Waveguide-fed Cylindrical DRA: Wide-Band Design

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Abstract - **A cylindrical dielectric resonator antenna (DRA) is excited by a thick ground plane slot, which is fed by a capacitive waveguide junction (CWJ) coupled waveguide end. The objective of using a CWJ is to substantially increase the power coupling to the DRA. The DRA when given an offset along its length and width relative to the slot leads to wide band operation of the DRA. Measurements were carried out to verify the simulations and a reasonable agreement between them is obtained.**

Index Terms — **Broad band operation, Dielectric resonator antennas, rectangular waveguide, waveguide slot.**

I. INTRODUCTION

The potential for the dielectric resonator as an effective radiating source was proposed by Long *et al.* in [1]. It has been shown that DRAs have higher radiation efficiency than printed antennas at higher frequencies due to the absence of ohmic loss and surface waves, in addition to compact size, light weight, low cost, and high power capability [2]. DRAs are made of high dielectric constant material with a very low loss tangent to the extent that losses are negligible even at millimeter-wave frequencies.

The DRA can be excited using different feed topologies. These include the coaxial probe feed to the DRA [3], the microstrip line [4], an aperture coupled by microstripline or coplanar waveguide [5, 6], the conformal strip excitation of the DRA [7]. However, feed line losses of these excitation methods are considerable at millimeter-wave frequencies. Today, a waveguide still plays an important role in microwave and millimeter-wave applications. Since the waveguide has metallic walls, it has an excellent shielding between the exterior and interior regions, thus avoiding radiation loss even in the millimeter-wave band. So far, however, there is very little work has been published for the rectangular waveguide fed DRA. The broad wall probe coupled DRA reported by [8], has used stacked DRA to achieve wide-band design. In this type of feeding, a hole is drilled for the probe, which creates undesirable air gaps between the probe and DRA. Besides, it generates ohmic loss and large probe self-reactance at millimeter-wave frequencies. X.Q. Sheng *et al.* have reported study of waveguide fed DRA with a cylindrical dielectric inside the waveguide to increase the coupling [9]. Keeping the cylindrical dielectric inside the waveguide is extremely difficult and not very robust mechanically. Moreover, using two DRAs will increase the cost of antenna. Recently the Author reported study of waveguide fed rectangular DRA [10], in which 10 dB bandwidth achieved was only 3.48%.

To increase the bandwidth of waveguide fed DRA, a cylindrical DRA excited with a slot given an offset along its length and width relative to the thick slot is used. In this technique the 10 dB bandwidth has enhanced up to 18.5% at 10 GHz centre frequency. The measured 10 dB bandwidth is 1.85 GHz.

II. ANTENNA DESCRIPTION

Fig. 1 shows the configuration of the waveguide-fed cylindrical DRA backed by centered CWJ. The basic antenna structure consists of a cylindrical DRA, slotted ground plane, CWJ and WR90 waveguide. A cylindrical DRA of radius = 7.19 mm, height = 6.1 mm and ε_r = 10 is used for simulation and measurement. The DRA is placed with the offsets x_w and y_w along its length and width relative to the coupling slot. The slot is cut on the centre of thick ground plane mounted on a CWJ attached to the waveguide end as shown in Fig. 1. A centered CWJ of length and height *l* and *h*, respectively, is inserted between the waveguide and the thick ground plane to enhance substantially coupling to the DRA. The length and height of CWJ is optimized using Ansoft HFSS commercial software [11]. The resonant frequency of the antenna is mainly determined by the slot length, DRA dimensions, and permittivity, ε_r of DRA.

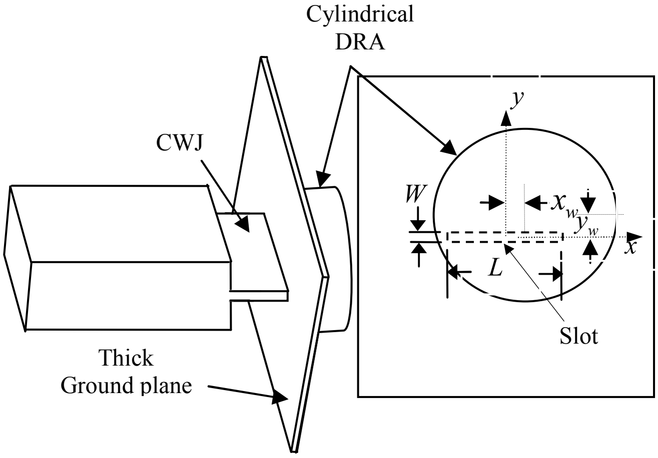


Fig. 1. Configuration of the waveguide fed Cylindrical DRA

III. COMPUTED AND MEASURED RESULTS

In the following investigations, the cylindrical DRA is placed with offsets x_w = 0.6 mm and y_w = 1.6 mm along its length and width relative to the thick slot, and the return loss and radiation patterns are simulated and measured. The standard WR90 waveguide with the dimensions of 22.86 mm × 10.16 mm is used for the measurement. Other parameters of the antenna are: length of CWJ, l = 8.8 mm, height of CWJ, h = 2.8 mm, length of slot, L = 9 mm, and width of slot, W = 0.8 mm. The size of ground plane used was 100 mm × 100 mm with thickness 1.3 mm. Fig. 2 comparing the measured return loss with the simulated data using commercial FEM code Ansoft HFSS. The discrepancy between simulation and experiment is mainly due to the nonuniform air gap between the DRA and ground plane. The measured 10-dB return loss bandwidth is 1.85 GHz, which is 18.5% at 10 GHz as center frequency. The measured radiation patterns at 9.7 GHz and 10.8 GHz both in *xz* and *yz* planes are shown in Fig. 3. The pattern shows almost similar in shapes both E and H planes with a minimum separation of 20 dB between cross polar and co-polar components at broad side direction. Fig. 4 shows the photograph of the fabricated antenna.

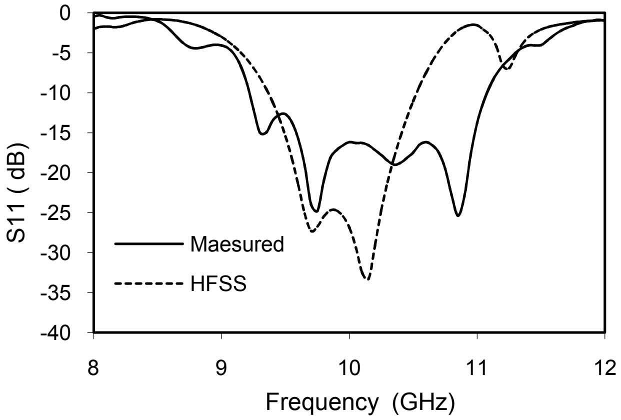
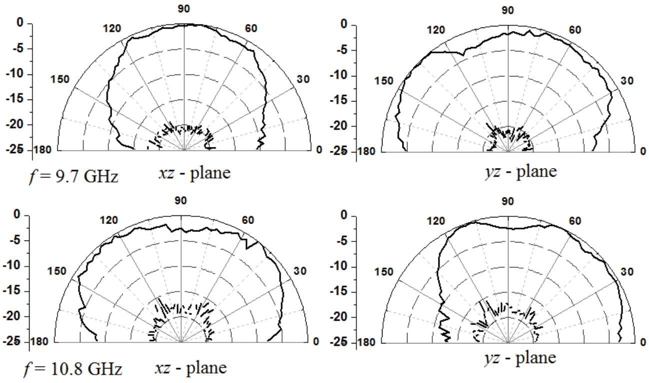


Fig. 2. Measured and simulated return loss



f = 9.7 GHz *xz* - plane

yz - plane

f = 10.8 GHz *xz* - plane

yz - plane

Fig. 3. Measured radiation pattern : ▬ co-pol, – – cross-pol

Fig. 4. Photograph of the fabricated antenna

IV. CONCLUSION

The proposed antenna gives wide band operation from 9.2 GHz to 11.05 GHz. It can be used in situations which require high band width like UWB and WLAN applications. The same design technique can be further scaled down for millimeter wave applications where, conductor antennas like microstrip fails to operate due to the inherent conductor loss.

ACKNOWLEDGMENT

This work is supported by Science and Engineering Research Council (SERC), Department of Science and Technology (DST) India under Fast Track Young Scientist Scheme.

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