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# Super-Directive Microstrip Patch Antenna Array with Metamaterial

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**Abstract :**
Microstrip antenna is well suited for many applications because of its properties like lightweight, planar structure and ease of fabricating, however it has limitation of low band width and gain. In this research, a design technique for enhancing gain of microstrip patch antenna in ultra wide band frequency spectrum is proposed. This paper presents the design of series fed microstrip patch antenna array with metamaterial. The advantage of this antenna is that it provides an overall planar structure. This antenna may find application in modern communication systems and radar systems.
**Index Terms:** Filter, Split Ring Resonator, Metamaterial.

## I. INTRODUCTION

In communication devices, requirement is of light weight and low profile antenna. Microstrip patch antenna meets the requirements of low profile structure, light weight, and ease of fabrication. But the main drawbacks of patch antennais its low directive gain. Several patch antennas can be connected in an array to improve the gain of antenna [2-4].

The elements in array of patch antenna can be fed by a single line as shown in fig (1) or by multiple lines as shown in fig (2).

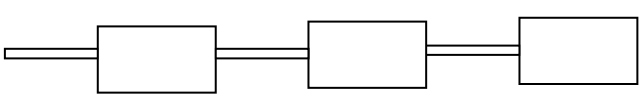


Fig (1). (Series fed patch antenna)

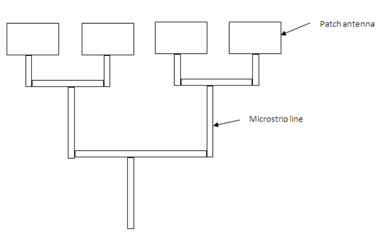



Fig (2)(Corporate fed antenna array )

First is referred to as series fed network while second is referred to as corporate fed network. Mutual coupling internal between the elements is one factor which must be taken care of in order to reduce electromagnetic coupling between the elements. In this work we are reducing the mutual coupling between elements by incorporating SRR Metamaterial into substrate.

## II. PATCH ANTENNA ARRAY DESIGN

Here we have designed a 1×2 patch antenna array using SRR Metamaterial. The microstrip patch antenna is the basic element of this array structure. Although the conducting area of the patch can be of any shape however for the ease of fabricating as well as for the ease of evaluating the performance, simple geometries of patch are used. A patch antenna with rectangular conducting area is as shown in fig (4).

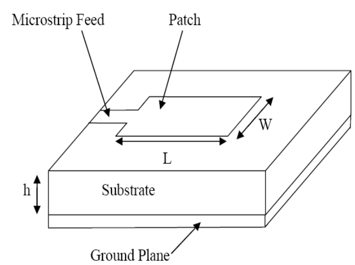



Fig (4) ( Design of rectangular patch antenna )

As for the substrate selection, the major consideration will be the dielectric constant and loss tangent. A high dielectric constant will result in a smaller patch size but this will generally reduce bandwidth efficiency. The parameters of interest of this patch antenna are frequency of operation (f), width (w) of patch, Length (L) of patch, Height of substrate (h), and Permittivity of substrate (ε (r)).

Three methods of analysis which are commonly used to find the Parameters of microstrip patch antenna are :Transmission line model, cavity model, and full wave analysis. For efficient radiation the width (w) of patch as given by Bahl and Bhartia [8] is

$$w = \frac{c}{2\ f\sqrt{\frac{\varepsilon\,(r)\,+\,1}{2}}}$$

Here ε (r) is the dielectric constant of the substrate. C is the velocity of light and f is the operative frequency.

The effective dielectric constant of medium as given by
Balanis[9] is

$$\mathcal{E}(eff) = \frac{\mathcal{E}(r)+1}{2} + \frac{\mathcal{E}(r)-1}{2}\sqrt{1+12\ \frac{h}{w}}$$

The length of patch as given by [10] is

$$L = \frac{c}{2f\sqrt{\varepsilon\,(\text{eff})}} - 2\Delta l$$

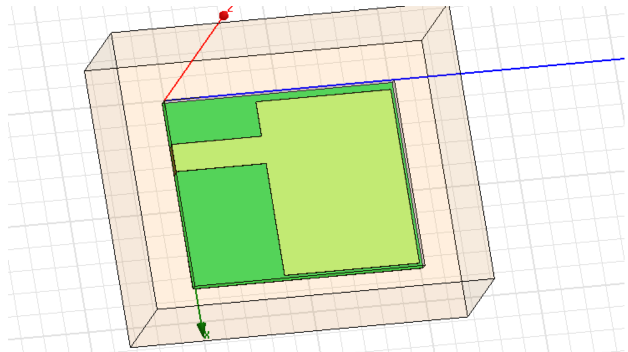
Δl here is the extension in length of patch. The Empirical formula for the extension of length as given
by Hammerstad[11] is

$$\frac{\Delta l}{h} = .412\frac{[\varepsilon\ (\text{eff}) +\ .3]\left[\frac{w}{h} +\ .264\right]}{[\varepsilon\ (\text{eff}) -\ .258]\left[\frac{w}{h} +\ .8\right]}$$

By using the above equations we obtain and to operate patch antenna on 7.55GHz the dimensions of patch that we obtain are

| | |
|---|---|
| Single Patch Antenna Design Specifications Frequency | 7.55 GHz |
| Substrate | Rogers RT / duriod 58809(tm) |
| Dielectric Constant | 2.2 |
| Substrate Height | 0.794 mm |
| Patch Length | 15.69 mm |
| Patch Width | 12mm |
| Conductor Thickness | 0.05 mm |

The structure of patch obtained by HFSS is as shown in fig



(Patch antenna)

Two elements of this patch antenna are connected in series to form array as shown ini fig().

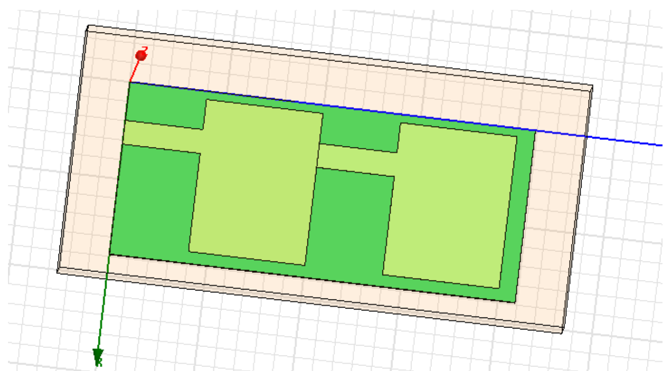
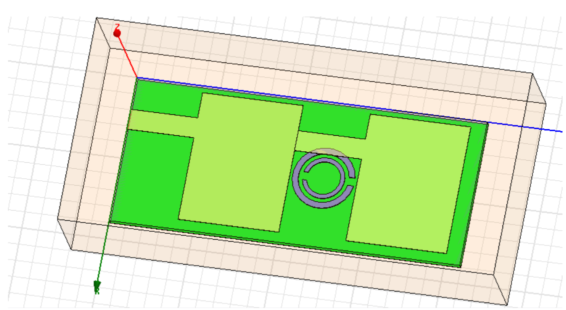


Fig (5). ( Series fed patch antenna with SRR )

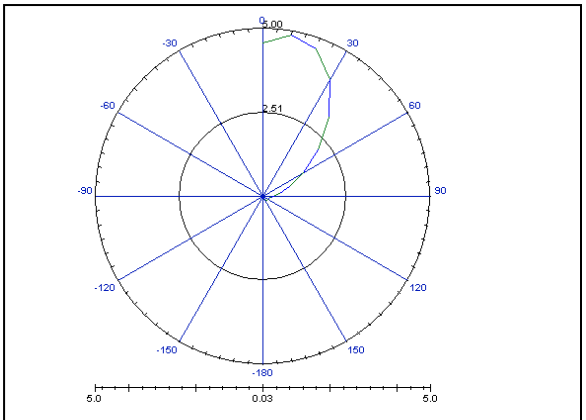
SRR is introduced in the array structure as shown in fig (5).

The dimensions of SRR metamaterial are with outer radius of 3.5 mm, width of strip equal to 0.5 mm, Gap space equal to 1mm. SRR is made up of copper material.

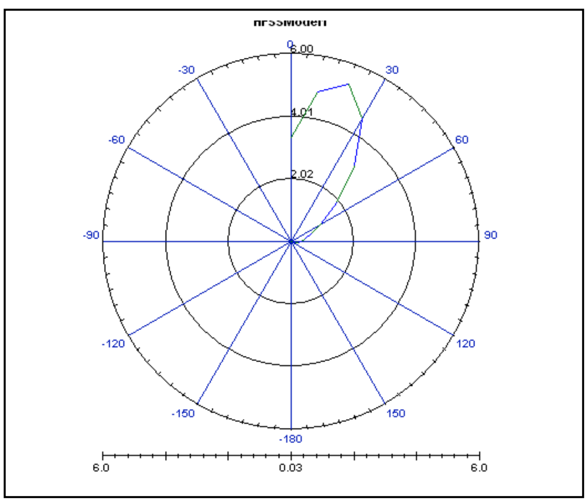


## III. RESULTS AND DISCUSSION

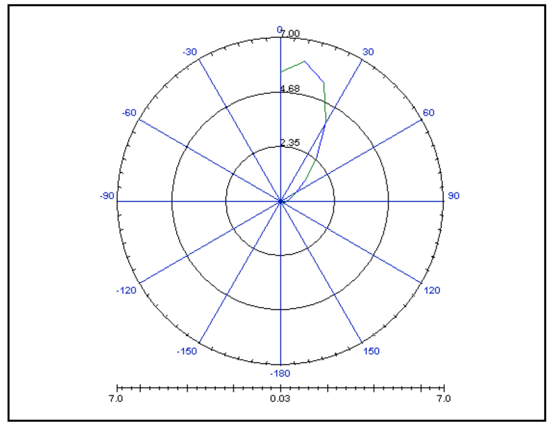
The graph of directive gain of single patch antenna is as shown in fig (). From the graph it is concluded that the maximum gain of this antenna is (4.875)

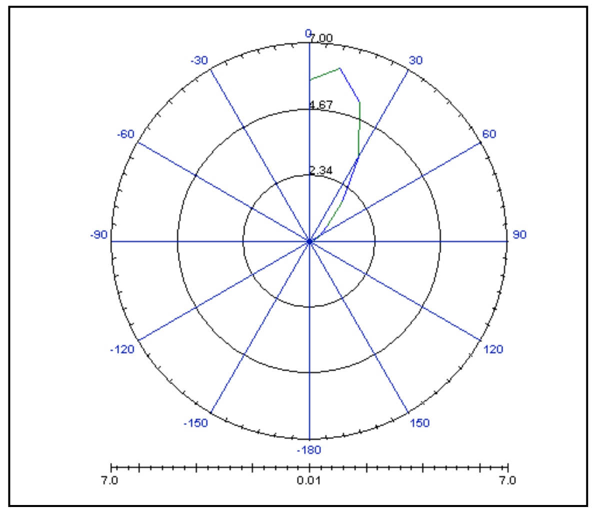



By using array of two antenna The graph of directive gain of single antenna array is as shown in fig (). From the graph it is concluded that the maximum gain of this antenna is 5.32




By incorporating single SRR element into array of two antenna the graph of directive gain of antenna array is as shown in fig (). From the graph it is concluded that the maximum gain of this antenna is (6.05)




By incorporating two elements of SRR element into array of two antenna the graph of directive gain of antenna array is as shown in fig (). From the graph it is concluded that the maximum gain of this antenna is (6.19)

## IV. CONCLUSIONS

A highly directive microstrip patch antenna array with metamaterial is designed and simulated. It has been observed that directivity increases by incorporating SRR metamaterial into substrate layer. It has also been observed that directivity increases further by increasing the number of SRR into substrate layer.

## V References

[1] Monish Gupta, Jyoti Saxena and AnilVohra"Highly Directive Patch Antenna Using Planar Metamaterial" "International Journal of Applied Engineering Research (IJAER)" Volume 4 Number 3 January (2009) pp. 89-96

[2] C. A. Balanis, "Antenna Theory - Analysis and Design," John Wiley & Sons, Second Edition, New York, 1997.

[3] David M. Pozar, Microwave Engineering, John Wiley & Sons, 1998.

[4] E. Hammerstad, F.A. bekkadal, Microstrip handbook, ELAB report, STF 44 A74169, University of Trondheim, Norway, 1975.

[5] Vesalago V. G.,"The Electrodynamics of substances with simultaneously negative values of permittivity and magnetic permeability", Sov.Phys.Usp., 10-4 (1968), 509-514.

[6] Pendry J. B.,et. al, "Extremely low frequency plasmas in metallic microstructures", Phys. Rev. Lett.76-(1996), 4773-4776.

[7] J. B. Pendry, A. J. Holden, D. J. Robbins and W. J. Stewart," Magnetism from Conductors and Enhanced Nonlinear Phenomena" IEEE Transactions on Microwave Theory and Techniques , Vol. , No. 11, November 1999.

[8] I.J.Bahl and P.Bhartia, Microstrip Antennas, Artech House,1980.pp. 31-83.

[9] Balanis, C.A., Advanced Engineering Electromagnetics, John Wiley & Sons, New York, 1989

[10] Kumar, G. and Ray, K.P., Broadband Microstrip Antennas, Artech House, Inc, 2003.

[11] Hammerstad, E.O., "Equations for Microstrip Circuit Design," Proc. Fifth European Microwave Conf., pp. 268-272, September 1975.