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Design and Analysis of High Efficient Coplanar Waveguide Fed Dielectric Resonator Antenna

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ABSTRACT

In this paper a high efficient coplanar waveguide fed rectangular dielectric resonator antenna (RDRA) have designed and analysed through 3D Electromagnetic Simulation Software HFSS. Solution frequency for analysing DRA taken as 1.96 GHz,maximum number of passes as 20,maximum delta S as 0.02 and sweep type as Fast. DRA made with Arlon AR1000(tm) with permittivity of 10 and patches are mounted on a FR_4 epoxy substrate with permittivity (εr) of 4.4. The capacitive feed DRA resonating maximum at a frequency of 3.4GHz , produces return loss of -36.7338 dB and 93.58% efficiency.

KEYWORDS: .Rectangular Dielectric Resonator Antenna(RDRA), HFSS(High Frequency Structure Simulator), Capacitive feeding,Arlon AR1000(tm), FR_4 epoxy.

INTRODUCTION

In 1939, R.D. Richmyer showed that non metalized dielectric objects can function similarly to metallic cavities which he called dielectric resonators (DRs).However practical application did not take place until 1960's when suitable dielectric compounds become available. The dielectric resonator has traditionally been used in filter and oscillator applications because its Q-factor can be made very high [1].The resonant frequency of antenna can be determined by changing shape and size of patch and permittivity of material. Generally, a denser substrate with moderate dielectric constants will result in higher antenna performance in terms of efficiency and wider bandwidth, but result in large antenna sizes [2].To over come the 4G technology and the development of 5G technologies aimed at increasing data rate.wireless communication network by a factor of 100 will impose stinging specifications like very large bandwidth, high gain, small size, and temperature independent performance on the design of the radio frequency (RF) electronics[3]. In olden days, these antennas are mainly ascertain by making use of ceramic materials characterized by high permittivity and high Q factor (between 20 and 2000). At present, DRAs made from plastic material are being ascertained.

(¡) The size of the DRA is proportional to with being the free-space wavelength at the resonant frequency and where it determined the relative permittivity of the material forming the radiating structure. As compared to conventional metallic antennas whose size is proportional to , DRAs are characterized by a smaller form factor especially when a material with high dielectric constant (ε_r) is selected for the design.

(ii) DRAs can be excited using different techniques which is helpful in different applications and for array integration.

(iii) The gain, bandwidth, and polarization characteristics of a DRA can be easily controlled using different design techniques[4-5].

The rectangular-shaped DRAs over come the cylindrical shaped DRAs and hemispherical ones they are easier to fabricate and have more design flexibility [6].The relationship between a DRA and the planar transmission line is easily managed by the various position of the DRA with reference to the line. The dielectric resonator antenna has dimensions and dielectric constant they are chosen properly for designing purpose.Due to we can avoid ground losses, better parametric results by the DRAs over the Microstrip patch antennas to increase the antenna bandwidth[7-9].

The resonant frequency of a rectangular DRA (length* Width* height) is given by

$$F_r = \frac{c}{(2\sqrt{\varepsilon_r})[(^p/_L)^2+(^q/_W)^2+(^r/_H)^2]^{1/2}}$$

Or

$$F_r = \frac{c}{2\pi\sqrt{\varepsilon_r}}\sqrt{k_x^2 + k_y^2 + k_z^2}$$

Where c is the velocity of light, εr=dielectric constant of DRA material, p,q,r are integers which represent the half-wave periodicity of electric field along the length(L), Width(W) and height(H).

$$K_x = \frac{\pi}{a},$$

$$K_z = \frac{\pi}{2b},$$

$$K_{Y0} = \sqrt{K_x^2 + K_z^2}.$$

Value of Ky can be determined by using the formula.

$$d = \frac{2}{K_Y}\tanh(\frac{K_{Y0}}{K_Y})$$

II. Antenna Design Methodology

The proposed antenna design consists of a rectangular shaped resonator and a center-fed Capacitive slot which is etched on an FR_4 substrate with dielectric constant 4.4. The rectangular-shaped resonator is placed above the substrate etched with the ground plane from the slot to the lower edge of the DR. The resonator material used is Arlon AR1000 (tm) has a dielectric constant of 10.

The figure 1 shows the design of capacitive feed dielectric resonator antenna.

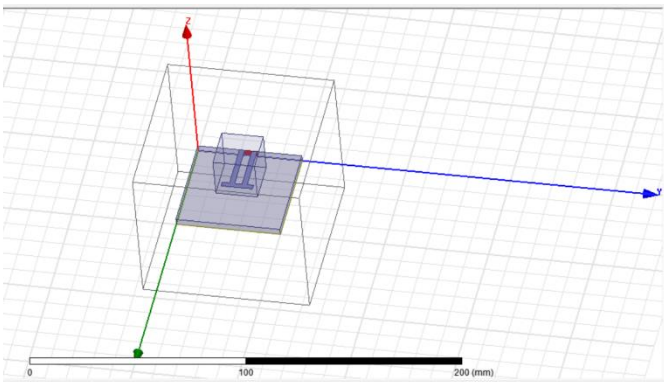

Fig.1.Design of capacitive fed RDRA

Table 1 shows the dimensions of RDRA

Ground plane length	50mm
Ground plane width	50mm
Substrate Length	50mm
Substrate width	50mm
Substrate Thickness	3.2mm
Resonator Length	20 mm
Resonator Width	20 mm
Resonator Height	20 mm

Table 1.Dimensions of RDRA

Return Loss: An antenna's return loss is a figure that indicates the proportion of radio waves arriving at the antenna input that are rejected as a ratio against those that are accepted. It is specified in decibels (dB) relative to a short circuit.

VSWR: VSWR stands for Voltage Standing Wave Ratio, and is also referred to as Standing Wave Ratio. VSWR is a function of the reflection coefficient(Γ), which describes the power reflected from the antenna.The VSWR is defined by the following formula:

$$VSWR = \frac{1+|\Gamma|}{1-|\Gamma|}$$

III. SIMULATION RESULTS

The proposed capacitive feed dielectric resonator antenna is designed and simulated in HFSS. The designed antenna is analyzed in terms of gain, return loss, VSWR, and radiation pattern.

A. Return loss plot:

Figure 2 shows return loss [S11] of the proposed capacitive feed DRA in dB. The plot gives the return loss at the feed position where the resonator antenna input was applied. The capacitive feed RDRA design produce -36.7338 dB return loss.

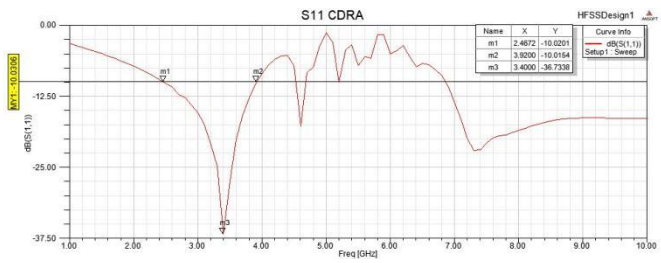

Fig.2. Return loss plot of capacitive fed RDRA

B. VSWR Plot:

Fig.3 Shows the VSWR plot of capacitive feed DRA in dB.VSWR value of less than 2dB proves that impedance is perfectly matched and such design gives better performance compared to a higher value of VSWR. The capacitive feed RDRA design shows a VSWR of 0.2624.

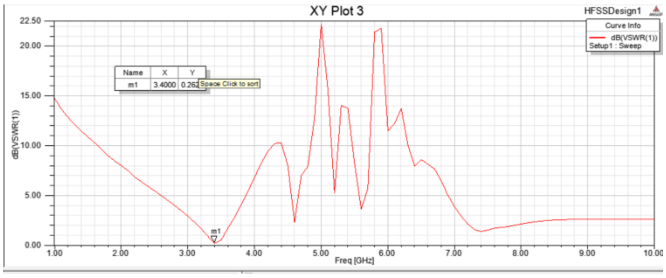

Fig.3. VSWR plot of capacitive fed RDRA

C. Radiation pattern:

Fig.4 shows the 3D polar of capacitive fed RDRA

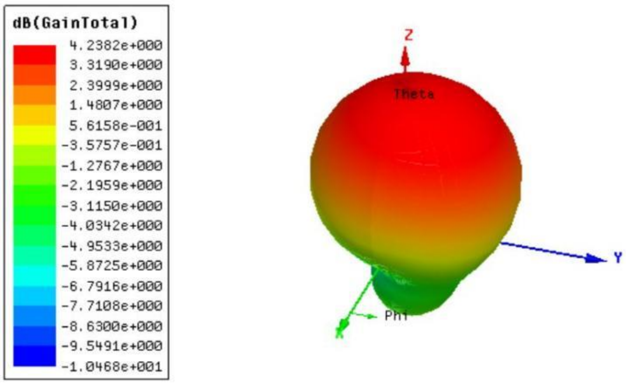

Fig.4. 3D polar plot of capacitive fed RDRA

Table.2 shows the parameters of the capacitive fed rdra

PARAMETERS	CAPACITIVE-FED RDRA
Resonant frequency(GHz)	3.4
Max U (W/sr)	0.14935
Peak Directivity	2.8354
Peak gain	2.6535
Peak Realized Gain	1.8768
Radiated Power(W)	0.66191
Accepted Power(W)	0.70729
Incident Power(W)	1
Radiation Efficiency	0.93584
%Bandwidth	45.49

Table.2 Parameters of the capacitive fed RDRA

IV. Conclusion

The capacitive fed rectangular dielectric resonator antenna (RDRA) is designed using High Frequency Structure simulator software. The capacitive fed DRA is radiating at 3.4 GHz frequency. It has been found that the capacitive fed dielectric resonator antenna shows a return loss of -36.7338dB and efficiency of 93.58%.

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