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Research Paper

Reconfigured Antenna with Switchable Polarization for S Band Wireless Applications

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Abstract: This article presents a polarization-switchable Microstrip Patch Antenna (MPA) that can be flexibly reconfigured. There are little parasitic patches connected to the corners of an MPA's circular patch as a radiator. The PIN diodes have made contact with O-shaped parasitic patch elements to form the circular patch. When the truncated corners are changed, enhanced the impedance bandwidth and axial ratio bandwidth has been obtained. 3.24 GHz is a resonant frequency for an impedance match (S11 less than 10dB) and for an axial ratio (AR less than 3 dB). The antenna's ability to transition between left- and right-handed circular polarizations (LHCP and RHCP) was verified by comparison of simulated and measured results observed. Vector Network Analyzer has also been used to evaluate the anticipated MPA under high RF strength in an anechoic room. Thus, the 5G networks and their related applications have been shown to work with these observed characteristics.

Keywords: PIN diode, Micro-strip Patch antenna design, Measurements

1. Introduction

Modern wireless communication systems have grown significantly due to the antenna properties of polarisation diversity. An antenna with a low profile, moderate weight, and easy construction is to be a switching polarisation. Using the frequency reuse principle, a switchable polarisation antenna may enhance the system capacity in communication networks. The patch element can be perturbed to provide circular polarisation (CP). There must be an equal amount of amplitude and a 90º phase shift between two orthogonal modes to achieve CP. In [1,2,3,4,5], by truncating two of the radiator's diagonal corners, the two orthogonal modes were created. A change in the antenna construction makes it difficult to achieve impedance matching in all two-polarisation states (LHCP and RHCP) at the same time. The switchable antenna has been offered either linear polarization (LP) and circular polarization (CP) [6]. By truncating two corners of the patch, polarisation switching between LHCP and RHCP was achieved [7]. An innovative microstrip patch antenna with polarisation diversity is given in this research. To switch between the LHCP and RHCP polarizations. As a radiator, little parasitic patches are attached to the circular patch of an MPA. To construct the circular patch, the PIN diodes contacted inverted U-shaped parasitic elements. The radiation from the patch element is controlled using PIN diode switches. Because of the antenna's physical dimensions being fairly altered, the shift in resonance frequencies is less noticeable between the two polarisation states. With its basic design, the antenna may be adapted to various frequencies as needed. Alternatively, the circuit's design parameters are optimised to provide impedance matching in various polarisation states. The working spectrum of today's modern technologies, such as LTE and 5G, requires a huge amount of bandwidth. Utilizing carrier aggregation, many channels may be used to transmit or receive at the same time, increasing the data rate. Within the same frequency range, channels can be utilized in different purposes.

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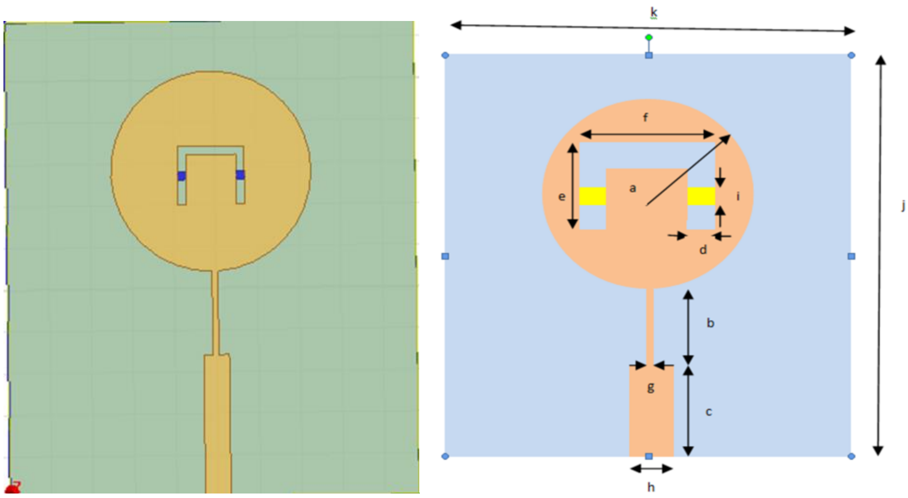
In order to handle additional channels, the band must have huge bandwidths. By reshaping the truncated corners, the impedance and axial ratio bandwidths may be enhanced. High Frequency Spectrum Simulator (HFSS) suite ANSYS Software [8] is used to design, build, and simulate the antennas. In all three-polarisation states, the observed findings are in agreement with the predicted values. At high RF power, the suggested reconfigurable antenna is also tested. As a non-linear device, the diode plays an important function in the system when RF power is high. Additionally, this circuit's performance is checked by employing high-power handling of anechoic chamber and expanding the transmission range.

Section 2 of the materials and methods explains the reconfigurable antenna design and its working philosophy. Measurements and simulations of both configurations are discussed in Section 3. Finally, in Section 4, the design is concluded by outlining the work's uses and benefits.

2. Experimental Methods

2.1. Materials

Figure 1.a depicts a simulated Microstrip Patch Antenna (MPA), which is formed of circularly shaped reconfigurable microstrips with truncated U-slot corners. On FR4 (Epoxy) substrates with 1.5 mm thickness and dielectric permittivity of 4.4, square-shaped parasitic patch strips were used to construct the single-fed. From characteristic impedance (CP) [1,2,9], a U-slot structure has been introduced into patch strips using the corner truncation approach. In [10], standard equation has been used to design, simulate, and manufacture the suggested antenna. Quarter wave microstrip lines have been used to stimulate the suggested structure.



a) b)

Figure 1. Proposed reconfigurable U-slot MPA a) simulated & b) geometric configuration

Table 1 Geometric coordinates of proposed microstrip

Geometric dimensional (units in mm)	a	b	c	d	e	f	g	h	i	j	k
U-slot strip	12	11	17	01	06	08	0.7	3.06	01	57	49

OR gate concepts were used to turn on and turn off the PIN diodes (MA4SPS402) in the circuit. Because of this, this patch strip has been polarized in either the left or right direction. On the patch strips, two PIN diodes have been employed in order to achieve the antenna's diversity and polarization characteristics. On each of their individual places, it has been inscribed. Switching has been used to control the range of frequencies and polarizations. The quarter wave line and its electrical features were used to manage the frequency variety. A "off" setting is used by these diodes. The U-slot patch strip provides resonances of 3.26 GHz and return losses S11 of -13.78 dB in simulated structure.

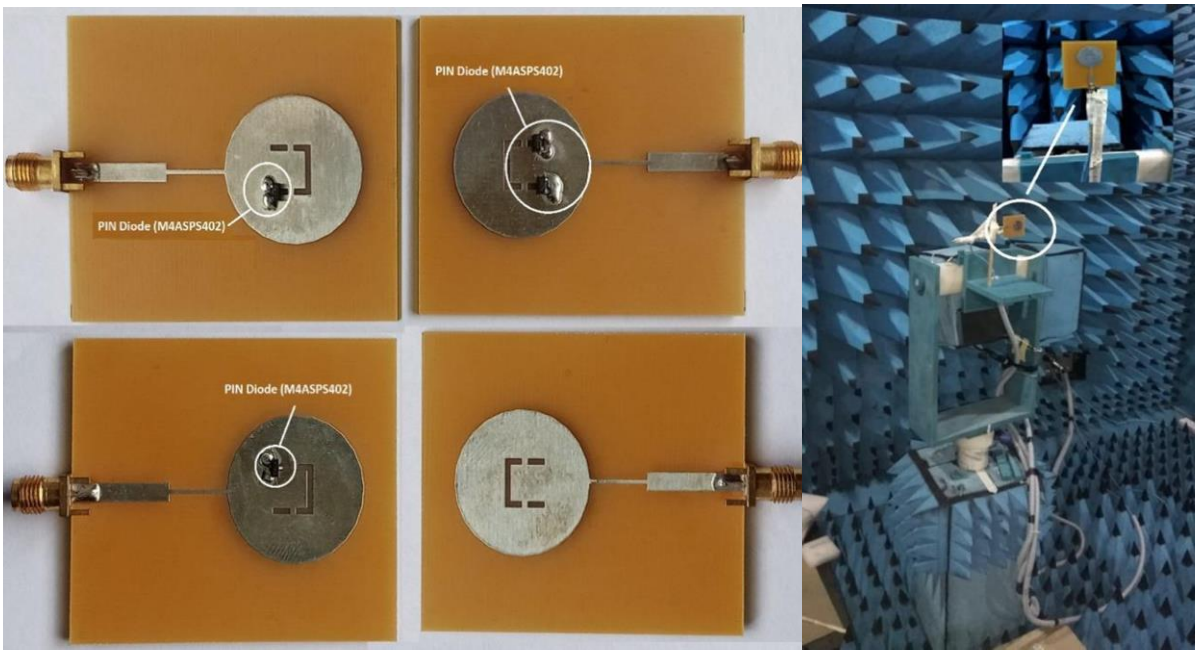


Figure 2. The reconfigurable prototypes with anechoic chamber measurement’s view

Figure 2 illustrates the construction and testing of the reconfigurable MPA prototypes. High Frequency Spectrum Simulator (HFSS) with improved Finite Element Methods (FEM) emulator suite was used to simulate the geometric coordinates of the proposed MPA, which was modelled using standard design equations [10]. Thus, the Monolithic Microwave Intergraded Circuit (MMIC) construction follows the simulation investigation. Additionally, MMIC has printed the PIN diodes on the conductive patch strips. Using a simplified version of normal mathematical design, these simulated results were attained and demonstrated by fabricating prototypes. Agilent (N99917A) Microwave Analyzer with Vector Network Analyzer (VNA) and anechoic chamber test-beds are used to compare and justify these results. The simulations and measurements have also been proposed with broad band parameters, and the findings must be explained in the manufactured structure's results and discussion section.

3. Results and Discussion

Figure 3 depicts the measured return losses. During the simulation, it achieved an output level of –13.78 decibels while measuring at –14.69 decibels for the resonance at 3.24GHz. The four potential scenarios for restructuring MPAs are presented in Figure 4. HFSS was used to demonstrate the outcomes of this experiment, which were in agreement with the measurements. Table 2 shows the numerical results in this study.

As illustrated, VSWR and frequencies are shown in Figure 5 collectively. The resonance frequency is 3.24 GHz, and the VSWR is 1.54. Working frequencies of 3.22 GHz to 3.28 GHz, or 25 percent of the average resonance frequency, could be achieved at VSWR of 2. As a result, this range is 2 percent more than the antenna's 50-ohm impedance. Figure 6 depicts the measured VSWR parameters, while the measured VSWR parameters are presented in Table 2's eighth column.

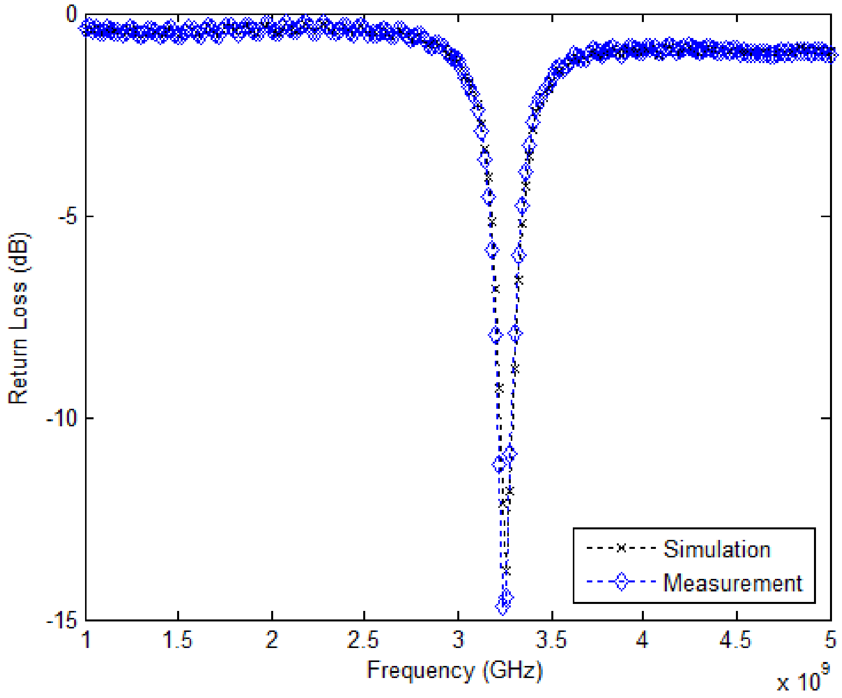


Figure 3. Measured return loss of reconfigurable U-slot MPAs with Non-switchable position

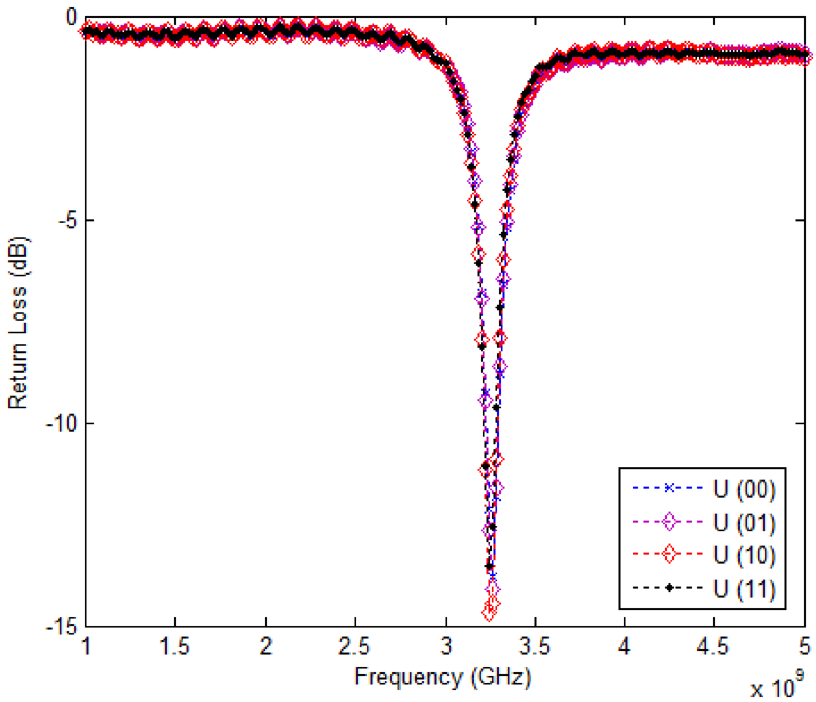


Figure 4. Measured return losses of reconfigurable U-slot MPAs with switchable position

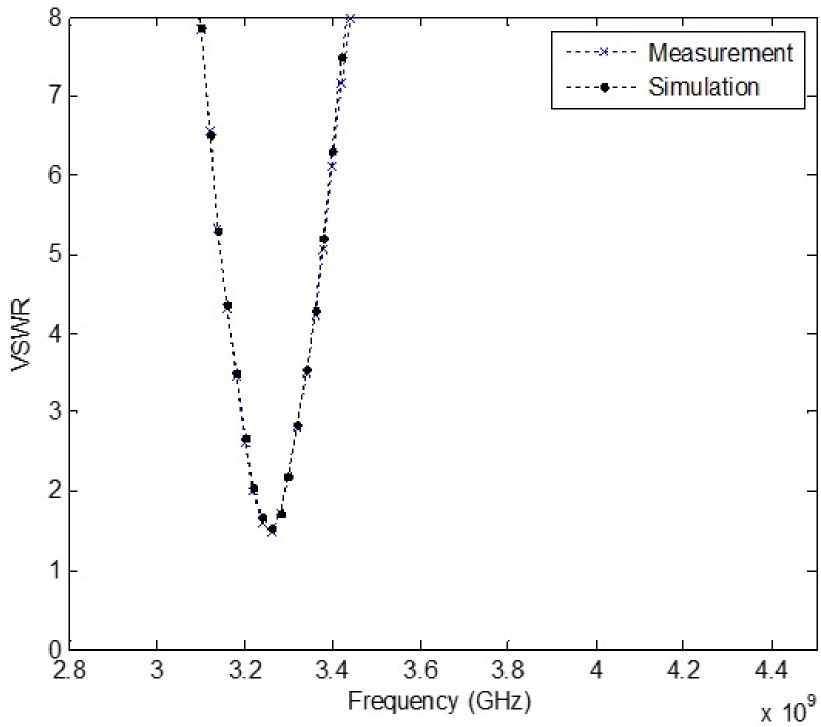


Figure 5. Measured VSWR of reconfigurable U-slot MPA

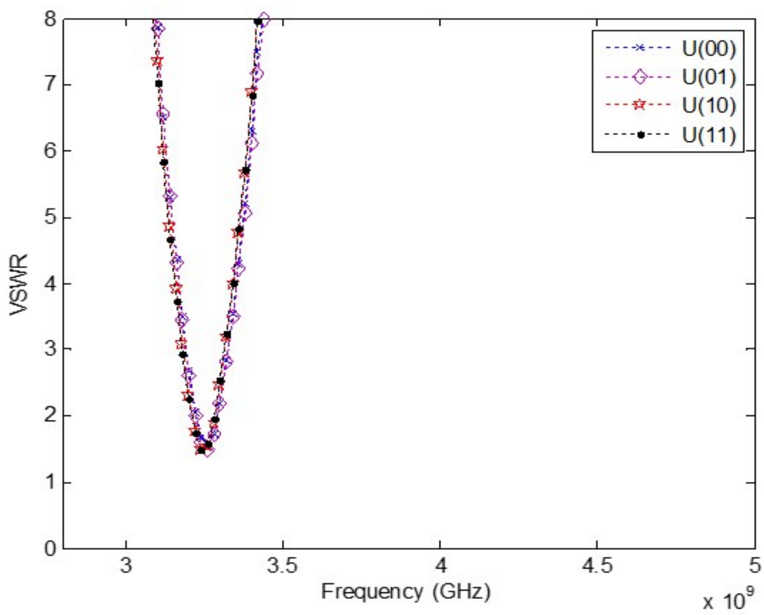


Figure 6. Measured VSWR of reconfigurable U-slot MPAs with switchable position

Figure 7 Measured radiation pattern in two orthogonal planes for reconfigurable U-Slot MPA Figure 7 shows the measured radiation patterns of the two orthogonal planes. Reconfigurable U-slot MPA at the feed point has shown decent Right Circular Polarization (RHCP), as shown in Fig 7 (a-b). The measured and simulated radiation pattern at 3.24 GHz and 3.26 GHz. Thus, peak power has been derived to be 4.2 dBi and 3.4 dBi respectively. Cross polarization levels of less than -20 dB have been recorded in Figure 7 (c-d) with impedance matching of 2.5 percent [3, 9, 11]. linear polarization reduces its quality. Hence, they have been achieved the good matching of circular polarization.

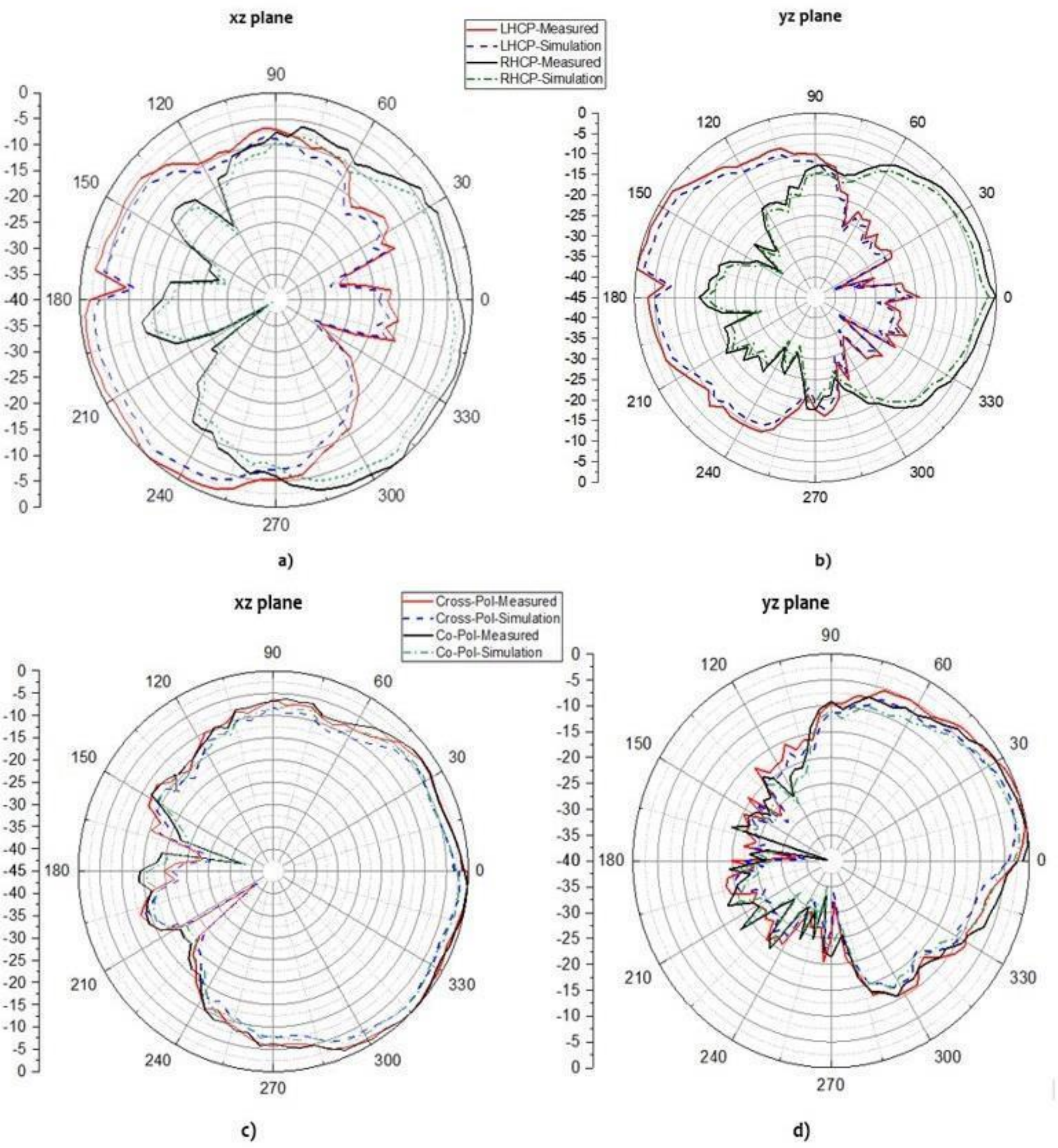


Figure 7. Measured radiation pattern of reconfigurable U-slot MPA

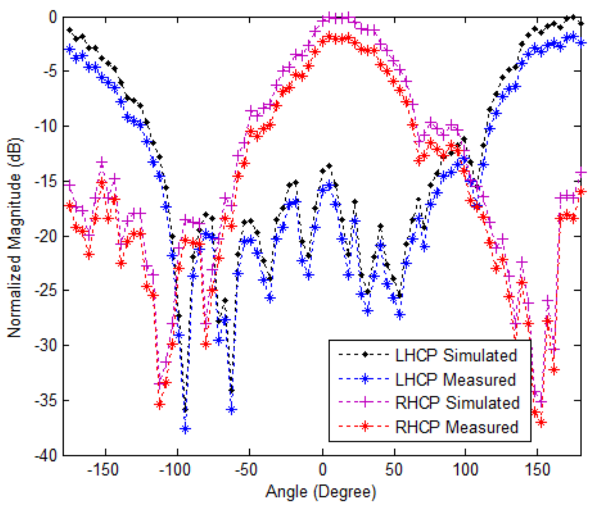


Figure 8. Measured yz plane of reconfigurable U-slot MPA

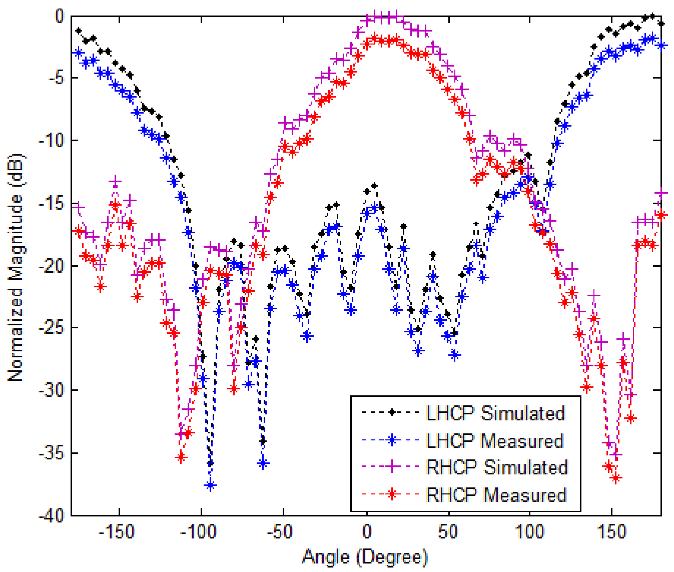


Figure 9. Measured xz plane of reconfigurable U-slot MPA

Figures 8 and 9, show the 2D orthogonal planes and excellent RHCP and LHCP values. Measured LHCP spins in linear patterns in both yz and xz planes [3,12], this is consistent with the RHCP.,

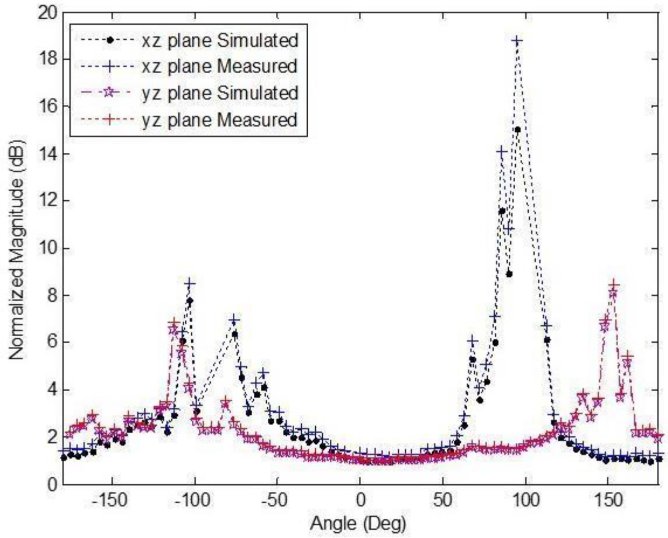


Figure 10. Measured axis ratio of reconfigurable U-slot MPA

Table 2. Measured reconfigurable MPA's characteristics

Proto-types	Diode 1	Diode 2	Polarization	Resonance (GHz)	S11 dB	IBW (MHz)	Gain	VSWR	3dB ABW (%)
U(00)	OFF	OFF	LP	3.245	-13.5	530	29.44	1.47	1.5
U(01)	OFF	ON	RHCP	3.24	-14.1	529	18.07	1.49	1.4
U(10)	ON	OFF	LHCP	3.24	-14.7	528	22.49	1.48	1.42
U(11)	ON	ON	LP	3.24	-13.78	531	23.88	1.54	1.43

RHCP and LHCP have Axial Ratio (AR <3dB) ranges of -100 to 100 degrees respectively. Figure 10 [1, 13], shows the AR ranges from -100 to 100 degrees from boresight in both orthogonal planes for simulated and measured RHCP and LHCP. It was possible to confirm the principle of functioning of a polarization-reconfigurable antenna by looking at these graphs. These and other chamber errors explain the modest discrepancies in observed and modelled radiation patterns, including axial ratios.

4. Conclusions

This study describes and illustrates a switchable reconfigurable microstrip patch antenna. By switching PIN diodes ON and OFF, the suggested antenna may transition between two distinct polarization states. The IBWs and ARBWs are also improved as a result of the truncated corner being reshaped. For demonstration drives, both antenna prototypes are built and tested on the FR4 substrate. Both CP sense achieve axial ratio and good impedance matching at the design frequency. The parasitic strips on the ground plane is to be enhanced the impedance bandwidth and the 3dB axial ratio bandwidth. It offers 15.4 percent success rate in measuring the IBW's measured bandwidth (2.98–3.58) GHz. In compared to the previously published study, loaded responsible stubs and strips on the ground plane significantly enhance the reported 3–dB axial – ratio bandwidth (ARBW) and 10 dB impedance bandwidth (IBW). Low profile, enhanced impedance bandwidth, and a 3-dB axial ratio bandwidth make this antenna is unique. The S band (2 GHz to 4 GHz) is a suitable frequency range for the proposed antenna. Such as WiFi IEEE 802.11.g and IEEE 802.11.b standards (2.4 GHz), Digital Audio Radio Service (DARS) (2.36 GHz) and majority of WiMax manufacturing equipment (3.5 GHz), and other surveillance applications like traffic signal, airport radar, etc.

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Conflict of Interest

The authors are no conflict of interest.

Author’s Contribution

KS, has contributed simulation, measurement, testing and, paper writing; VRR has contributed the fabrication of antennas and mathematical modelling and CE has contributed the paper writing and anechoic chamber testing.

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