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FREQUENCY RECONFIGURABLE ANTENNA FOR KU-BAND APPLICATIONS

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ABSTRACT

In this study, a unique design in frequency reconfigurable antenna approach is proposed .The shown design in this paper can be used for Ku band downlink especially in satellites. A special employment includes a rectangular slot with four PIN diodes where the frequency reconfigurability is obtained. Four PIN diodes are used in the defected ground Structure where these diodes help in achieving reconfigurability easily. The antenna is designed and fabricated on FR4 substrate of dielectric constant 4.4 and thickness 1.6 mm. Simulation results of the proposed antenna are also shown in the study. Antenna design and simulation is done by using HFSS software.

Keywords: cedar shaped, PIN diode, reconfigurable antenna, defected ground structure.

1. INTRODUCTION

Antennas working at different frequencies & polarization are usually installed for better reception quality at different positions in wireless platforms, such as Mobile phones, satellite base stations or Radar stations. For various applications such as navigation, Communications, surveillance etc [1], Wireless systems requires more than one antenna. The uses of multiple antennas are undesirable because of increase in system size and material cost. The best solutions for this are to have one antenna that can be reconfigured to operate at different frequencies and provide several functions. This multifunction antenna configuration is called as reconfigurable antenna. An antenna can be easily reconfigured by either incorporating active devices or by having multiple ports [2-5].

Reconfigurability of an antenna can be achieved by changing its characteristics like frequency and radiation properties. Due to the introduction of wireless communications concept such as cognitive radio which employs reconfigurable narrow band communication and wideband sensing, frequency reconfigurability attracts different attention [6-10]. Frequency reconfigurability is generally accomplished by fusing switches over slots, for example switches and PIN diodes. The switches utilize de-biased signals to change the current way and to abbreviate the electrical length of the antenna. Designing a reconfigurability approach that consolidates electronic switches has delivered more efficient antennas with size reduction.

This paper explains about a cedar-shaped micro strip antenna [11] with a rectangular slot in the ground plane with four PIN diodes [12-14] placed at different positions is designed and presented. The main advantage of the proposed antenna is that it can resonate at multiple frequencies. A single antenna can be used to radiate these frequencies rather than employing many antennas. The rest of the paper covers the antenna design, analysis of PIN diodes, simulation results and conclusion.

2. ANTENNA DESIGN

This antenna is fabricated using Fr4 substrate with permittivity 4.4 and of dimensions Ls*Ws, with thickness 1.6mm. Antenna includes a defected ground structure in the back plane with size Lg X Ws. DGS [Defected Ground Substrate] [4] includes a rectangular slot with 4 diodes s1, s2, s3, s4 [3]. Complete antenna structure is shown in Figure-1 & Figure-2.

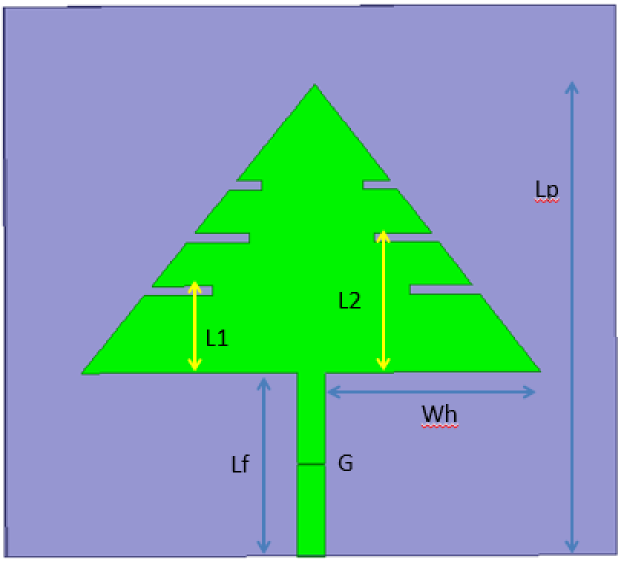

Figure-1. Front view of cedar shaped antenna.

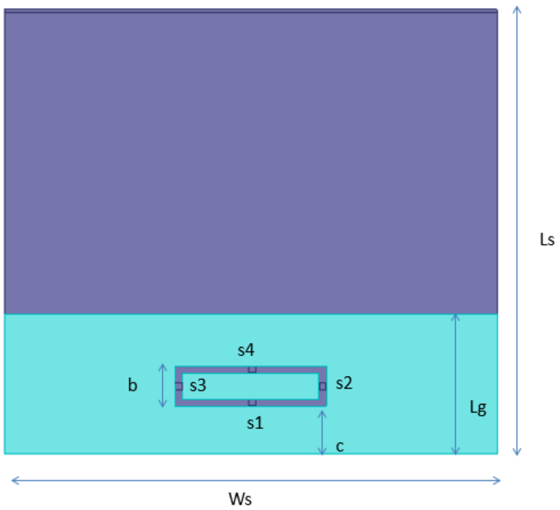

Figure-2. Rear view of cedar shaped antenna.

Antenna structure is developed by special cuttings which are known as TRIMS .These Trims are created on the patch with the defined measurements and the patch can be turned to a cedar shaped antenna by placing rectangular slots over a equilateral triangle where the complete magnitudes are shown in the Table-1. A tiny gap of size 0.2 mm is positioned in the feed line which acts as a capacitor. Dimensions are framed in Table-1.

Table-1. Dimensions of the antenna.

S. No	Label	Dimensions(in mm)
1	Lp	51.46
2	Lf	20
3	Wh	23
4	G	0.2
5	L1	8.46
6	L1	14.2
7	Ls	65
8	Ws	60
9	Lg	19
10	b	5.5

The feeding technique used in this design is microstrip feed line [5]. The feed line dimensions are L_f X 3 mm. The diodes used in this antenna design i.e., S1, S2, S3, S4 are PIN diodes, ON & OFF states of the PIN diode is obtained by biasing the diode properly. Talk about this diode mainly focuses on its division as it fits under RF resistor controlled by current. PIN diode is in ON state which provides low impedance in forward bias and in reverse bias it exhibits high impedance and diode is in OFF state. The equivalent circuits of the PIN diodes in ON/OFF stage are shown below i.e., Figure-3.

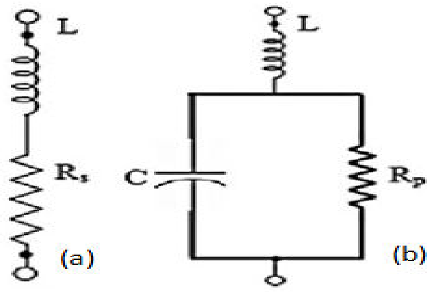

Figure-3. PIN diode equivalent circuit (a) ON state (b) OFF state.

Design & simulation of the proposed antenna is carried out by using HFSS software. The PIN diode used in this simulation is BAR50-02V. The variables in the equivalent circuit of this diode in ON and OFF states are Rs=3 Ω and C =0,04pF. This application of this diode can be mainly seen in mobile communications.

3. SIMULATED RESULTS AND DISCUSSIONS

Electrical properties such as return loss, VSWR and bandwidth are used to characterize the gratification of the proposed antenna. The mismatch in the transmission line is précised by return loss. The return loss is below -10dB for the proposed antenna. Antenna can operate at some range of frequencies and this range is the bandwidth of the antenna. Transmission line is measured using VSWR. VSWR of the proposed antenna is below 2dB.

By changing the states of PIN diodes, frequency reconfigurability of the proposed antenna can be achieved. The generalized states of different configurations of the PIN diodes used in this antenna with their bands are mentioned in Table-2. In this ON state is indicated with ‘1’ and OFF state is indicated with ‘0’.

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Table-2. Different combinations of diodes and their bands in each case.

Case	Diodes				Bands	Number of bands
	S1	S2	S3	S4		
1	0	0	0	0	6.8-7.08 9.16-9.52 10.8-11.66 14.6-14.88	4
2	0	1	1	0	7-7.29 14.06-14.67	2
3	1	0	0	0	7-7.3 10.08-12.31 13.14-14.204	3
4	1	1	1	0	7 - 7.3 9.16-10.68 11.0-12.13	3
5	1	1	1	1	7-7.59 10.14-11.56	2

We here have comparatively shown the return loss of 5 cases of antenna into two sets. Where CASE 1&5 belongs to set -1 and their return loss i.e. s_{11} is shown in the Figure-4.

Table-3. Configuration of diodes in set-1.

Set 1:

S. No	Diodes	STATE	
		Case 1	Case 5
1	S1	OFF	ON
2	S2	OFF	ON
3	S3	OFF	ON
4	S4	OFF	ON

Table-4. Configuration of diodes in set-2.

Set 2:

S. No	Diodes	STATES		
		Case 2	Case3	Case4
1	s1	OFF	ON	ON
2	s2	ON	OFF	ON
3	s3	ON	OFF	ON
4	s4	OFF	OFF	OFF

The second set includes the rest of the cases i.e. 2, 3 & 4 of proposed antennas. The conditions of these cases are in table 3. The return loss of these cases is in Figure-5.

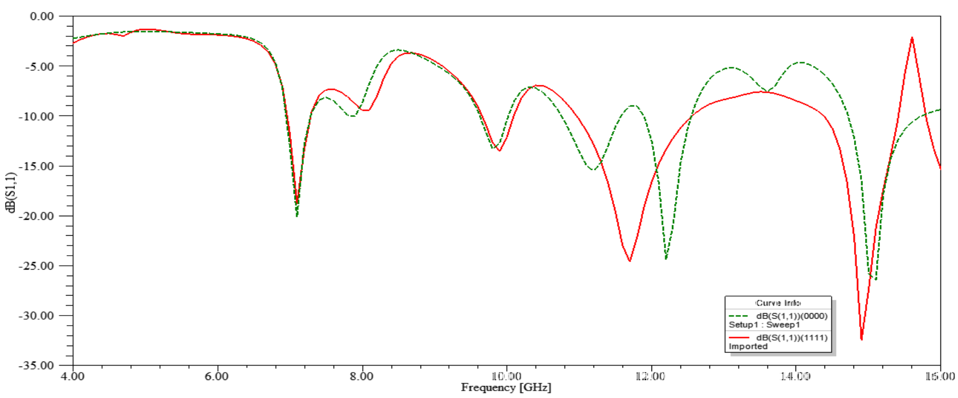

Figure-4. Return loss of the proposed antenna for the cases of set-1.

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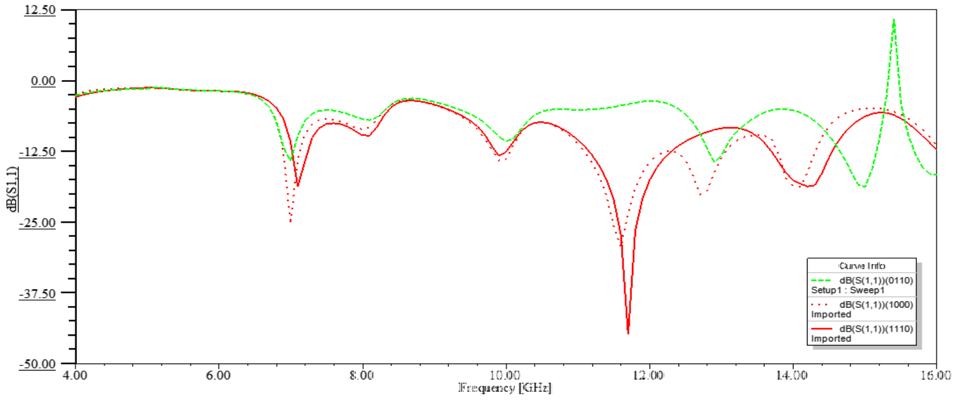

Figure-5. Return loss of the proposed antenna for the cases in set-2.

4. INDIVIDUAL GAINS OF THE ANTENNA FOR DIFFERENT CASES

Gain has major impact on antenna's efficiency and directivity. Simply Gain can be described as the capability of the antenna in converting the input power into the electromagnetic waves. Here the minimized five cases gains are shown below.

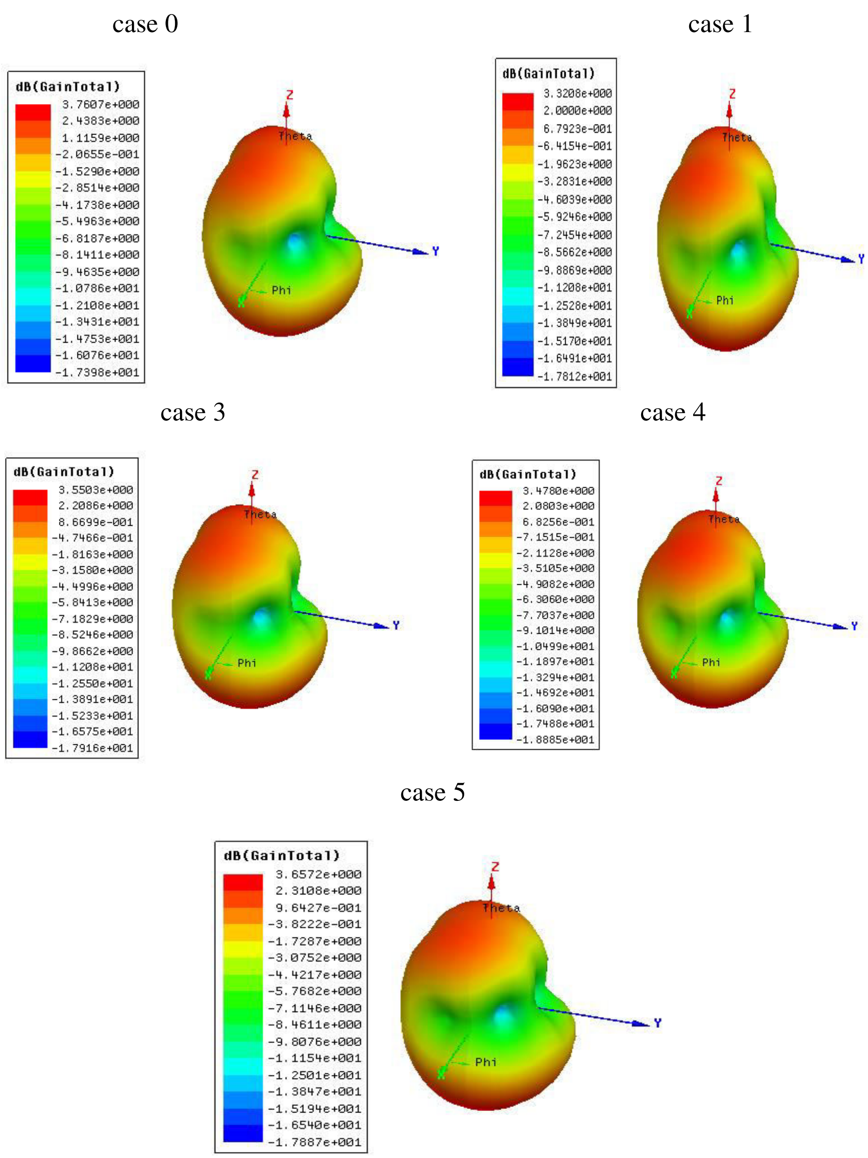

Figure-6. Antenna radiation pattern in 3D.

The distribution of gain over the area of operation of the antenna can be seen as a continuous path in gain vs frequency graph. Here we have just shown a single graph i.e., case 5

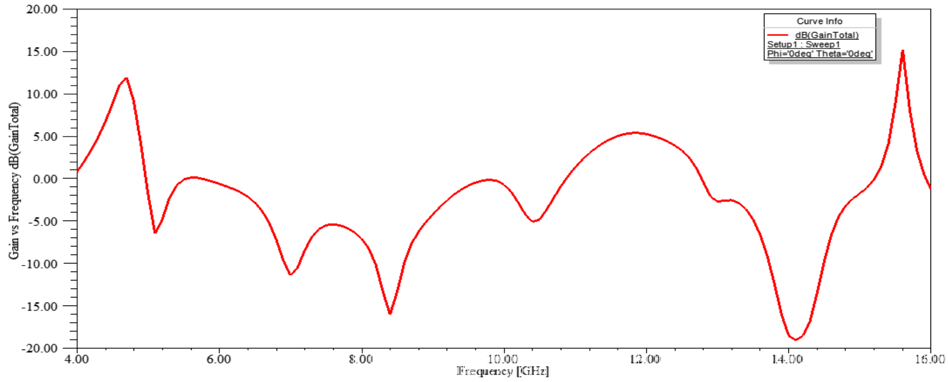

Figure-7. Gain vs frequency of (1111) case.

Three dimensional representation of the strength of the antenna is widely known as radiation pattern. These parameter variations with respect to 5 cases are shown in Figure-8.

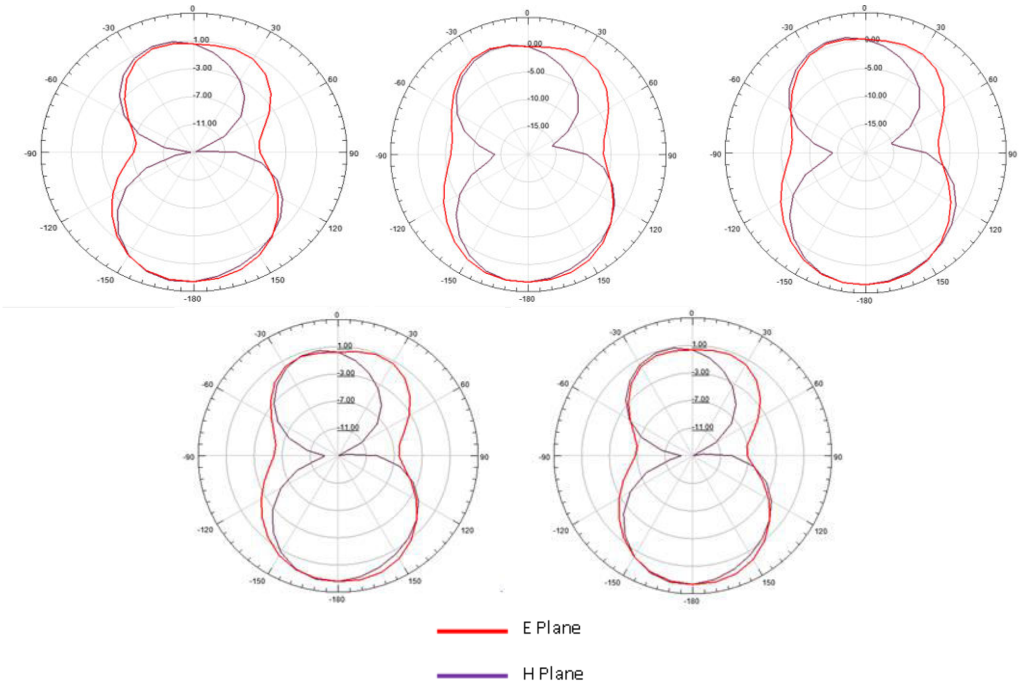

Figure-8. Antenna radiation pattern for diode conditions.

CONCLUSIONS

A First hand design is proposed in this paper which has wide range of applications in satellite communications especially in Ku band, military usage, radar applications ,X band radar frequency sub bands and can be used in many domestic services like weather checking, vehicle speed detection. The proposed designs have good number of bands which considerably ranges from 7 GHz to 15 GHz. Although we have a good range of frequencies, other nearer frequencies can be achieved by either modifying the number of trims or installing more number of diodes in the DFG. With the help of this advanced design reconfigurablilty can be easily achieved.

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