International Journal of Advance Research in Science and Engineering
Vol. No.4, Issue 08, August 2015
www.ijarse.com
IJARSE
ISSN 2319 - 8354

DESIGNING OF META MATERIAL BASED PATCH ANTENNA WITH IMPROVING ANTENNA GAIN & SIZE

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ABSTRACT

In this paper, the ground plane of a microstrip patch antenna is loaded with periodic array of complementary split ring resonator(CSRR) and split ring resonator(SRR) structure. A microstrip patch antenna is designed to resonate at 6 GHz in the band 5.5 to 6.5 GHz with 17% efficiency, 40% size reduction and peak gain of 8 dBi. Complementary K-shaped AMCs in antenna ground plane resonates at 2.4 GHz in the band 2.379-2.436 GHz with 2.38% impedance bandwidth and peak gain of 6.37 dB. Compared to the antenna which is loaded with Complementary k-shaped artificial magnetic conductors (AMCs) in antenna ground plane, the antenna loaded with CSRR & SRR ground achieve higher directivity, higher efficiency and miniaturization of size. Both loaded with k- shaped structure and loaded with CSRR & SRR Structure are designed and simulated by using Sonnet Lite Software.

Keywords: Patch Antenna, Metamaterials, Gain enhancement & Miniaturization of Size

I. INTRODUCTION

Microstrip patch antennas are used for mobile phone applications due to their small size, low cost, ease of production etc. The Microstrip antenna has proved to be an excellent radiator for many applications because of its several advantages, but it also has some disadvantages. Lower gain and narrow bandwidth are the major drawbacks of a patch antenna. A survey on the existing solutions for the same which are developed through several years and an evolving technology metamaterial is presented. Metamaterials are artificial materials characterized by parameters generally not found in nature, but can be engineered. They differ from other materials due to the property of having negative permeability as well as permittivity. Metamaterial structure consists of Split Ring Resonators (SRRs) to produce negative permeability and thin wire elements to generate negative permittivity. Performance parameters especially bandwidth of patch antennas which are usually considered as narrowband antennas can be improved using metamaterial. Metamaterials are also the basis of further miniaturization of microwave antennas. In this paper, the ground plane of a microstrip patch antenna is loaded with periodic array of complementary split ring resonator structure. A microstrip patch antenna is designed to resonate at 6 GHz in the band5.5 to 6.5 GHz with 17% efficiency, 40% size reduction and peak gain of 8 dBi. Compared to the antenna which is loaded with Complementary k-shaped AMCs in antenna ground plane, the antenna loaded with CSRR and SRR Structure achieve higher directivity , higher efficiency and miniaturization of size. Both antennas are designed and simulated by using Sonnet Lite Software.

II. DESIGN AND SIMULATION

Meta Material based Micro strip patch antenna is designed using Sonnet Lite Simulator is shown in the figure (1).

1. Desired frequency = 6 GHz
2. Substrate dielectric ε_r = 2.2 (Rogers 5880)
3. Height of Substrate = 1.56 mm
4. Thickness of Conductor = 0.0023 µm.

There are four essential parameters for design of a Meta material based Microstrip Patch Antenna. The desired frequency (f_o) of the antenna must be selected appropriately. The frequency range used is from 5.5GHz to 6.5GHz and the design antenna must be able to operate within this frequency range. The desired frequency selected for this design is 6 GHz. The dielectric material of the substrate (ε_r) selected for this design is ROGERS-5880 which has a dielectric constant of 2.2 and loss tangent equal to 0.001. The dielectric constant of the substrate material is an important design parameter. Low dielectric constant is used in the prototype design, because it gives better efficiency and higher bandwidth, and lower quality factor Q. The low value of dielectric constant increases the fringing field at the patch periphery and thus increases the radiated power. The proposed design has patch size independent of dielectric constant. So the way of reduction of patch size is by using higher dielectric constant and ISOLA-IS640 is good in this regard. The small loss tangent was neglected in the simulation. Height of dielectric substrate (*h*): For the micro strip patch antenna to be used in cellular phones, it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate is selected as 1.56 mm.

III. SIMULATED RESULTS OF MICROSTRIP PATCH ANTENNA

The software used to model and simulate the microstrip patch antenna is Sonnet Lite software. Sonnet Lite is a full-wave electromagnetic simulator. It analyzes 3D and multilayer structures of general shapes. An evaluation version of the software was used to obtain the results for this thesis.

The Microstrip antenna consist of a planar resonant radiating element parallel to, but separated, from a ground plane by a

thin dielectric substrate ($t << \lambda$) was designed and simulated on Sonnet lite software. The Rogers5880 substrate of The Microstrip antenna consist of a planar resonant radiating element parallel to, but separated, from a ground plane by a dielectric 2.2 was used with height 1.56 mm. The input impedance of patch R_{in} is used to calculate the 50 Ohm input impedance location of the patch where the feed line has to be connected. Fig. 2 shows the simulated single patch microstrip antenna with Microstrip line feed. The actual radiating element is the large rectangle and the smaller rectangular section is a feed line. The impedance matching is necessary in order to match the 50Ω transmission line to the relatively high impedance at the edge of the antenna element.

IJARSE
ISSN 2319 - 8354

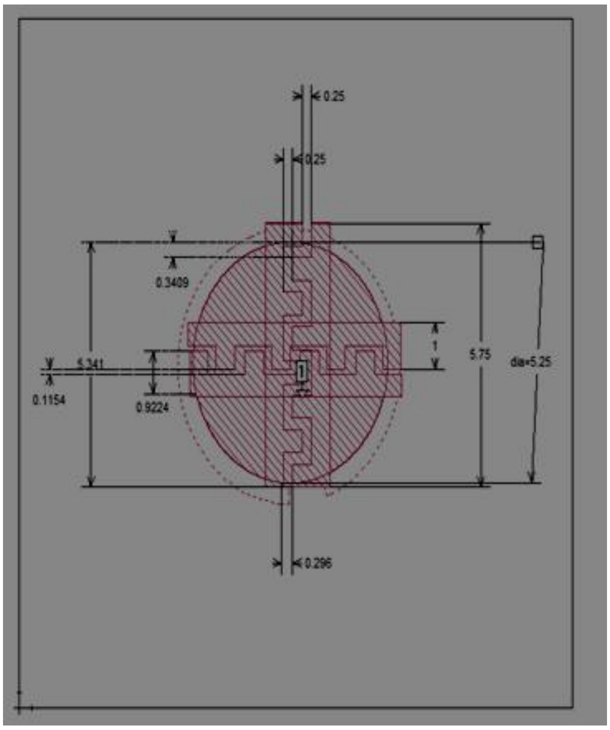

Fig 1: Meta Material Based Micro Strip Patch Antenna Designed Using Sonnet Lite Simulator

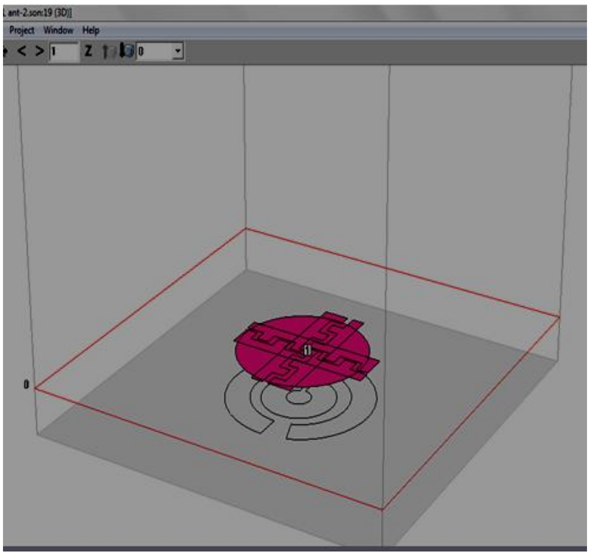

Fig.2: 3D View of Meta Material based Microstrip Patch Antenna Designed Using Sonnet Lite

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ISSN 2319 - 8354

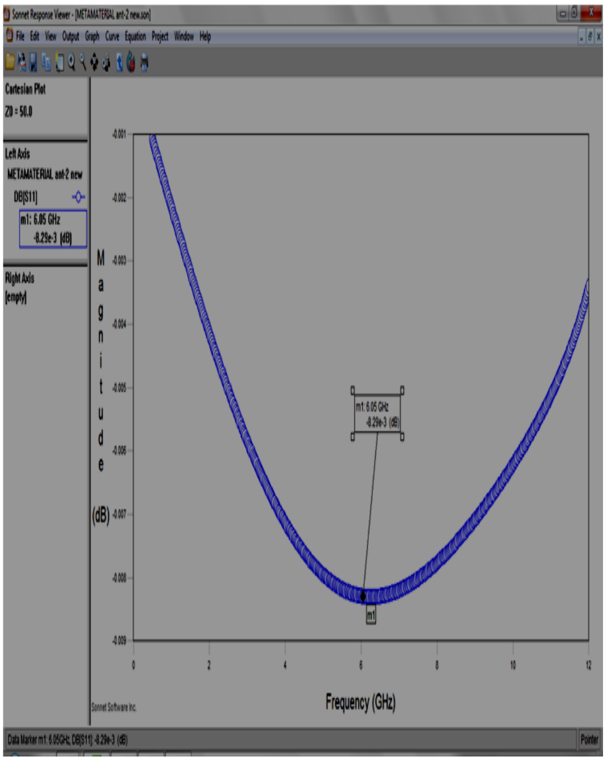

Fig.3: S-parameter Plot for Return Loss v/s Frequency for Meta Material Based Micro Strip Antenna

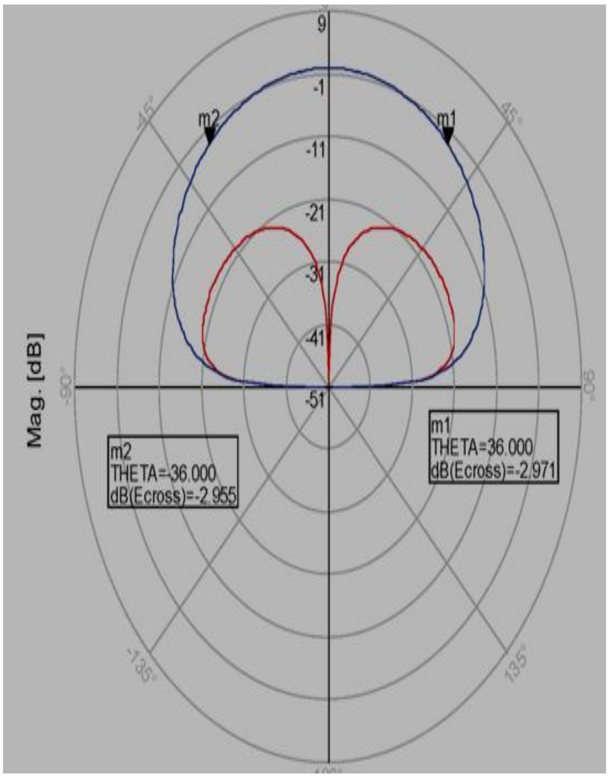

Fig.4: S-parameter Plot for Return loss v/s Frequency for Meta Material Based Micro Strip Antenna

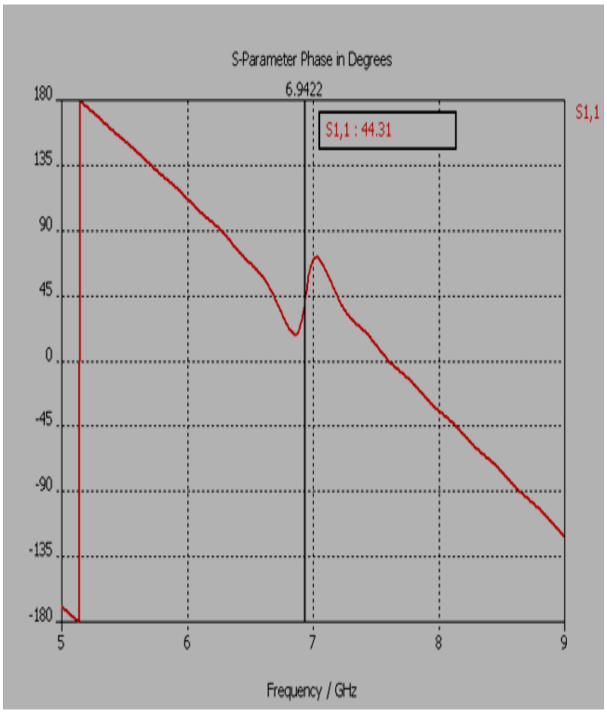

Fig.5: S-Parameter Phase in Degrees

The above figure .5 represents the phase response of micro strip Patch Antenna at 6 GHz .Here the phase is around 120.31 degree.

Now for the elevation pattern the antenna shall be simulated only at 6GHz, which is the operating frequency for this design of the patch antenna. Here we have a few different specifications than for the S-Parameters, as frequency at 6GHz.

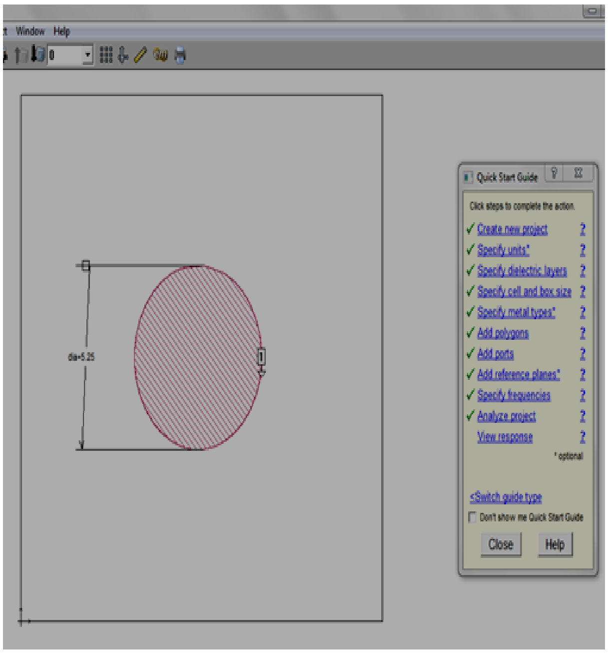

Fig. 6: Microstrip Patch Antenna

IV. RESULTS AND DISCUSSION

There is a 40 % reduction in size of an antenna when it is loaded with CSRR and SRR structure. This is a very major task to reduce the size of an antenna upto 40% . At resonant frequency of 6 GHz, the return loss is -27.18 dB and directivity is 2.8 dBi for antenna with CSRR and SRR structure, but when it is loaded with K-shaped AMC then, return loss is -27.71 dB and directivity is 2.38. The radiation characteristics and impedance characteristics for antenna are shown in Table 1.

Table 1. Impedance Characteristic and Radiation Characteristic for Antenna with K-Shaped AMCS and with CSRR & SRR Structure

Parameter	Patch Antenna	
	With K-shaped AMC	With CSRR & SRR
Band operation(GHz)	2.379-2.436	5.5-6.5
Return loss(S11)(dB)	-27.71	-27.18
Impedance Bandwidth(%)	2.38	2.87
Antenna Size improvement (%)	10%	40%
Antenna Directivity improvement	1.5dBi	2.8dBi
Antenna Efficiency improvement (%)	8%	17%

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