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Circular Polarization Wideband E-Shaped Patch Antenna for Wireless Applications

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***Abstract*— A new Circular Polarization Reconfigurable Wideband E-Shaped Patch Antenna allowing polarization switching is presented. The antenna shape consists of a two slot which are switched on and off using pin-diodes. Two antennas allowing switching either between linear and circular polarization or between two circular polarizations are demonstrated. Zeland IE3D is used as a design tool to simulate microstrip antenna that E shaped microstrip antenna which is operated at 2.45 GHz frequencies.**

***Index Terms*— E-shaped patch antenna, microstrip antenna, PIN diodes, polarization agile, reconfigurable antennas, RF switches.**

I. INTRODUCTION

RECENTLY, a polarization reconfigurable antenna, which can offer various polarizations at the same operating frequency, has received considerable attention because it has the potential to improve the performances of wireless communication systems. For example, the switchable polarization antenna can be used to mitigate signal fading in multipath propagation environments and provide double transmission channels for frequency reuse radio transceivers; moreover, it can be applied to multisystem operation in order to reduce the number of the required antennas. For single-fed microstrip patch antennas, a simple method to achieve the polarization switching is by changing the electric characteristics of perturbation segments through PIN diodes, and several polarization reconfigurable antennas based on the method have been proposed [1]–[2]. These past works mainly concentrate on the designs related to the switching between left-hand circular polarization(LHCP)and right-hand circular polarization (RHCP) or between linear polarization (LP) and circular polarization (CP). but it is a dual-fed design and the number of the required diodes is two, which would make the antenna structure and dc-bias network complicated.

Examples of efforts toward the realization of polarization agile antennas using different methods have been reported in [3]–[4]. However, several challenging problems still exist in these designs, particularly the antenna bandwidth, gain, design complexity, and performance symmetry upon switching. In [4]–[5], the achieved bandwidth is less than 2.8% which is not satisfactory for some wireless applications such as WLAN IEEE 802.11 b/g (4%). In [3] and [5], slot antenna designs are used to achieve wider bandwidth 4.2% and 11%, respectively. However, the realized gain is found to be smaller compared to that attained by the microstrip patch designs. Moreover, in the former design, the biasing circuit for the diodes is relatively complicated. In [6], the antenna geometry is sophisticated and impedance matching at each polarization mode requires a reconfigurable matching network. This antenna configuration imposes design complexity and fabrication inconvenience that limit its practical application. In addition, the antenna performance varies through its switching states because of its asymmetrical geometry, which narrows the overlapped bandwidth along the antenna polarization modes to 2.24%. To overcome these difficulties a circularly polarized microstrip patch antenna with inherent wide bandwidth and simple symmetrical shape is required.

Recently, a linearly polarized (LP) E-shaped patch antenna that exhibit a dual/wide bandwidth was proposed in [13]. It has been increasingly used in the last decade for dual/wideband applications because of its design simplicity [14]–[17]. In [18], an evolved version of an E-shaped patch with unequal slots to produce CP fields with wideband characteristics (9.27%) has been introduced. Therefore, the E-shaped patch antenna becomes attractive for wideband polarization agile designs.

In this communication, a novel simple design for a circularly polarized reconfigurable antenna with wideband and symmetrical performance is proposed. It is based on the popular E-shaped patch antenna with two RF PIN diodes added in the slots' regions at optimized positions. Therefore, if one switch is ON and the other is OFF, the two slots' lengths will become effectively unequal and circular polarization is obtained. If the switches' states are reversed, circular polarization (CP) with opposite orientation is obtained at the same frequency band due to the structure symmetry. The design avoids a reconfigurable matching network and complicated biasing circuit. Simulations and measurements results show good agreement, thus validating the design concept proposed in this communication.

II. THEORITICAL CONSIDERATION:

A. *ANALYSIS OF E_Shape MICROSTRIP ANTENNA*

The width of the microstrip patch element (W) is given by.[1]

$$(W) = \frac{c}{2f_c\sqrt{\frac{\varepsilon_r + 1}{2}}} \quad (1)$$

The effective of the dielectric constant (εeff)

$$(\varepsilon_{reff}) = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r + 1}{2}\left[1 + \frac{12\,h}{W}\right]^{-\frac{1}{2}} \quad (2)$$

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The effective length (L eff) is given as

$$(L_{eff}) = \frac{c}{2f_{c}\sqrt{\varepsilon_{reff}}} \quad (3)$$

The length extension (DL) is given by

$$(\Delta L) = 0.412 \times \frac{(\varepsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)} \quad (4)$$

The actual length (L) of patch is obtained by

$$(L) = L_{eff} - 2\Delta L \quad (5)$$

B. Antenna design specifications

The E-shape microstrip patch antenna is constructed on grounded two layers of dielectric sheets (air and FR4), and a vertical probe connected from ground to the upper patch. The FR4 substrate with relative dielectric constant of 4.2, thickness of h=10mm, and loss tangent=0.02. An air-filled layer with dielectric permittivity of 1 and thickness of 5mm is sandwiched between the substrate and the ground plane. The slots having dimensions of length Ln and width Wn, where n is number of iteration are cut from the rectangle. At first

iteration two parallel slots having length L=30mm and width W1=7mm are cut from main rectangle.

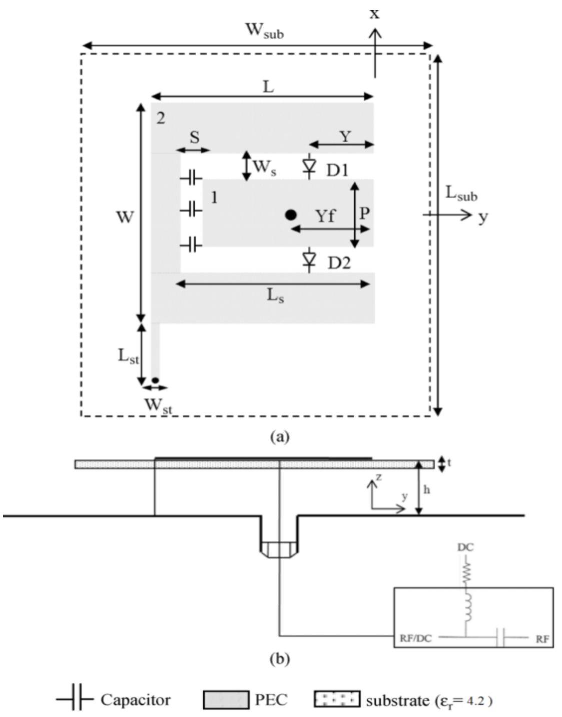

Fig. 3. Geometry of a single-feed reconfigurable E-shaped patch antenna with integrated DC biasing circuit: (a) top view; (b) side.

view:Lsub=140mm,Wsub=80mm,W=77mm,L=43mm,Wst=0.3mm,Lt=28mm,Ws=7mm,Ls=30mm,S=0.5mm,t=0.787mm,h=10mm,p=17mm,Yf=14mm.

III. RESULTS AND DISCUSSION

We are using IE3D simulation software for simulation of microstrip patch antenna.

A. Return Loss

From figure 3.1 the return loss of E_Shape microstrip antenna is obtained showing - 20db at the desired frequency of 8.6 GHz . The impedance bandwidth calculated from the graph showing a bandwidth of 3.6%.From the E_Shape microstrip antenna model obtained in IE3D software two parallel slots are cut and an E shaped patch is obtained .The return loss of the E shaped patch antenna from the figure 6 is lower than E shaped patch antenna alone. Thus, showing that better impedance matching is done and the bandwidth obtained coves a range of 2.45Ghz. It can be observed that the antenna has clearly resonant frequencies: 2.45GHz. It agrees well with the explanation given above. The antenna frequency band with–10 dB return loss covers the frequency range of 2.4–2.57 GHz. It has a bandwidth of 7% with the center frequency.

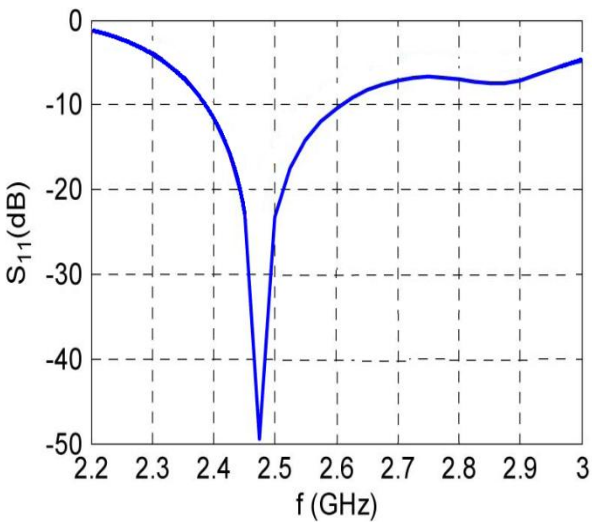

Figure3.1 : Return loss* of *Rectangular microstrip antenna at 2.45 GHz

B. Gain

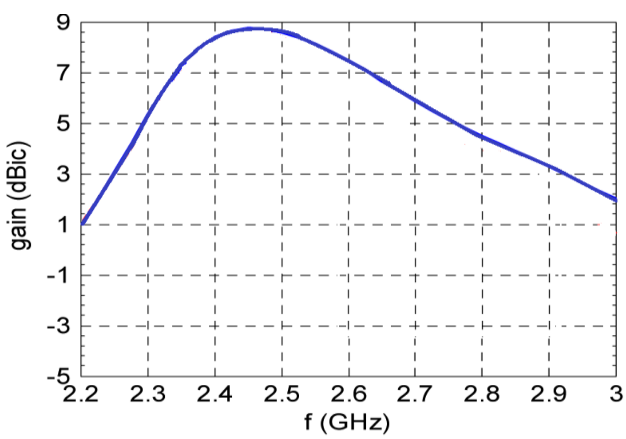

Figure3.2 : GAIN of Rectangular microstrip antenna at 2.45 Ghz

Antenna gain relates the intensity of an antenna in a given direction to the intensity that would be produced by a hypothetical ideal antenna that radiates equally in all directions (isotropically) and has no losses. Since the radiation intensity from a lossless isotropic antenna equals the power into the antenna divided by a solid angle of 4π steridians, we can write the following equation:

Gain = 4π * Radiation Intensity/Antenna Input Power

Figure 3.2 shows the gain of the antenna. The gain of the proposed antenna is 8.7 dBic at 2.45 GHz.

C. *Axial Ratio*

The axial ratio is the ratio of orthogonal components of an E-field. A circularly polarized field is made up of two orthogonal E-field components of equal amplitude (and 90 degrees out of phase). Because the components are equal magnitude, the axial ratio is 1 (or 0 dB).

The axial ratio for an ellipse is larger than 1 (>0 dB). The axial ratio for pure linear polarization is infinite, because the orthogonal components of the field are zero.

Axial ratios are often quoted for antennas in which the desired polarization is circular. The ideal value of the axial ratio for circularly polarized fields is 0 dB. In addition, the axial ratio tends to degrade away from the main beam of an antenna, so the axial ratio may be indicated in a spec sheet (data sheet) for an antenna as follows: "Axial Ratio: <3 dB for +-30 degrees from main beam". This indicates that the deviation from circular polarization is less than 3 dB over the specified angular range.

Figure 3.3 shows the Axial ratio of the antenna. The gain of the proposed antenna is 8.7 dBic at 2.45 GHz. Good agreement between simulated and measured results is observed.

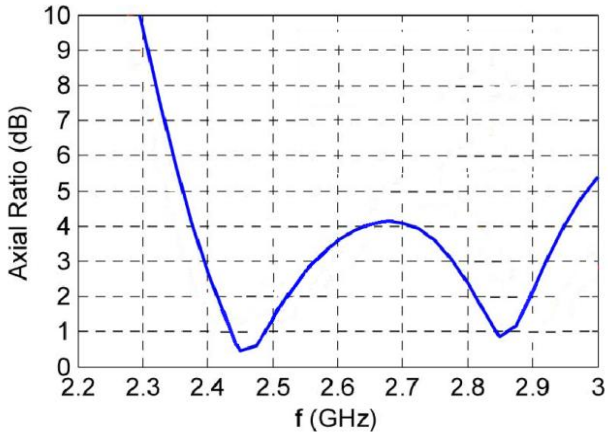

Figure3.3: AXIAL RATIO of Rectangular microstrip antenna at 2.45 Ghz

Due to the structure symmetry, S11 and the axial ratio are maintained when switching between the two states, which is an advantage of this design and the measured effective overlapped bandwidth (10 dB and 3 dB axial ratio) is 7% (2.4–2.575 GHz).

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IV. CONCLUSION

The high potentiality of a switchable patch antenna has been proposed for Wireless applications. The proposed design exhibits a 7% effective bandwidth with maximum realized gain of 8.7 dBic at 2.45 GHz. The proposed antenna can produce a linear- or circular polarization according to Dc bias voltages. The technique has been successfully applied to microstrip antennas with switchable polarization and it offers a solution to the problem of the change in impedance when switching between polarizations. The proposed antenna is suitable for applications in wireless communications and mobile satellite communications..

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