Multiband Reconfigurable Antenna for Cognitive-Radio

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***Abstract*— A yagi uda shaped frequency reconfigurable antenna has been presented in this paper. This antenna is designed for four bands B1-1.6 GHz, B2-1.4GHz, B3-1.3GHz and B4-2.6GHz used for various applications like GPS, FDMA, PCS, Bluetooth, etc. For the proposed antenna return loss is better than -10dB and VSWR is below 2 for each band. PIN diodes are used to switch frequencies between different bands. The antenna structure proposed is compact in size.**

***Index Terms*—Patch antenna, frequency reconfigurable antenna.**

I. INTRODUCTION

Reconfigurable antennas consist of antenna elements each having some intelligence means each having ability to configure the physical structure of individual element through which polarization, radiation and frequency properties of antenna will change. A multi-band reconfigurable antenna enables a single antenna element to perform multiple functions by changing its architecture thereby dynamically changing its properties (operation frequency, radiation pattern, polarization). Multiband antenna enables a single antenna to work on multiple bands by reconfiguring itself.

Frequency reconfigurable antennas have reconfiguration of frequency by changing the structure while other parameters remain unchanged. So frequency reconfigurable antennas can be applied among a wide arrangement.

In ref [3] a reconfigurable multiband and wideband patch antenna, employing dual-patch elements and C-slots with compact volume, has been represented and studied using simulation and measurement. Two PIN diode switches are used to switch ON and OFF two patch elements. In ref [4] designs of compact five-band printed antennas for fixed and reconfigurable systems is represented. The design procedure is described in detail. By adding four varactor diodes in the design reconfigurability is achieved.

Ref [7] says that reconfigurable antenna changes array factor as well as array element factor and also the advantages of antenna. Different antenna structures are presented in [8]-[11] that would reduce dynamic range by the use of different kinds of switches. Antennas functionality depends on antennas radiating elements parameter, such as sizes shapes and positions of radiating element over the aperture. Modifying these antenna parameter changes the frequency. The PIN diodes are used as a switch because they have really high conductivity (10^{18}carrier/cm^3) which is near that of metal controlled under dc bias is presented in [8].

Switching controls and their types is briefly discussed in [9]. Ref [13] represents the basic yagi-uda shaped antenna which will be the base of further design.

II. ANTENNA DESIGN

Various dimensions have been experimented till now by changing dimensions and keeping the shape constant. They are like when the size of length and width is interchanged, when the substrate height is reduced by 1.57mm it was observed that different bands were obtained which had shift in frequencies in some cases and in some cases it remained same with improved Return Loss, when the number of patches are increased from P1 to P8 to P1 to P12 here it was observed that the Return Loss was improved by 0.16 in case when D1 was in ON state. Moreover when patches were reduced to P1 to P4 the Return Loss was degraded by 0.19 in similar case of diode D1 switching condition. The experiment giving the best results are proposed in the paper below.

The geometry of the proposed antenna is yagi-uda antenna with its parameters is shown in fig.1. The antenna is printed on FR4 substrate with dielectric constant of ε_r=4.4 and the thickness is 1.6mm.

The type of feeding used is microstrip feeding technique. The software used to model and simulate this antenna is HFSS 13. The optimized parameters of the antenna are shown in the table 1. The ground is of 80x60mm^2. The four parasitic patches on the main patch are placed and their height and width and gaps are also shown in table 1.

Four PIN diodes (D1 to D4) are introduced between the gaps of parasitic patches for the purpose of switching. Depending on the state of diode, the electrical length of patch can be changed and their resonating patch is reconfigured. And depending on the state of PIN diodes four different bands can be observed.

TABLE 1 DIMENSIONS OF AN ANTENNA

Length (mm)	Width (mm)	Gap (mm)
h=36	w=26	-----
h1=32	w1=4	g1=2
h2=28	w2=2	g2=1
h3=24	w3=1	g3=1
h4=20	w4=1	g4=1

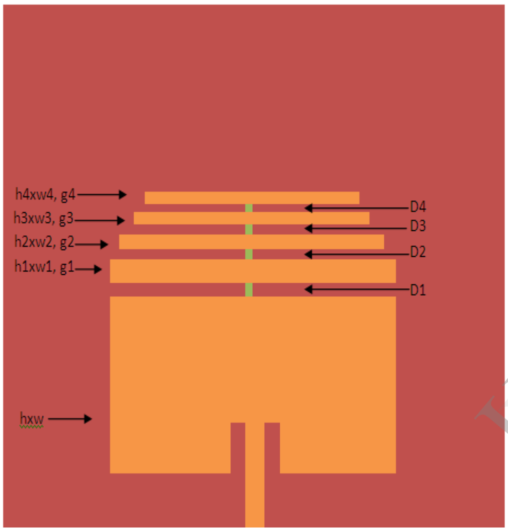


Fig. 1. Antenna Geometries

III. WORKING OF PIN DIODE

The ON and OFF conditions of switches are realized by forward a reverse biasing of the PIN diodes. When the PIN diode is forward biased, the switch is ON. The switch has low impedance characteristics and acts as a closed circuit and thus the current can flow through the diode as shown in Fig.2.

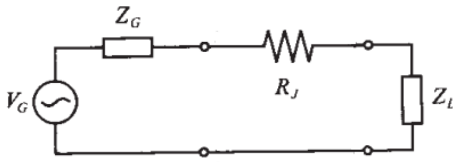


Fig.2. PIN diode when forward biased

When a PIN diode is reversed biased, the switch is OFF, this switch exhibits high impedance characteristics and act as an open circuit. This means to no connection and PIN diode in reverse diode acts as a capacitor (C_J) as shown in Fig. 3

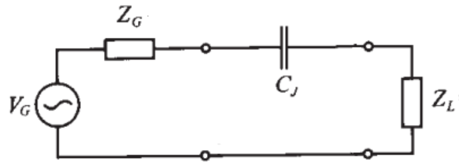
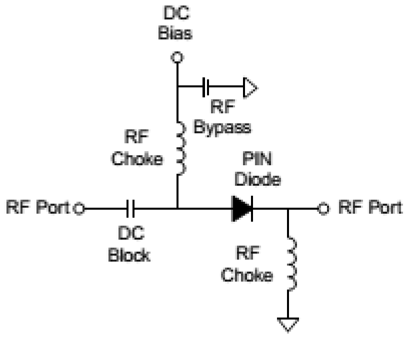


Fig. 3. PIN diode when revese biased

Where V_G, Z_L and Z_G are applied voltage, load impedance and input impedance respectively in Fig.2 and Fig 3.



IV. RESULTS AND DISCUSSIONS

The performance of the proposed antenna is characterized its electrical properties such as VSWR, Bandwidth and Return Loss. After simulation of the above antenna following were the results for Return Loss for all four conditions of PIN diodes.

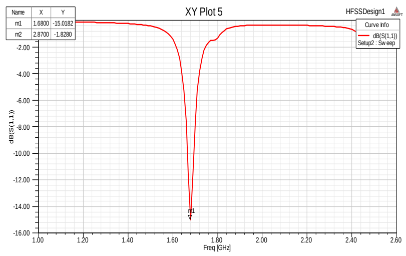


Fig. 4. RL when D1 is ON

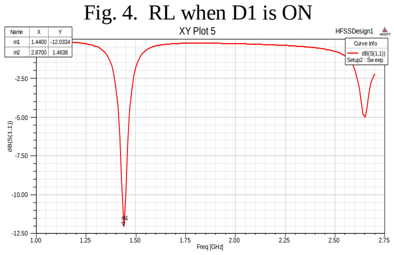


Fig. 5. RL when D1 and D2 are ON

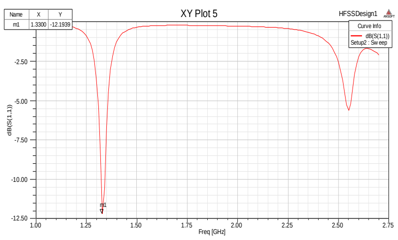


Fig. 6. RL when D1, D2 and D3 are ON

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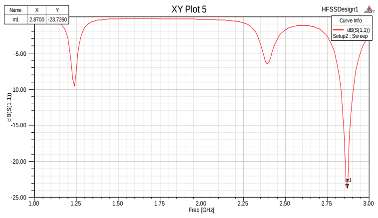

Fig. 7. RL when All are ON

Fig. 4. To Fig. 7. shows simulated results for Return Loss(RL) of this proposed antenna. The goal of the design is to achieve good peformance i.e. RL which is below -10 dB. When all diodes are ON the first resonance of 2.6 GHz is obtained. Here all patches and antenna act as a single antenna and gives the RL of –23.72 dB. Similarly when only D1is ON, the patch with the length and height h1xw1 act as a single antenna and the length of the antenna is changed. As the frequency of patch antenna depends on length and width the frquency resonates to 1.6 GHz. Similarly when other diodes are ON or OFF the change in frequency as the lenghth goes on changing as well as other parameters shown below is observed.

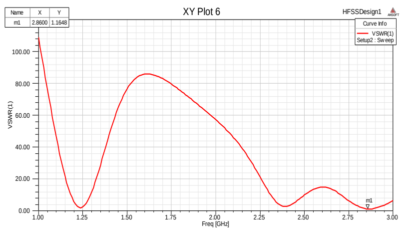

Fig. 8. VSWR when all diodes are ON

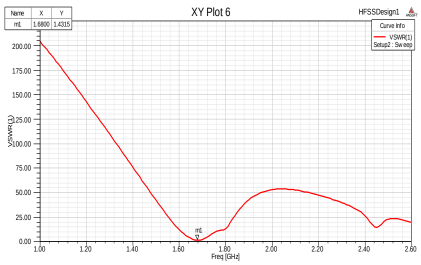

Fig. 9. VSWR when D1 are ON

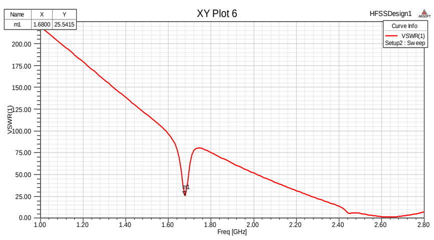

Fig. 10. VSWR when D1and D2 are ON

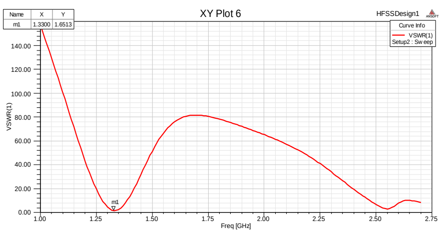

Fig. 11. VSWR when D1, D2 and D3 are ON

Fig.8 to Fig 11. Shows VSWR against frequency for all the four bands. VSWR of antenna is closely related to RL. The value of VSWR is low for all the freqency bands, it should be below 2dB, this condtion is satisfied in all the cases. When all diodes are ON we get VSWR as 1.16 and it can be observed that as RL improves the VSWR is also improved.

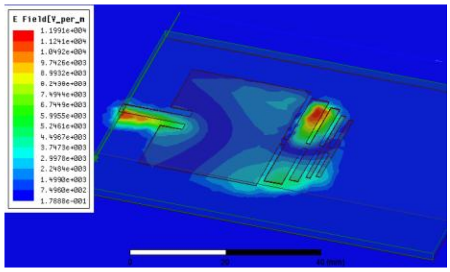

Fig. 12. Current distribution when all diodes are ON

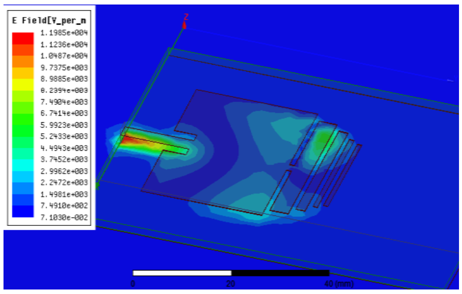

Fig. 13. Current distribution when D1 are ON

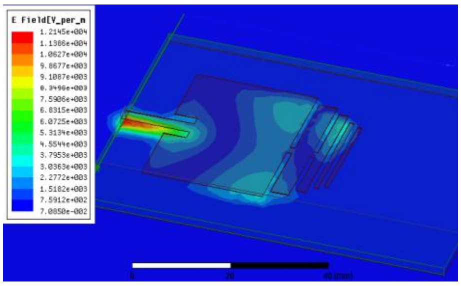

Fig. 14. Current distribution when D1and D2 are ON

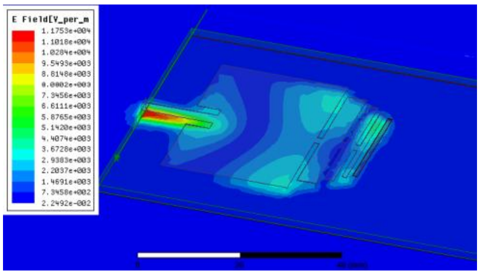

Fig. 15. Current distribution when D1, D2 and D3 are ON

The electric fied distribution for each case considered is show in Fig 12 to Fig. 15. From the given distributions we can observe that when D1 is ON electric field is distributed over parasitic patches and as the length of antenna is changed the electrical length also changes and thus the resonant frequency is changed.

TABLE 2 RESULTS OF ELECTRICAL PARAMETRES FOR ALL PIN CONDITIONS CONSIDEREDS

Diode Condition	Comparison	Freque ncy	Return Loss
When D1 is ON	Simulated	1.6	-16.23
	Practical	1.7	-15.70
When D1 and D2 is ON	Simulated	1.4	-12.03
	Practical	1.5	-17.67
When D1,D2 and D3 is ON	Simulated	1.3	-10.31
	Practical	1.5	-16.26
All are ON	Simulated	2.6	-23.72
	Practical	2.8	-30.00

V. TESTING

The testing of the fabricated antenna was performed on ROHDE& SCHWARZ ZVH8 cable and network analyzer 100 KHz to 8GHz.The simulation 3 and simulation 4 are fabricated and tested. The simulated and the tested results are approximately same. There is a slight shift in frequency band when compared to simulated results which are not more than 0.2 GHz. Return Loss is deteriorated as compare to simulate results due to the external noise and other practical disturbances.

The comparative study is done of the simulated and tested results and which is shown in table 7.1 for both the simulations.

VI. CONCLUSIONS

The antenna is working on four bands successfully with the return Loss less than -10dB and their testing on antenna analyzer is giving all most accurate results.

The proposed structure is very simple to study and implement because it has planar structure. It is compact in size. The antenna possess great Return Loss and VSWR

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