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A New Quadri Polarization Reconfigurable Circular Patch Antenna

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ABSTRACT

In this paper, the feed point of the circular patch can be switched. The antenna is composed of circular radiating patch and switchable feed network. Simulated and measured results indicate that the antenna can achieve reconfigurable quadri-polarization diversity features with an invariable operating frequency and excellent radiation performance. The proposed antenna is fabricated on FR4-eproxy substrate. The parameters of proposed antenna was simulated using HFSS 13.0 software in term of return loss, gain, VSWR, and radiation pattern. This type of antenna can be used for wireless applications.

Keywords: High frequency structural simulator, Microstrip line feed, Circular Patch Antenna and Reconfigurable Antenna.

1. INTRODUCTION

Antennas play very important role in the field of wireless communications. Some of them are Parabolic Reflectors, microstrip Antennas, Slot Antennas, and Folded Dipole Antennas. Each type of antenna is good in its own properties and usage. We can say antennas are the backbone for wireless communication without which the world could have not reached at this age of technology. Microstrip patch antennas play a very significant role in today's world of wireless communication systems. A Microstrip patch antenna is very simple in the construction using a conventional Microstrip fabrication technique.

Rectangular and circular patch antennas are the most commonly used microstrip patch antennas. Dual characteristics, circular polarization, dual frequency operation, frequency agility, broad band width, feed line flexibility, beam scanning and triple band frequencies can be easily obtained from these patch antennas. Micro strip antennas are widely used in the microwave frequency region because of their simplicity and compatibility with printed circuit technology, making them easy to manufacture. Generally a microstrip antenna or a patch antenna consists of a patch of metal on top of the grounded substrate. The substrate is made of a dielectric material.

Various methods are used to feed a micro strip antenna such as inset feed, coaxial feed, aperture coupled or slot coupled feed and proximity coupled feed. Microstrip patch antennas have the important advantage of being low profile and if the substrate is thin enough, they may also be comfortable. Basic structure of microstrip patch antenna Circular or rectangular microstrip patch has been modified for some applications to other shapes. Hexagonal shape microstrip antenna has smaller size compared to the square and circular microstrip antennas for a given frequency. The small size is an important requirement for portable communication equipments. Microstrip Line feed is used to feed the antenna. Moreover thick substrate properties are used for improvement of proposed antenna. HFSS software is used to carry out the results. HFSS software is a fully featured software package for electromagnetic analysis and design in the high frequency range.

In recent years, polarization reconfigurable antennas have received much attention due to their attractive advantages, such as avoiding the detrimental fading loss caused by multi-path effects and reusing the frequency spectrum to increase the channel capacity. Corresponding to this trend, many efforts have been made on the exploration of polarization reconfigurable microstrip antennas which could switch their polarization characteristics in real time.

A polarization reconfigurable patch antenna was proposed to switch between the left-hand circular polarization (LHCP) and right-hand circular polarization (RHCP). The function was realized by electrically controlling two inserted PIN diodes between the rhombus-shaped patch and the Y-shaped feed line. Two slot antennas with switchable vertical and horizontal polarizations for the WLAN application, realized by a switchable feed structure controlled by PIN diodes, were proposed. However, these designs could merely implement two switchable polarization states.

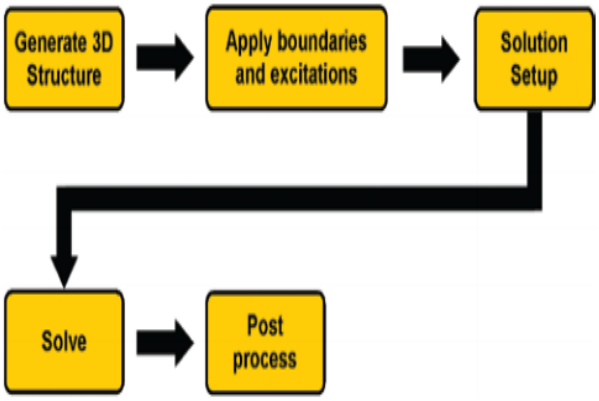
The proposed design can offer more than four reconfigurable linear polarization directions by adding more switchable paths in the feed network. Details of the antenna design are described, and both simulated and experimental results are presented.

2. SOFTWARE SIMULATION-HFSS

HFSS is a high-performance full-wave electromagnetic (EM) field simulator for arbitrary 3D volumetric passive device modeling that takes advantage of the familiar Microsoft Windows graphical user interface. It integrates simulation, visualization, solid modeling, and automation in an

easy-to-learn environment where solutions to your 3D EM problems are quickly and accurately obtained. Ansoft HFSS employs the Finite Element Method (FEM), adaptive meshing, and brilliant graphics to give you unparalleled performance and insight to all of your 3D EM problems. Ansoft HFSS can be used to calculate parameters such as S Parameters, Resonant Frequency, and Fields.

There are six main steps to creating and solving a proper HFSS simulation. They are:
1. Create model/geometry
2. Assign boundaries
3. Assign excitations
4. Set up the solution
5. Solve
6. Post-process the results



3. FEEDING TECHNIQUE

Microstrip patch antennas can be fed by a variety of methods. These methods can be classified into two categories, contacting and non-contacting. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as microstrip line. In the non-contacting scheme, electromagnetic field coupling is done to transfer power between the microstrip line and the radiating patch.

The four most popular feed techniques used are the microstrip line, coxial probe, aperture coupling and proximity coupling. To obtain a desirable return loss at the resonant frequency, a microstrip patch antenna must be matched to the transmission line feeding it. The microstrip line is also a conducting strip. It is easy to fabricate and simple to match by controlling the feed position and rather simple to model. This conducting strip is directly connected to the edge of the microstrip patch.

The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure. This conducting strip and the patch are also made from the same material. However as the substrate thickness increases surface waves and spurious feed radiation increase, which for practical designs limit the bandwidth (typically 2-5%).This is an easy feeding scheme, since it provides ease of fabrication and simplicity in modeling as well as impedance matching.

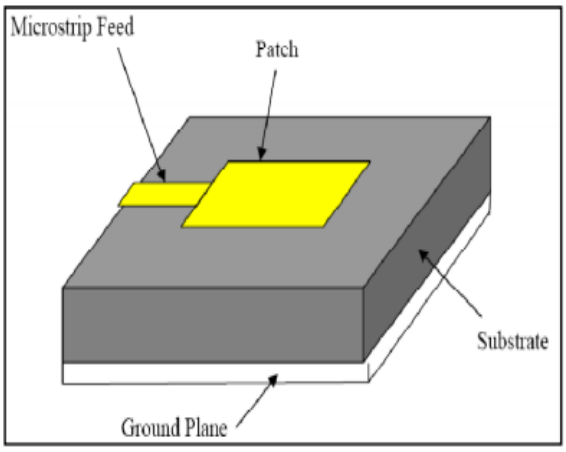


Fig.1. Microstrip Line Feeding

4. ANTENNA DESIGN

Design Calculation

Step 1: Calculation of the Width (W): The width of the Microstrip patch antenna is given by following equation:

$$W = \frac{c}{2 * f_r}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

Step 2: Calculation of Effective Dielectric Constant (εreff): The following equation gives the effective dielectric constant as

$$\varepsilon_{reff} = \frac{\varepsilon_{r+1}}{2} + \frac{\varepsilon_{r-1}}{2}\sqrt{1+12\frac{h}{w}}$$

Step 3: Calculation of Effective Length (effL): The effective length is given as:

$$L_{eff} = \frac{c}{2 f r \sqrt{\varepsilon_{reff}}}$$

Step 4: Calculation of the Length Extension (Δ L): Equation below gives the length extension as:

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)\left(\frac{w}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{w}{h} + 0.8\right)}$$

Step 5: Calculation of Actual Length of Patch (L): The actual length of the antenna can be calculated as:

$$L = L_{eff} - 2 \times \Delta L$$

5. CIRCULAR PATCH ANTENNA

A patch antenna also known as rectangular patch antenna is a type of radio antenna with a low profile, which can be mounted on a flat surface. It consists of a flat rectangular sheet or "patch" of metal, mounted over a larger sheet of metal called a ground plane. The two metal sheets together form resonant piece of microstrip transmission line with a length of approximately one-half wavelength of the radio waves. The radiation mechanism arises from discontinuities at each truncated edge of the microstrip transmission line. The radiation at the edges causes the antenna to act slightly larger

electrically than its physical dimensions, so in order for the antenna to be resonant, a length of microstrip transmission line slightly shorter than one-half wavelength at the frequency is used.

A variant of the patch antenna commonly used in mobile phones is the shorted patch antenna, or planar inverted-F antenna (PIFA). In this antenna, one corner of the patch (or sometimes one edge) is grounded with a ground pin. This variant has better matching than the standard patch.

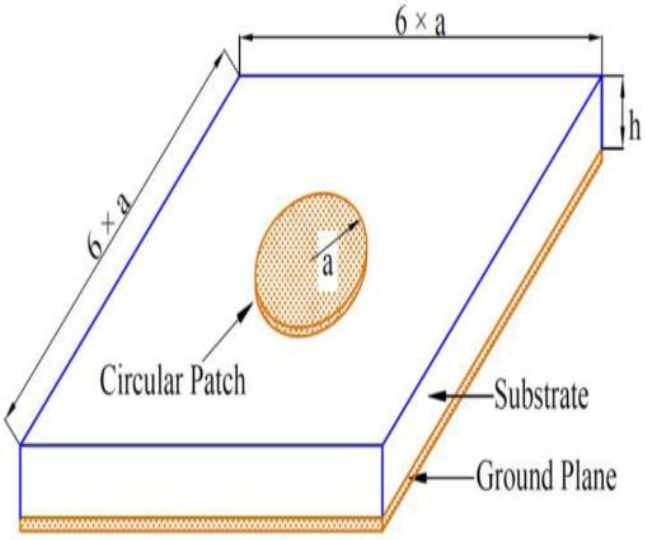


Fig.2. Circular Patch Antenna

6. PARAMETERS OF CIRCULAR PATCH ANTENNA

In this section parameters of a circular slot antenna has been discussed which is printed on a dielectric substrate of FR4 with relative permittivity (εr) of 4.4. It shows the patch with finite ground plane.

Table 1. Parameters of Circular patch Antenna

PARAMETERS	***DIMENSION***
Substrate thickness	3.1mm
Substrate width	100mm
Dielectric constant	4.4
Input Impedance	50 ohms
Substrate radius	28mm

7. GROUND PLANE

A ground plane is often made as large as possible, covering most of the area of the PCB which is not occupied by circuit traces. In multilayer PCBs, it is often a separate layer covering the entire board. This serves to make circuit layout easier, allowing the designer to ground any component without having to run additional traces; component leads needing grounding are routed directly through a hole in the board to the ground plane on another layer. The large area of copper also conducts the large return currents from many components without significant voltage drops, ensuring that the ground connection of all the components are at the same reference potential.

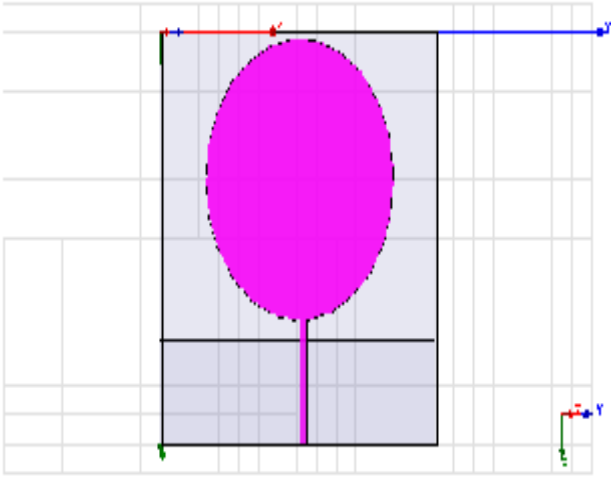


Fig.3. Ground Plane

8. COAXIAL FEED

Coaxial feeding is feeding method in which that the inner conductor of the coaxial is attached to the radiation patch of the antenna while the outer conductor is connected to the ground plane.

The coaxial feed introduces an inductance into the feed that may need to be taken into account if the height h gets large (an appreciable fraction of a wavelength). In addition, the probe will also radiate, which can lead to radiation in undesirable directions.

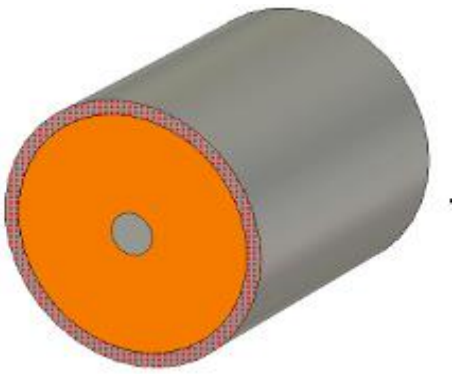


Fig.4. Coaxial Feed

9. STIMULATED RESULTS AND ANALYSIS

The antenna is stimulated using a substrate FR-4 and the result is stimulated using HFSS (High Frequency Structural Stimulator) and using HFSS antenna parameter like Bandwidth (GHz), Gain (dB) and Efficiency (%).

A. Radiation Pattern

In the field of antenna design the term radiation pattern or antenna pattern or far-field pattern refers to the directional (angular) dependence of the strength of the radio waves from the antenna or other source.

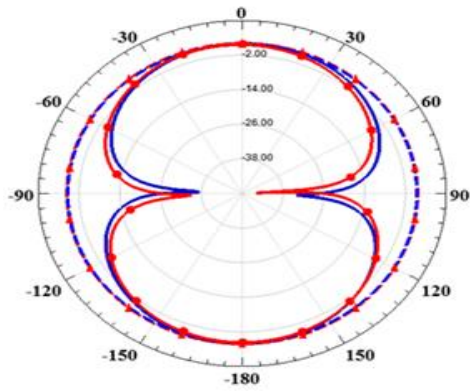


Fig.5. Radiation pattern of circular patch antenna

B. Gain Pattern

In the field of antenna design the term radiation pattern or antenna pattern or far-field pattern refers to the directional (angular) dependence of the strength of the radio waves from the antenna or other source.

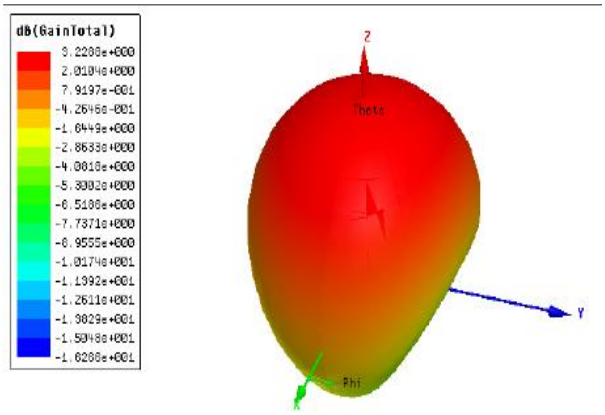


Fig.6. Gain measurement of circular antenna

C. Return Loss

It is a parameter which indicates the amount of power that is "lost" to the load and does not return as a reflection. Hence the R_L is a parameter to indicate how well the matching between the transmitter and antenna has taken place.

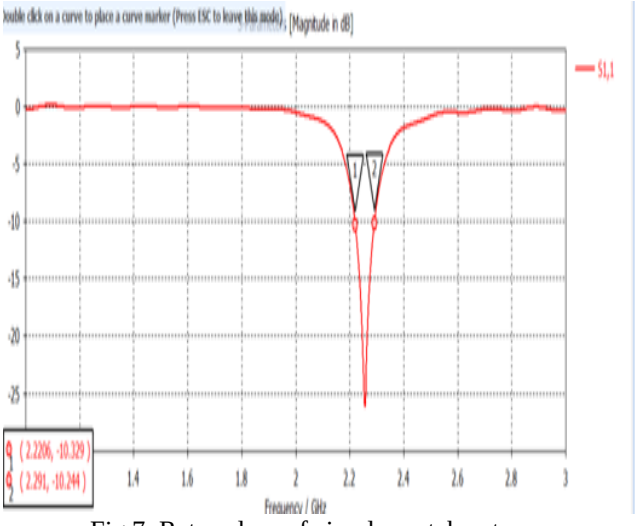


Fig.7. Return loss of circular patch antenna

D. Comparison of Antenna Results

Table 2.Comparision of Antenna Results

PARAMETERS	***RECTANGULAR ANTENNA***	***CIRCULAR ANTENNA***
Patch Parameter	4.4	4.4
Return loss (db)	-26.6153	-26.9391
VSWR	0.8117	0.7820
Bandwidth	2GHz	2GHz
Gain (db)	5.1218	6.7784
Directivity	7.2180	7.7825

10. CONCLUSION AND FUTURE WORK

The proposed design can offer more reconfigurable linear polarization directions by adding more switchable paths in the feed network. The proposed antenna is very attractive for wireless communications. In future, the proposed antenna can be developed by adding four feed points at different polarization angles.

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