Volume 2 No.1, January 2012 ISSN 2224-3577
International Journal of Science and Technology

http://www.ejournalofsciences.org

A Novel Design of a Microstrip Patch Antenna with an EndFire Radiation for SAR Applications

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ABSTRACT

The major disadvantage of microstrip antennas is its low gain and the rectangular or circular patch antennas do not have an endfire radiation. In this paper a design of microstrip antenna with four circular patches is presented. The model when simulated produces an endfire radiation and hence the gain can be increased in a particular direction. The proposed model is simulated using Ansoft HFSS software and various antenna parameters are measured. The antenna works at 5GHz where applications like synthetic aperture radar (SAR) are operated.

Keywords: *microstrip, endfire, SAR.*

I. INTRODUCTION

The extensive, rapid and explosive growth in wireless communication technology and communication systems is prompting the extensive use of low profile, low cost, less weight and easy to manufacture antennas. All these requirements are efficiently realized by microstrip antennas. The applications of microstrip antennas are wide spread because of their advantages due to their conformal and simple planar structure [1],[2]. The tremendous growth in demand for wireless RF systems in applications such as local area networks, point-to-point communications, and applications in medical and industrial sectors exploit instrumentation, scientific and medical (ISM) bands. For example, radio frequency identification (RFID) systems are gaining popularity in manufacturing units, purchase departments, logistics and transportation, etc., where identification is a prime concern. At present, some RFID systems operating at S-band (2.45 GHz) are commercially available. RFID systems operating in the next higher ISM band (around 5.8 GHz) are under active development [3]. The proposed antenna in this paper can be designed to be used at such frequencies.

The drawbacks in microstrip antennas (MSA) are its relatively low efficiency, low power and it is a poor end fire radiator. In this paper the proposed model overcomes this drawback and acts as a good end fire radiator and produces a pencil beam of radiation. The losses (**q**) can be reduced by increasing thickness of the dielectric substrate, increasing the thickness, results the increasing factor of the power delivered by the source goes into a surface wave [4],[5].

In this paper the design of microstrip antenna with four patches fed by four isolated coaxial feeds is presented which works at 5 GHz frequencies and acts as a good end fire radiator.

II. ANTENNA MODEL

The proposed antenna model is shown in the figure 1 given below.

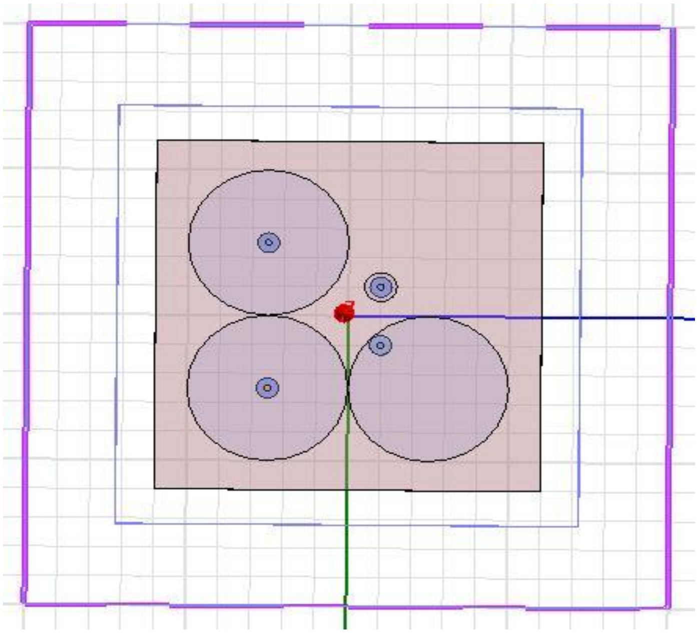

Fig 1: construction model of the antenna

A. Patch Elements

Four patch elements, out of which three are of same size of bigger radius (2.5cm) and the last one smaller in radius (0.5cm) are placed on substrate made of material Rogers RT/ duroid 5870(tm) of permittivity 2.33 and a loss tangent of 0.0012. The patch elements are drawn in HFSS using the draw circle option available in the “draw” menu. The patch element is chosen as circular in shape rather than rectangular patches because the directivity of circular patch antenna is more when compared with rectangular patch antenna for same given parameters [5]. The arrangement of the patches on the substrate material is chosen such that the gain obtained will be maximum. The patches after placing on the substrate are assigned perfect E boundary.

B. Feeding

The four patch elements are given individual feeding by coaxial feeding method. The feeding method is easy to fabricate, low spurious radiation, difficult to model accurately, narrow bandwidth of impedance matching. The location of the feed element with respect to the patch also plays a role in obtaining the antenna parameters. Hence they should be placed accordingly such that max radiation is obtained.

C. Construction of the Antenna

The substrate chosen is dielectric Rogers RT/ duroid 5870(tm) with dimensions 12cm x 12cm x 0.64cm. The antenna is constructed by placing the four chosen patches on x-y plane on the substrate at different coordinates. The three bigger circular patches are placed at (2.5, 2.5, 0.64), (2.5, -2.5, 0.64), (-2.5, -2.5, 0.64) and the smaller one is placed at (-1, 1, 0.64). Here 0.64 refers to the substrate height. The feeding is given separately to the four patches.

III. RESULTS AND DISCUSSIONS

A. Return loss

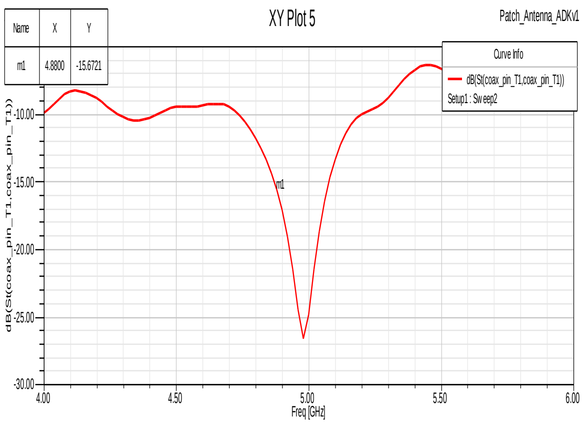

Fig 2: Return loss

The above figure shows the return loss graph for the proposed antenna. It can be seen that the minimum value is obtained at 5GHz and the minimum value obtained is -24.8dB. Hence the antenna works well at that frequency and there are wide applications for patch antennas at that frequency.

B. 2D – gain

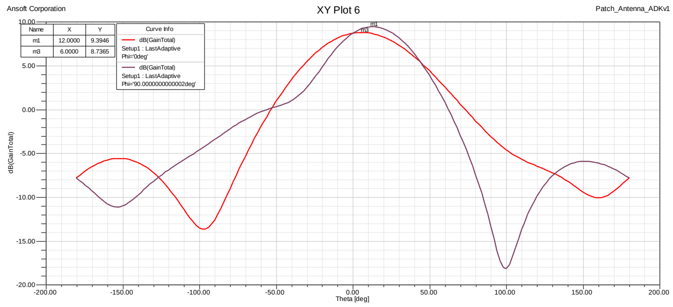

Fig 3: 2D gain total

The two dimensional plot of the gain of the antenna is shown in the graph above. The maximum gain obtained from the graph is 9.4dB which is a good value for the antenna working.

C. 3D gain

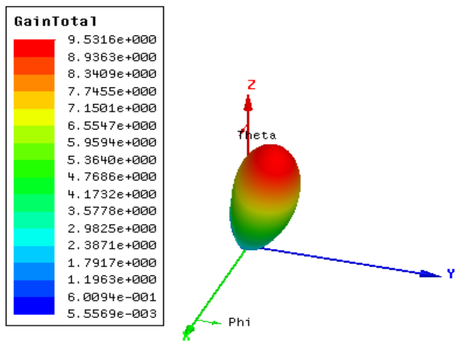

Fig 4: 3D gain

The 3 dimensional pattern of the gain indicates that a high directional beam of radiation is produces and hence the antenna performs well as a good endfire radiator. The peak gain of the antenna is obtained as 9.5dB which is a good value for the antenna to behave well.

D. Radiation pattern

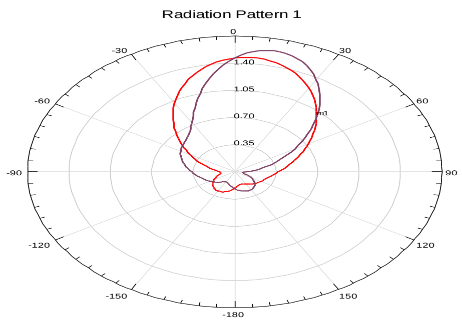

Fig 5: Radiation pattern

In all the basic microstrip antennas the radiation pattern is broad and it can be acted as a good end fire radiator. But this problem does not exist in this antenna. The figure shows the radiation pattern of the antenna. It is clear from the graph that the radiation is not distributed but directed along a single direction hence it can be used as a good end fire radiator.

E. E field vector

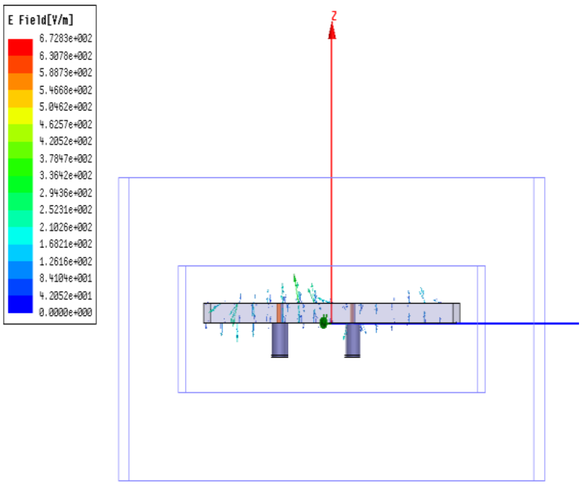

Fig 6: E field vector distribution

F. H field vector

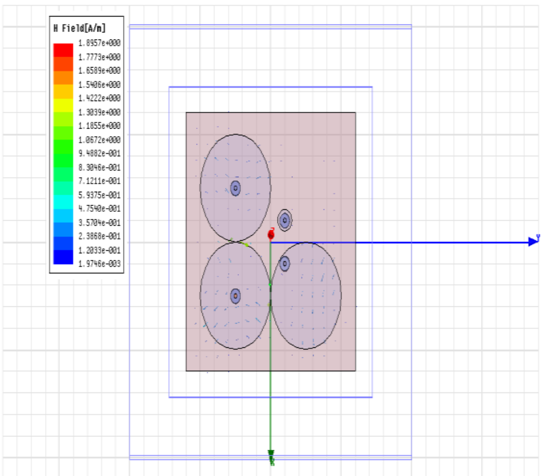

Fig 7: H field vector distribution

G. Axial ratio

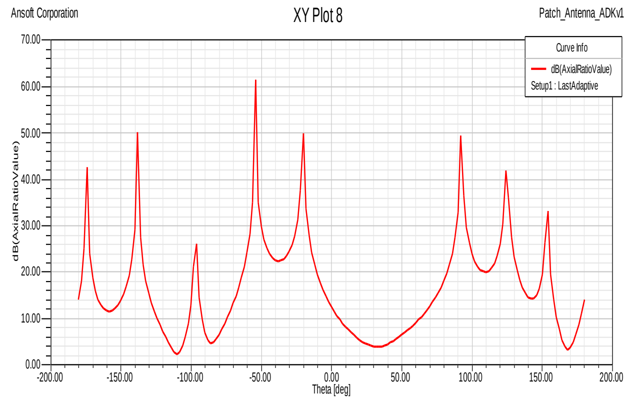

Fig 8: Axial ratio

The figure shows the graph of axial ratio. As seen from the graph the peak value of axial ratio obtained is 60dB which indicates that the antenna has very high directivity in one direction.

H. Antenna Parameters

Quantity	Value	Units
Max U	0.0036944	W/sr
Peak directivity	9.5896	
Peak gain	9.5316	
Peak realized gain	7.7534	
Radiated power	0.0048412	W
Accepted power	0.0048707	W
Incident power	0.0059878	W
Radiation efficiency	0.99395	
Front to back ratio	100.68	

IV. CONCLUSIONS

The proposed microstrip circular patch antenna operating at 5 GHz is designed using Ansoft HFSS and the simulated results are observed. A return loss of -24dB and a peak gain of 9.4dB is observed. But due to the placing of the patches close to each other there would be mutual coupling losses. Reducing surface-wave excitation and lateral radiation reduces mutual coupling. It can be concluded that change in current distribution and change in antenna geometry play a major role in manipulating the radiation pattern of antenna arrays. The antenna seems to work well at 5 GHz where a wide variety of applications are present [6] like IEEE 802.11a [7] which employs the 5 GHz U-NII band and ISM band (5.15–5.825 GHz) which is the higher band used in RFID systems [8,9]. Particularly it can be used in Synthetic Aperture Radar which is a very successful remote sensing technology [11]-[17].

ACKNOWLEDGMENT

The authors like to express their thanks to the department of ECE and the management of K L University for their support and encouragement during this work.

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