



Dielectric Resonator Antenna for X band Microwave Application

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ABSTRACT: A simple Dielectric Resonator Antenna (DRA) for X band frequency operation is proposed in this paper. X band is a microwave band lies between frequency range 8 to 12 GHz. In proposed DRA reflector plane is used beneath the microstrip feed line with a small air gap, introduced between feed substrate and reflector plane to reduce the back lobe. Slot coupling is used to excite this DRA. Proposed DRA design gives dual band operation in X band and resonates at frequency 8.6 GHz and 10.3 GHz. Antenna design offers minimum return loss of -20.3 db and -24.5 db at 8.6 GHz and 10.3 GHz respectively. It also offers high front to back ratio (FBR) of 12.35db and 9.83 db at 8.65 GHz and 10.3 GHz respectively. Return loss impedance bandwidth of 390 MHz (4.5%) for Band I and 730MHz (7.3%) for band II is obtained. Simple DRA design with high FBR is proposed here for X band application that shows a total bandwidth of 11.8%. DRA is analysed using Ansoft HFSS based on finite element method. Radiation characteristics of this DRA are observed at resonating frequencies. This DRA is useful at microwave X band application such as satellite communication.

Keywords: DRA, X band, microwave application, front to back ratio

I. INTRODUCTION

In recent years, researchers have got much attention on investigation of DRA due to its attractive features as light weight, small size, low loss and temperature stability. Dielectric resonators have received great interest in recent years for their potential applications in microwave and millimetre wave communication systems. They have been widely used as a tuning component in shielded microwave circuits such as filters, oscillators, and cavity resonators. With an appropriate feed arrangement, they can also be used as antennas, and they offer efficient radiation [1]. Also micro strip antenna at higher microwave band applications such as satellite communication and radar application usually offers high metallic losses. So, the DRA can be a good alternative for these requirements as it overcomes the problem of high losses due to minimum surface wave losses. DRA generally made up of temperature stable dielectric materials of high dielectric constants (10-100) for microwave applications. Resonant frequency of DRA can be easily varied by suitably choosing the dielectric constant of the resonator material and its dimensions [4]. DRAs of different shapes such as disc, hemispherical, rectangular, and ring have been presented in the literature [3],[4],[8],[9]. The rectangular dielectric resonators are preferred because they are easy to fabricate and offer more degree of freedom to control the resonant frequency and quality factor. Many investigations have been conducted to enhance bandwidth and gain of DRA [7],[8],[10],[13] but front to back ratio (FBR) of DRA has not been presented so far. Micro strip fed DRA act as a magnetic dipole and suffers with problem of back lobe. So in this paper reflector plane is used to improve the FBR. This paper presents a simple dielectric resonator antenna that operates at X band and useful in satellite communication. The proposed antenna is simulated using FEM based HFSS simulator and the various performance characteristics are observed and discussed.

The return loss band width of DRA can be calculated as

$$\% BW = \frac{f_H - f_L}{f_c} * 100 \quad \dots\dots\dots (1)$$

f_H - high cut off frequency

f_L - low cut off frequency

f_c - centre frequency



II. ANTENNA GEOMETRY

DRA design has a substrate of dimension 4.5 cm x 4.5 cm x 0.16 cm. FR4 epoxy having dielectric constant 4.4 is used here. DRA is chosen of rectangular shape with dimension 1cm x 2 cm x 0.5 cm. Dielectric material(sapphire) with high dielectric constant of 10 is used. High dielectric constant material improves coupling and reduces the size but also lowers Bandwidth. The DRA size (length, width & height) of the DRA has been chosen such that (L> W > h).The design parameters for the design is summarized in the table I shown below and geometry of the DRA is shown in figure 1. Foam is used to introduce air gap. The dimension of the DRA is approximated by relation given below [18].

$$hdra = \frac{\lambda_0}{4\sqrt{\epsilon_{dra}}} \dots\dots(2)$$

TABLE I

DESIGN PARAMETERS OF PROPOSED DRA

DRA design parameters	Dimensions
Substrate (FR4 Epoxy)	Lsub=5cm, Wsub=4.5cm, hsub=0.16cm
Ground Plane	Lg=5cm, Wg=4.5cm
Slot	ls=0.31, Ws=0.062,
DRA	Ldra=1 cm, Wdra=2 cm, hdra=0.5 cm
Stub length	Lstub=0.5 cm
Feedline	Lf=2.9cm, Wf=.06cm
Relector plane	Lr =5cm, Wr =4.5cm
Airgap(Foam)	0.05cm

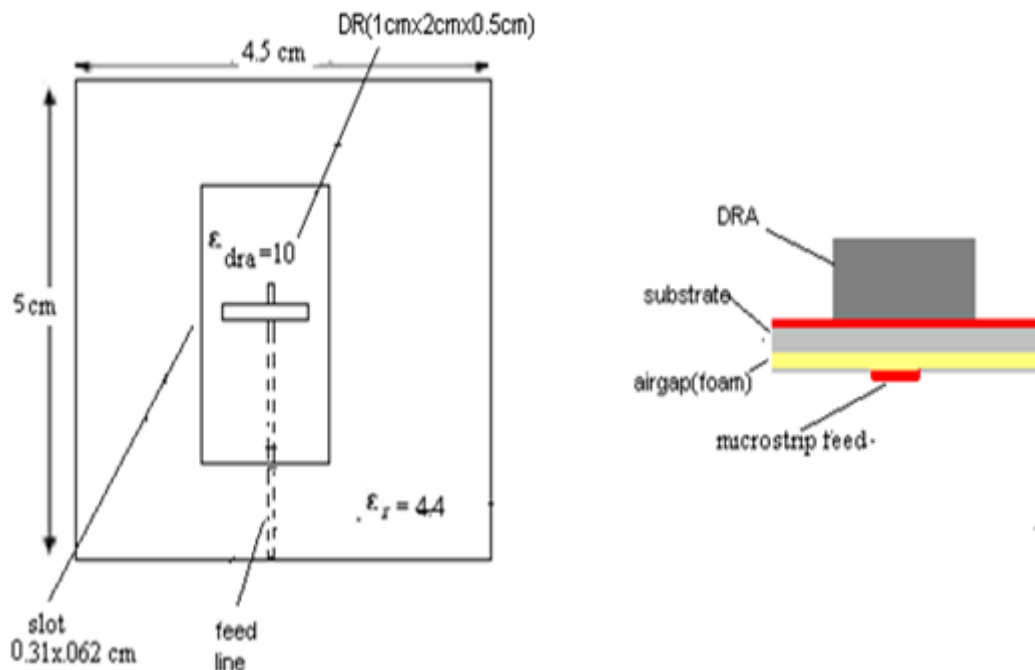


Fig. 1 Rectangular DRA (i) Front view (ii) Side view

III. RESULTS AND DISCUSSION

To analyse the antenna performance, HFSS simulation tool based on FEM is used. The simulated results as return loss, VSWR, radiation pattern, gain plot are shown in this section. Figure 2 gives the return loss plot of the proposed DRA. It is clear from the figure that DRA is operating in X band with resonant frequencies 8.6 GHz and 10.3 GHz. The bandwidth obtained is 390MHz (8.81- 8.42GHz) and 730MHz (10.61- 9.88GHz).Minimum return loss of -20.3 db and



-24.5 db is observed at 8.6 GHz and 10.3 GHz respectively. The VSWR versus frequency plot is also shown in figure 3 showing good agreement in specified bandwidth.

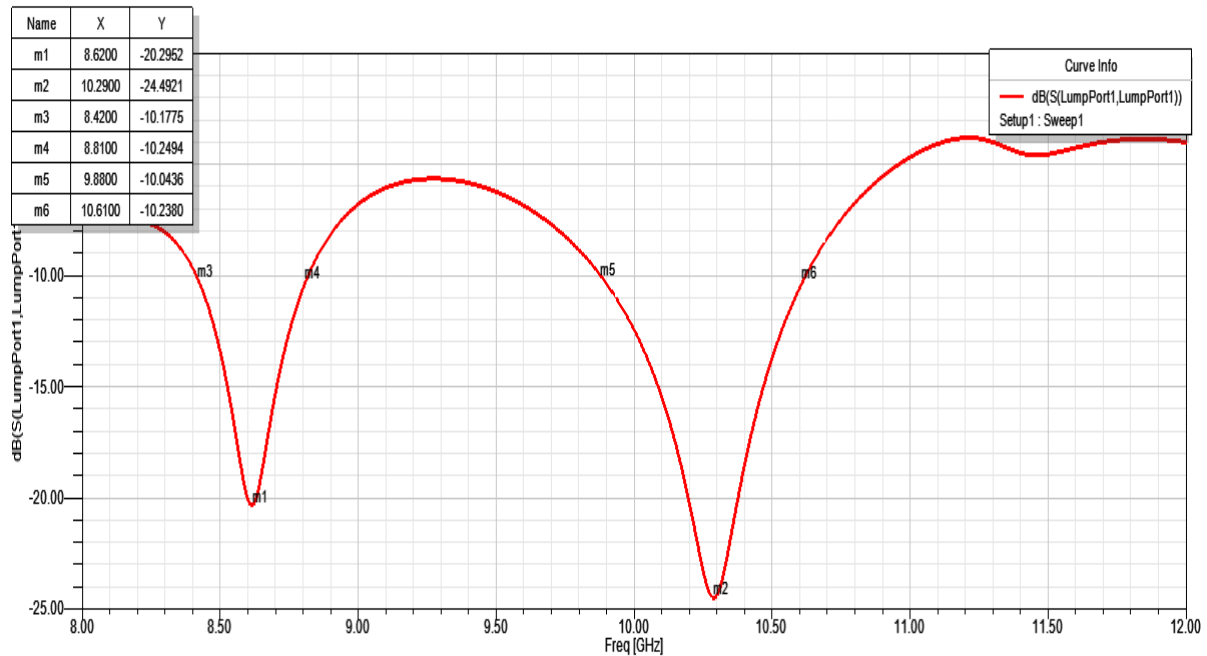


Fig. 2 Return loss Vs frequency plot

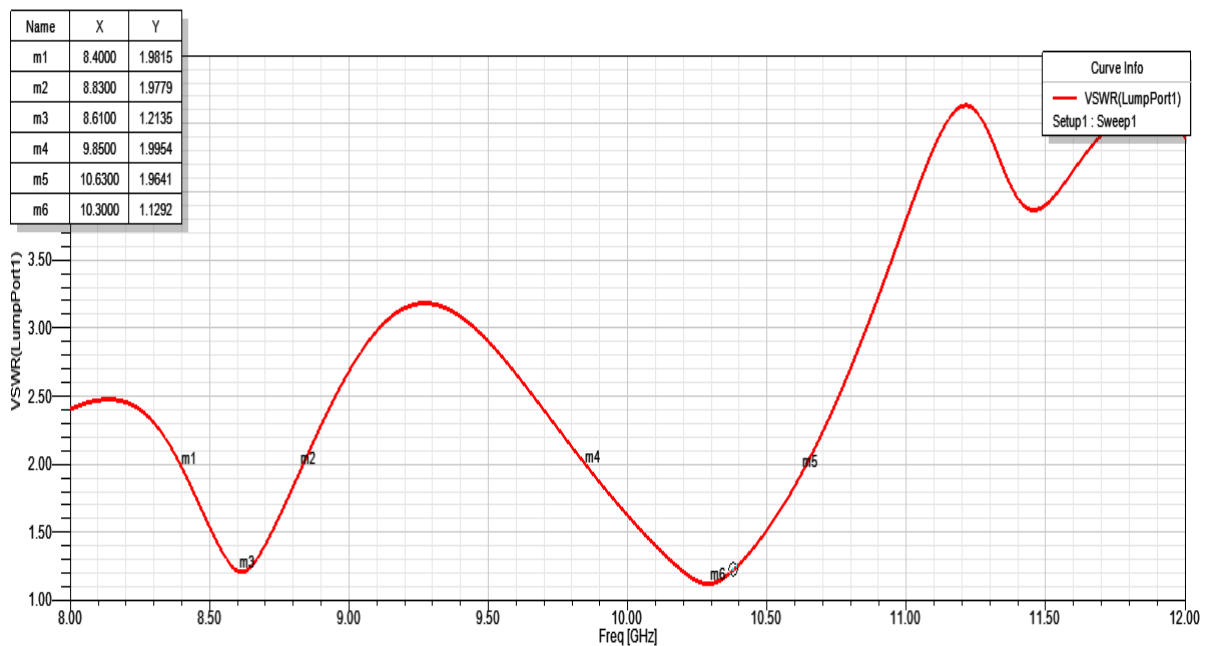


Fig. 3 VSWR Vs frequency plot

The radiation patterns of the proposed DRA at resonant frequencies 8.6 GHz and 10.3 GHz are shown below in fig. 4 & 5 respectively. It is radiating mostly in broadside direction. It is clear from fig. 4 and 5 that the back lobe is minimized due to the reflector plane and improved FBR of 12.35db and 9.83db is observed at 8.6 GHz and 10.3 GHz respectively. This DRA shows reasonably good radiation for $\Phi=0^\circ$ but radiation pattern is slightly broadened for $\Phi=90^\circ$. The 3 D plot of DRA is shown in fig. 6 showing overall radiation characteristic at 8.6 GHz. Simulated gain plot with respect to frequency for the DRA is also observed and given in figure 7. Maximum gain of 3.9 db and 4.1 db is observed for $\Phi=0$ degree and $\Phi = 90$ degree respectively.

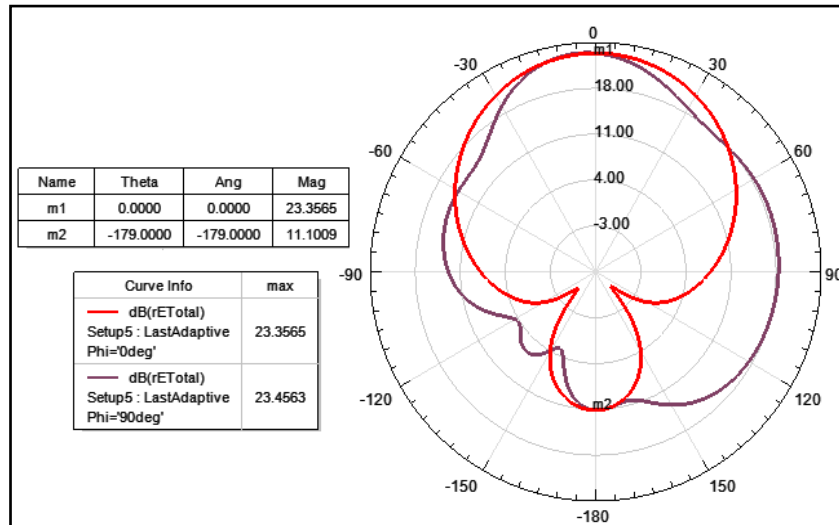


Fig. 4 Simulated radiation pattern of the proposed antenna at 8.6 GHz

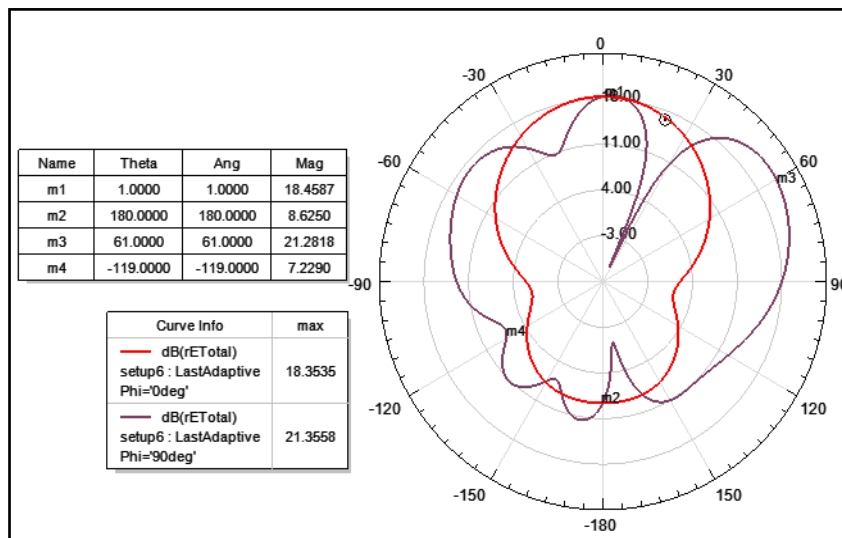


Fig. 5 Simulated radiation pattern of the proposed antenna at 10.3 GHz

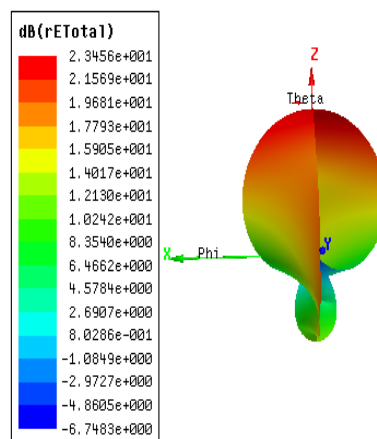


Fig. 6: Radiation Pattern (3 D) plot at 8.6 GHz

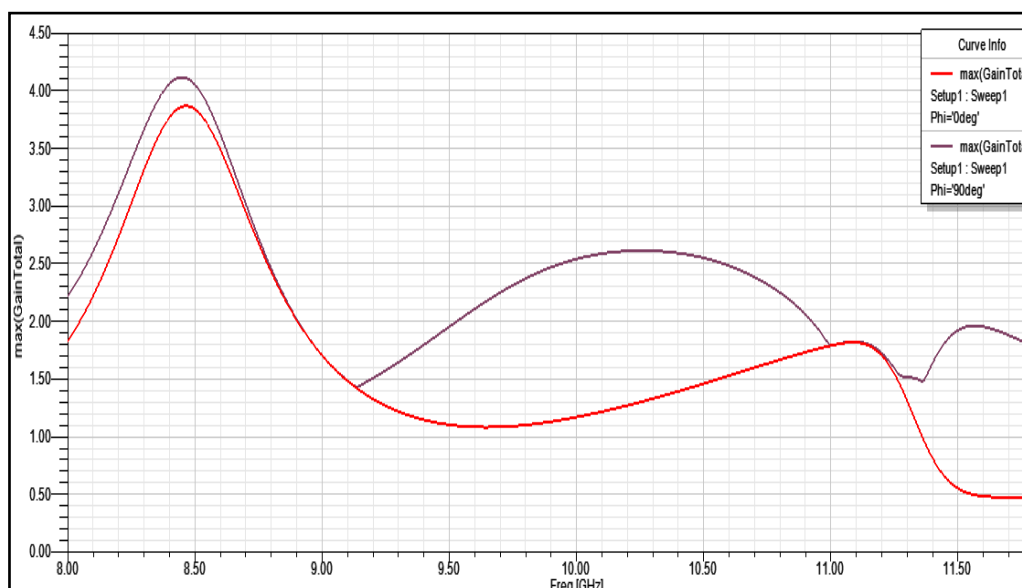


Fig. 7 Gain Vs Frequency plot of proposed DRA (Max Gain for $\Phi=0^\circ$ is 3.9db & $\Phi=90^\circ$ is 4.1db)

TABLE II
 PERFORMANCE SUMMARY OF PROPOSED DRA

DRA with Reflector Plane	Freq band (f_L - f_H) (GHz)	Resonant Freq(GHz)	Min Return Loss(db)	BW(MHz)	%BW	FBR (db)
Band I	8.42-8.81	8.6	-20.3	390	4.6	12.35
Band II	9.88-10.61	10.3	-24.5	730	7.2	9.83

IV. CONCLUSION

A simple dielectric resonator antenna for X band operation has been proposed in this paper. The reflector plane with a small air gap, below the microstrip feed line has improved the performance of the DRA. The proposed DRA can be used for microwave applications typically used at X band where use of microstrip antenna offers the problem of high metallic losses. The main features of the proposed DRA are its small size and high microwave frequency operation. This DRA can be useful in satellite communication as it offers total BW of 11.8 %, high front to back ratio and good gain.

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BIOGRAPHY



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