Design and Ground Plane Consideration of a CPW-Fed UWB Antenna

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Abstract

In this paper, a novel ultrawideband (UWB) antenna with co-planar waveguide (CPW) feed is presented. The antenna is based on an egg-shaped conductor printed on a 30×40 mm^2 FR4 substrate of 1.6-mm thickness. Two configurations of the antenna are studied. In the first, the ground plane features a large egg-shaped slot, and in the second, the ground plane is partial and rectangular in shape. The measured and computed return loss responses are given. Other characteristics of the antenna are computed using a Finite-Element-based EM solver. The radiation patterns, peak gain, and radiation efficiency of both configurations are presented and compared. The results show that the design based on the large slot yields better omnidirectional patterns and higher gains in the principal planes. The second design has slightly larger radiation efficiencies, and larger peak gains at high frequencies.

1. Introduction

In 2002, the Federal Communication Commission (FCC) declared the 3.1-10.6 GHz frequency band for use in commercial communication applications [1]. Since then, the interest in UWB wireless communication has increased tremendously, and has led to extensive research effort aiming at innovating and developing new antennas for UWB operation.

Printed antennas have proved to be a good choice for these systems due to their low profile, small size, light weight, low cost, and ease of fabrication and integration in microwave circuits [2]. With CPW feeds, extra advantages are acquired, such as wider bandwidth, better impedance matching, lower radiation loss, and less dispersion [3-4].

Several CPW-fed UWB antenna designs have been reported in the literature. These can differ, among other factors, by the shape of the conductor and the configuration of the ground plane. In [5], the presented CPW-fed UWB antenna is based on circular disc conductor, and a partial rectangular ground plane. The antenna in [6] features a step-typed monopole conductor with a step-slope ground plane. In [7], the antenna consists of an open annulus strip as a ground plane and an open crescent patch in the inner space of the annulus as a radiating element. The authors of [8] introduce annular slot and round corners into the ground and use a round-edged bowtie-shaped conductor.

In this paper, we present two variations of a small-sized CPW-fed UWB antenna based on an egg-shaped conductor. In the first, we use a ground plane with a large egg-shaped slot, leading to a slot antenna, and in the second, we employ a partial rectangular ground plane. In both designs, the conductor and the feed are the same. The shape of the conductor is suitable for obtaining higher bandwidths.

2. Antenna Geometry

The two designs, Design I and Design II, are shown in Fig. 1. Both are printed on a 1.6-mm-thick FR4 epoxy substrate with dielectric constant ε_r of 4.4 and size 3cm × 4cm. The 50-Ω feed line is 3mm wide and 5mm long. The egg-shaped conductor is obtained by combining a circle and an ellipse at their centers. The circle has a radius of 9mm, which is also the minor radius of the ellipse. The major radius of the ellipse (along the Y-axis) is 12.06.

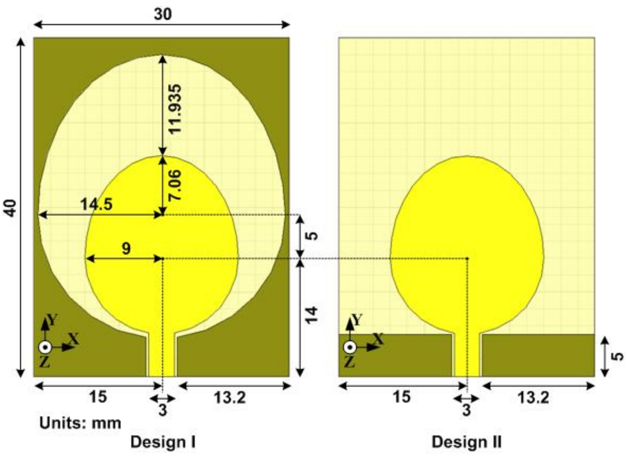

Fig. 1. Configuration of Design I (left) and Design II (right)

For Design I, a large egg-shaped slot is incorporated in the ground plane. The shape of the slot is also a combination of a circle and an ellipse, where the radius of the circle and the minor radius of the ellipse are equal to 14.5, and the major radius of the ellipse is 18.995. In Design II, the ground plane is rectangular and is cut at the feed level.

3. Results and Discussion

The two designs were simulated in Ansoft HFSS [9] which is based on the Finite-Element Method (FEM). Prototypes were fabricated and the return loss (S_{11}) was measured. Figs. 2 and 3 depict the measured and computed return loss of Design I and Design II, respectively. Despite some discrepancies between the measured and computed S_{11} for Design I, due to fabrication issues, the UWB operation of both designs is demonstrated in the S_{11} plots.

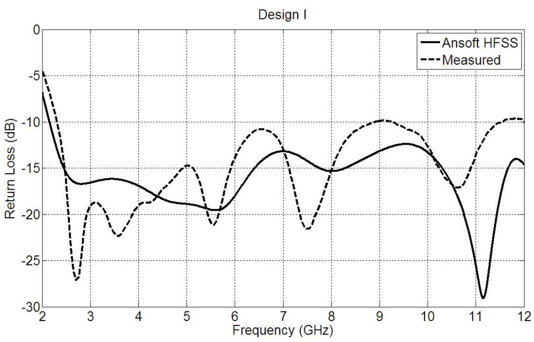

Fig. 2. Return loss of Design I

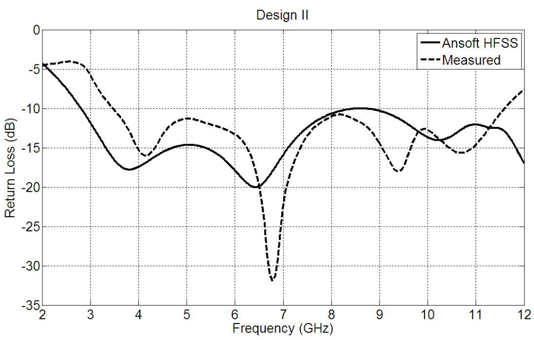

Fig. 3. Return loss of Design II

The computed peak gain of the two designs is shown in Fig. 4. Design I has an almost flat gain in the 6–12 GHz range, with an average of about 5 dB. Compared to Design II, Design I yields higher peak gain values for frequencies up to 7 GHz, but smaller ones beyond that. This is due to the fact that Design II loses its omnidirectional radiation property at high frequencies, which leads to higher peak gain values.

The computed radiation patterns are given in Fig. 5 for 4, 8, and 12 GHz. At 4 GHz, both designs exhibit omnidirectional patterns with equal gain in the XZ-plane, and a pattern with the shape of figure '8' in the YZ-plane. At this frequency, Design I has a larger gain in both planes. At 8 GHz, Design II patterns become directional and sidelobes appear, unlike Design I, which has more consistent omnidirectional patterns. This is also evident at 12 GHz where the pattern of Design I is still satisfactorily omnidirectional. At high frequencies, Design I offers better gains in the XZ and YZ planes, although Design II has higher peak gain values.

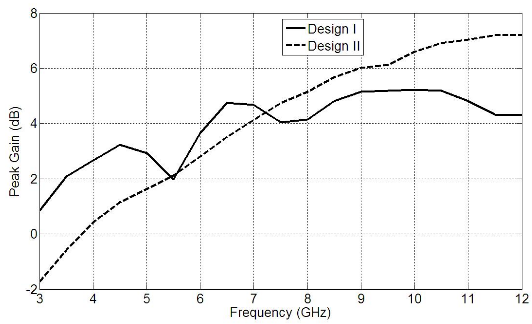

Fig. 4. Peak gain of the two designs

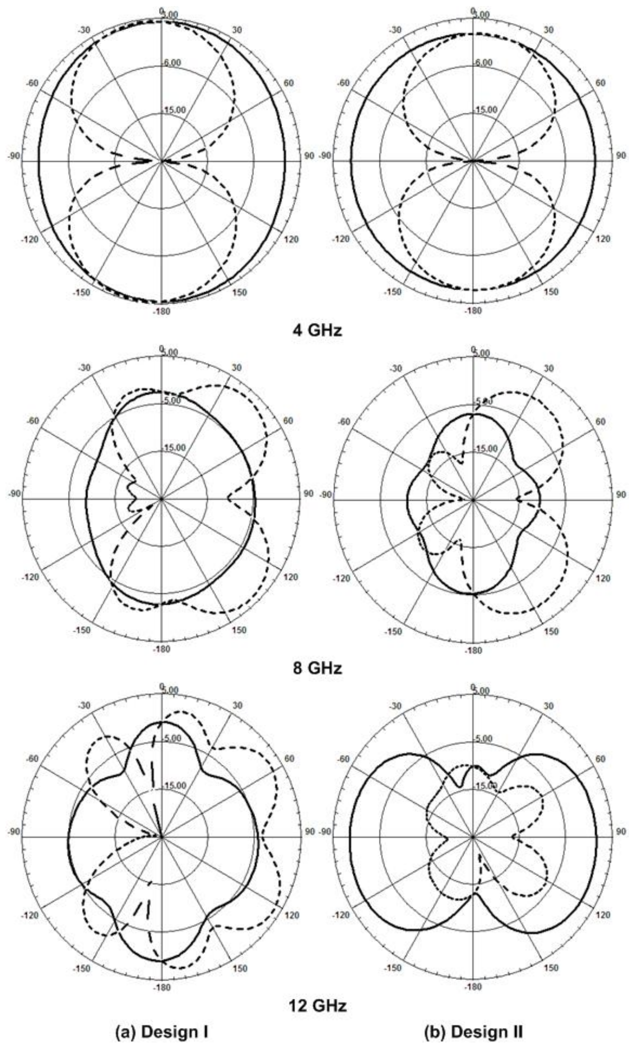

Fig. 5. Radiation patterns of Design I (left column) and Design II (right column) in the XZ-plane (solid line) and the YZ-plane (dotted line)

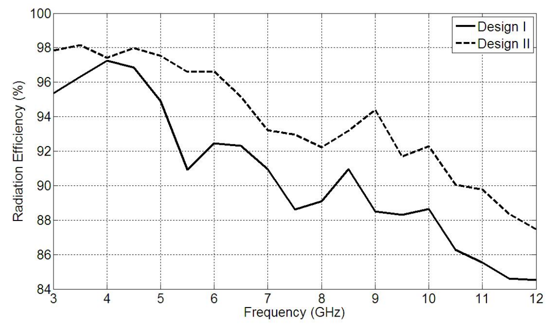

Fig. 6. Radiation efficiency of the two designs

Fig. 6 shows the radiation efficiency of the two designs. For both, the efficiency decays with increasing frequencies due to more losses in the substrate at higher frequencies. Design II has a slightly larger efficiency.

4. Conclusion

Two designs of an UWB CPW-fed printed antenna based on an FR4 epoxy substrate and an egg-shaped conductor were presented. Design I is a slot antenna, where the slot is also egg-shaped, whereas Design II has a partial small rectangular ground.

Measured and computed return loss plots demonstrated the UWB operation of the two designs. Computational results done using HFSS showed that Design I had much better omnidirectional radiation properties and higher gains in the XZ and YZ planes. Design II offered slightly larger radiation efficiencies, and for frequencies larger than 7 GHz, it resulted in higher peak gains.

5. References

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