# A Microstrip Antenna With Circular Polarization Switching Capability for X-band Applications

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***Abstract* – This paper describes a novel microstrip patch antenna with switchable circular polarization. A square patch whose two top corners are truncated by a square portion is used to realize the proposed antenna. Two Schottky diodes connected in the opposite direction are used to correlate the separated corner segments with the patch by their switching operation. As a result, RHCP and LHCP can be alternated by controlling the state of the two diodes. High impedance networks grounded through a via-hole are employed to isolate the DC bias networks from the RF signal. The measured 3-dB axial ratio bandwidth for both RHCP and LHCP is around 1%.**

***Index Terms* – Microstrip antennas, reconfigurable antennas, circular polarization, polarization diversity.**

## 1. Introduction

Antennas with polarization switching capability are very attractive for wireless and satellite communication systems. Besides, circularly polarized antennas are apposite owing to its alignment flexibility between transmitter and receiver [1].

Several antenna structures with circular polarization (CP) switching have been proposed. A microstrip square ring antenna with CP diversity has been presented in [2] by employing a perturbing dual-sided dual-loop structure. By changing the states of two PIN diodes of the front-sided dual-loop, dual CP can be achieved. In [3], a wideband multilayer antenna with dual CP has been discussed. The stacked square patches fed by two orthogonally positioned aperture-coupled striplines and a branch line coupler are used to excite dual CP. A technique to excite desired CP has been developed in [4] by attaching two piezoelectric transducers (PET) controlled perturbers to create perturbation in the patch. A design of a microstrip antenna with switchable slots (PASS) has been reported in [5] where two PIN diodes are placed in the center of two orthogonal slots to switch between them and therefore the antenna can radiate either RHCP or LHCP. A dual-circularly polarized microstrip antenna that can generate conical-beam radiation pattern by exciting the second order mode has been presented in [6]. To obtain CP diversity, a hybrid coupler is used to feed the antenna.

In this paper, a new reconfigurable microstrip antenna with switchable CP sense is investigated for X-band applications. A truncated patch separated from two corner segments by a slot is used to realize dual CP by switching two Shocttky diodes connected between the patch and each corner segment. The antenna can radiate RHCP and LHCP by depending on the ON/OFF condition of the diodes. Configuration and operating principle of the antenna as well as measured and simulated results are discussed in the subsequent sections.

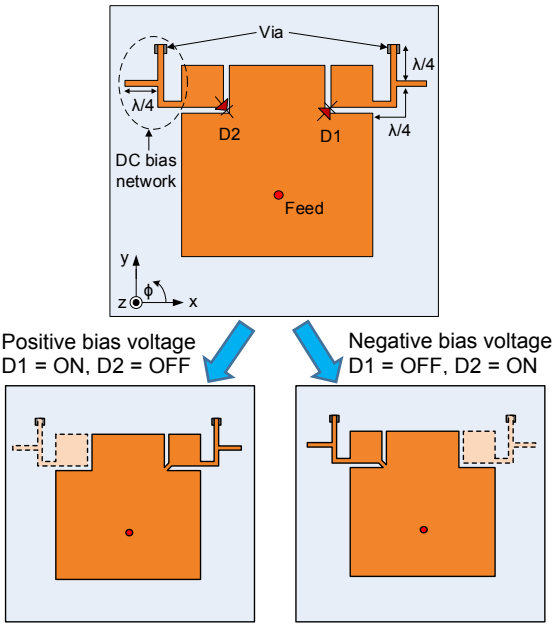
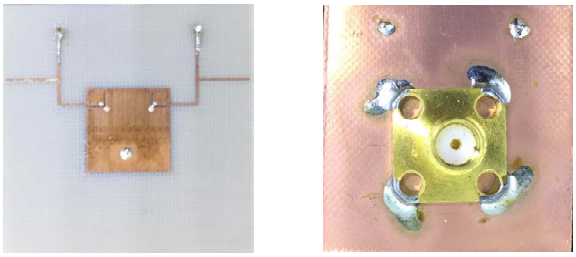



Fig. 1. Schematic layout of the proposed antenna and its switching operation.

## 2. Antenna Configuration and Its Operational Mechanism

Fig. 1 shows the schematic layout of the antenna. The antenna consists of a truncated corner square patch with two square corner segments and DC bias networks. Top two corners of the patch are truncated and two corner segments are separated from the patch by a narrow slot. Two diodes (D1 and D2) are integrated between the patch and corner segments in the opposite direction with each other so that only one diode can be ON at a certain time. A bias network which consists of high impedance microstrip lines with a length of quarter wavelength is used for each diode where one of the sides is connected to the corner segment and the other side is connected to the ground plane through a via-hole. DC bias voltage combining with the RF signal is applied to the patch using a bias tee.

The corner segments provide perturbation to generate CP. By turning the diodes ON/OFF, the sense of CP can be



(a) Top (b) Bottom

Fig. 2. Fabricated X-band antenna (28.2 mm × 28.2 mm).

TABLE I
Status of the Diode Conditions and Their Corresponding Sense of Polarization

| Bias Voltage | D1 | D2 | Sense of Polarization |
|---|---|---|---|
| Positive | ON | OFF | LHCP |
| Negative | OFF | ON | RHCP |

switched. Status of the diode conditions and their corresponding sense of polarization are presented in Table I. When a positive bias voltage is applied, D1 becomes ON and D2 is OFF. So left hand circular polarization (LHCP) is excited. Otherwise, right hand circular polarization (RHCP) is generated when D1 and D2 are turned OFF and ON respectively by applying negative bias voltage.

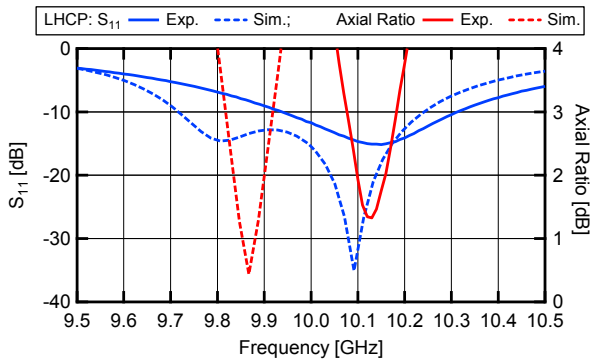
## 3. Experimental and Simulation Results

A prototype antenna is fabricated on a 0.8-mm thick Teflon glass fiber substrate with dielectric permittivity of 2.15. Design and simulations have been carried out using FEM of Keysight Technologies' EMPro. Low barrier silicon Schottky diodes (MSS30,154-B10B, Aeroflex / Metalics Inc.) are used in the fabricated antenna as switching diodes. During simulation, ON condition of the diode is considered by replacing the diode by a 3-ohm resistor and a capacitor of 0.22 pF is connected for the OFF condition of the diode. Fig. 2 illustrates the photograph of the prototype antenna for X-band with a dimension of 28.2 mm × 28.2 mm.

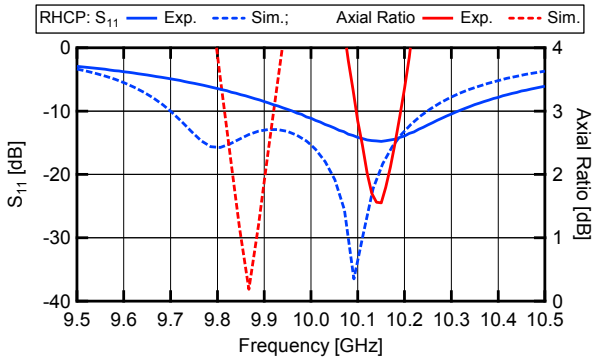
Fig. 3 shows the measured and simulated return loss and axial ratio of the antenna. For positive bias voltage, the measured 10-dB return loss bandwidth is 3.65% and 3-dB axial ratio bandwidth of 1.09% is obtained with a minimum value of 1.32 dB at 10.13 GHz. On the other hand, for negative voltage, measured 10-dB return loss bandwidth is 3.5% and a 3-dB axial ratio bandwidth of 0.99% with a minimum value of 1.55 dB at 10.15 GHz is achieved. From the figure, it is observed that there is some mismatch between experimented results and simulated results. This mismatch might be due to replacing the diodes by an equivalent resistor or capacitor during simulation. It can be mentioned here that the parasitic elements, conductor loss and lead inductance of the diodes and vias are not considered during simulation.

## 4. Conclusion

A dual sense circular polarization microstrip antenna has been presented where only two Schottky diodes are used to switch between RHCP and LHCP. DC bias networks are successfully realized to control the ON/OFF mode of the diodes. At both CP sense, the antenna shows almost similar results. 3-dB axial ratio bandwidth of 1.09% and 0.99% are obtained for LHCP and RHCP, respectively. The proposed antenna structure is very compact and simple. Moreover, its structure makes it suitable for an array configuration. As a result, the proposed antenna is attractive for various X-band applications.




(a) Bias voltage = 0.8 V, D1 = ON, D2 = OFF




(b) Bias voltage = -0.8 V, D1 = OFF, D2 = ON

Fig. 3. Return loss and axial ratio of the antenna.


## Acknowledgment

The authors would like to thank Dr. Takayuki Tanaka, Saga University for his fruitful discussions.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