 6.

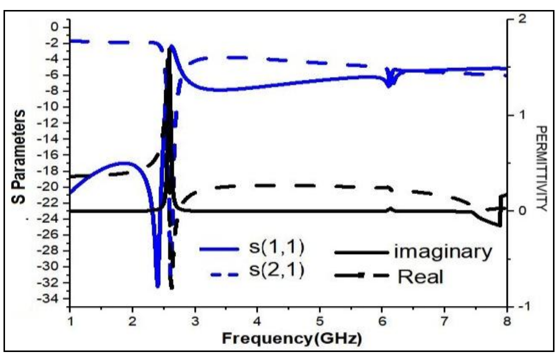


***Fig 5.** Magnetic Response of SRR*

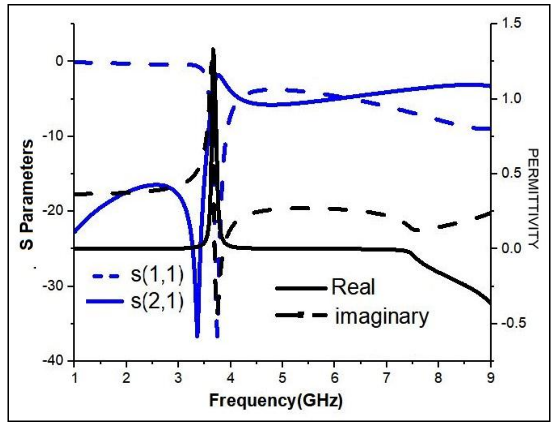


***Fig 6**. Magnetic Response of CSRR*

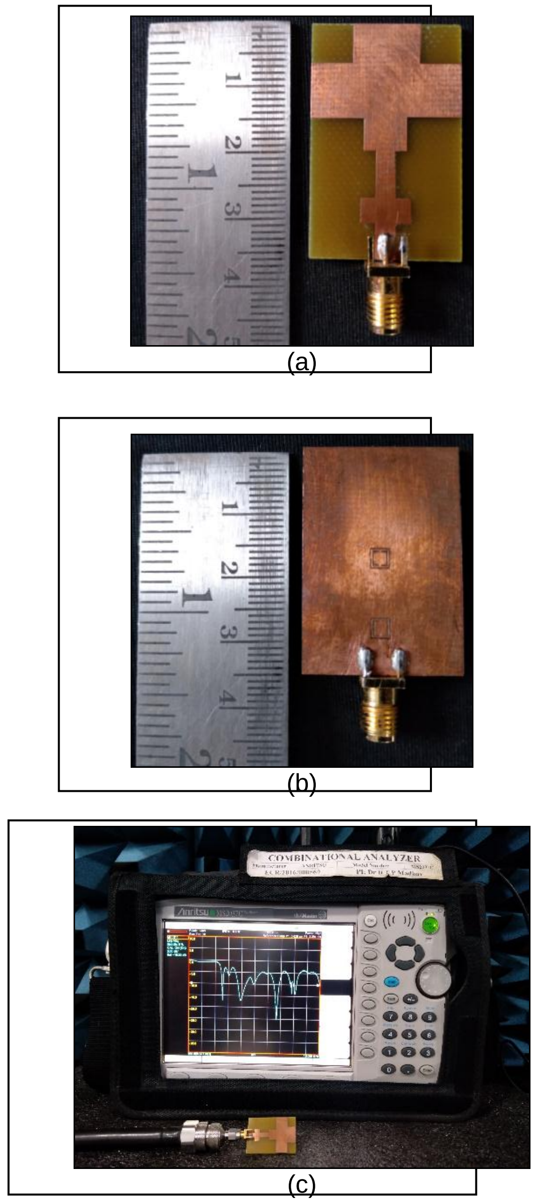


***Fig 7**. Prototype and Measurements, (a) Top View, (b) Bottom View, (c) Reading on VNA*

The fabricated antenna picture is shown in Fig 7. Fig 7(a) shows the front side of the antenna, Fig 7(b) shows the bottom side with CSRR structure and Fig 7(c) gives the measurement analyzed result of S_{11} on Anritsu-CA.

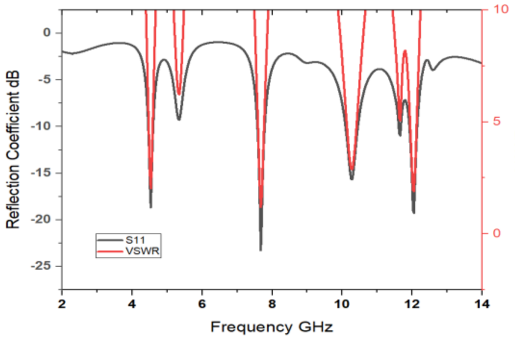


Fig 8. *S11 and VSWR Curve*

Fig 8 shows the reflection coefficient and VSWR result of the designed antenna model. Antenna is working in the quad-band with sharp narrow bandwidths at 4.5 GHz, 7.8 GHz, 10.5 GHz and 12 GHz respectively. The VSWR also showing same bands with ratio of 2:1.

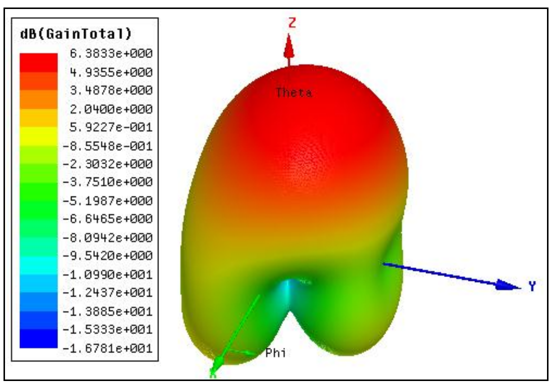


Fig 9. *3D Gain at 4.5 GHz*

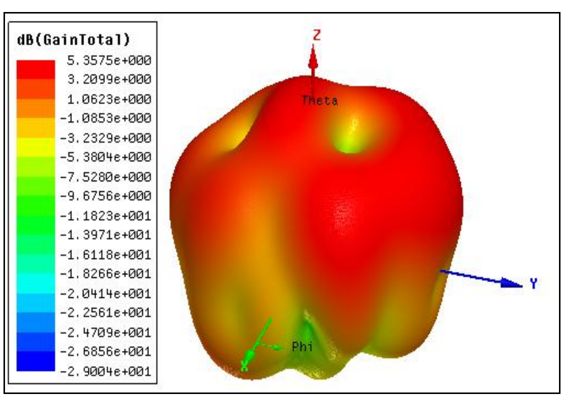


Fig 10. *3D Gain at 7.8 GHz*

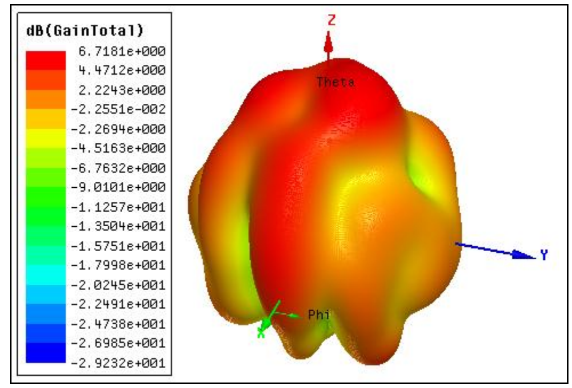
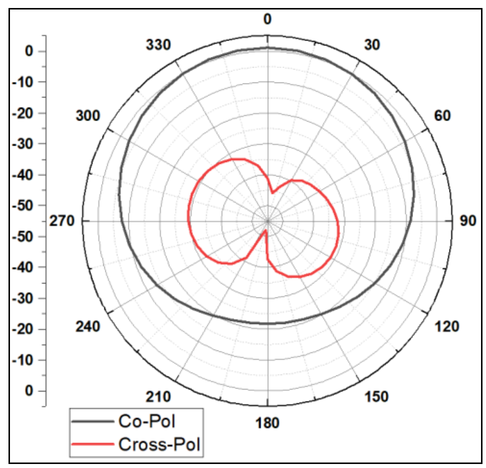
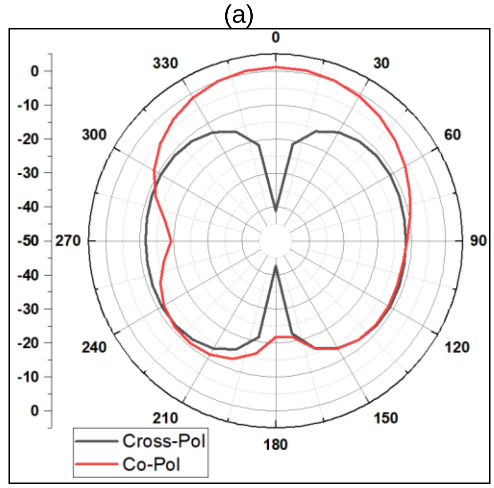


Fig 11. *3D Gain at 10.5 GHz*

Fig 9, 10 and 11 shows the radiation pattern at three working frequencies 4.5, 7.8 and 10.5 GHz respectively. Antenna showing peak gain of 6.3 dB, 5.3 dB and 6.7 dB at these three resonant frequencies. Fig 12 shows the polar plot in both E & H-planes at 4.5 GHz.



(a)



(b)

Fig 12. *Single element Radiation curve for E & H-Planes at 4.5 GHz*

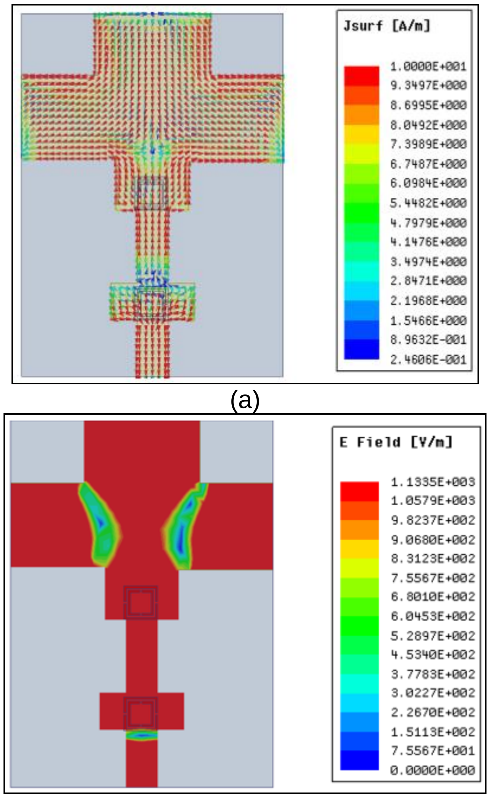


Fig 13*. Current distribution and Electric field distribution*

Fig 13 giving the current and electric field representation of the single element antenna at 4.5 GHz. The antenna gin can be improved by a greater number of radiating patch elements and by making it to in an array configuration. Single element antenna is converted in to 2x1 and 4x1 array model as shown in Fig 14 and 15.

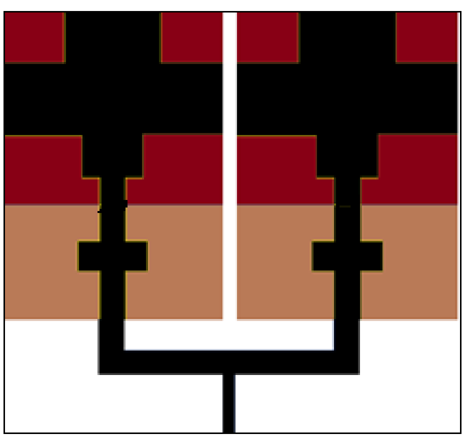


Fig 14. *2X1 Array Structure*

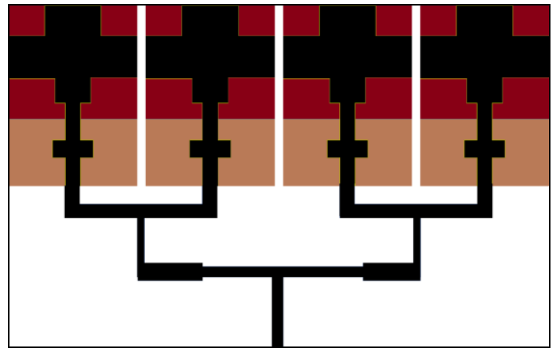


Fig 15. *4X1 Array Structure*

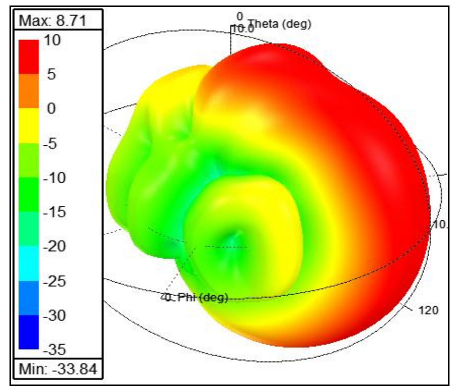


Fig 16*. Gain of 2x1 Array at 4.8 GHz*

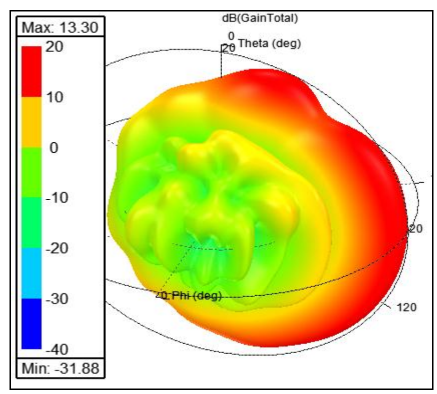


Fig 17. *Gain of 4X1 Array at 4.8 GHz*

Fig 16 & 17 exhibiting the 3D gain plots of the 2x1 and 4x1 array antenna. 8.7 dB is attained with 2x1 array antenna and 13.3 dB is attained with 4x1 array antenna at 4.5 GHz.

4 CONCLUSION

A microstrip line fed monopole antenna with CSRR is proposed in this paper for wireless communication applications at 4.5, 7.8, 10.5 and 12 GHz respectively. The prototype of antenna is carried on FR4 substrate and the measurement results are collected from Anritsu combinational analyzer. Antenna gain is improved by taking array configuration and obtained 13 dB gain from 4x1 array configuration. The simulation & the measured values are having good correlation with each other and giving confidence for applicability in the real time wireless communication applications.

5 ACKNOWLEDGEMENTS

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