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Wideband L-Shaped Circular Polarized Monopole Slot Antenna with E-Shaped Microstrip Feeding

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ABSTRACT: A wideband circularly polarized L-shaped monopoleslot antenna with a single E-shaped feed is designed. The measured results demonstrate that the antenna has an axial ratio (AR) < dB, a reflection coefficient <_ dB, and circular polarization (CP) bandwidth. This feature is attractive for compact wireless devices that operate at low frequencies in which planning for the smallest circuit board area combined with the shortest length for signal routing are the two major concerns. The antenna is extremely low-cost and does not require any truncation error, reflector surfaces or via connections, all of which increase the fabrication cost.

KEYWORDS: Broadband antenna, circular polarization (CP),monopole, slot antennas.

I.INTRODUCTION

Circular polarization (CP) is getting more attention inmodern mobile wireless communications. The advantageof a CP scheme is more pronounced in direct satellite-to-land communication [1] as the CP is more resistant to bad weather conditions and less sensitive to the orientation of the corresponding mobile device. In many applications, wideband circular polarization is desirable. There are several design techniques proposed in the literature to achieve wideband circular polarization.

In this letter, a wideband CP L-shaped monopole slot antenna with an E-shaped feed is presented. The proposed antenna can be placed at the top portion of a system ground plane, different from the designs with a slot at the center of the ground plane. A CP bandwidth of more than 23% is achieved without using a truncation corner, a reflector surface, or any connecting wires for the feed line [7], which makes it easy to fabricate at a low cost for practical applications.

II.RELATED WORK

The sequential rotation technique described in [2] can potentially increase the axial ratio (AR) bandwidth considerably (about 20%). However, the additional circuit components (a wideband power combiner and a quadrature phase shifter) demand a much larger board footprint. Another technique is to use a printed slot antenna. The printed slot antennas usually have a wider impedance bandwidth compared to microstrip antennas. Several printed slot antennas with circular polarization have been proposed recently [3]–[7].

The common problem among them is that the antenna occupies a large board space in the middle of the system circuit board of the mobile device and makes the planning of remaining componentpositions and required signal line routing difficult. In addition, in [3] and [5], the AR bandwidth is less than 5%, which is not suitable for many applications. In [4], 18% CP bandwidth was obtained at the expense of removing a significant portion of the circuit board. Also, the effect of the ground plane is not clear. The CP bandwidth in [6] is only 6%. The design is sensitive to the ground plane size, and many design parameters need to be optimized, which imposes unnecessary challenges for designers and manufacturers. Reference [7] reports 47% CP bandwidth. However, this bandwidth is achieved by truncating the corner of the circuit board and using the reflector metallic surface. The truncated corner increases the manufacturing cost and reduces the valuable circuit board real estate. Using the reflector surface significantly increases the profile of mobile devices particularly for applications at lower frequencies such as GPS and low-data-rate iridium

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satellite access. Also, the design is sensitive to the precise distance between the antenna and the reflector.

III. ANTENNA STRUCTURE

The proposed structure of the antenna is shown in Fig. 1(a). The antenna is fabricated on an FR4 substrate with a dielectric constant of 4.3 and a loss tangent of 0.02. The thickness of the substrate is 0.8 mm. The size of the antenna is ($G \times G$) 70 $\times$ 70 mm^2, which is suitable for most mobile devices. An L-shaped monopole slot is cut at the left corner of the board. The width of each arm is $S = 11$ mm, and the length is $L_s = 30.5$ mm. A C-Shaped feed line is etched on the other side of the substrate. The lower arm of the feed, which is parallel to the horizontal slot [Fig.1(a)], has a width of $W_{f1} = 2$ mm and a length of $L_{f1} = 21$ mm. The distance between the lower edge of this line and the upper edge of the slot is 0.5 mm, and the line is terminated at the edge of the board (open). The vertical side of the C-section feed line has a width of (W_{f2}) 1.5 mm and a length of (L_{f2}) 23.75 mm. (As this line is very close to the edge of the vertical slot, its extension to the edge of the board causes electric field perturbation on the vertical slot. Therefore, it is necessary to bend the feed line to form a C-shaped line.) The upper side of the C-section is terminated at the connector on the edge of the board ($W_{f3} = 1.5$). The feed line is designed to achieve the widest overlapped bandwidth in terms of AR and reflection coefficient.

The L-shaped structure generates electric fields between the grounds on each slot. The electric fields on these slots are perpendicular to each other. By adjusting the width of the slot (S) and the length of the horizontal portion of the feed line (L_{f1}), a 90° phase difference between these orthogonal electric fields over the band of interest can be created. In Section IV, the effect of various slot widths and the horizontal lengths of the feed line on the axial ratio are discussed. The fabricated antenna is shown in Fig.1.

This type antenna has low profile and easy to match. The wideband CP L-shaped monopole slot antenna with a E-shaped feed is design and then the antenna produced circular polarization.

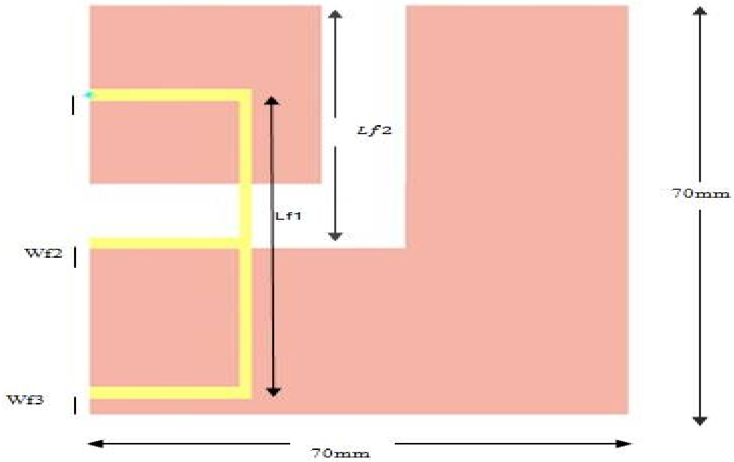

Fig.1. (a) Geometry of the L-shaped circular polarized monopole slot antenna

IV. SIMULATIONS AND MEASUREMENTRESULTS

Simulations were performed by using ADS. The simulated and measured AR is shown in Fig. 2(a). The simulated and measured radiation patterns at 3GHz, 8GHzare shown in Fig. 3. The antenna is designed to produce a right-hand circular polarization at broadside ($\theta = 0^{\circ}$), while a left-hand circular polarization is considered to be the cross polarization. Fig. 2 also demonstrates the simulated and measured gain of the antenna versus frequency. Theoverall gain is 7.841 with efficiency of better than 90% for the axial ratio of less than 3db(3-8GHz) bandwidth ($AR <$ dB). The AR and reflection coefficient overlap each other perfectly.

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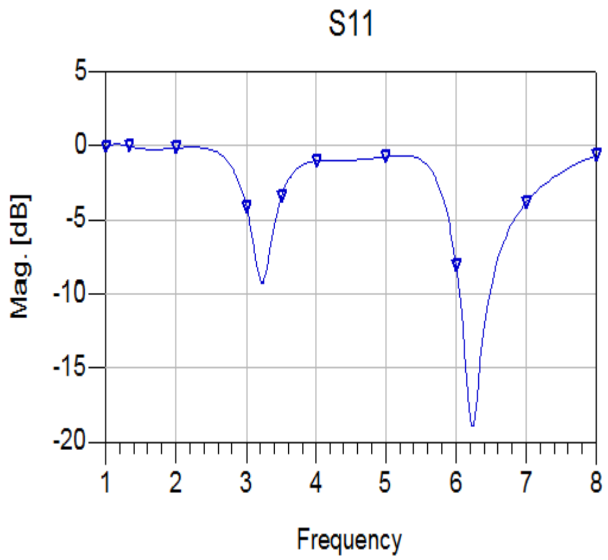

Fig 2(a) Simulated output

Fig. 2 also demonstrates the simulated and measured gain of the antenna versus frequency. The overall gain 7.841 with efficiency of better than 90% for the axial ratio of less than 3db (3-8GHz) bandwidth ($AR<3$ dB).This can be attributed to the edge connector that creates an asymmetric electric field in the antenna configuration and measurements setups.

Therefore the total measured CP bandwidth of antenna causes fabrication errors, and makes the antenna unsuitable for low-profile mobile application.

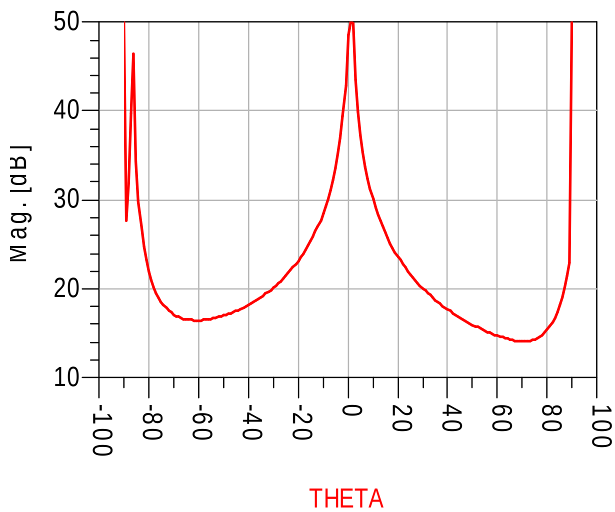

Fig. 3 Axial ratio output

The measured results show that the antenna has an axial ratio (AR) < dB, a reflection coefficient <_ dB, and circular polarization (CP) bandwidth. This feature is attractive for compact wireless devices that operate at low frequencies.The antenna is extremely low-cost and does not require any truncation error, reflector surfaces or via

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connections, all of which increase the fabrication cost.

Table 1.Antenna parameters

Power radiated(watts)	**9.307**
Effective angle(steradians)	**2.36**
Directivity(dB)	**7.25901**
Gain(dB)	**7.8421**
Maximum intensity	**3.9402**
Angle of U max	**0**
E(theta)max(mag, phase)	**0.1713,84.21**
E(phi) max(mag, phase)	**0.0179,-93.73**
E(x) max(mag, phase)	**0.13,84.40**
E(y) max(mag, phase)	**0.1085,83.913**
E(z) max(mag , phase)	**0,-180**

The overall gain is 7.841 with efficiency of better than 90% for the axial ratio of less than 3db (3-8GHz) bandwidth ($AR<3$ dB) is obtained. The power radiated from this antenna is obtained as 9.307.Thus the simulation results and antenna parameters are obtained.

V.CONCLUSION

A low-profile, low-cost, L-shaped monopole slot antenna with a C-shaped feed was introduced in this letter. The simulation and measurement results proved that the antenna has a wideband CP performance of at least 23%. Due to the geometry of the antenna ($\lambda/4$ monopole slot), it occupies half the real estate on the corner of circuit board compared to the $\lambda/2$ slot antenna, which requires the area at the center of the board. This feature significantly facilitates the floor planning and signal routing in high-density mobile device environments and operates at a low gigahertz range where the footprint and the profile are major concerns.

The antenna does not require any truncation corner, reflector surface, or via connections, which results in a significant reduction of the circuit board fabrication cost. Extensive parametric studies were conducted, which identified the sensitive design dimensions affecting the AR and reflection coefficient bandwidth as were discussed herein. GPS and low-data-rate iridium satellite access for automobile telematics are among the antenna applications.

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