CPW Fed Elliptical Patch Antenna with Polarization Reconfigurability

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***Abstract*—A CPW fed elliptical patch antenna with reconfigurable polarization states among elliptical polarization (EP) and circular polarization (CP) is proposed. The proposed antenna has an elliptical patch on which cuts have been made symmetrical to minor axis of ellipse to obtain elliptical polarization. Circular polarization (CP) and Elliptical polarization are generated due to the discontinuity introduced by the cuts. In the proposed antenna, CPW feeding is used to increase the percentage bandwidth.**

Keywords—Polarization Diversity, Elliptical Polarization, Circular Polarization, CPW Feeding, Return Loss.

I.INTRODUCTION

Polarization reconfigurable antennas allows the system to double the system capacity [1] by allowing the system to use the same frequency with different polarizations [2]. If antenna can be switched between any two polarizations either from elliptical to circular or circular to elliptical [3]. Significant changes can be made in control system performance. Polarization reconfigurable [4] antennas have received much attention in radar, mobile wireless communications, radio frequency identification (RFID), direct broadcasting system (DBS), the global positioning system (GPS) and sensor systems due to their ability to mitigate multipath effects and to provide flexible orientation capability for both transmitter and receiver [5].

In the proposed antenna, when the antenna is physically and electrically in symmetric shape with respect to the feed line, circular polarization is generated else elliptical polarization is generated when the antenna is physically and electrically in asymmetric shape [6]. To electrically switch between elliptical polarization and circular polarization, PIN diodes or RF MEMS switches [7] can be employed [8]. Circular polarization (CP) and Elliptical polarization are generated due to the discontinuity introduced by the cuts [9].

II.ANTENNA GEOMETRY

The proposed antenna structure is depicted in Figure 1. Dimensions and the notations of the antenna are shown in Table 1. CPW feeding [10] structure is used in the proposed antenna. Proposed antenna is designed on a Rogers RT Duroid

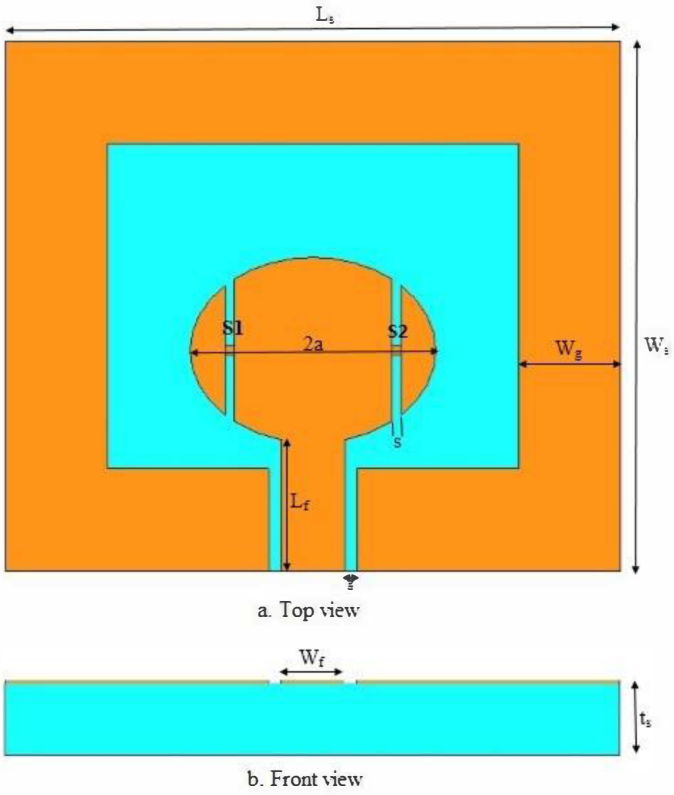

Fig. 1. Structure of proposed antenna.

5880 dielectric substrate with a dimension of 35mm x 30 mm x 0.254 mm. Elliptical patch and ground are employed in the same plane. Elliptical patch has a major axis length of 7mm. Feed line is having a dimension of 7.9mm x 3.4mm. Elliptical patch is surrounded by ground which has a width of 3.4 mm. Rogers RT Duroid 5880 is having a relative permeability [11] of $\varepsilon_r = 2.2$ and dielectric loss tangent of $\tan\delta = 9\times10^{-4}$.

III.ANTENNA OPERATION

The structure has been modeled and optimized with the commercial software Ansoft HFSS using FEM (Finite Element Method). The proposed antenna is simulated without using any PIN diodes. In Antenna I, both switches are OFF, so we removed the copper part on the patch in switch positions S1 and S2. When the switch state is ON, we simulated the antenna by keeping the copper part at that position of the switch. The proposed antenna is generating Circular Polarization when both the switches are both the switches are

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either OFF or ON [12]. It is generating elliptical polarization when any one switch is in ON state and other is in OFF state.

TABLE 1: DIMENSIONS OF ANTENNA

Literals	Parameter	Dimension (in mm)
T_s	Thickness of substrate	0.254
2a	Major axis of elliptical patch	7
W_s	Width of Substrate	30
L_s	Length of Substrate	35
L_f	Length of Feed line	7.9
W_f	Width of feed line	3.4
g	Gap between feed line and ground	0.8
W_g	Width of Ground	5.8
s	Width of Switch	0.5

The polarizations generated corresponding to the states of the switches 1 and 2 are shown in Table 2.

Table 2: Polarizations generated corresponding to the switch states.

MODE	S1 state	S2 state	Polarization Obtained
MODE I	OFF	OFF	CP
MODE II	OFF	ON	LHEP
MODE III	ON	OFF	RHEP
MODE IV	ON	ON	CP

IV.PARAMETRIC ANALYSIS

Parametric analysis is done to resonate around 2.4GHz with good return loss for proposed antenna in all Modes.

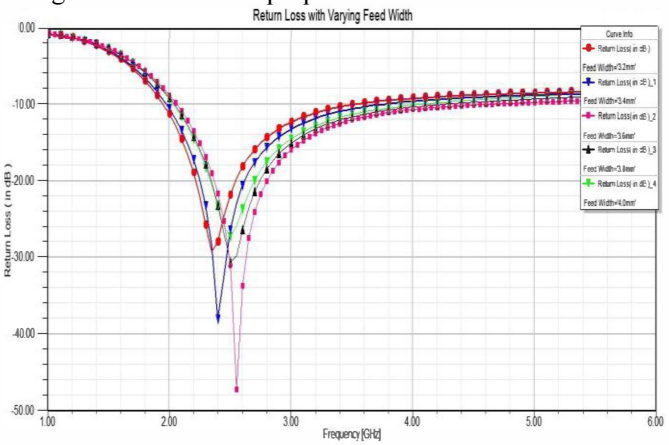

Fig. 2. Return loss curve of parametric analysis of feed width for Mode IV.

Initially feed length and width are taken as 7.5mm and 3.6mm. Initially feed length is kept constant and feed width is varied from 3.2mm to 4mm in steps of 0.2mm.

Above figure shows the return loss curve of parametric analysis of feed width of Mode IV. From the results, feed width is chosen as 3.4mm and feed length is varied in steps of 0.2mm from 7.1mm to 7.9mm. Parametric analysis is done for all modes for choosing feed length. From the results of parametric analysis of all modes for feed length to resonate between 2.3GHz to 2.5GHz, feed width is chosen as 7.9mm.

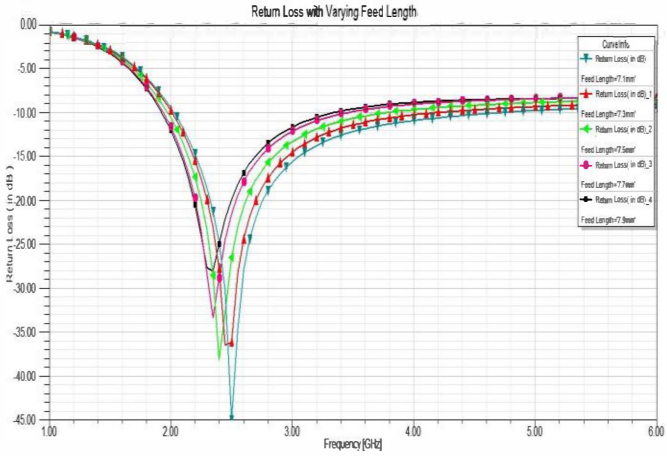

Fig. 3. Return loss curve of parametric analysis of feed length for Mode IV.

V.RESULTS AND DISCUSSIONS

A. Return Loss

The following figure shows the return loss for Mode I when both switches are in OFF state.

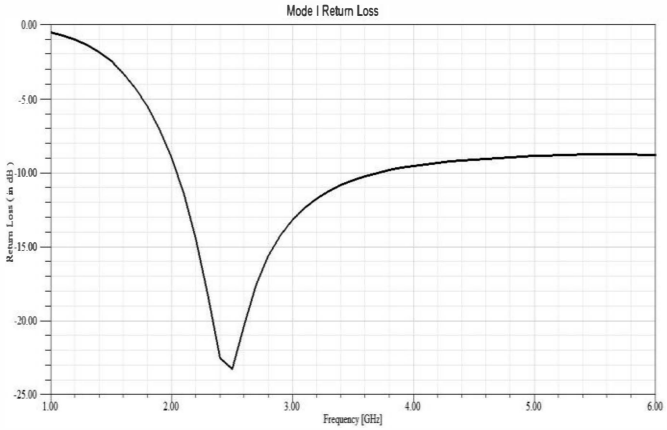

Fig. 4. Return loss of proposed antenna in Mode I.

Antenna in Mode I is resonating at 2.46 GHz with a return loss of -23.73dB, a VSWR of 1.13 and bandwidth percentage of 67.07.

Below figure shows the return loss curve for mode II. Antenna in Mode II is resonating at 2.38 GHz with a return loss of -41.78dB, a VSWR of 1.01 and bandwidth percentage of 62.60.

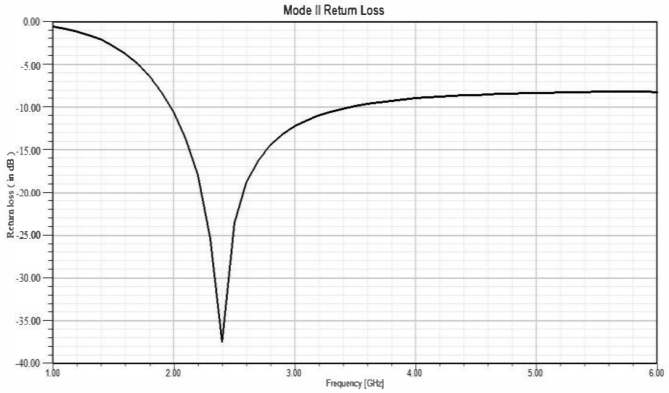

Fig. 5. Return loss of proposed antenna in Mode II.

The following figure shows the return loss for Mode III when S1 is in OFF state and S2 in in ON state.

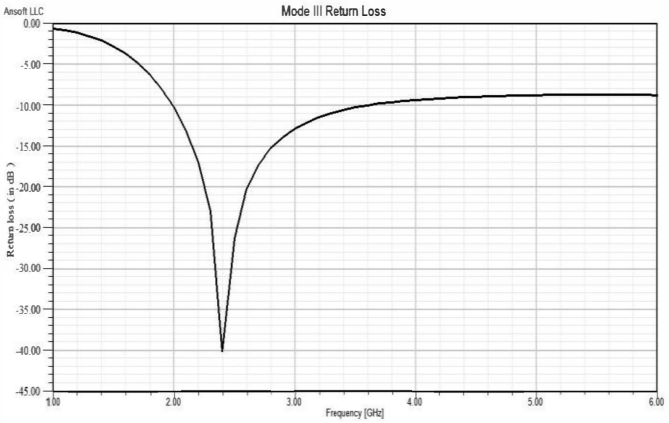

Fig. 6. Return loss of proposed antenna in Mode III.

Antenna in Mode III is resonating at 2.41 GHz with a return loss of -43.36dB, a VSWR of 1.01 and bandwidth percentage of 66.8.

The following figure shows the return loss for Mode IV when both switches are in ON state.

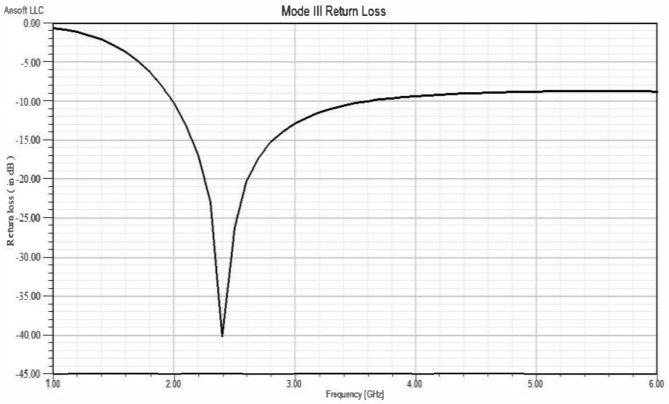

Fig. 7. Return loss of proposed antenna in Mode IV.

Antenna in Mode IV is resonating at 2.32 GHz with a return loss of -29.3dB, a VSWR of 1.07 and bandwidth percentage of 67.07.

B. Axial Ratio

The following figure shows the axial ratio values at different frequencies for different modes.

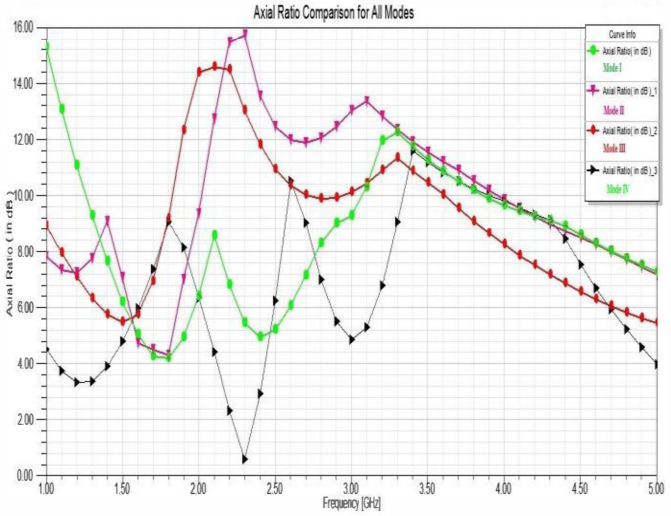

Fig. 8. Axial ratio of proposed antenna in all modes

In Mode I when both switches are off, the antenna is having an axial ratio of 4.94dB at 2.46 GHz. Ideal value of axial ratio for genereating circular polarization is 0 dB and allowable range is zero dB to 5 dB [2]. Hence antenna operating in mode I is generating circular polarization. In Mode II when S1 is in OFF state and S2 is in ON state, the antenna is having an axial ratio of 13.55dB at 2.38 GHz. In Mode III when S1 is ON state and S2 is OFF state, the antenna is having an axial ratio of 11.82dB at 2.41 GHz. Hence antenna in mode II and mode III are generating Elliptical Polarization because axial ratio values are in between CP and LP. In Mode IV when both switches are in ON state, the antenna is generating circular polarization with an axial ratio of 0.85dB at 2.32 GHz.

From the results, Antenna in Mode I has the highest operating frequency (2.46 GHz) compared to others and the operating frequencies for Antenna in Mode II and Mode III are 2.38 GHz and 2.41 GHz. Mode IV has the lowest frequency (2.32 GHz). Following table shows the Comparison of generated Frequencies and their corresponding Return Loss, VSWR and Axial Ratio.

TABLE 3: RESONANT FREQUENCY, RETURN LOSS, VSWR, IMPEDANCE BANDWIDTH AND AXIAL RATIO COMPARISON FOR ALL MODES.

MODE	Mode I	Mode II	Mode III	Mode IV
f_r (in GHz)	2.46	2.38	2.41	2.32
RL (in dB)	-23.73	-41.78	-43.36	-29.36
VSWR	1.13	1.01	1.01	1.07
BW %	67.07	62.60	66.80	66.81
AR (in dB)	4.94	13.5	11.80	0.85

Where

- f_r - Resonant Frequency
- RL - Return Loss
- VSWR - Voltage Standing Wave Ratio
- BW % - Bandwidth Percentage
- AR - Axial Ratio

C. Radiation Pattern

The following figures shows the radiation pattern of all modes of proposed antenna for $\underline{\phi}$ = 0° and $\underline{\phi}$ = 90°. $\underline{\phi}$ = 0° radiation pattern is co polarization pattern and $\underline{\phi}$ = 90° is cross polarization radiation pattern.

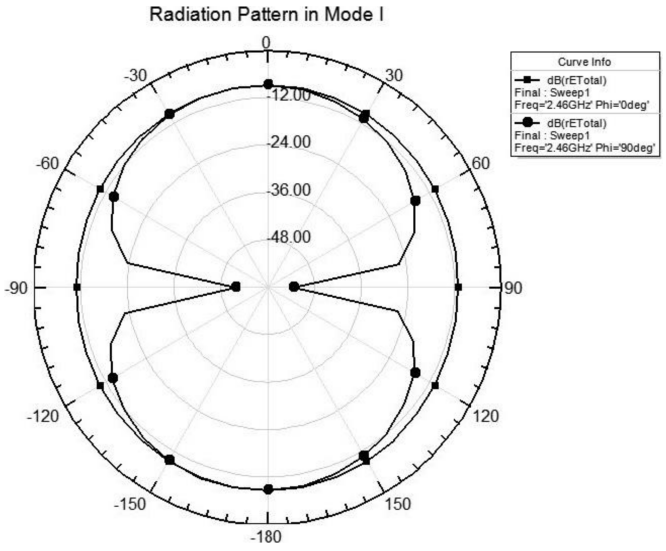

Fig. 9. Radiation pattern in mode I for $\underline{\phi}$ = 0° and $\underline{\phi}$ = 90°.

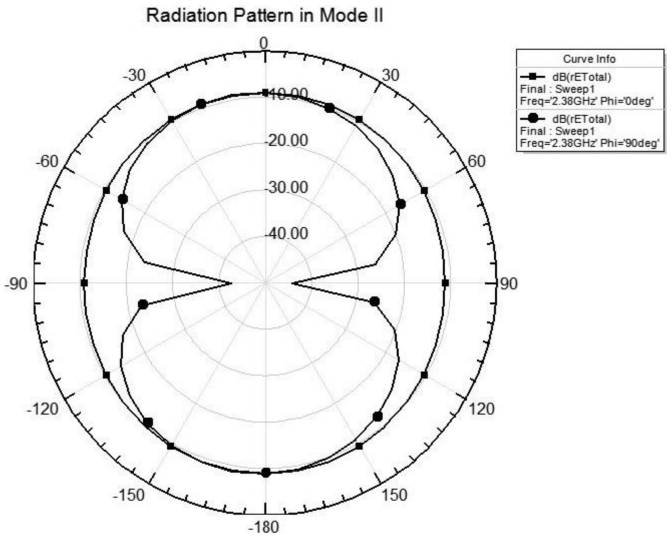

Fig. 10.Radiation pattern in mode II for $\underline{\phi}$ = 0° and $\underline{\phi}$ = 90°.

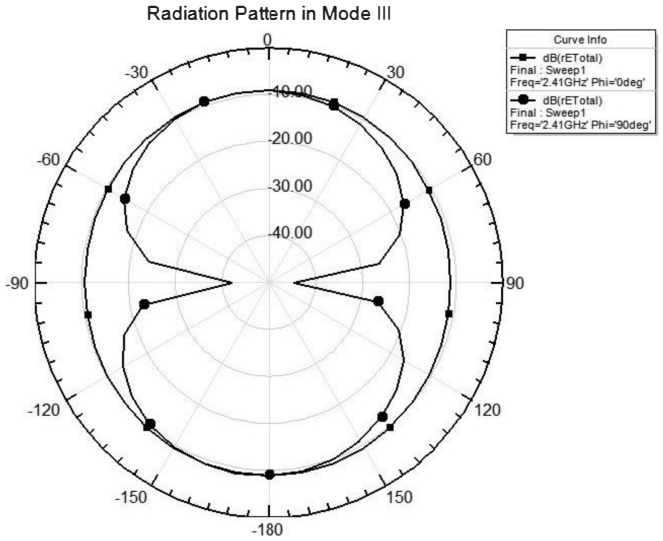

Fig. 11.Radiation pattern in mode III for $\underline{\phi}$ = 0° and $\underline{\phi}$ = 90°.

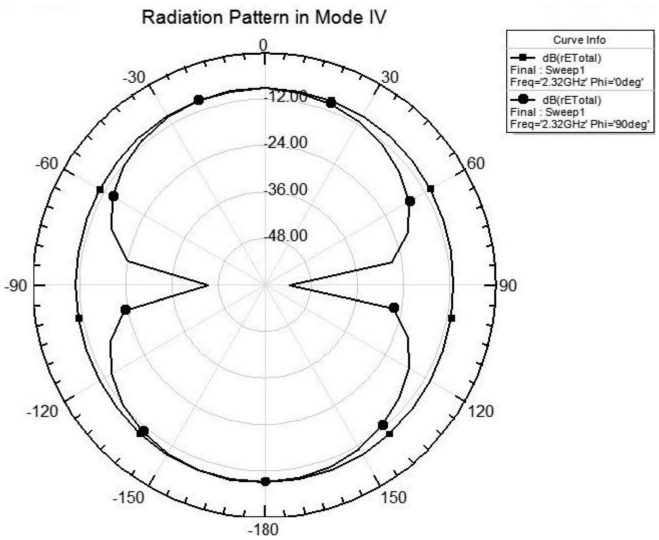

Fig. 12. Radiation pattern in mode IV for $\underline{\phi}$ = 0° and $\underline{\phi}$ = 90°.

VI.CONCLUSION

A compact very thin CPW antenna with Polarization Reconfigurability in a simple method has been designed and it is generating Circular Polarization and Elliptical Polarization. All operating modes have good return loss with better impedance bandwidth. The antenna can be switched between Circular Polarization and Elliptical Polarization by changing the switch states of S1 and S2. When antenna is switched from one mode to other, resonant frequency slightly varies from 2.32 GHz to 2.46 GHz.

In the future, the proposed antenna will be manufactured and measured results will be compared with simulated results.

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