A Circularly Polarized Planar Monopole Antenna with Wide AR Bandwidth Using a Novel Radiator/Ground Structure

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Abstract

A wide band circularly polarized CP) printed monopole antenna is proposed. The 3 -dB axial ratio (AR) is realized by protruding a horizontal stub from a vertical monopole and creating a slot on the ground plane beneath the protruded stub. The monopole and slot resemble rotated T- shape structures when viewed from the top. The proposed antenna has a size of 25×25 mm2. Numerical results show that the antenna can realize an S11 ? -10 dB impedance bandwidth of 85.6

Index terms— monopole, circularly polarized (cp), axial ratio.

The presented antenna consists of a microstrip-fed vertical radiator and a rectangular ground plane structure. To realize broadband CP, a horizontal stub is protruded from the vertical radiator above the ground plane, and an identical slot structure is created on the ground plane just beneath the radiator. In this design, the 3-dB AR bandwidth reaches as large as 5.26 GHz which is about 73.9 % which covers the WLAN (5.2 GHz, 5.8 GHz), WiMAX (5.5 GHz) and other wireless systems in C band. Another uncommon technique is introducing sequential array configuration [7], [8] aside using slot antennas. This method can realize wideband AR but the design is complicated due to the array design and the use of a power divider and a large circuit board. Recently, research has gone into using planar monopole antennas to realize broadband CP [9] - [12] but some of these designs have wide AR bandwidths and/or suffer from design and fabrication complexities. There is a

1 Introduction

ith the rapid development of wireless communications systems, antennas with different polarizations have become very important. Circular polarization (CP) has become very useful in many communication systems due to its resilience to polarization mismatch which is otherwise a problem in linearly polarized (LP) antennas. A lot of research has focused on implementing CP in slot antennas due to their relatively wide impedance bandwidths [1] - [7]. In [1] - [3], L shaped ground strips were embedded inside a square slot to achieve and improve the AR bandwidth. In [4] - [6], perturbations in the form of feed lines were introduced in the slot antenna to realize CP characteristics. Antenna Design

2. The evolution of the proposed antenna is shown in Fig. 2. in order to explain how the CP performance is introduced into the antenna. Four separate antennas will be discussed. These are: antenna 1 (Ant 1), antenna 2 (Ant 2), antenna 3 (Ant 3), and antenna 4 (Ant 4). Ant 1 is a fundamental monopole antenna which has been widely used [13] while Ant 4 is the proposed antenna. At the first stage, Ant 1, which is simply a micro strip antenna which consists of a vertical monopole and a ground plane, is designed. In Ant 2, a horizontal stub is protruded from the radiating monopole (towards the +y axis) at a short distance above the ground plane. The radiator, here, resembles a rotated uneven Tshaped monopole. In Ant 3, a slot is created on the ground plane just beneath the radiating monopole, along the +x axis. Lastly, in Ant 4, a horizontal slot is created on the ground plane along the initial slot and towards the +y axis to resemble a rotated Tshaped slot. The effect of each antenna will be discussed in Section III.

III. The antennas were simulated with Ansoft commercial high frequency structure simulator (HFSS) software. To demonstrate the performance of the proposed antenna from stages 1 to 4, the S 11 bandwidth and AR performances have been compared in Fig. 3. It can be noticed in Fig. 3(a) that Ant 1 resonates around 4.5 GHz which corresponds to a quarter of the guided wavelength for the monopole's length above the ground plane. The bandwidth is however very small and the impedance matching becomes poor after 5 GHz. It is also linearly polarized with an AR value around 50 dB as seen in Fig. 3(b). To enhance the S 11 bandwidth significantly, a horizontal stub is protruded from the monopole, like in Ant 2. From Fig. 3, the S 11 bandwidth is greatly enhanced due to another resonance at 8 GHz. The AR is also improved from 50 dB to about an average of 20 dB average across band, except at 9 GHz. bandwidth of Ant 3, a slot is created from the initial slot in Ant 3 and extended towards the +y axis to complete the slot structure on the ground plane. Here, the overall slot resembles an uneven rotated T-shape, like the monopole structure. This is illustrated in the proposed design (Ant 4). Fig. 3(a) shows that Ant 4 has better S 11 performance than Ant 1 and Ant 2, but not Ant 3. Ant 3 has an S 11 bandwidth from 4 GHz -over 12 GHz, while Ant 4 has an S11 bandwidth from 4 GHz -10 GHz. However, the AR performance shows a significantly improved performance in Ant 4: from 4.6 GHz to 9.8 GHz. Here, a phase difference of 90 0 is achieved over a wide bandwidth between E VER and E HOR .

2 Results and Discussion

3 Parametric Analysis

The results of parametric studies on the proposed antenna are presented in this section. The parameters discussed here are the stub length (S L), slot length (S D), slot length (S W), slot width (S M), slot position (S T), and stub position (S H). For each varying parameter, the other dimensions remain fixed as the values indicated in the caption of Fig. **??**. The results will be discussed to provide knowledge on how the antenna's S 11 and AR performances are affected by each parameter.

4 A. Effect of S L

The results of different S L values on AR and S 11 are shown in Figs. **??**(a) and (b). It can be realized that the S 11 does not significantly change when S L is varied except at low frequency, between 4 GHz -7 GHz, where the S 11 worsens as S L increases. In the AR plot in Fig. **??**(b), the AR value decreases (improved CP) as S L increases from 3mm to 5mm, especially between 6 -8 GHz. For an AR ? 3 dB threshold, the bandwidth however is largest when S L = 3mm.

5 B. Effect of S W

The effect of S W values on AR and S 11 bandwidths is demonstrated in Fig. **??** When S D is small, there is considerable coupling between the ground and monopole which is reduced when a gap of adequate length is created. When the gap is relatively big however, (e.g. S D = 5mm), the worst S 11 is achieved since the ground plane's effective area is reduced. In the AR plot, a small gap produced a poor AR at lower frequencies below 6.5 GHz, which improved when the S D increased. After 6.5 GHz, an insignificant change is noticed with changes in S D .

6 D. Effect of S M

The effect of S W on AR and S 11 bandwidths is demonstrated in Figs. **??**(a) and (b). S M does not affect the S 11 and AR significantly. The S 11 plot remains unchanged except at low frequency where an increase in S M worsens the S 11 slightly. The AR plot is also significantly affected only at lower frequency when S M = 0.25mm. At S M = 0.5mm and 0.75mm, the AR remains unchanged except with S M = 0.5mm realizing a slightly larger bandwidth than S M = 0.75mm.

7 E. Effect of S T

The effect of S W on AR and S 11 bandwidths is shown in Figs. 9(a) and (b). The S 11 plot shows no significant change except very slightly at lower frequency. In the AR plot however, significant changes are noticed, i.e., when the gap between the horizontal slot and top edge of the ground is close, the AR is worsened but improves when the gap is increased. The largest bandwidth for AR ? 3 dB is achieved when the gap, S T , is 2mm.

8 F. Effect of S H

The effect of S H on AR and S 11 bandwidths is shown in Figs. **??**0(a) and (b). A significant change is noticed in the AR plot while a slight change is noticed in the S 11 plot when S H changes. From Fig. **??**0 (b), it shows that the AR bandwidth is dependent on S H . When S H is 3mm, a wideband AR is achieved from 5.5 -8 GHz. When S H increases to 5mm, the AR shifts to about 7.8 -9.2 GHz. The largest bandwidth is realized when S H = 4mm.

V.

9 Conclusions

A novel, low profile, broadband CP monopole antenna is introduced in this work. The results show that the antenna can achieve a broadband AR bandwidth from 4.54 -9.8 GHz (73.9 % fractional bandwidth) and an impedance bandwidth from 4 -10 GHz (85.7 % fractional bandwidth). To achieve CP performance, a rotated T-shaped monopole and a rotated T-shaped slot are employed. In addition to the simple structure, the proposed antenna provides a novel design in enhancing AR bandwidth and CP operation. The proposed antenna is useful for wireless communications in C-band, [1] [2]

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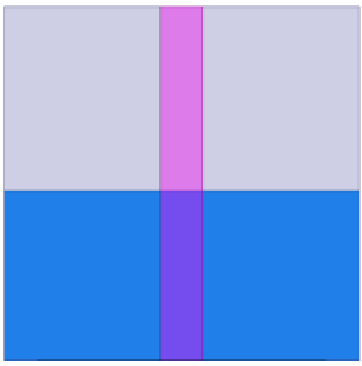

Figure 1: Fig. 2 :

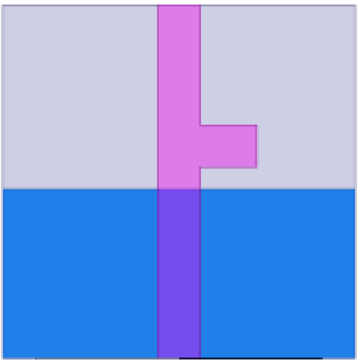

Figure 2: FA

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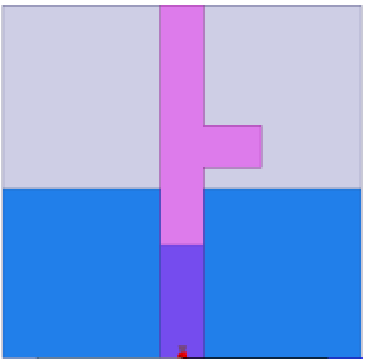

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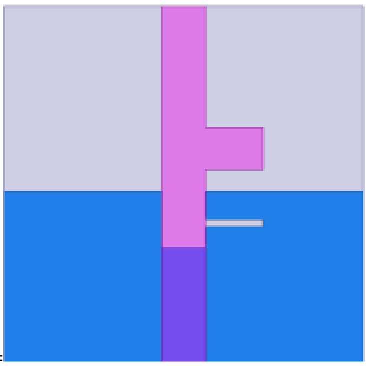
4 

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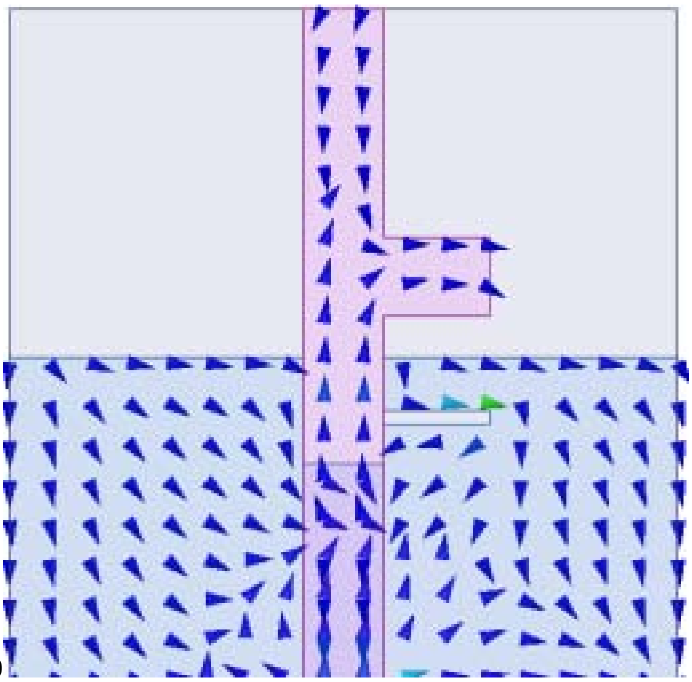
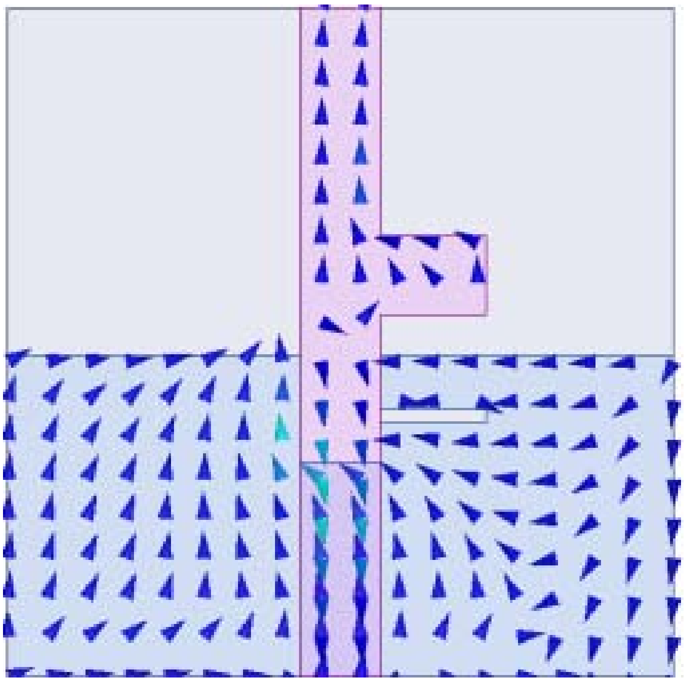
5678910 

Figure 5: Fig. 5 :Fig. 6 :Fig. 7 :FFig. 8 :Fig. 9 :Fig. 10 :



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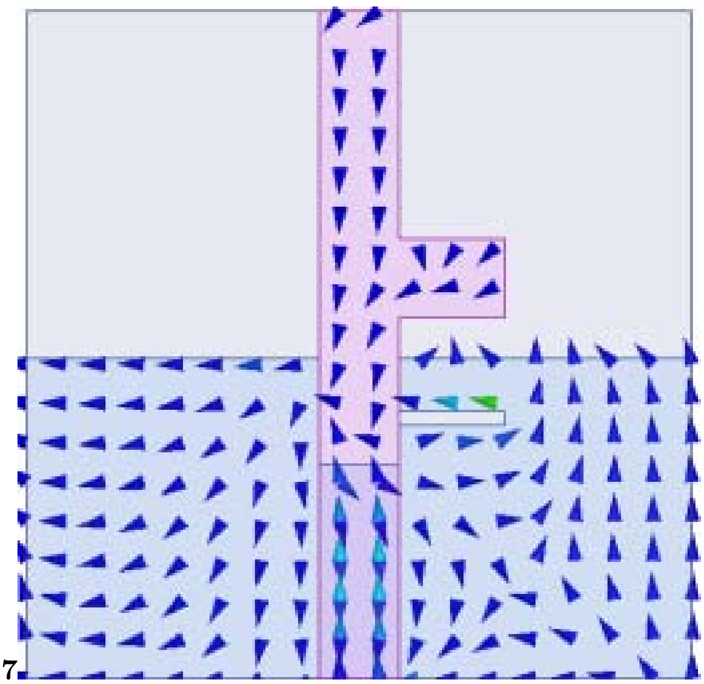

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Figure 8:

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