Design Investigation of a Novel Dual-Band Circularly-Polarized Microstrip Antenna for 2.4 GHz and 5.7 GHz

Behzad Naimian, Mohammad H. Neshati, and Mostafa Attaran Kakhki

***Abstract*—In this paper, a single-fed multiple slotted square patch antenna is proposed to obtain dual-band Circular Polarization (CP) radiation patterns. Inserting four T-shaped slits at the patch edges of a square microstrip antenna, the proposed antenna is designed and fabricated. The simulation and measurement results including return loss, radiation patterns and Axial Ratio (AR) are presented. Compared to the reported designs in literature, a patch size reduction as large as 32% is obtained. Measured results show that -10 dB bandwidths of return loss for lower-band and higher-band are 71 MHz and 299 MHz respectively. Also, the minimum return losses are -49 dB at 2.497 GHz and -22 dB at 5.887 GHz. Measured results show that AR bandwidths are 13 MHz for lower and 15 MHz for higher band. The introduced antenna is successfully designed and fabricated and the measured results are in a very good agreement with those obtained by numerical investigation.**

***Index Terms*—Dual-band, circular polarization (CP), microstrip antennas, square patch.**

I. Introduction

Microstrip patch antennas provide favorable features such as thin, flat low-profile and low cost in production procedure. They are also very attractive for circularly polarized (CP) operations because of the simple structure such as single feed and no need for divider and phase shifter.

In recent years, a few single-feed dual-band CP microstrip antennas including: aperture-coupled stacked patches [1]-[3], a spur-line filter implanted in a nearly square microstrip patch [4] and a circular microstrip patch with two pairs of arc-shaped slots [5] have been reported in literature. To obtain a CP patch antenna at lower band, size of the patch is normally same as the size of a regular patch working at the fundamental mode, which is generally big size [6]. To achieve a small size dual-band CP antenna with a low frequency band, a novel design based on a single-layer slit-loaded square microstrip antenna has been proposed [7], [8].

In this paper, a single-feed multiple slotted square patch antenna to produce a CP radiation is introduced. Compared to the conventional regular-size CP designs, the size of the proposed antenna is considerably reduced. For dual-band CP antenna, two resonant modes of TM_{10} and TM_{30} are considered in this structure.

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II. Antenna Structure

Fig. 1 shows the proposed dual band CP antenna. It is made up of a square patch with two pairs of *T*-shaped slits inserted at the edges of the patch and a rectangular slot is placed at the center. The square patch is printed on FR4 substrate with ε_r =4.4 and its thickness is h=1.6 mm. Table I shows the detailed dimensions of the antenna parameters. The two resonant modes of TM_{10} and TM_{30} are used for making the dual-band, while CP radiation patterns is achieved using the center slot. The upper arms of *T*-shaped slits are of the same size, while the center arm of one of them has a different size to obtain CP, especially at higher frequency band. The square patch is fed by a 50 Ω SMA coaxial probe located on the patch diameter. By using *T*-shaped slits a patch size reduction as large as 32% has been obtained compared to the reported conventional CP designs without the inserted slits.

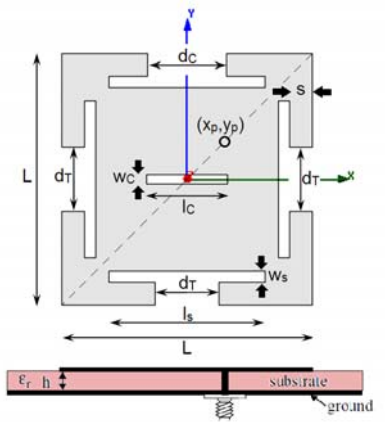

Fig. 1. Geometry of the proposed antenna: a) top view, b) side view.

TABLE I: Parameters of the Proposed Antenna

Parameters	L	l_S	w_S	s	d_T	d_C	l_C	w_C	x_P, y_P
Size (mm)	23.5	14.7	1.1	2.1	6	7.4	7.5	0.8	3.5

III. Simulation and Measurement Results

A. Antenna Simulation

The proposed antenna has been simulated using Ansoft HFSS software and antenna characteristics including return loss, radiation patterns and *AR* are considered.

Fig. 2 shows the simulated return loss of the antenna. It can be seen that two resonance frequencies at f_1=2.437 GHz and

f_2=5.726 GHz are obtained. Reflection coefficient at the two mentioned resonance are S_{11}= -25.78 dB and S_{11}= -21.32 dB respectively. The impedance bandwidth of -10 dB is 68 MHz for low-band and 317 MHz for high-band. Fig. 3-a and Fig. 3-b show xz plane and yz plane radiation patterns respectively. Moreover, simulation results show that AR bandwidths are 21 MHz for lower band and 61 MHz for higher band.

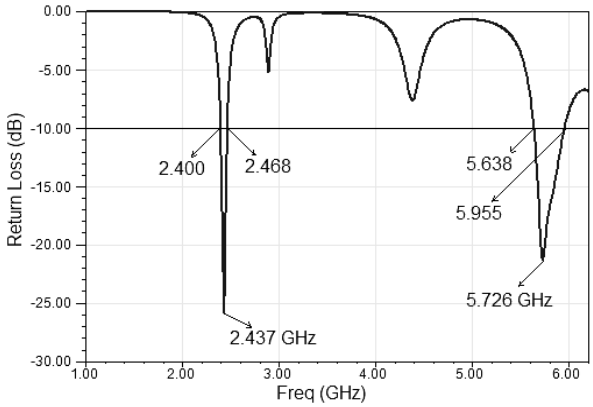

Fig. 2. Simulation return loss of the proposed antenna.

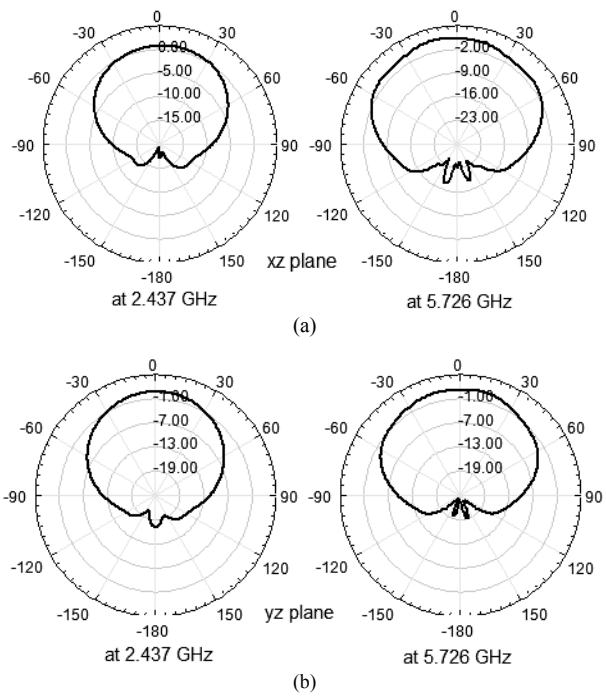

Fig. 3. Simulated right hand radiation patterns, RHCP: a) xz plane, b) yz plane at resonance frequencies.

B. Antenna Measurement

The fabricated proposed antenna is shown in Fig. 4. The antenna parameters have been measured using HP8051 network analyzer for return loss. Also radiation patterns have been measured in an echoic chamber. Fig. 5 shows the measured return loss of the antenna. Reflection coefficients are -49.05 dB at 2.497 GHz and -22.33 dB at 5.887 GHz. Impedance bandwidths of -10 dB for lower and higher resonance are 71 MHz and 299 MHz respectively. Fig. 6-a and 6-b show measured xz plane and yz plane radiation patterns respectively at the two obtained resonance frequencies. Moreover, measured *AR* for low-band is 13 MHz and for high-band is 15 MHz. All measured and simulated results for the proposed antenna are summarized in Table II and Table III.

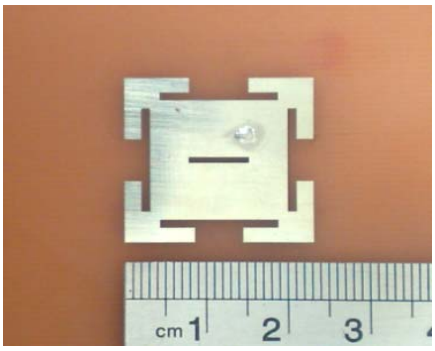

Fig. 4. Photograph of the fabricated proposed antenna

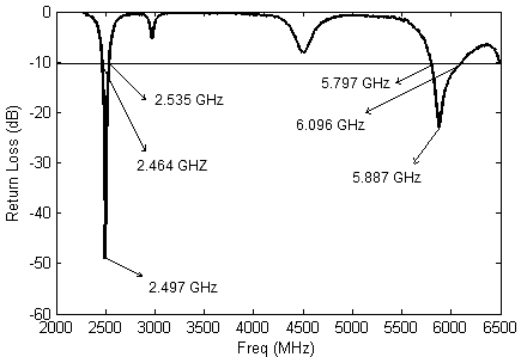

Fig. 5. Measured return loss of the proposed antenna.

IV. Conclusion

In this paper, a compact single-feed multiple slotted dual-band square patch antenna with CP radiation patterns has been proposed and successfully implemented. Inserting a center slot with suitable dimensions and modifying one of *T*-shaped slits, excitation of a pair of two near-degenerate resonant modes for dual-band CP radiation is achieved. Measurement results of the designed antenna, demonstrates sufficient impedance bandwidth and good RHCP radiation characteristics for the two operating bands. Compared to the conventional CP designs, the size reduction of the patch is as large as 32% for the proposed design. Two resonance frequencies are 2.497 GHz and 5.887 GHz. Reflection coefficient at the two mentioned resonance are -49.05 dB and -22.33 dB respectively. The impedance bandwidth of -10 dB is 71 MHz for low-band and 299 MHz for high-band. Moreover, measured results show that AR bandwidths are 13 MHz for lower band and 15 MHz for higher band.

The introduced antenna is successfully designed and fabricated and the measured results are in a very good agreement with those obtained by numerical investigation. This kind of antenna should be used in the design of microwave communication systems circuits, where small size and Circularly Polarized (CP) radiating wave is needed.

TABLE II: Summerized measured and Simulated Results

	Resonance frequency (GHz)		**Return loss (dB)**	
	f_1	f_2	at f_1	at f_2
Simulated	2.437	5.726	-25.78	-21.32
Measured	2.497	5.887	-49.05	-22.33

TABLE III: SUMMERIZED MEASURED AND SIMULATED RESULTS

	Impedance Bandwidth (MHz)		**AR Bandwidth (MHz)**	
	at f_1	at f_2	at f_1	at f_2
Simulated	68	317	68	317
Measured	71	299	71	299

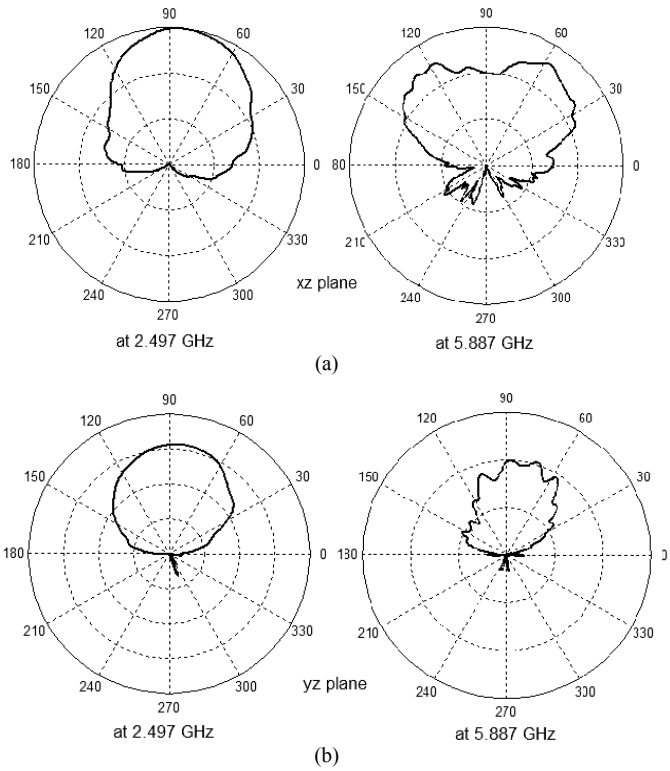

Fig. 6. Measured righat hand radiation patterns, RHCP: a) xz plane, b) yz plane.

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