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Application of a Dielectric Resonator Antenna to the X-Band Microwave Frequency

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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 usedbeneath the microstrip feedlinewith asmall air gap, introduced between feedsubstrate and reflector planeto reducethe back lobe. Slot coupling is used to excite this DRA. Proposed DRA design gives dual band operation in X band andresonatesatfrequency8.6GHzand10.3GHz.Antennadesignoffersminimumreturnlossof-20.3dband-24.5dbat
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 GHzand 10.3 GHz respectively. Return loss impedance bandwidth of 390 MHz (4.5%) for Band I and 730MHz (7.3%) forband II is obtained. Simple DRA design with high FBR is proposed here for X band application that shows a totalbandwidth of 11.8%. DRA is analysed using Ansoft HFSS based on finite element method. Radiation characteristics ofthis DRA are observed at resonating frequencies. This DRA is useful at microwave X band application such as satellitecommunication.

Keywords:DRA,Xband, microwaveapplication, frontto back ratio

INTRODUCTION

In recent years, researchers have got much attention on investigation of DRA due to its attractive features as lightweight, small size, low loss and temperature stability. Dielectric resonators have received great interest in recent yearsfor their potential applications in microwave andmillimetrewave communication systems. They have been widelyused as a tuning component in shielded microwave circuits such as filters, oscillators, and cavity resonators. With anappropriate feed arrangement, they can also be used as antennas, and they offer efficient radiation [1]. Also micro stripantenna at higher microwave band applications such assatellite communication and radar application usually offershigh metallic losses. So, the DRA can be a good alternative for these requirements as it overcomes the problem of highlosses due to minimum surface wave losses. DRA generally made up of temperature stable dielectric materials of highdielectric constants (10-100) for microwave applications. Resonant frequency of DRA can be easily varied by suitablychoosing 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 dielectricresonators are preferred because they are easy to fabricate and offer more degree of freedom to control the resonantfrequency and quality factor. Many investigations have been conducted to enhance bandwidth and gain of

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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 amagneticdipoleandsufferswithproblemofbacklobe.Soi nthispaperreflectorplaneisusedtoimprovetheFBR.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 areobserved anddiscussed.

ANTENNAGEOMETRY

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 usedhere. DRA is chosen of rectangular shape with dimension 1cm x 2 cm x 0.5 cm. Dielectric material(sapphire) with highdielectric constant of 10 is used. High dielectric constant material improves coupling and reduces the size but alsolowers Bandwidth. The DRA size (length, width & height) of the DRA has been chosen such that (L> W > h).Thedesignparametersforthedesign issummarized inthetableI shownbelowand geometryoftheDRAisshown infigure 1.Foamisused to introduceairgap.ThedimensionoftheDRAisapproximate d byrelationgivenbelow[18].

$$hdra = \frac{\lambda 0}{4\sqrt{\varepsilon dra}} \quad \text{……..(2)}$$

TABLEI

DESIGNPARAMETERSOFPROPOSEDDRA

DRAdesign parameters	Dimensions
Substrate(FR4Epoxy)	Lsub=5cm,Wsub=4.5cm,hsub=0.16cm
GroundPlane	Lg=5cm,Wg=4.5cm
Slot	ls=0.31,Ws=0.062,
DRA	Ldra=1cm,Wdra=2cm,hdra=0.5 cm
Stub length	Lstub=0.5 cm
Feedline	Lf=2.9cm,Wf=.06cm
Relectorplane	Lr=5cm,Wr =4.5cm
Airgap(Foam)	0.05cm

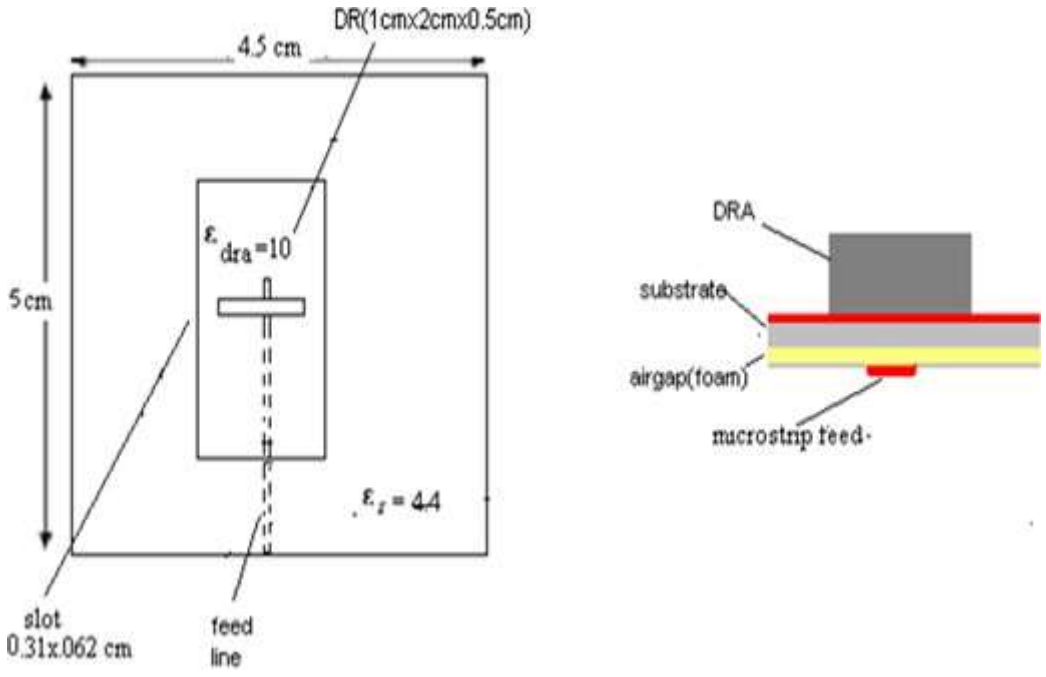

Fig.1 RectangularDRA(i)Frontview(ii))Sideview

RESULTSANDDISCUSSION

To analyse the antenna performance, HFSS simulation tool based on FEM is used. The simulated results as returnloss, VSWR, radiation pattern, gain plot are shown in this section. Figure 2 gives the return loss plot of the proposedDRA. It is clear from the figure that DRA is operating in X band with resonant frequencies 8.6 GHz and 10.3 GHz. Thebandwidthobtainedis390MHz(8.81-8.42GHz)and730MHz(10.61-9.88GHz).Minimumreturnlossof-20.3dband

-24.5 dbisobservedat 8.6GHzand10.3GHzrespectively. TheVSWRversusfrequencyplot isalsoshowninfigure3showing goodagreementinspecified bandwidth.

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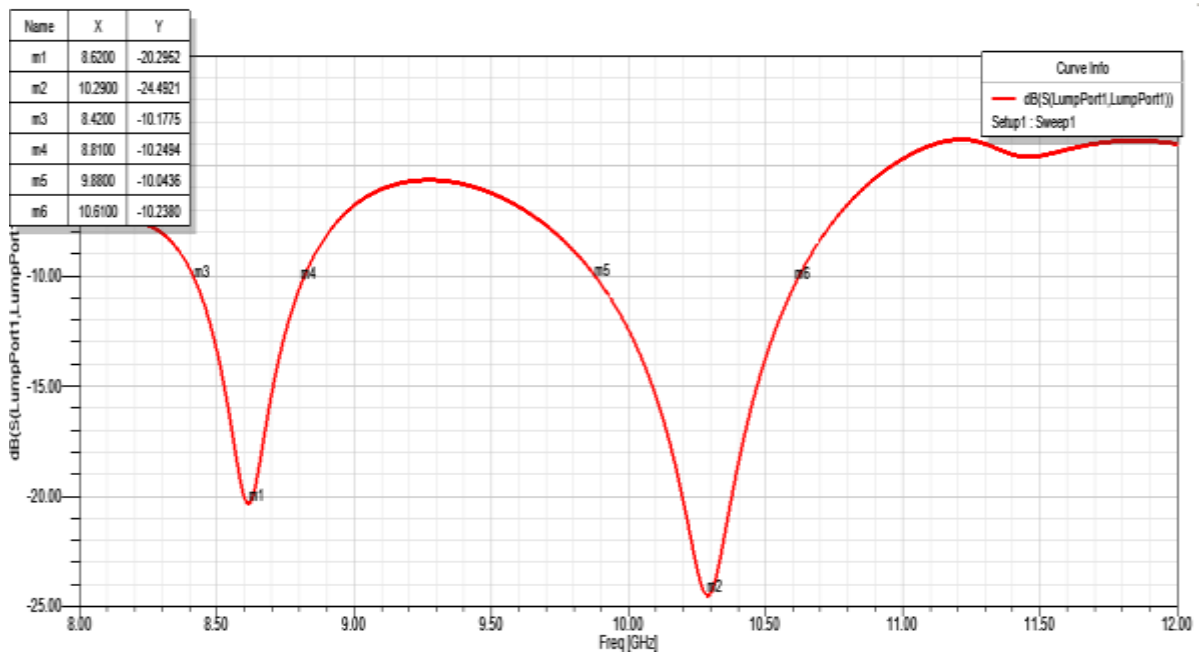

Fig.2ReturnlossVsfrequencyplot

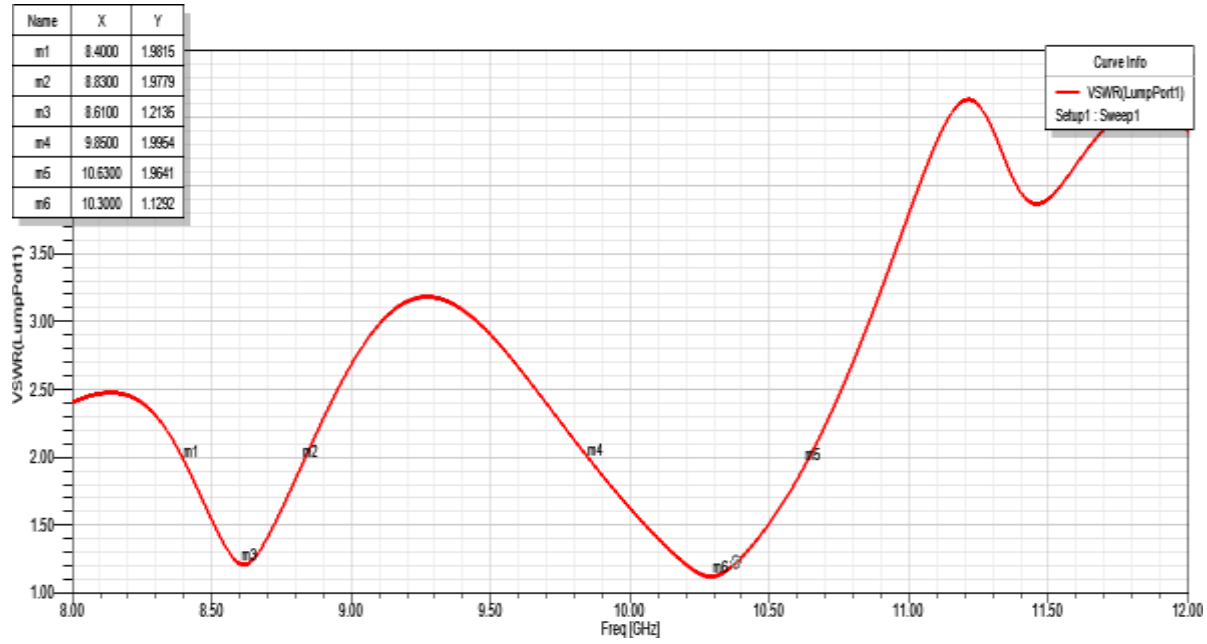

Fig.3 VSWRVsfrequencyplot

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 minimizeddue 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 $\Phi=0^{o}$ but radiation pattern is slightly broadened for $\Phi=90^{o}$.The 3 Dplot of DRA is shown in fig. 6 showing overall radiation characteristic at 8.6 GHz. Simulated gain plot with respect tofrequency for the DRA is also observed and given in figure7. Maximum gain of 3.9 db and 4.1db is observed for Φ=0degreeandΦ = 90degreerespectively.

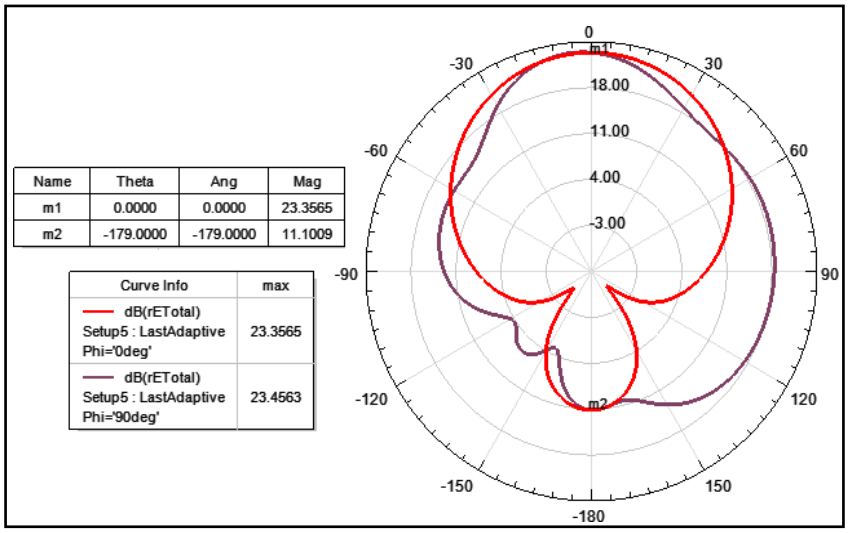

Fig.4Simulatedradiationpatternofthepropose dantennaat8.6GHz

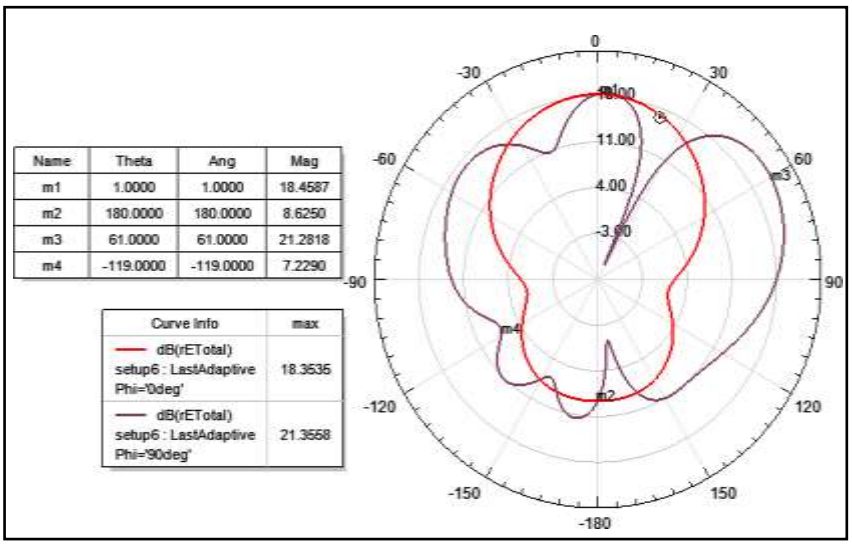

Fig.5Simulatedradiationpatternofthepropose dantennaat10.3GHz

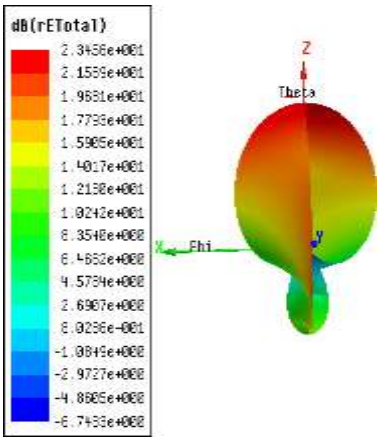

Fig.6:RadiationPattern(3D)plotat8.6GHz

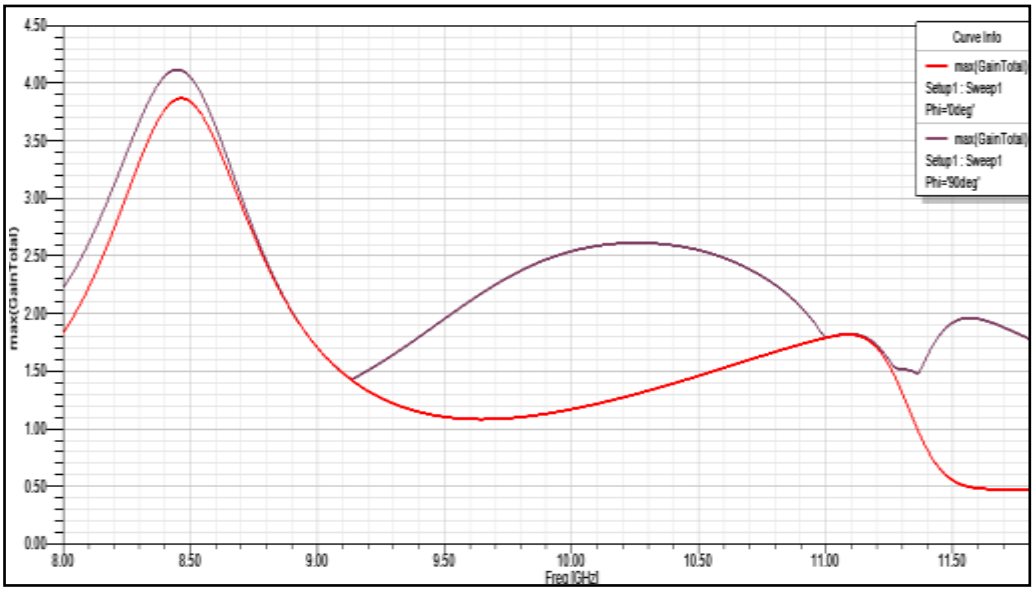

Fig.7GainVsFrequencyplotofproposed DRA(MaxGainfor$\Phi=0^0$is3.9db&$\Phi=90^0$is4.1db)

TABLE II
PERFORMANCESUMMARYOFPROPOSEDDRA

DRA withReflectorPlane	**Freqband (f_L-f_H)(GHz)**	**Resonant Freq(GHz)**	**Min ReturnLoss (db)**	**BW(MHz)**	**%BW**	**FBR (db)**
BandI	8.42-8.81	8.6	-20.3	390	4.6	12.35
BandII	9.88-10.61	10.3	-24.5	730	7.2	9.83

CONCLUSION

A simple dielectric resonator antenna for X band operation has been proposed in this paper. The reflector plane witha small air gap, below the microstrip feed line has improved the performance of the DRA. The proposed DRA can beused for microwave applications typically used at X band where use of microstrip antenna offers the problem of highmetalliclosses.ThemainfeaturesoftheproposedDRAareitssmallsizeandhighmicrowavefrequencyoperation.This DRA can be useful in satellite communication as it offers total BW of 11.8 %, high front to back ratio and goodgain.

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