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ON IMPROVING IMPEDANCE MATCHING OF A CPW FED LOW PERMITTIVITY DIELECTRIC RESONATOR ANTENNA

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Abstract—In this paper, a new coplanar waveguide (CPW) feed structure is proposed to improve impedance matching of low-permittivity dielectric resonator antennas (LPDRAs). The structure is studied experimentally for a two element-rectangular LPDRA array. In the proposed structure, a horizontal strip is centrally connected at the center strip of the CPW and symmetrically added to a coplanar rectangular coupled slot. The dielectric radiators are fed by the CPW through the slot. Based on the above design concept, several antenna prototypes have been successfully designed, fabricated and tested. The measured results show that the proposed antenna exhibits unique and attractive features in terms of impedance matching, gain and the realization of an array.

1. INTRODUCTION

Dielectric resonator antennas (DRAs) have received extensive attention as they have many attractive features, such as high radiation efficiency, considerable bandwidth, light weight, small size and low profile [1–7], [10]. Moreover, DRAs can accommodate a variety of feed structures. Such as coaxial probes [1, 2], microstrip feed line coupling to a narrow slot [3], aperture coupling [4] and CPW feeds [5–7]. Among the various feeds, the CPW feed is very suitable for the design of the active integrated circuits due to its co-planar configuration. Additionally, a CPW feed has low dispersion and radiation losses. Therefore, the CPW has been extensively employed to feed DRAs.

In this paper, the authors propose a CPW fed low permittivity DRA (LPDRA). Since matching the impedance of LPDRA may be difficult [5], the objective in this design is to improve the coupling between the CPW feed and the DRA. For this design as shown in Fig. 1, the feed network consists of a coupled rectangular slot, and the two dielectric resonator radiators are fed by a CPW feed at the two ends of the rectangular slot. To effectively couple the power to the dielectric radiators, a horizontal strip is centrally connected at the end of the center strip of the CPW and symmetrically added to the slot aperture. Hence, this layout forms a T-shaped signal strip in the CPW and two parallel feed slots for each dielectric radiator. The above structure has many attractive features. First, the measured results in the following sections show that the two parallel slots can excite dual resonant modes when properly constructed. Therefore, the antenna has potential for broadband operation. Second, this structure display a number of degrees of freedom in adjusting and improving impedance matching. For example, a T-shaped strip can improve coupling compared to a straight strip in the aperture coupled structure [8, 9]. In addition, by adjusting the location of the radiators on the slot, the impedance matching can be improved. In this study, several designs are experimentally investigated, and the corresponding return loss, the radiation patterns, and the gain are analyzed and discussed in the following sections.

2. ANTENNA CONFIGURATION

The perspective view of the proposed antenna configuration is shown in Fig. 1, where two rectangular dielectric radiators are made of a microwave substrate of dielectric constant $\varepsilon_1 = 10.8$. They have the identical dimension of the length $a = 24$ mm, the width $b = 14$ mm and the height $c = 6$ mm, and are fed by a CPW at the two ends of the

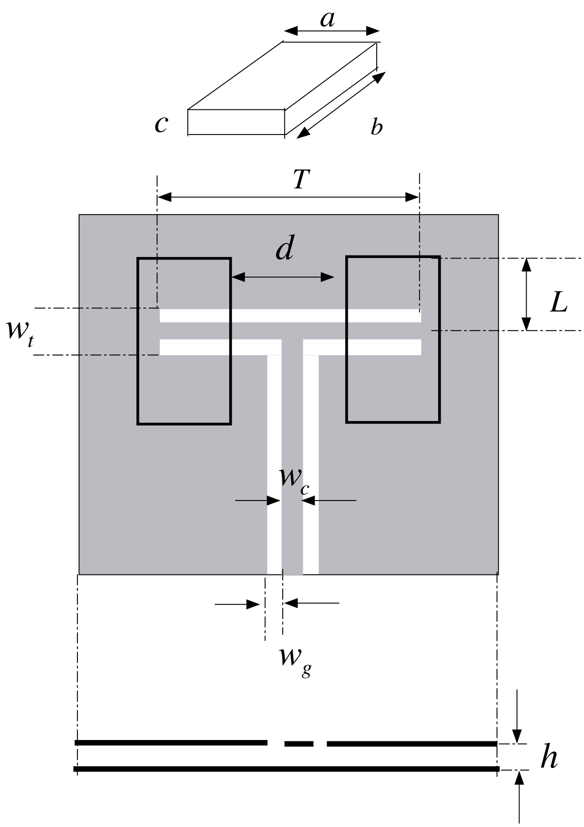

Figure 1. The antenna configuration.

coupled rectangular slot. The slot is centrally added by a horizontal strip, and the width of the strip is 8 mm. The width W_c of the center strip of the CPW is 8 mm, and the width W_g of the gap is 2.5 mm. The length T of the coupled rectangular slot is 60 mm and the width W_t is 12 mm. The CPW and the slot are etched on a Roger RT/Duroid substrate of thickness $h = 1.5$ mm and dielectric constant $\varepsilon_r = 2.2$. In order to get uni-directional radiation, a finite metal plate of 78 mm by 78 mm is employed on the bottom of the substrate. The other design parameters are shown in Fig. 1. For the cases studied here, the spacing d and the tuning length L, both shown in Fig. 1, are set as variable parameters to study their effects on the antenna performances.

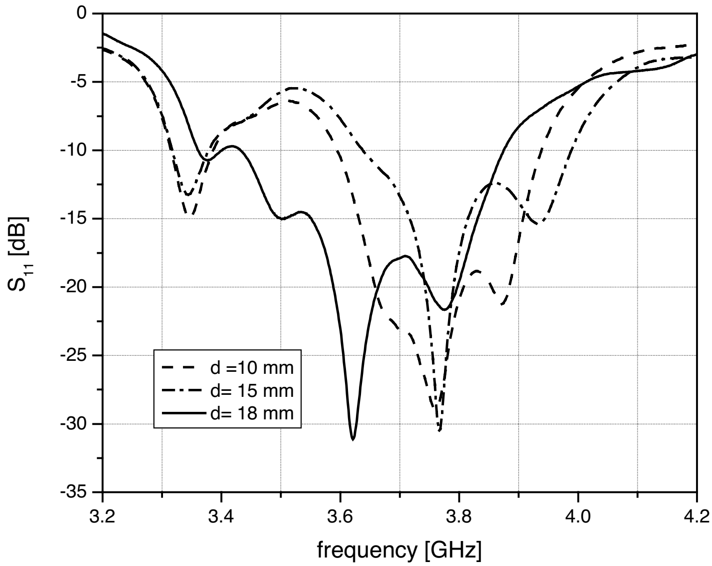

Figure 2. Measured return loss curves versus frequency for various spacing d.

3. MEASURED RESULTS

The proposed structure with various design parameters have been constructed. As a first step, the spacing d is varied and its effect on impedance matching is investigated. Fig. 2 shows the measured return loss curves versus frequency for various spacing d when $L = 6\,\mathrm{mm}$. As d is increased from 10 to 15 mm, the antenna exhibits three resonant modes within the frequency range from 3.3 to 4.1 GHz. The lower frequency resonant mode may be due to the mutual coupling between the two rectangular dielectric radiators and it should become weak as the spacing is increased. The higher and medium frequency modes are two close resonant modes. As expected, as d is further increased to 18 mm, the lower resonant frequency tends to disappear. The higher resonant frequencies shift to lower values and merge into a wider band when $d = 18\,\mathrm{mm}$. Therefore, good impedance matching can be implemented when $d = 18\,\mathrm{mm}$ and $L = 6\,\mathrm{mm}$.

Next, the effect of the tuning length L on impedance matching of the antenna is studied. Here, the spacing d is fixed at 18 mm, which is the optimum value obtained from the above measurements and corresponds to the weak mutual coupling between the two LPDRAs. Several measured return loss curves are plotted in Fig. 3. It can

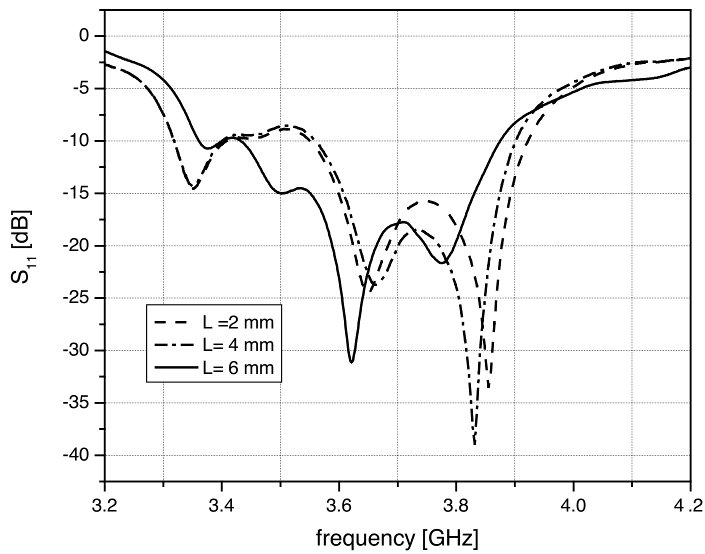

Figure 3. Measured return loss curves versus frequency for various tuning length L.

be observed that the offset length has little effect on the resonant frequencies but significant effect on impedance matching occurs, especially at higher frequencies.

Based on the above experimental results, the antenna can achieve good impedance matching when the spacing and the tuning length are fixed at $d = 18\,\mathrm{mm}$ and $L = 6\,\mathrm{mm}$, respectively. For the present design, the radiation patterns of the proposed antenna were measured in an anechoic chamber. Figs. 4–5 show the measured radiation patterns at the two resonant frequencies $f = 3.62\,\mathrm{GHz}$ and 3.78 GHz. These results demonstrate that the proposed antenna can display very stable radiation patterns within the interested frequency range. With reference to Figs. 4–5, the front-to-back radiation ratio is better than 20 dB even when there are edge diffractions in the back region due to the finite ground plane. Fig. 6 shows the measured gain. As expected, the antenna achieves a high gain due to the use of a backed CPW where a peak gain is around 8 dB at the resonant frequency $f = 3.62\,\mathrm{GHz}$ and the maximum gain difference is about 3 dB within the selected frequency range.

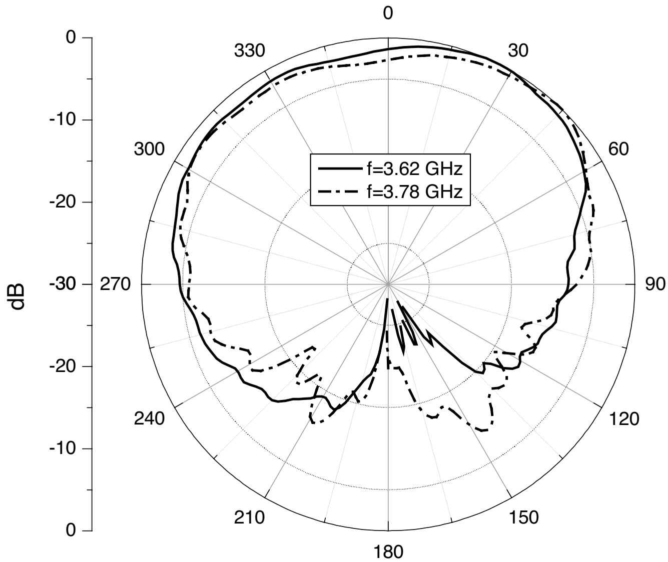

Figure 4. Measured radiation pattern in the E plane.

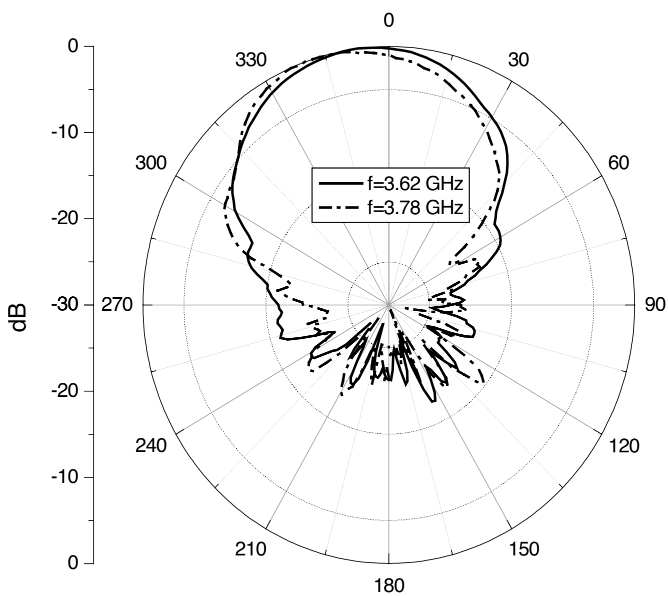

Figure 5. Measured radiation pattern in the H plane.

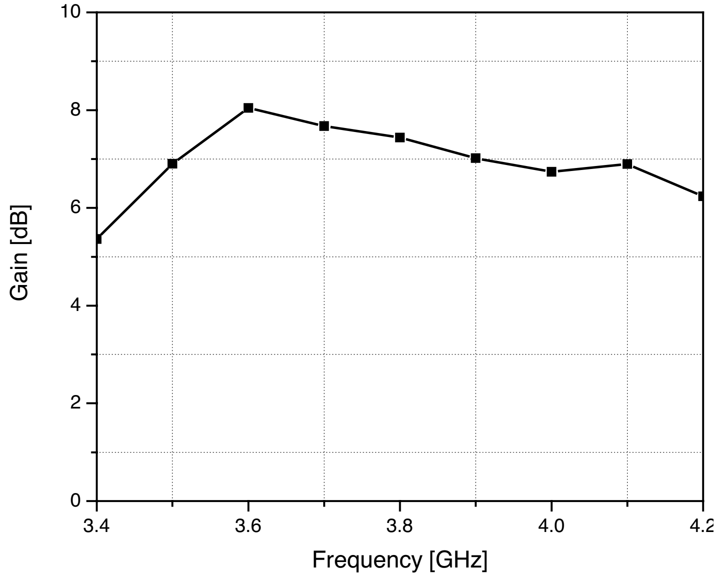

Figure 6. Measured gain.

4. CONCLUSION

A method for improving impedance matching of an aperture coupled CPW fed LPDRA array has been demonstrated experimentally by employing a CPW feed line into a coupled slot. The proposed antenna can be built to have good impedance matching simply by tuning the location of the LPDRAs on the coupled slot. By changing the spacing between the LPDRAs, resonant frequencies can be adjusted easily, which supplies another alternative method to modify the resonant frequencies while maintaining a constant volume of the DRAs. Since the overall structure takes on the front of a CPW Tee, it can be used to feed a broadband large CPW fed LPDRA array.

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