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DESIGN OF RECONFIGURABLE SLOT ANTENNA USING VARACTOR DIODE AT FREQUENCY 4.5GHZ

Kratika Aole
Department of EC
ITM Gwalior, M.P, India

Shivani Mittal
Department of EC
ITM Gwalior, M.P, India

Rachit Jain
Department of EC
ITM, Gwalior, M.P, India

***Abstract*— In this Research Paper, reconfigurable slot antenna for LTE (2.6GHz), AMT-fixed service (4.5GHz), and WLAN (5.4GHz) applications is displayed. There are two L-shaped slots and a U-shaped slot placed in the ground plane. The size of the antenna is short down as a result of these slots. There are three varactor diodes placed in these slots. This is done for the intention of frequency, directivity, and polarization reconfiguration. The directivities and polarization conditions of the antenna are changed at various frequencies i.e. at 2.6GHz, 5.4GHz, and at 4.5 GHz. These three various types of frequencies correspond to different states of the antenna. The states of the antenna are swapped by redirecting the varactor diodes on and off. The varactor diodes are used in this paper as they have the characteristic of fast frequency tuning.**

***Keywords*— Directivity, Polarization, Reconfigurable, Slot, Varactor Diodes**

I. INTRODUCTION

A reconfigurable antenna is a sort of antenna is able to modify its frequency and radiation characteristics actively, in a controlled and undo manner.
A way to provide a dynamic response, reconfigurable antennas combine an inside apparatus which includes Microwave switches, varactors, mechanical button and tunable substance, that authorize the planned reconstruct of the RF currents over the antenna surface and construct reversible moderation of its characteristics. Reconfigurable antennas vary from modish antennas because the reconstruction system lies interior of the antenna, slightly than in an exterior beam forming grid.
The reconfiguration ability of reconfigurable antennas is used to expand the antenna performance in a changing situation or to satisfy changing work demand.

Different types of Antenna Reconfiguration

Reconfigurable antennas broadly differ according to their antenna parameter that is variably varied, typically the frequency of performance, radiation sequence or polarization

Frequency reconfiguration

Frequency reconfigurable antennas can vary their frequency of operation variably. They are specifically used in situations in which different type of communication systems coincide because many antennas requirement can be changed by a single reconfigurable antenna. Frequency reconfiguration is basically gained via bodily or electrical moderation to the antenna variables using RF-switches, impedance loading or tunable substance.

Radiation sample reconfiguration

Radiation sample reconfigurability is built on the intentional moderation of the spherical dispensation of the radiation sample. Beam steering is the major extended approach and includes of steering the way of enhanced radiation to maximum the antenna gain in a joint way with mobile equipment. Pattern reconfigurable antennas are usually designed using rotatable structures or changeable and reactively-packed parasitic components. For the past ten years, meta material-ground reconfigurable antennas have achieved so much attention because of their mini form factor, broad beam steering range and wireless executions. Plasma antennas are also encountered as substitute with tunable directivities.

Polarization reconfiguration

Polarization reconfigurable antennas are able of shifting betwixt unlike polarization methods. The ability of switching in parallel, perpendicular and circular polarizations may be used to bring down polarization inconsistency losses in portable equipment. Polarization reconfigurability may be construct by making difference in the balance in the different ways of a multimode grid.

Compound reconfiguration

Compound reconfiguration is the ability of at a single time tuning various antenna frame work, for occurrence frequency and radiation design. The majorly known application of compound reconfiguration is the fusion of frequency sharpness and beam-scanning to come up with upgrade spectral regulation. Compound reconfigurability is attained by mixing in the similar construction unlike single-framework reconfiguration methods or by re-modelling dynamically a pixel plane.

Reconfiguration methods

There are various sorts of reconfiguration methods for antennas. Basically they are electrical component (for illustration using RF-MEMS, PIN diodes, or varactors), visual, somatic (mainly mechanical), and using matters. For the reconfiguration method using stuff, the substance may be rigid, fluid crystal), (dielectric fluid or fluid metal).

Varactor Diode

Varactor diodes or Varicap diodes are semiconductor models that are holistically used in the electronics field. They are also used inside the RF design field.

Varactor diode is a sort of diode whose inside capacitance changes with respect to the back-pedal voltage. It always chores in backward bias state and is a voltage-depending on semiconductor apparatus. Varactor diode is introduced by various names as Varicap, Voltcap, Voltage variable capacitance, or Tuning diode.

Mark of Varactor Diode

From the diagram given below, it is apparent that the icon of the varactor diode is identical to that of the PN-junction diode. The diode has two terminals: anode and cathode. One exit side of the symbol constitute of the diode, and the other exit has two parallel lines that act of the conductive plates of the capacitor. The distance between the plates convey their dielectric.

Functioning of Varactor Diode

The work of the varactor diode is to keep stock of charges, so it is always worked in reverse bias way. When a forward bias voltage is put in, the electric current go along, as a outcome, the depletion region becomes zero, which is non-acceptable .The junction capacitance of a p-n junction diode is conversely proportional to the width of the depletion layer need to enhance the capacitance of a varactor diode, the reverse bias voltage should be opposite down. It causes the width of the depletion layer to lower, giving outcome in higher capacitance. Similarly, enhancing the reverse bias voltage should lower the capacitance

Pin Diode

A PIN diode is a type of diode with a broad, un-doped intrinsic semiconductor region in the middle of a p-type semiconductor and an n-type semiconductor region. The p-type and n-type zones are basically highly doped because they are used for ohmic exposure .The broad intrinsic field is in difference to an local p–n diode. The broad intrinsic zone makes the PIN diode an inferior rectifier (one basic work of a diode), but it makes it prominent for attenuators, quick switches, photo-detectors, and high-voltage power electronics approach .The PIN photodiode was invented by Jun-Ichi Nishizawa and his co-mates in 1950. It is a semiconductor device .The PIN diode respects the standard diode equation for truncated-frequency signals. At large frequencies, the diode looks like an just about perfect (very straight forward, even for higher signals) resistor. The P-I-N diode has a fairly large stored charge adrift in a chunky intrinsic field. At a small-adequate frequency, the accumulated charge can be packed swept and the diode switch off. At large frequencies, there is not much time to clean the charge from the drift field, so the diode never switch off. The time needed to scrap the stored charge from a diode intersection is its backward re-take time, and it is basically long in a PIN diode. For a provided semiconductor substance, on-state impedance, and minimum usable RF frequency, the backward healing time is static.

Designing of Reconfigurable Antenna

The antenna is designed using CST Microwave Studio.The ground plane is comprises of length 27mm and width 25mm. Two L type slots and a U slot is placed on the ground plane. Three varactor diodes are included in the placed slot. The length, width, and height of the varactor diodes are taken 1mm, 1mm, and 0.4 mm respectively. Substrate RO4350B is used over the ground plane. The height of used substrate over the ground plane in the designing process is 0.8mm. The relative permittivity of substrate in this design is 3.48. Stepped feed line with dimensions
l_f = 7mm, W_f = 1.68mm, l_p = 9.6mm, W_p = 8mm is taken. Here l_f is length of feed, W_f is width of feed, l_p is length of patch and W_p the width of the patch.
d = 1mm, width of L slot, t_1= 7.5mm, vertical length of L slot, , t_2= 9.2mm, horizontal length of the L slot, t_3= 2mm and t_4= 12mm. are dimensions of U slot.

The optimized parameters given above is calculated from the following formula; -
Width of the patch

$$wp = \frac{c}{2fr}\sqrt{\frac{2}{\epsilon r + 1}} \qquad (1)$$

Where f_r = resonant frequency

Effective dielectric constant

$$\varepsilon_{r\,eff} = \frac{\varepsilon_{r+1}}{2} + \frac{\varepsilon_{r-1}}{2}\sqrt{\frac{1}{1+12\frac{h}{wp}}} \qquad (2)$$

Where h = height of the substrate and w_p = width of the patch.

Effective length of the substrate is given by

$$L_{eff} = \frac{c}{2\sqrt{\varepsilon_{reff}}}\left(\frac{1}{f_r}\right) \qquad (3)$$

Length extension ΔL is given by

$$\Delta L = .412h\left|\frac{(\varepsilon_{reff}+0.3)(0.264)}{(\varepsilon_{reff}-0.258)(\frac{w_p}{h}+0.8)}\right| \qquad (4)$$

Finally, length of the patch is given by

$$L = L_{eff} - 2\Delta L \qquad (5)$$

The design of antenna (side view) is shown in Fig. 1.RO4350B substrate is used in the middle of ground plane and feed line. In Fig. 2, there is a U-shaped slot with and two L-shaped slots placed in the ground plane (front view). Single varactor diode is inserted in each of these slots. The ground plane is made of perfect electrical conductor while the stepped feed line is made of copper material. The front view of antenna is used to show the slots inserted on the ground plane.Fig.3. shows the patch element drawn on the substrate. It is nothing but stepped feed line. Length & width of patch is shown in this figure. Length & width of the feed line is also shown in this figure.50ohm input impedance of the feed point is considered in the antenna design. Varactor diodes are indicated in the design as a lumped RLC component for both ON & OFF conditions. In the ON state of varactor diodes, R= 3.5ohm, L= 0.01nh, C= 0.45nf is taken [1]..

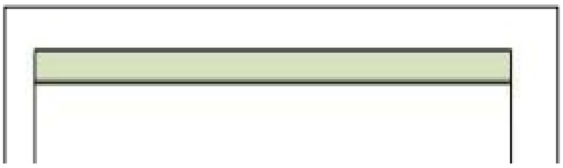

Fig 1 Side View Of Antenna

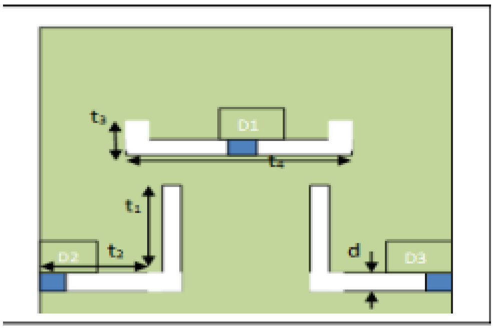

Fig 2 Front View of Antenna

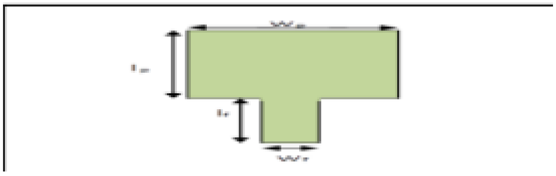

Fig 3 Patch Element on the Substrate

Table -1 Information of Varactor Diode Configuration

Antenna	D1	D2	D3
State 1	Off	Off	Off
State 2	On	Off	Off
State 3	On	On	On

In state1, the antenna operates at 4.5 GHz for AMT-fixed service application. In state 2, the antenna operates at .6GHz for LTE application. Finally, in state 3, the antenna operates at 5.4GHz for WLAN application.

II. RESULT

The Reconfigurable antenna is designed by using CST Microwave Studio. It is observed that the antenna operates at frequency varies within 2.6/4.5/5.4GHz according to the different condition of the antenna as shown in Table-1. Some corrections had been found in resonance frequencies by the use of varactor diodes as they have voltage hang on the capacitance. When the voltage is enlarged capacitance is shortened since capacitance of varactor diode is oppositely proportional to the voltage applied. When capacitance is slow down frequency is enhanced as capacitance of varactor diode is opposite proportional to the frequency. As a result, there is right side shift of resonance frequency. Fig.4 shows the return loss for state 1. Antenna resonates at frequency of 4.5 GHz

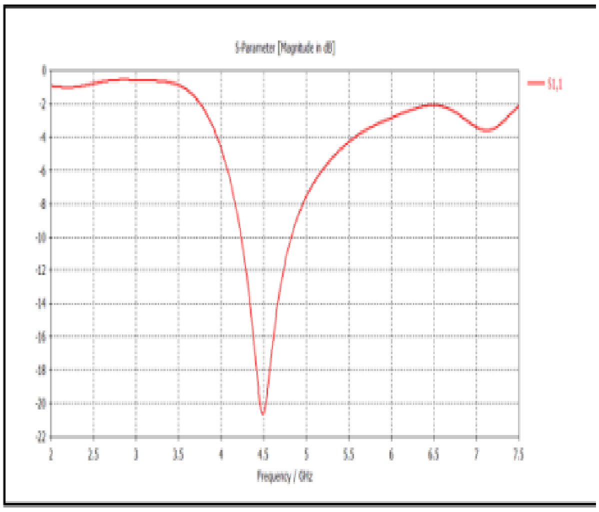

Fig 4 Return loss VS Frequency for State1

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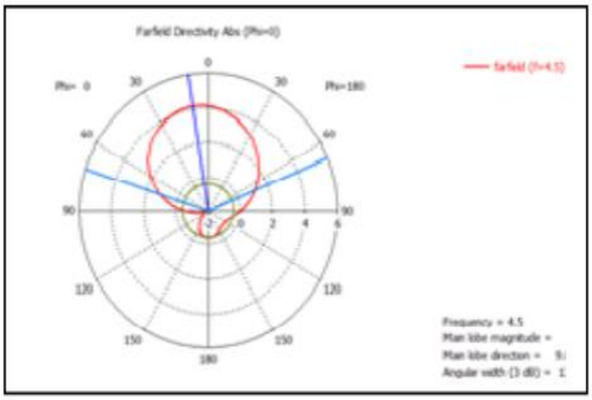

Fig 5 Right Elliptical Polarization for State 1

Fig.5 displays the right sided elliptical polarization for state 1 as phase difference for two different components of the wave is not identical to fundamental multiple of 90 degrees and it is in positive (clockwise) direction

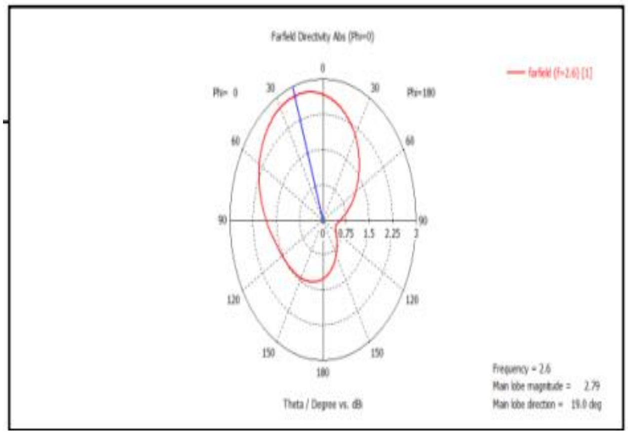

Fig.6 represents the antenna displays linear polarization as phase difference of two different components of wave is 0 degree.

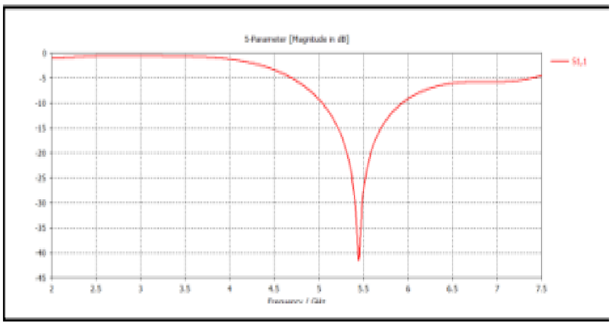

Fig 7 Return loss VS Frequency for state3

Fig.7 displays return loss for state 3 at 5.4 GHz. It is observed that the antenna shows left side elliptical polarization as the phase difference between two different components of wave is not identical to fundamental multiple of 90 degrees and it is in negative (anticlockwise) direction.

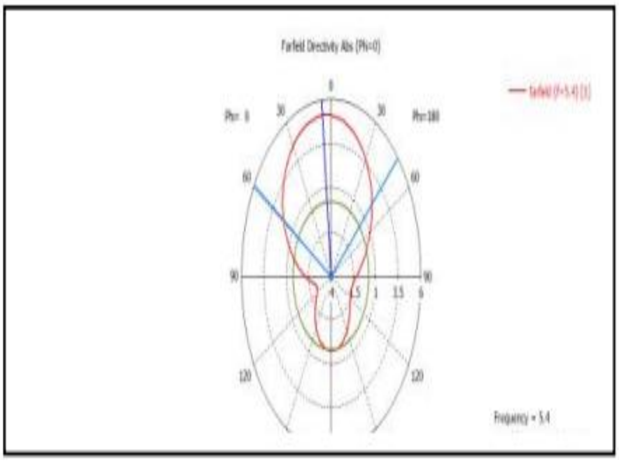

Fig.8 Left Elliptical Polarization for State 3

Table 2 contrast the results of frequency, directivity and polarization for state-1 by using the two diodes i.e varactor diodes and PIN diodes

Parameters	PIN DIODE [2]	VARACTOR DIODE
Frequency	2.3GHz & 4.5GHz(Dual Band)	4.5GHz(Single Band)
Directivity	2.33dBi at 2.3GHz & 3.45 dBi at 4.5GHz	4.15dBi
Polarization	Linear for 2.3GHz & Right Elliptical for 4.5GHz	Right Elliptical

Table 2. Comparisons of parameters in state 1

Table-2, frequency, Polarization and Directivity is differentiated using PIN diodes [2] and varactor diodes. It is seen that, in state 1 PIN diode works in double band whereas varactor diode works in single band. Directivity is good in varactor diode as compared with PIN diode. PIN diode show various polarization characteristics for different frequencies in double band. Varactor diode shows right elliptical polarization

In Table 3, frequency, Polarization, and directivity is contrasted for state 2. With the use of PIN diode antenna resonates at 2.3 GHz while antenna resonates at 2.6 GHz with the use of varactor diodes. Directivity in this case is also best with the use of varactor diode. With the usage of both PIN diode and varactor diode, antenna shows linear polarization.

Parameters	PIN DIODE [2]	VARACTOR DIODE
Frequency	2.3GHz	2.6GHz
Directivity	2.25 dBi	2.79dBi
Polarization	Linear	Linear

TABLE-3COMPARISON OF PARAMETERS IN STATE 2

In Table-4 compares the polarization, directivity and frequency for PIN diodes and varactor diodes in state 3. The antenna resonates at 5.8 GHz with usage of PIN diodes while it resonates at 5.4 GHz with usage of Varactor diodes. Directivity in this situation is better with the use of PIN diodes. The antenna shows left elliptical polarization in both the cases dual band in state 1. This is because varactor diodes operates only when it is in reverse bias condition while pin diode operates for both forward and reverse bias condition. In state 2 there is a frequency shift of 0.3 GHz towards right when compared with the use of pin diodes. There is also increase in directivity from 2.25dBi to 2.79 dBi in state 2 when we are using varactor diodes in the slot in place of pin diodes.

PARAMETERS	PIN DIODE [2]	VARACTOR DIODE
Frequency	5.8GHz	5.4 GHz
Directivity	5.43 dBi	5.13 dBi
Polarization	left elliptical	left elliptical

Table4. COMPARISON OF PARAMETERS IN STATE 3

III. CONCLUSION

We have operated our reconfigurable slot antenna at 2.6 GHz, 4.5GHz, and at 5.4GHz for LTE, AMT, and WLAN applications respectively. These applications are obtained by using varactor diodes in the slots. The size of the antenna is shortened by the use of these slots. With the help of varactor diodes, directivities at single resonating frequency of the antenna get large for the application

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