ANALYSIS OF PROBE-FED RECTANGULAR DIELECTRIC RESONATOR ANTENNAS ON A FINITE GROUND PLANE USING METHOD OF MOMENT

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Abstract- *The rigorous moment method analysis of probe-fed rectangular dielectric resonator antenna on a finite ground plane and finite substrate is presented. The antenna and the ground plane are modeled as a linear and surface electric current , but the dielectric and the substrate are assumed as a volume polarization current The dielectric resonator (DR) is treated via a set of combined field integral equations. The associated coupling is then formulated with sets of mixed potential integral equations (MPIE).The coupled integral equations are solved by the method of moments (MoM) in the spatial domain using Galerkin's procedure. The input impedance, E-plane and H-plane patterns obtained from the MoM have a good agreement with measurements and simulated results published in the past.*

I. INTRODUCTION

Dielectric resonators (DRs) are widely used in shielded microwave circuit such as filters and oscillators. In recent years the dielectric resonator antenna (DRA) has become the subject of many researches. This antenna offers advantages such as compact size, high radiation efficiency and wide bands simple feed structure over conventional types of antennas. Also they are very compatible with MMIC fabrication. Literature survey shows that dielectric resonators have been studied in hemispherical, cylindrical, cylindrical ring and rectangular geometry. By comparing the other geometries it can be found that RDRs have a few advantages in fabrication process, and electrically they have some independent aspect ratios, which could be chosen to provide the required radiation characteristics. [1-8].Input impedance and resonance frequency of an aperture coupled and probe-fed rectangular dielectric resonator antenna has been computed using method of moment [9-11]. In this paper, the dielectric and finite substrate are modeled using volume polarization current. The probe and ground respectively are modeled using linear current and surface current. These are formulated as a set of coupled equations in the spatial domain using the mixed potential integral equation (MPIE) formulation. The MoM in its Galerkin form is then applied to the resulting operator equation to obtain the unknown currents. The resulting current is then used to calculate secondary parameters such as input impedance and pattern of antenna.

II. FORMULATIONS AND INTEGRAL EQUATIONS

Fig. 4 shows the structure of fed-probe RDRA on finite ground plane and finite substrate also, an air gap exists between dielectric resonator and ground plane. For modeling impressed field the current on the probe is divided into two parts: 1-the excitation current $\vec{J}_f$, 2-the induced current $\vec{J}_i$. These linear currents flow only in z direction at the center of the probe .The polarization current in the dielectric and substrate, respectively are $\vec{J}_d$ and $\vec{J}_s$. Finally; the surface current on the finite ground plane is $\vec{J}_p$. Now by these assumptions we can say that the total electric field at any point is:

$$\vec{E}_{total} = \vec{E}_i(\vec{J}_f) + \vec{E}_s(\vec{J}_i) + \vec{E}_s(\vec{J}_p) + \vec{E}_s(\vec{J}_d) + \vec{E}_s(\vec{J}_s) \quad (1)$$

$\vec{E}_i$: Impressed field

$\vec{Es}$: Scattered field

By enforcing the boundary conditions on antenna and finite ground plane the following equations must be satisfied on them:

$$\hat{z}\bullet[\vec{E}_i(\vec{J}_f) + \vec{E}_s(\vec{J}_i) + \vec{E}_s(\vec{J}_p) + \vec{E}_s(\vec{J}_d) + \vec{E}_s(\vec{J}_s)] = 0$$

(2) On the body probe

$$\hat{z}\times[\vec{E}_i(\vec{J}_f) + \vec{E}_s(\vec{J}_i) + \vec{E}_s(\vec{J}_p) + \vec{E}_s(\vec{J}_d) + \vec{E}_s(\vec{J}_s)] = 0$$

(3) On the surface of finite ground plane

Because of the polarization currents exist in the volume of DR and substrate, the integral equation in each volume is:

$$[\vec{E}_i(\vec{J}_f) + \vec{E}_s(\vec{J}_i) + \vec{E}_s(\vec{J}_p) + \vec{E}_s(\vec{J}_d) + \vec{E}_s(\vec{J}_s)] = j\omega(\varepsilon_d - \varepsilon_0)\vec{J}_d$$

(4) In $V_{\text{dielectric}}$

$$[\vec{E}_i(\vec{J}_f) + \vec{E}_s(\vec{J}_i) + \vec{E}_s(\vec{J}_p) + \vec{E}_s(\vec{J}_d) + \vec{E}_s(\vec{J}_s)] = j\omega(\varepsilon_s - \varepsilon_0)\vec{J}_s$$

(5) In $V_{\text{substrate}}$

The coupled equations 2-5 can be written in an integral form by expressing the fields in terms of vector potential A and scalar potential Φ:

$$\begin{aligned}\vec{E}_s &= -j\omega\vec{A}_s - \vec{\nabla}\phi_s \\ \vec{A}_s &= \int J(r')G_A^s(r|r')ds' \\ \Phi_s &= \int \rho^s(r')G_\phi^s(r|r')ds'\end{aligned} \tag{6}$$

The Green function is the corresponding Green function in free space.

Galerkin's MoM procedure is used to solve the coupled eqn.2-5.Because of complexity in the structure the basis function for expanding the currents are chosen pulse function.

After calculating the unknown currents for all of the structure, the input voltage between probe and the shield of coaxial cable with the distance of R_B has been found according to the total of electric field in that region. After that, the input impedance will be obtained by dividing this voltage to the magnitude of current.

III. NUMERICAL RESULTS

To verify the validity of the model, the computed input impedance is compared with measurement and simulation results [10]. The parameters of the DRA analyzed are listed in the Table 1. These parameters are as the same as parameters in [10]. A good agreement between experimental and computed results will be found in Fig1. Finally, the investigation of the air gap effects on input impedance in Fig2-3 is done. We should note that the exact experimental investigation of the air gap is very hard because the wavelength is very small.

IV. CONCLUSION

A MoM technique has been developed to analyze a probe-fed rectangular dielectric resonator antenna on a finite ground plane. By increasing the air gap, the real part of input impedance will be decreased, but the imaginary part of input impedance will be increased.

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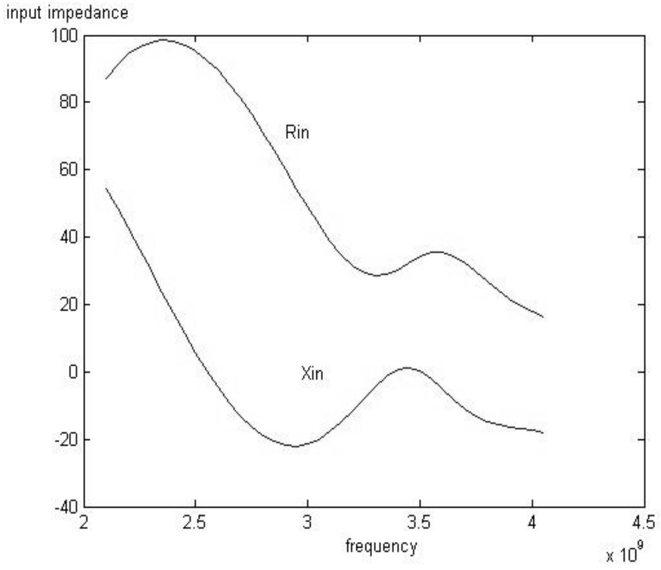

Fig.1 input impedance versus frequency

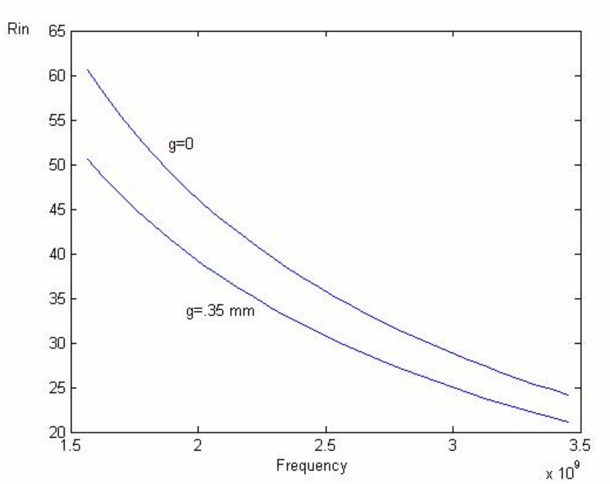

Fig.2.Real part of input impedance versus frequency for
g=0
g=.35mm

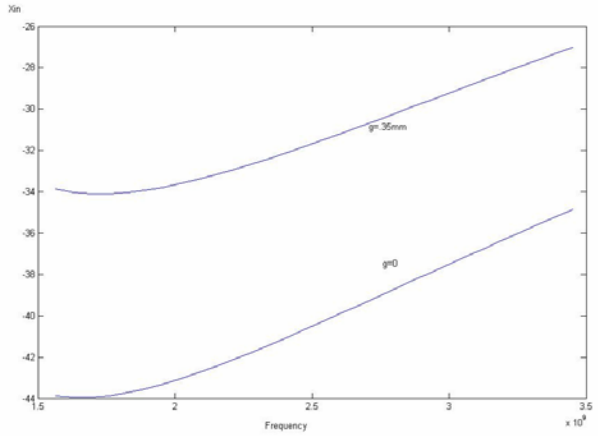

Fig.3.imaginary part of input impedance versus frequency for
g=0
g=.35mm

L	Rb	s	h	a	b
9.5	2	1.5	9.5	19	19

X_{PEC}	Y_{PEC}	X_{sub}	Ysub	Z_{sub}	g
80	80	6	100	100	-

Table1. The parameters of antenna structure

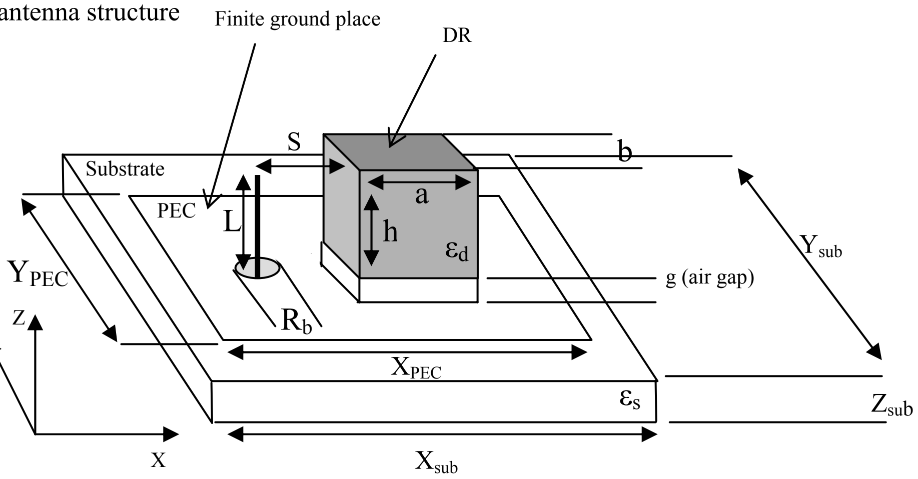

Fig.4 rectangular dielectric resonator antenna structure with ε_d=38