Dear Dr. Neshati,

The Technical Program Committee (TPC) of CEM’09 Computational Electromagnetics International Workshop is happy to inform you that your contribution titled

[11] Numerical Investigation of a Rectangular Dielectric Resonator Antenna Array Fed by Dielectric Image Line

has been reviewed and accepted. Thank you for submitting your high-quality research results to CEM’09.

Registration: Kindly complete your workshop registration and hotel reservation by June 10, 2009.

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Since papers will be edited for inclusion in the IEEE Xplore, LaTeX format is strongly preferred. Please submit a zipped package containing all necessary files (e.g., LaTeX file, style file, eps figures etc.) so that your paper can be reproduced. It will be extremely important that all submissions conform to the template format.

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Social program: We are planning a highly enjoyable and culturally rich social program as part of CEM’09. Social events are still in the planning phase. It is most likely that the social events will take place on July 20-21-22 in the afternoon, and all day on July 23. Please plan to attend full four days of CEM’09 in order to take advantage of the social program. Furthermore, since there exist endless touristic attractions near Izmir, participants may also want to stay longer beyond CEM’09.

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Best regards,

On behalf of CEM'09 Technical Program Committee,

Ms. Nilay Erarslan

Numerical Investigation of Rectangular Dielectric Resonator Antenna and Array Fed by Dielectric Image Line

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Abstract — In this paper a single rectangular DRA structure fed by Dielectric Image Line (DIL) through a slot is numerically investigated. Also, a 3-element RDRA array structure is also studied based on the Finite Element Method (FEM). The effects of the width of the ground plane and slot size are studied on the radiation performance of the DRA. Results show that for a single DRA, peak gain of 7.7 dB at 10 GHz is obtained with a broadside radiation pattern with. In array, a 3-element DRA is considered and maximum gain of 10.2 dB is obtained which is 44.68% higher than the gain of the single element.

1. INTRODUCTION

In recent years, the application of Dielectric Resonators (DRs) as an antenna for microwave and millimeter wave communication systems have been the subject of many researches in literature. DRs made of low loss and high dielectric constant materials have been widely used as an energy storage component or tuning element in microwave circuits such as filters and oscillators. DRs are small in size, low in cost and light in weight offering high radiation efficiency. It has been reported that cylindrical, hemispherical, cylindrical rings and rectangular shaped DRs could operate as an efficient antennas. Common methods for fed DRAs are all types of transmission line such as coaxial probe, microstrip line, microstrip-slot coupled and coplanar waveguide [1].

The radiation efficiency of the communication system is reduced at high frequencies due to skin effect and high conductive loss of microstrip lines. Dielectric transmission lines such as Dielectric Image Line (DIL) have lower losses due to absence of metallic loss at microwave frequencies, compare to conventional transmission line [2, 3]. Rectangular DRAs fed by DIL can be excited at their resonant frequency through a narrow slot on the ground plane.

In this paper a RDRA fed by DIL which is excited through a narrow slot on the ground plane is numerically investigated. Also, a 3-element RDRA array structure is also studied based on the Finite Element Method (FEM). The effects the width of the ground plane and slot size are studied on the radiation performance of the DRA. Width of the ground is varied from 10 mm to 140 mm, while the slot size is optimized for the best ground size based on the acceptable recitation pattern. Results show that the optimum width of the ground is nearly 100 mm, while the optimum slot size is 3.7 mm in length and 0.144 mm in width for maximum gain and broadside radiation pattern perpendicular to the ground plane. The structure provides a good return loss with peak gain of 7.7 dB at 10 GHz.

In the array structure 3- element DRA are used with same dimension. The slots size and the distance between elements are optimized for the best return loss, radiation pattern and wide impedance bandwidth. The slot length and width are 3.5 mm, 0.144 mm respectively, while the distance between elements is 12.9 mm. Maximum gain of 7.05 dB is obtained at 10.1 GHz. For the antenna array the obtained gain is 10.2 dB which is 44.68% higher than the gain of the single element.

2. ANTENNA STRUCTURES

A. Single Antenna

The geometry of the antenna structure is shown in Fig. 1-a. A rectangular DRA of length *a*, width *b*, height *c* with the relative permittivity of ε_{rd} is placed on the ground plane with width *W*. A slot of length *l* and width *w* is etched at the center of the metal plane to excite the resonator at the dominant mode. DIL, as the transmission media, comprise a rectangular dielectric slab of relative permittivity ε_r placed under the ground plane. Dimensions of structure are summarized in Table1.

B. Array antenna

The geometry of the array structure is shown in Fig. 1-b. this structure is same the structure of single antenna. In array structure three rectangular DRA with same dimension is placed on the ground plane. Three slots with distance *s* excited resonators.

The most important feature of this structure is placing the feed network of the RDRA at the backside of the ground plane, isolating the radiating parts from spurious radiation provides by the DIL especially at high frequencies. The slot width is chosen smaller than the wavelength of guided wave by the DIL. For a strong coupling between DIL and the RDRA, the slot should be placed in a region of strong magnetic fields [4].

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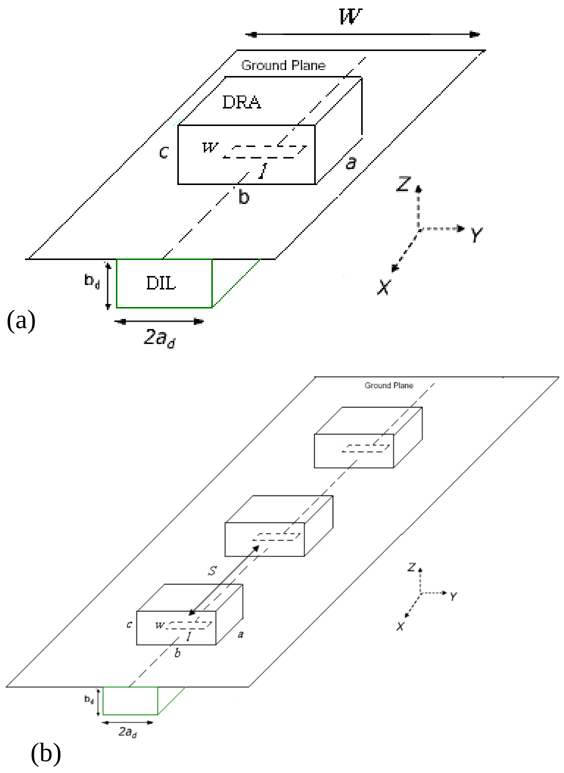


Fig. 1. The geometry of the DRA fed by DIL through a narrow slot a) single antenna, b) array antenna

Table 1. Antenna Dimensions

DRA		DIL	
a	6.2 mm	a_d	4.25 mm
b	6 mm	b_d	4.03 mm
c	6.1 mm	ε_r	10.2
ε_{rd}	10.2		

3. ANTEENA SIMULATION

The RDRA structure is numerically investigated using HFSS. Simulated technique in HFSS is based on the Finite Element Method (FEM) that calculate the full 3-D electromagnetic field inside and outside (far field) of the structures.

Fig. 2-a shows the detailed structure of the single antenna defined in simulations. A standard metal waveguide is used to excite the DIL, at the input and output of the transmission media. Three sections of waveguide using a proper tapering provide transition from TE_{10} mode of the metal rectangular waveguide to dominant mode of the DIL.

This structure has two ports that port one is defined as the input to excite the TE_{10} mode of metal waveguide. The second port at the output is terminated to a matched load so; a traveling wave is propagated in DIL which efficiently excites the RDRA at the resonance frequency. The slot on the ground plane upon which the RDRA is located determines the amount of power coupled from the DIL to the resonator. The slot operates as a magnetic current in parallel to the resonator length exciting the RDRA at the principal TE_{111} mode of the operation [].

Fig. 2-b shows the detailed structure of the array antenna. A linear E-plane array with 3- elements RDRA on the ground plane placed in x-direction. 3-slots located at the centering of any RDRA that will ensure strong coupling to the internal magnetic fields of DRA []. The distance between of slots is about 0.5 λ and has been optimized for good results.

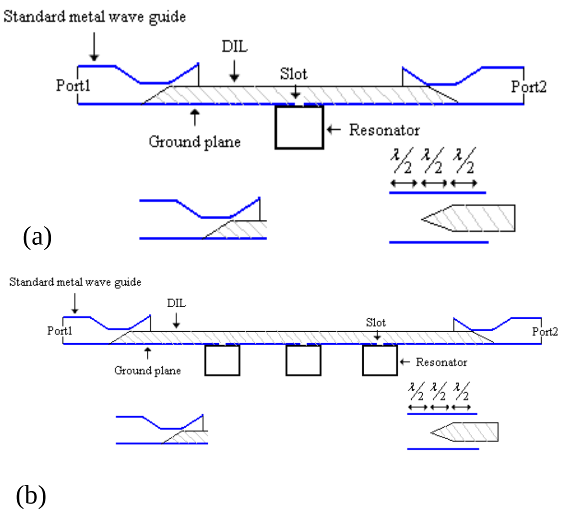


Fig. 2. Detailed feed structure of RDRA in simulation: a) single antenna, b) array antenna

4. RESULTS AND DISCUSSION

There are two design parameters in the single antenna structure under consideration. The length of slot is not well defined requires studying. Also the width of ground plane is influenced on radiation characteristics of antenna structure. This parameter optimized to achieve maximum coupling, minimum return loss and good radiation pattern.

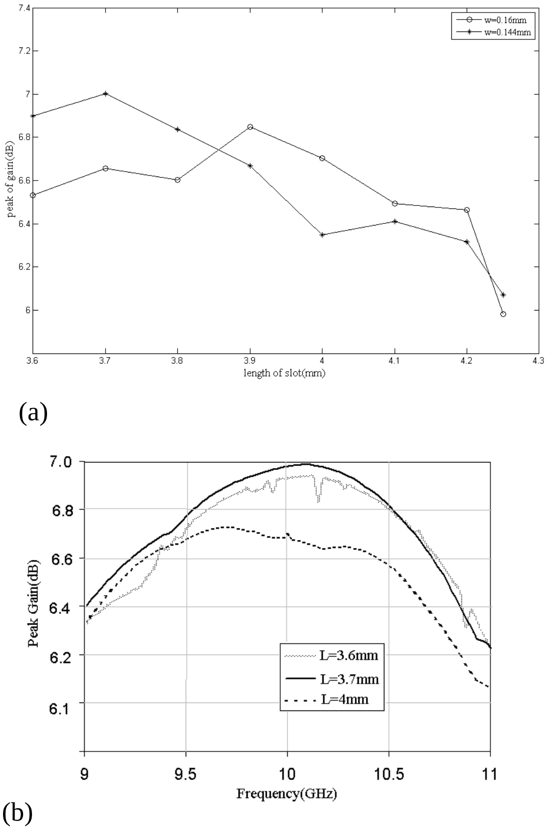
A. Effect of slot length

The length of slot is varied for two different width of slot. The slot size can play important role in controlling the amount of power coupled through the slot. In this section slot is on an infinite ground plane excited the RDRA. Fig. 3-a shows the effect of the slot on the antenna gain. Fig. 3-b shows the antenna gain versus frequency for different slot length and constant slot width of w = 0.144 mm. From both figures can be seen that maximum gain of 7 dB is obtained for the optimum slot length and width of *l* = 3.7 mm and *w* = 0.144 mm respectively. Return loss of optimum slot size is shown in Fig. 4. From this figure can be seen the optimum slot has good return loss.

B. Effect of width of ground plane

For considering the effect of width of ground plane, it has varied from 10 mm to 140 mm for 17 different widths. Fig. 5 shows the effect of the width of ground plane on the antenna gain. From this figure can be seen for W = 100 mm the maximum gain is obtained. The antenna gain versus frequency for W = 60, 100 and 140 mm is shown in Fig. 6. It can seen the width of ground plane has effect on the gain of antenna. From this figure optimum width of ground plane is nearly 100 mm.

return loss and radiation pattern for optimum ground plane and slot size are shown in Fig. 7-a and Fig. 7-b respectively. This structure provides broad side radiation pattern perpendicular to the ground plane and good return loss with peak gain of 7.7 dB at 10 GHz.



(a)

(b)

Fig. 3. a) Peak gain of RDRA versus slot length for two values of width, b) RDRA gain versus frequency for different slot length and constant width of *W*=0.144mm

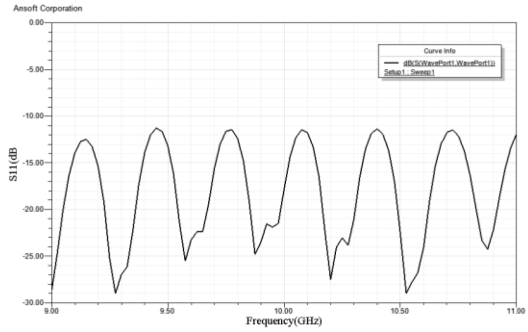


Fig. 4. return loss for optimum slot

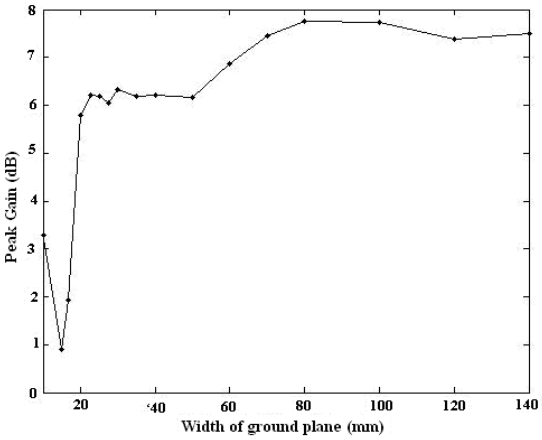


Fig. 5. Peak gain of RDRA versus width of ground plane

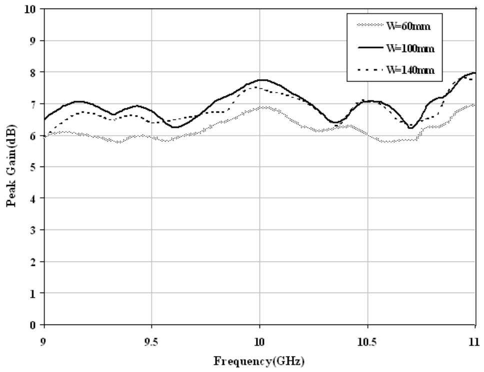
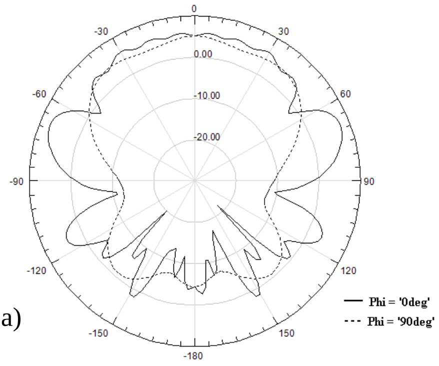
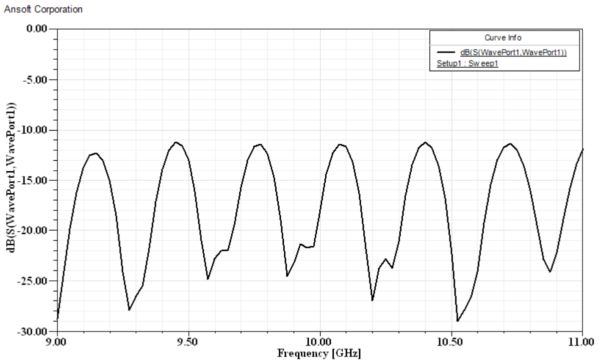


Fig. 6. RDRA gain versus frequency for different width of ground plane



(a)



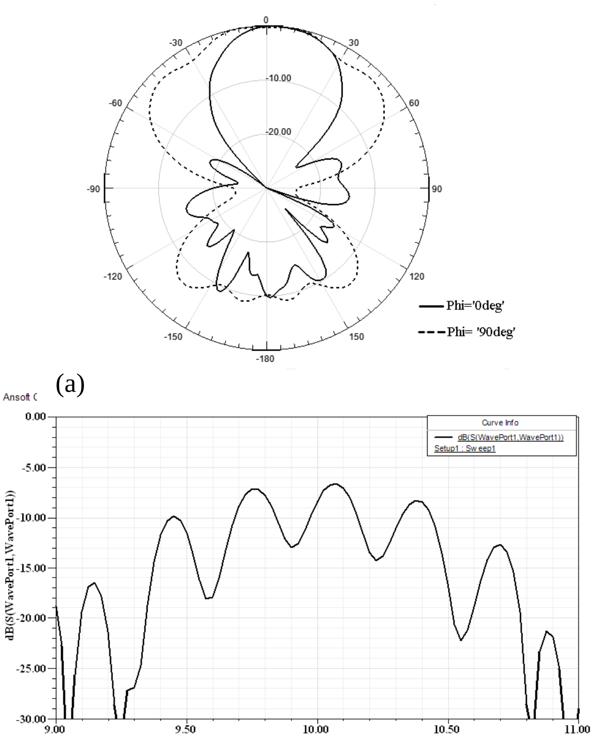
(b)

Fig. 7. a) Radiation pattern b) Return loss at optimum slot size and width of ground plane

C. Results of array

In the array structure three DRA elements are used with same dimension. The slots size and the distance between elements are optimized for the best return loss, radiation pattern and wide impedance bandwidth. The slot length and width are 3.5 mm, 0.144 mm respectively, while the distance between elements is 12.9 mm.

Radiation pattern is shown in Fig. 8-a has low side lobe level (SLL) and E-plane patterns is more directive in broadside. Fig. 8-b shows return loss of array antenna structure. It is more compare with return loss of single antenna. Fig. 9 shows the gain of array antenna versus frequency which is wideband. Maximum gain is 10.2 dB dB at 10.1 GHz which is 44.68 % higher than the gain of the single element.



(a)

(b)

Fig. 8. a) Radiation pattern b) Return loss of array structure

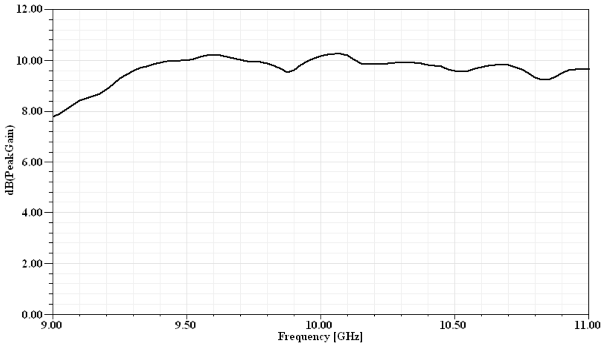


Fig. 9. peak gain versus frequency for array structure

5. CONCLUSION

6. REFERENCES