Single-Point-Fed Broadband CP Antenna With Enhanced Axial Ratio

Ubaid Ullah[1], Slawomir Koziel[2], Ismail Ben Mabrouk[1], Qammer Abbasi[3], and Akram Alomainy[4]

[1]Networks and Communication Engineering department, Al Ain university of Science and Technology, Abu Dhabi, UAE
[2]School of Science and Engineering, Reykjavik University, Reykjavik, Iceland
[3]James Watt School of Engineering, University of Glasgow, UK
[4]School of Electronic Engineering and Computer Science, Queen Mary University of London, UK

***Abstract*—In this paper, a compact single-point-fed circularly polarized antenna with enhanced axial ratio (AR) bandwidth is investigated. A combination of parasitic strips and modified geometry of the wide-slot is used to improve circular polarization (CP) performance of the antenna. The total footprint of the antenna is only 25×25 mm^2. With the proposed technique, an impedance bandwidth $|S_{11}| \leq$ -10 dB of ~70-percent (4.2 GHz- 9.05 GHz), and AR bandwidth ≤ 3 dB of 48-percent (5.4 GHz to 8.65 GHz) has been achieved with the average realized gain of 3.1 dBi through the CP operating band. A stable bidirectional radiation pattern with left hand CP and right hand CP in the ±*z*-direction is observed.**

Keywords—Circularly polarized antennas, compact antennas, wide-slot antennas, EM-driven design.

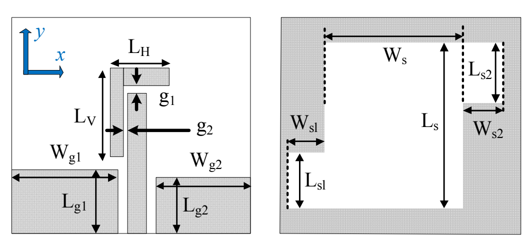
I. Introduction

Importance of circularly polarized antennas has been widely discussed in the literature. In the recent years, design of CP antennas with wide impedance and axial-ratio (AR) bandwidth have been thoroughly investigated. A number of single-point and multipoint excitation techniques for CP antennas have been proposed. One of the major shortcomings of the multipoint feeding for single element antennas is complex design of the feeding circuitry and large physical size of the antenna [1-2]. Alternatively, conventional single point feeding techniques can produce CP for only a fraction of the total impedance bandwidth of the linearly polarized wideband antennas. This can be improved by appropriate topological modifications of the ground plane, feed, and/or resonator shape. All of these techniques have been successfully used for enhancing AR performance of the single-point feed antenna [3-4]. A disadvantage of geometry modification techniques is a large number of adjustable parameters which control the critical performance figures, including the impedance bandwidth and AR bandwidth [5]. Due to practical difficulties in handling geometry parameters, geometry modifications of the antenna should be kept to minimum.

In this paper, we propose a new feeding technique for excitation of the CP modes in the wide-slot antennas. A simple inverted L-shape parasitic strip is placed in close proximity of the main mictrostrip line monopole extension from the coplanar waveguide (CPW). The fundamental orthogonal components of the CP are induced by the parasitic strip, while additional CP is generated by simple topological modification of the wide slot. The coupling between the parasitic strip and the main monopole is of a capacitive nature and the modified wide-slot structure induce currents along the *x*- and *y*-direction which are of equal amplitudes. Due to simple modification of the wide-slot, only a few adjustable parameters are necessary and a compact size of only 25×25 mm^2 along with a simple geometry can be maintained.

II. Antenna Design

Geometry of the proposed antenna design has been shown in Fig. 1, along with all the parameters. The antenna is realized on a Rogers R04003C substrate (ε_r = 3.38, tanδ = 0.0027, h = 0.813 mm) and outer dimensions $L_s \times W_s$. The structure is fed through a 50 • CPW. An inverted L-shape parasitic strip is placed in close proximity of the microstrip line monopole extension from the CPW. In Fig. 1(a), L_H and L_V are responsible for the initial horizontal and vertical components of the CP fields instigated in the antenna. Furthermore, a wide rectangular slot in the ground plane is perturbed at the opposite corners where the maximum electric field exists because of the 90-degree bend. With this perturbation, additional current paths along the horizontal plane (W_{s1}, Ws_2) and vertical plane (L_{s1}, L_{s2}) are created. To merge all the CP modes, the distance (g_1 and g_2) between the parasitic strip and the microstrip line monopole is adjusted. The length and the width of the perturbed slot is tuned as well. Finally, rigorous EM-driven optimization [6] of all geometry parameters is applied to improve both the impedance and AR bandwidth. Because of a relatively small smaller number of adjustable parameters the major performance figures including impedance bandwidth and AR bandwidth are readily tuned. The final values of the optimized parameters are listed in Table I.



(a) (b)

Fig. 1. Geometry of the proposed CP antenna: (a) parameterized front view, (b) back view.

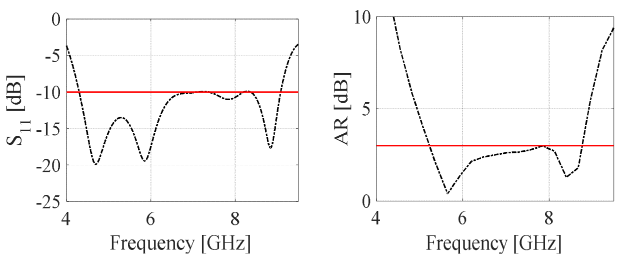
TABLE I Optimized Parameter Values of Antenna of Fig. 1

Parameter	Value [mm]	Parameter	Value [mm]	Parameter	Value [mm]
L_s	25	L_{g2}	7.29	L_2	5.49
W_s	25	W_{g2}	11.19	W_2	2.16
L_{s2}	4.14	L_m	15.62	L_c	19.58
W_{s2}	6.63	W_m	1.35	W_c	12.73
L_{g1}	8.37	L_1	7.28	L_{s1}	4.64
W_{g1}	11.19	W_1	1.37	W_{s1}	7.45
g_2	0.33	g_1	0.86		

III. Numerical Results

The simulated results of the proposed antenna in terms of S_{11} and AR are shown in Fig. 2. A 70-percent (4.2 GHz to 9.05 GHz) impedance bandwidth and AR bandwidth (AR ≤ 3 dB) of 48-percent (5.4 GHz to 8.65 GHz) has been achieved. Figure 3 shows the realized gain of the antenna. It can be observed that the gain response is relatively stable in the CP operating band with the average of 3.1 dB. The radiation patterns (cf. Fig. 4) indicate that both left-hand circular polarization (LHCP) and right-hand circular polarization (RHCP) is achieved in the *–z*-direction and *+z*-direction, respectively.

The proposed antenna been compared with recently published state-of-the-art CP structures. The data gathered in Table II demonstrates that the proposed antenna exhibits better performance in almost all aspects including S_{11}, AR, and the overall footprint.



(a) (b)

Fig. 2. Simulated characteristics of the proposed antenna: (a) $|S_{11}|$, (b) AR.

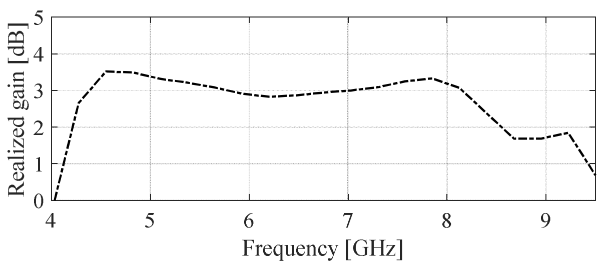
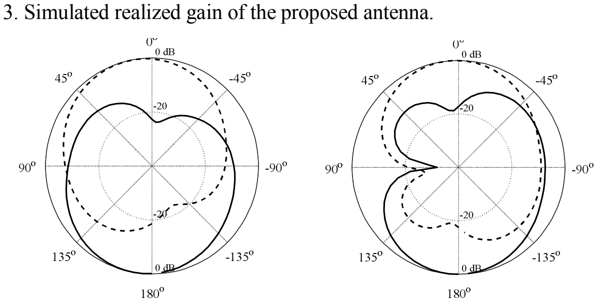


Fig. 3. Simulated realized gain of the proposed antenna.


(a) (b)

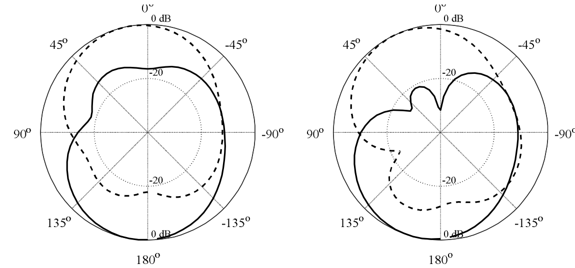

(c) (d)

Fig. 4. RHCP (—) and LHCP(----) radiation patterns of the proposed antenna in the *xz*-plane at (a) 5.5 GHz, (b) 6.5 GHz, (c) 7.5 GHz, (d) 8.5 GHz

TABLE II Comparison with State-of-The-Art CP Antennas

Ref	%AR	%BW	Size [mm^2]	Year
[4]	27	111	2500	2013
[7]	22	37	2500	2015
[8]	14	27	400	2015
[9]	30	51	19158	2013
[10]	41.3	84	784	2017
This work	48	70	625	2018

IV. Conclusion

A single-point-fed structurally simple compact wideband CP antenna is presented. The fundamental CP mode are excited using an inverted L-shape parasitic strip. Additional CP is induced in the structure by modifying the topology of the conventional rectangular wide-slot on the ground plane side of the structure. Simple geometry of the antenna allows for efficient optimization of its all parameters. A wideband response both in terms of S_{11} and AR is achieved with stable radiation pattern and realized gain characteristics.

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