GAIN ENHANCEMENT OF APERTURE-COUPLED DIELECTRIC-RESONATOR ANTENNA WITH SURFACE MOUNTED HORN

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ABSTRACT:

We present a novel aperture coupled rectangular dielectric resonator antenna (DRA) with quasi-planar surface mounted horn to achieve high gain DRA. Adjusting the slant angle and position of the horn for a fixed horn height can optimize the gain of DRA. We achieved measured gain 8.5 dBi for the proposed structure. This shows a 4.9 dB increase in gain at 6.0 GHz over the standard DRA without surface mount horn. The cross-polarization of the antenna is better than 33 dB in both E-and H-planes. Total height of the fabricated structure is only 0.172 λ_0 i.e. 8.61 mm.

1. INTRODUCTION

Modern broadband communication systems and radars require lightweight compact antennas with high gain and wide bandwidth. Dielectric resonator antenna (DRA) offers several advantages such as wide bandwidth, small size, ease of fabrication and high radiation efficiency. The rectangular DRA can be designed as a compact, low profile antenna [1, 2]. However, it suffers from low gain. Several efforts have been made to increase the gain of the DRA. They include employing an offset dual-disk dielectric resonator (DR) [3], stacking parasitic DR with an air gap between the driven and parasitic DRs [4], and using composite layered DR of high permittivity [5]. These efforts resulted in the gain improvements of up to 2.7dB over a single DRA element. Hakkak and Ameri [6] have achieved a 7-dBi gain from a dielectric resonator loaded waveguide antenna with parasitic dielectric directors. However, this structure is very long and hence not suitable for compact antenna applications.

The quasi-planar surface mounted horn with an aperture coupled patch antenna has been used for enhanced gain [7]. In this work, we proposed an aperture coupled rectangular DRA with surface mounted horn for gain enhancement. The proposed technique is mechanical stable and easy to fabricate. The simulation results, obtained using the Microwave Studio software, shows an impedance bandwidth of 3.6% and a maximum gain of 8.9 dBi (neglecting metal losses) at 6.0 GHz. The measured antenna gain with mounted horn is 8.5 dBi at 6.0 GHz and without horn the DRA has 3.6 dBi gain. Thus the surface mounted horn improves gain of the DRA by 4.9 dB.

2. ANTENNA CONFIGURATION

The proposed antenna structure is shown in Fig.1 (a). The fabricated antenna structure is shown in Fig. 1(b). The surfaces mounted horn is made of copper sheet with aperture size 48.1 mm × 43.1 mm. The size of the ground plane is 60 mm × 60 mm. The slot-coupled rectangular DRA acts as a feed to the surface mounted short horn. The DRA is located at the centre of the rectangular coupling slot in the ground, and is excited by a 50-Ω microstrip line. The parameters of rectangular DRA are: length = 12.8 mm; width = 7.3 mm; height = 6.35 mm; dielectric constant = 9.8; and loss tangent = 0.002. The dimensions of slot coupled feeding structure are: slot length = 6.4 mm; slot width = 1.24 mm; stub length (s) = 1.6 mm; microstrip width = 1.16 mm; substrate dielectric constant = 3.38; loss tangent = 0.0022 and thickness = 0.508 mm. The dimensions of surface mounted horn are: area at lower (substrate) level = 27 mm × 32 mm; taper angle = 45^o: and height (H) = 8.1 mm

(~ $\frac{\lambda_o}{4\sqrt{2}}$). The total height of structure is only 0.172 λ_0, i.e., 8.61 mm at 6.0GHz. Therefore, the total antenna structure is quasi-planar in nature.

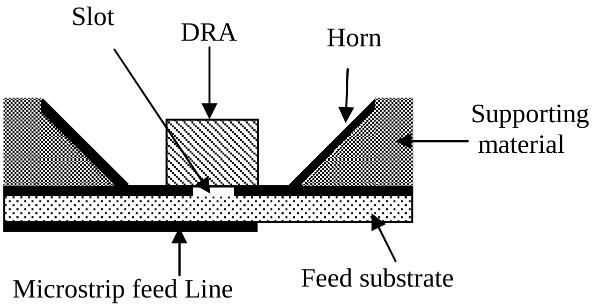

Fig. 1(a). Antenna Configuration.

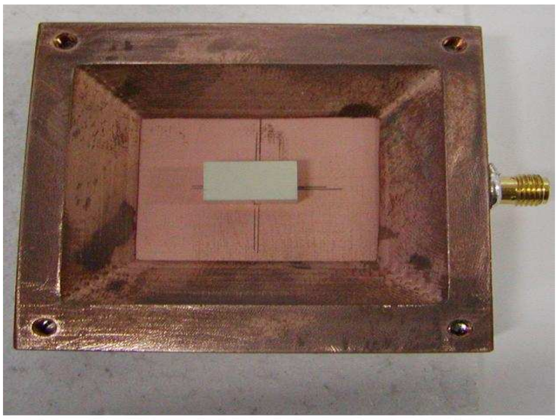

Fig. 1(b). Fabricated Antenna.

The simulation results, obtained using CST Microwave Studio software, show the 10 dB return loss bandwidth of 3.2% and a maximum gain of 8.7 dBi at 6.0 GHz. The measured antenna gain with the surface mounted horn is 8.5 dBi at 6.0 GHz; without the surface mounted horn it is 3.6 dBi. This shows a 4.9 dB gain improvement through the use of the surface mounted horn, due to the combined radiation from both the aperture and DRA.

3. RESULTS AND DISCUSSIONS

In our case the quasi-planar horn made out of a copper block by milling it. The quasi-planar horn in reference [7] is made out of the PVC block and its inner surface is painted with silver epoxy and outside horn structure is left as PVC. Thus there is a need to compare two kind of surface mounted horn to obtain the optimum gain of the antenna. Thus Fig.2 compares the performance of the quasi-planar horn with several kinds of supporting materials. A horn of thin metal supported by Styrofoam has a maximum gain of 9.7 dBi, whereas PVC (ε_r = 2.2) supported horn has the lowest gain of 7.3 dBi at 6.0 GHz. The gain of a horn made of out of copper is 8.7 dBi. The simulated performance of the quasi-planar horn made of copper block agrees with the experimental results. The simulation results are obtained by Microwave Studio. The simulation further shows that the gain can be further improved by about 1 dB if the surface mounted horn made of thin copper/ aluminium sheet is supported on a foam structure.

Fig. 3 shows the measured and simulated return loss of the antenna structure. It shows that the antenna has 3% bandwidth at 1:2 VSWR. The simulated and measured E-plane radiation pattern at 6.0 GHz is shown in Fig. 4. The measured E-plane front-to-back ratio is 23 dB and 3-dB beamwidth is 52^o. The measured H-plane front-to–back ratio is 20 dB and 3-dB beamwidth is 64^o. Overall good agreement between simulated and measured is observed. The measured beamwidths correspond to a gain about 9.2 dBi. Fig. 5 shows that the cross-polarization level in E-plane is better than 33 dB. Likewise, the cross-polarization level in H-plane is also better than 33 dB.

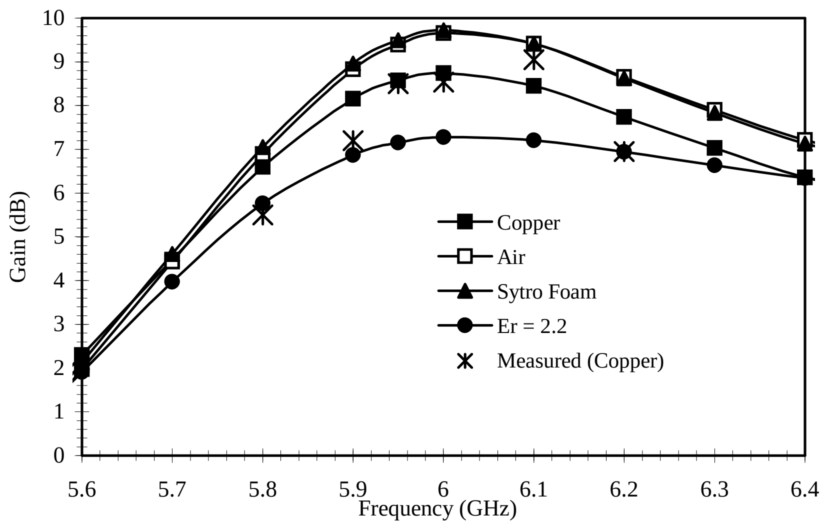

Fig. 2. Gain of DRA with horn supporting material block

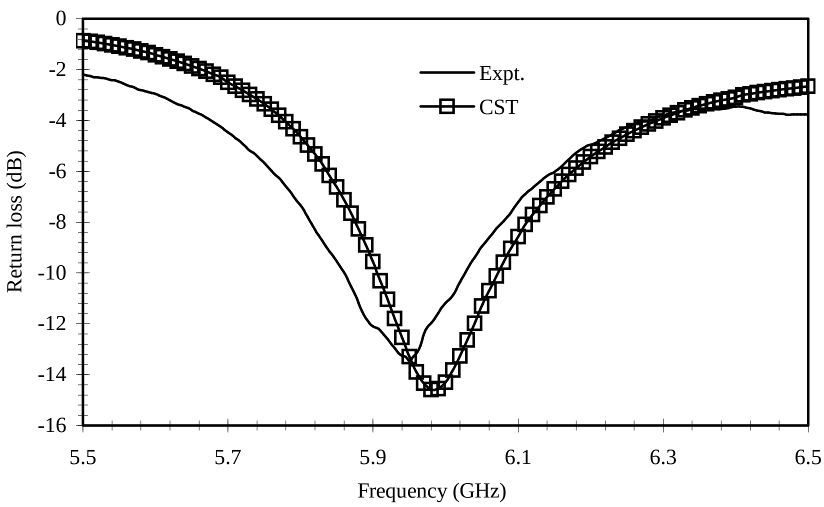

Fig. 3. Measured and simulated return loss against frequency.

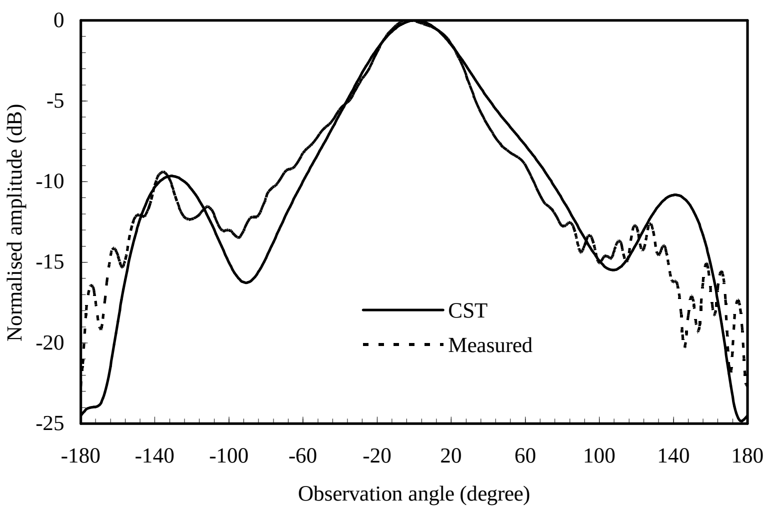

Fig. 4. E-plane radiation pattern at 6.0 GHz.

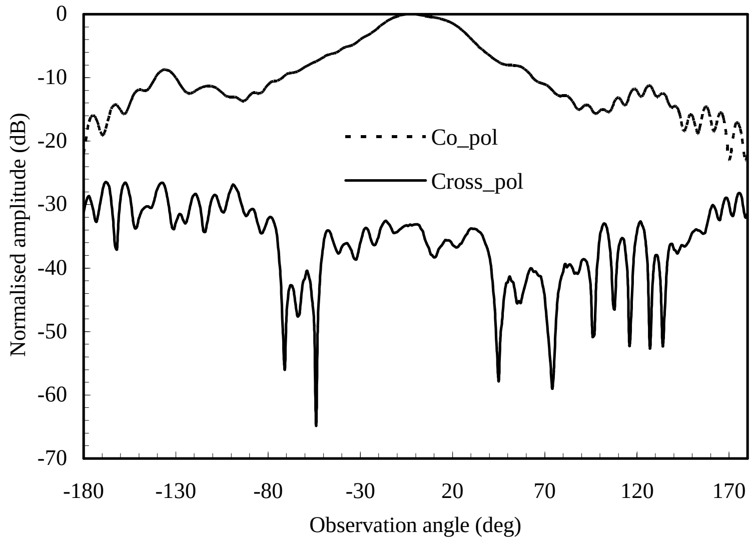

Fig. 5. Measured E-plane radiation patterns at 6 GHz.

4. CONCLUSION

We have developed a slot-coupled rectangular DRA with a quasi-planar surface mounted horn to achieve a high gain and low profile. The measured gain of the antenna is 8.5dBi at 6.0GHz, the cross-polarization level is better than 33 dB and the front-to-back ratio is 23dB. The total height of the structure is only 8.6 mm. The antenna can be easily adapted to low-profile, high-gain, and array applications.

ACKNOWLEDGEMENT

This research is supported by an Australian Research Council Discovery grant and fellowship. We are thankful to CSIRO ICT centre, Sydney Australia for providing measurement facility.

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