Design of Microstrip Patch Antenna for L5 and S band Application.

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Abstract— **An accurate real time positioning system is very important parameter. The requirement of indigenous regional navigational satellite system is driven by the fact that access to Global Navigation Satellites System, like global positioning system (GPS) is not guaranteed in hostile situations. The design of frequency reconfigurable microstrip patch antenna is mandatory to overcome the crucial situations. The proposed reconfigurable microstrip patch antenna is used to switch the frequency between L5 band (1.17 GHz) and S band(2.49 GHz). The reconfigurability for the designed antenna is achieved by incorporating RF PIN diode between the radiating elements and resonance slot which has a low-profile structure with maximum gain of 8.51dB and with low cross polarization of approximation <-30dB. In this project, review of the frequency reconfigurable microstrip patch antenna for IRNSS application has presented.**

KEY WORDS: Microstrip Patch Antenna, RF Pin Diode, Frequency Reconfigurability, IRNSS.

I. INTRODUCTION

The Indian regional navigational satellite system (IRNSS) developed by the Indian Space Research Organization (ISRO) is an autonomous regional satellite navigation system which is under the complete control of Government of India. The requirement of indigenous regional navigational satellite system is driven by the fact that access to Global Navigation Satellite System, like GPS is not guaranteed in hostile situations. Design of IRNSS antenna at user segment is mandatory for Indian region. The IRNSS satellites will be placed at a higher geostationary orbit to have a larger signal footprint and minimum satellites for regional mapping. IRNSS signals will consist of a Special Positioning Service and a Precision Service. Both will be carried on L5 band (1176.45 MHz) and S band (2492.08 MHz). As it is be long range communication system needs high frequency signals and high gain receiving antennas. So, different antennas can be designed to enhance the gain and directivity. Based on this the rectangular Microstrip patch antenna is designed by using various software simulations. The performance of the designed antennas was compared in terms of return loss, bandwidth, directivity, radiation pattern and gain.

II. LITERATURE REVIEW

The [1] focuses on the use of IGS(IRNSS/GPS/SBAS) receiver single frequency (L5 band) data for ionospheric studies over Indian region. It describes the use of the simulations data for the study of local variations in ionospheric conditions . Therefore , NavIC signal analysis is useful tool for ionospheric studies. NavIC satellites also transmit signal in S-Band, which is unique. So, the L and S-bands together useful to explore the NavIC .

In [2] , it describes the merits and demerits of selecting the antenna to enhance the gain and diversity. It also provides the detailed discussion of Rectangular Microstrip Patch antenna with special reference to design parameters and selection of substrate.

In [3] , the frequency reconfigurability approach is explained for UHF band using PIN diodes. The array elements are used due to compactness. Also, an acceptable omnidirectional and stable measured radiation patters with low polarization are explained using three cases.

The paper [4] explains frequency reconfigurability achieved by connecting an additional small patch to main patch through PIN diodes. The impedance and axial ratio bandwidth are enhanced by using the proximity coupled feed is explained along with the three polarization states
.
The [5] describes the L5 and S band parameters like return loss , VSWR , gain and radiation pattern of the indivisual band . Both antenna having co-axial feed single-layer patch and low -cost fabrication is explained.

III. ANTENNA CONFIGURATION

Antenna has been an essential component of Space born remote sensors including Active/Passive Microwave Sensors. It operates by using EM spectrum properties of light and sound. In this the proposed antenna is a reconfigurable microstrip patch antenna .The microstrip *patch antennas are mostly used due to its low cost, planar structure, low profile, lightweight and easy to fabricate. To obtain the reconfiguration mechanism in the antenna, the RF switches are placed in the structure, by which the frequency and others schemes are controlled. In a compact frequency reconfigurable multi band antenna with large tuning range is designed using PIN diodes. The defected ground plane was used for impedance matching and to enhance the property of radiation pattern. In dual-band antenna was designed in stacked formation using PIN diodes. The three low resistance RF PIN diodes are used between radiating element and slot, as a switch to achieve the frequency reconfigurability. It has continuous dual frequency tunability feature for the low band (1.68 GHz to 1.93GHz) and the high band (2.11 GHz to 2.51 GHz). It provides unidirectional radiation pattern at all operating frequencies.*

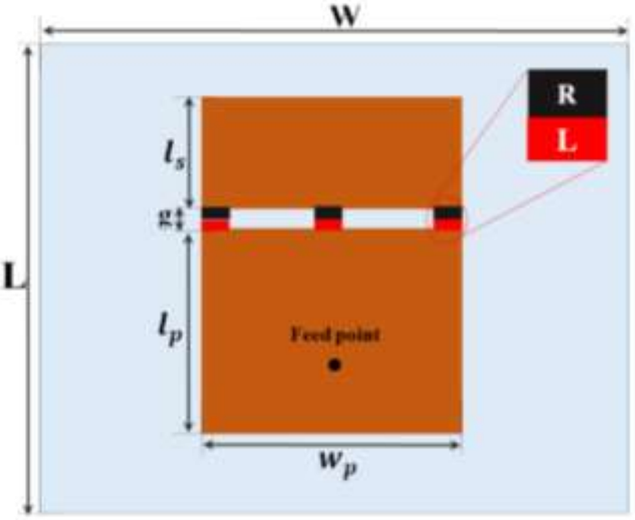

Fig. 1. The proposed schematic layout of the reconfigurable microstrip patch antenna.

Fig. 1 shows the proposed schematic layout of the reconfigurable microstrip patch antenna with optimized dimensions of L=120mm, W=120mm, patch length (lp) =37.5mm,patch width (wp) =48mm, slot length (ls)=28mm and g=2mm. It is printed on top of the dielectric substrate (εr) =2.2 (RT/Duriod), loss tangent=0.0009 and thickness of 1.575mm. The metallic ground plane of size L×W mm2 is printed on back side of the substrate. The proposed antenna is fed by a 50Ω coaxial connector. The gap g between the slot and the patch is used to fix the PIN diodes (Model No.: SMP1340) for frequency reconfigurable mechanism.

The antenna analysis is done using the 3D EM simulation software (HFSS). In 3D EM simulation the ON state PIN diode: L = 0.45 nH and RS = 1.2Ω, and for OFF state PIN diode: L = 0.45 nH, RP = 5 MΩ, and CT = 0.14 pF were used.

IV. RESULTS AND DISCUSSION

A Microstrip Patch Antenna as shown in Fig. 2 has been designed with the Duriod substrate with εr= 2.2.

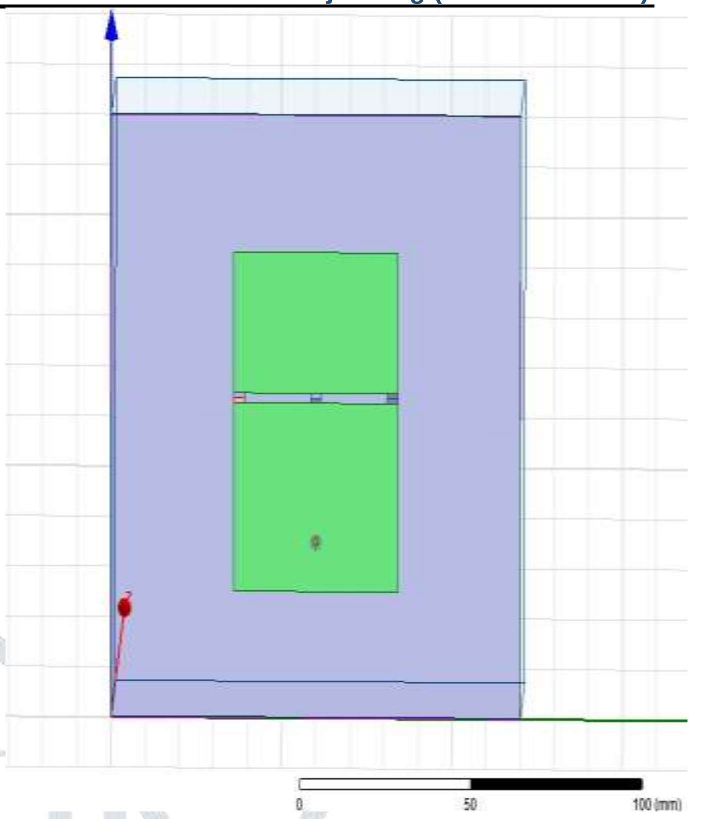

Fig 2: Microstrip rectangular patch antenna model.

Reflection coefficient (S_{11}), surface current distributions, radiation pattern and gain are examined using open and add space boundary conditions in 3D simulation. It resonates at 2.4895 GHz (OFF state) and 1.1753 GHz (ON state) for frequency reconfigurability. The analysis is as below :

A. Reflection Coefficient

It represents the amount of power being reflected backwards from the antenna input to the excitation port. It is measured in decibel (dB) and given by:

$$S_{11}(dB) = 20 \log_{10}| (Z_a - Z_c) / (Z_a + Z_c) | \quad \ldots\ldots\ldots(1)$$

where, Z is the impedance of the antenna and Z is the characteristic impedance of the 50 ohm SMA port.

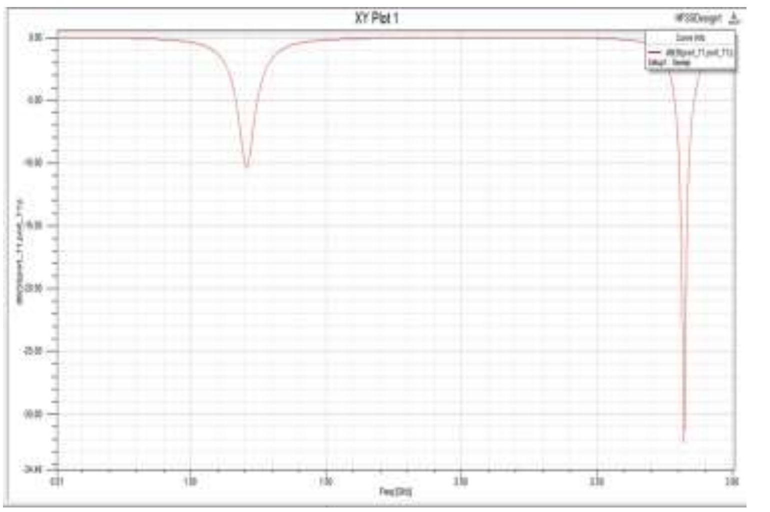

Fig 3:Reflection coefficient of antenna.

When PIN diodes are in ON state the antenna resonates at 1.1753 GHz (Reflection coefficient of -13.61 dB) and in OFF state it is 2.4895 GHz(reflection coefficient of -21.60 dB) shown in Fig 3. It is observed that the antenna has a very good independent switching between both the bands without disturbing each other.

B. SURFACE CURRENT DISTRIBUTION

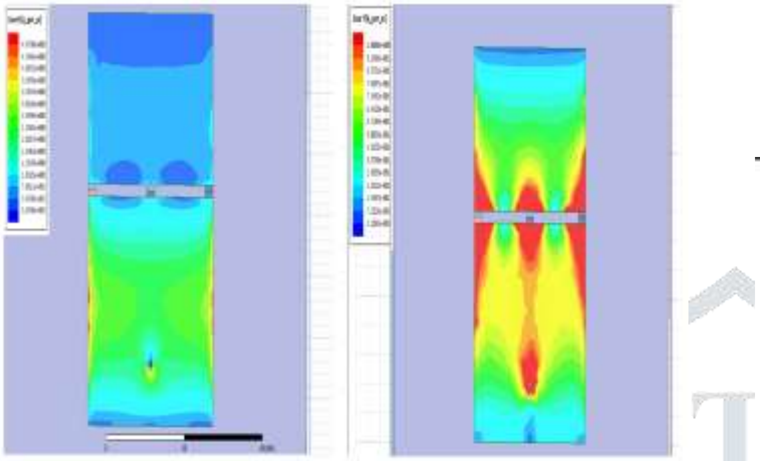

Fig 4: surface current distribution of proposed antenna (a) at OFF state and (b) at ON state.

The (a) and (b) shows the surface current distribution of the proposed antenna at 2.4895 GHz and 1.1753 GHz respectively. It is observed that at 2.4895 GHz , most of the current is concentrating on rectangular patch and very less current is observed at slot as shown in figure. In ON state, the current is distributed more in slot as PIN diodes acts as a bridge in between patch and slot.

C. RADIATION PATTERN AND GAIN

Fig shows the radiation pattern for both yz-plane and xz-plane at 1.1753 GHz and 2.4895 GHz. The simulated radiation pattern shows that it has low CP <-20 dB in yz-plane and <-30 dB in xz-plane for both the ON state and OFF state. The proposed antenna has peak gain of 8.515 dB at 2.4895 GHz .It is calculated by:

$$G(dB) = 10*\log_{10}(\eta_{rad} D) \ldots\ldots\ldots\ldots.(2)$$

where, η_{rad} and D is the radiation efficiency and directivity of the antenna, respectively.

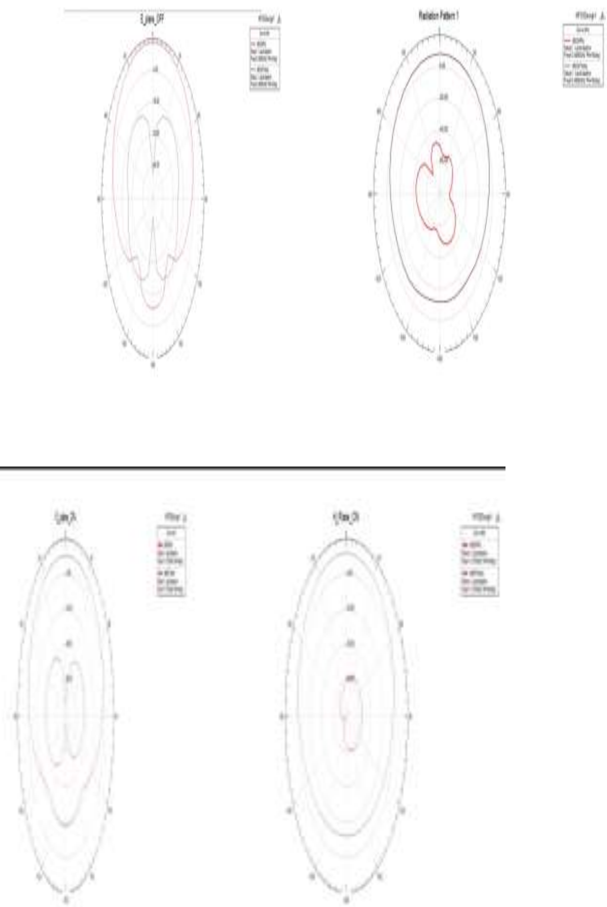

Fig 5. simulation radiation pattern of proposed antenna, (a) E-Plane when OFF state (b) H-Plane when OFF state (c) E-Plane when ON state and (d) H-Plane when ON state.

V. CONCLUSIONS

The frequency reconfigurable microstrip antenna is designed and simulated. The proposed antenna independently switching the resonant frequency of 1.1753 GHz and 2.4895 GHz using RF PIN diode ON and OFF mechanism. It has the maximum gain of 8.51 dB and good cross polarization level of <-30dB .It has simple and compact structure which allows to use the proposed antenna in frequency bands.

VI. REFERENCES

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