

# Frequency Reconfigurable Antenna

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**Abstract**— The development of smart antennas for mobile phones has recently received much interest due to compact size of multimode phones and requirements keep the amount of RF power absorbed by a user below a certain level. In this paper a Yagi Uda shaped Frequency Reconfigurable microstrip patch antenna is presented. The proposed reconfigurable antenna has four patches designed to cover the frequency band from 1.9GHz to 2.4GHz. The antenna exhibits the property of change in frequency which results in change in return loss characteristics depending upon the configuration request. The frequency reconfiguration capability of antenna is achieved with the help of PIN diode which acts as a switch to reconfigure the antenna. Small rectangular patches have been inserted to act like switches to obtain re-configurability. The antenna is simulated on Asoft HFSS software. The simulated results give return loss lower than -dB and VSWR below 2.5.

**Keywords**— Frequency Reconfigurable Antenna, Mobile Antenna, Yagi Uda Antenna, Patch Antenna component.

## I. INTRODUCTION

Wireless communication and sensing systems have experienced enormous development over the past two decades. They are bringing information to us with convenience and flexibility at low cost. There are many wireless communication systems in our daily lives such as cellular radio systems, mobile satellite system, wireless local area network, etc. All these systems are still undergoing a great evolution, with constantly emerging new solutions. Common problems that are hard to tackle today, such as the need for a number of communication standards in a single mobile device, the necessity of diversity, and ever growing requests for the capacity of a communication channel, will soon grow unsolvable by means of classical antennas. Therefore, re-configurability will become a key need in the near future. In this context, there is an evident interest in developing new reconfigurable antennas, which allow the dynamic reconfiguration of antenna parameters. This change is achieved by many techniques that redistribute the antenna currents and thus alter the electromagnetic fields of the antenna's effective aperture. Reconfigurable antennas can address complex system requirements by modifying their geometry and electrical behavior, thereby adapting to changes in environmental conditions or system requirements (i.e., enhanced band-width, changes in operating frequency, polarization, and radiation pattern).

## II. LITERATURE SURVEY

With the ever increasing demand of the customers for access to large number of standards/application with in single portable device; the field of mobile communication has advanced a lot but still need a lot of research for its culmination. This advancement in mobile communication has resulted in getting access to several applications [1-2] such as GSM 900 (880-960MHz), GSM 1800 (1.71-1.88GHz), PCS1900 (1.859-1.99GHz) AND UMTS (1.9-2.17GHz) DCS1800, WLAN, Bluetooth, Wi-Fi, 4G etc. As antenna forms the backbone of every wireless communication system, an extensive research has been carried out on an antenna which can work on all such standards/frequencies. From the designer's point of view, antennas having small size, light weight, low profile, flexibility and excellent rejection ratio in the transmitting band [3]. Also, with the change in operating standards/frequencies, the size of the antenna changes accordingly, which need to be addressed strongly keeping the view of portability of mobile phones. Extensive research has been carried out in the last two decades to find ways of reducing the size of resonant antennas so that they will fit within a given volume inside a handset [3-5]. However, this gives rise to restriction and compromise regarding polarization, radiation efficiency, bandwidth and further more increases the sensitivity to manufacturing tolerance. Unfortunately, the performance requirements for the antenna are rarely relaxed with the demand for smaller size. Mobile phone antennas should have a return loss better than 6dB and VSWR OF 3:1. Since each communication protocol may operate in a distinctive frequency band, instead of using several antennas it is highly desirable to have one broadband or multi-band antenna to meet the antenna needs of multiple system. Most current multiband antenna designs used for mobile device can be categorized into three types: planar inverted F antenna (PIFA's), slot antenna, monopole antennas[7-16]. Among different antennas multiband planar inverted F antenna (PIFA) antennas are mostly used for mobile headset for multimode operation. Many methods are used to enhance the performance and the number of frequency bands for mobile phone antenna like by adding monopole antenna as a parasitic antenna, by etching different shaped slot antenna and shorting the patch with capacitive load etc. For example, Z.D. Liu et al. explained a dual resonance antenna structure for several frequency ranges which can be used as an internal antenna for mobile phone [7]. Lin and D.-B. et al. Proposed compact quad-band PIFA by tuning the defected ground structure [8] while Saidatulet al. add fractal apertures to increase the resonant path and

### III. ANTENNA DESIGN

therefore reduce the antenna size [9]. Ciais et al. use shorted parasitic patches with capacitive loads and slots to achieve quad band and wideband operations [10]. Han, H.-T. Kim et al, inserts tow long slots for dual band operations [11] while Anguera et al. Inserts F-shaped and rectangular slots to accomplish dual mode resonance [12]. Lin and D.-B.et al. cut an open-ended slot on the ground to broaden the operational bandwidth [13]. Isohatala et al. proposed a planner antenna having low SAR value [14] while Song et al. presented a triple band PIFA [15]. So, the PIFA antenna can provide several desirable properties but the main drawbacks of above described antennas are limited coverage of multiple standards, small operational bandwidth and poor isolation among transmitting bands with degrade the signal quality and its 3D structure which may be challenging in fabrication [16]. Although size of these antenna are small but at cost of other important antenna parameter like radiation efficiency, gain etc. to access multimode communication we need such antenna which has a wider input impedance bandwidth and can easily be fabricated. Multiple band antennas should dynamically alter transmit and/ or receive RF characteristics by keeping all antenna parameters in tolerable range. The challenge in front of antenna designer is not only create new design of antenna structure which are capable of providing this facilities but also manage the interference among wireless strands which can limit their usefulness. Frequency reconfigurable patch antennas have attracted significant attention due to their ability to cover multiple frequency bands [17-23]. A lot of work has been carried out frequency reconfigurable micro strip patch antenna for mobile communication standards summarized in [20]. One of the merits of frequency reconfigurable is that the antenna can provide rejection of interfering signals in the bands that are not in use so that the filter requirements of the front end circuits can be gently reduced [20]. Reconfigurable antennas have more advantages for example: saving energy; reducing the number the antennas thus reducing the mutual interference between then as compared with conventional antennas [20]. In literature there have been many reports on the design and implementation of reconfigurable antenna for the operation of multiple band. However, there is no single efforts to design an antenna which can be operated on multiple bands like WCDMA, FDMA, PDC, GPS, GSM, PCS, UMTS, WLAN, Bluetooth, Wi-Fi, etc. without adding complexity to the system on the account of minimizing interference for the inter portability of multiple standards. Therefore present work is focused on design of a frequency reconfigurable antenna structure consisting of number of parasitic patches which can be made to resonate at desired frequency when operated in consonance with PIN diodes. This may result in reduction in number of antennas on wireless equipment and saves the area and power requirements. In this paper a novel frequency reconfigurable Yagi-Uda shaped antenna which can switch its resonating frequency for different standards like Bluetooth, Wi-Fi, WLAN, 3G, UMTS, WCDMA, GSM, CDMA. With high isolation and within 2.5:1 VSWR (voltage standing wave ratio) has been proposed.

The geometry of the proposed frequency reconfigurable Yagi-Uda shaped antenna for multimode wireless applications with optimized parameters is depicted in Fig.1. This antenna was printed on FR4 epoxy substrate with the dielectric constant of 4.4 and substrate thickness of 1.57mm. The software used to model and simulate the proposed antenna was Ansoft HFSS 13, which is an industry-standard simulation tool for 3D full-wave electromagnetic field simulation.

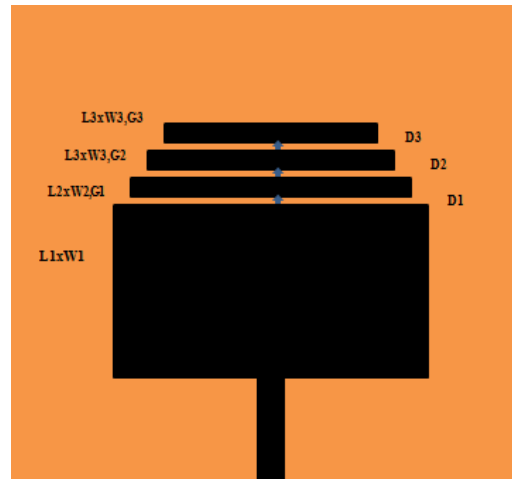


Fig1: Yagi Uda shaped frequency Reconfigurable microstrip antenna.

The optimized parameters of proposed antenna are: length=50mm, width=50mm on a ground 50x50mm. The four parasitic patches on the top patch metallization are properly place don its length, width and gap were optimised for desired frequency range as shown in table 1. Antenna is fed by micro-strip transmission line with the metal strip of width 4mm and length 5mm.

Table 1: Geometry parameter of frequency reconfigurable Yagi Uda shaped antenna

LENGTH(mm)	WIDTH(mm)	GAP(mm)
L1=28	W1=38	-----
L2=0.8	W2=32	G2=0.5
L3=0.6	W3=28	G3=0.5
L4=1	W4=26	G4=0.5

Three PIN diodes are introduced in between the gap of parasitic patch to connect and disconnect them. According to state of PIN diode; electrical length of patch antenna can be altered so that resonating frequency of patch can be reconfigured. The proposed antenna can work on four different bands depending upon the state (ON/OFF) and number of PIN diode.

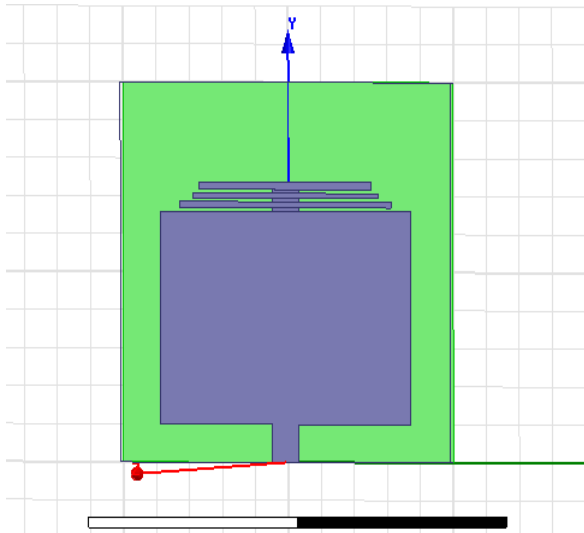


Fig2: Simulated Yagi Uda shaped Frequency Reconfigurable microstrip Antenna.

#### IV. MODELING OF PIN DIODE

The ON and OFF condition of switches are realized by forward and reverse biasing of PIN diodes. Ideally, when a forward bias is applied to make the switch ON, the switch would have low impedance characteristic, acts as short and the current can flow through the diode. On the other hand, when a reverse bias is applied to make the switch OFF, the switch exhibits high impedance characteristics and acts as open circuit which implies that there is no connection. In order to explain the working of PIN diode; electrical circuit is shown in Fig 3. If diode is forward biased it can be modeled as a resistor of 0.01 ohm and if diode is in reverse biased, it can be modeled as a parallel combination of 0.1pF capacitor and 1Kohm resistor.

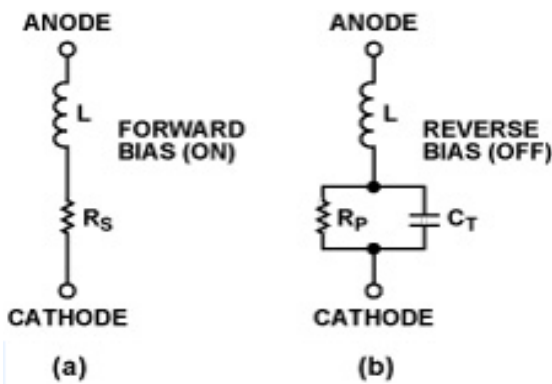
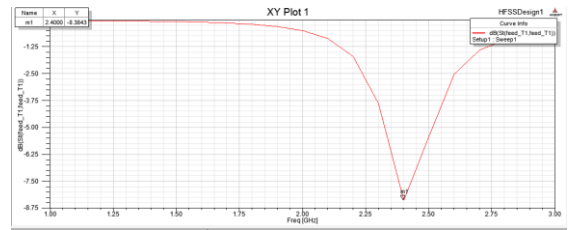


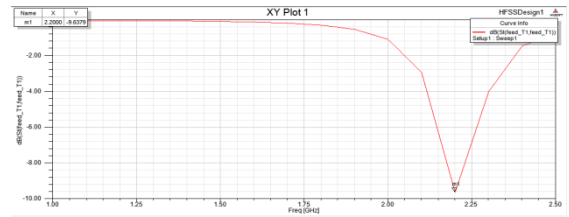
Fig3: PIN diode under (a) forward (b) reversed biased condition

#### V. RESULT AND DISCUSSION

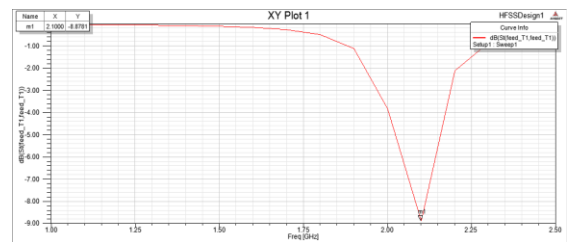
The performance of proposed antenna is characterized by two electrical properties, which include VSWR and return loss.



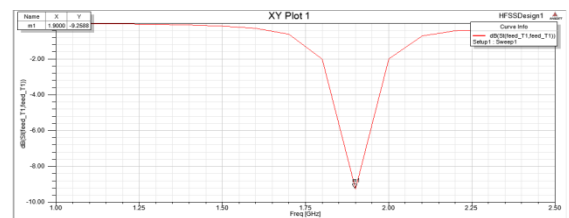
(a) 2.4GHz-When all diodes are OFF



(b) 2.2GHz-When D1 is ON



(c) 2.1GHz-When D2 is ON

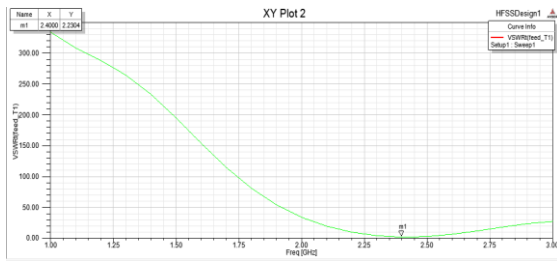


(d) 1.9GHz-When D3 is ON

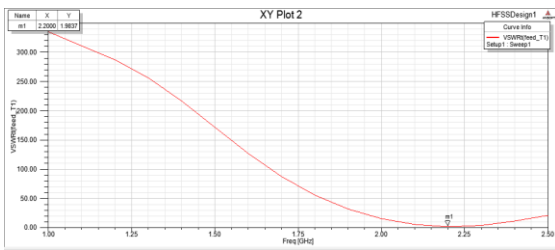
Fig 4 shows the simulated results for return loss of this antenna

The overall goal of the propose antenna design is to achieve good performance in the return loss below 6dB. When no diode is switched ON antenna have resonance in a frequency range of 2.36-2.41GHz (Bluetooth802.15.1, Wi-Fi, WLAN). As diode D1 is forward biased there is conducting path between parasitic patch length L1 and main patch Length L hence the resonating frequency of the antenna is according to equivalent length of L1 and L and antenna have second resonance in the frequency range of 2.22-2.28GHz[3G, ITM(1.885-2.2GHz)]. Similarly when diode D2 and D3 is forward biased antenna will resonate in the frequency band 2.14-2.19GHz [UMTS (1.92-2.17GHz), WCDMA]; 1.88-1.92GHz [PHS, CDMA].

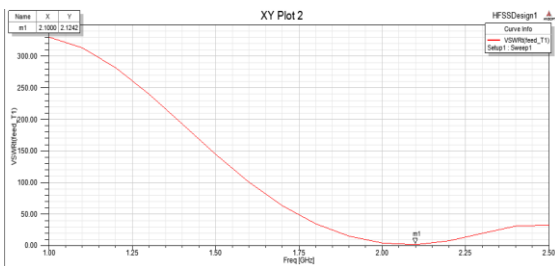
FREQUENCY	DIODES	RETURN LOSS(dB)	VSWR
2.4GHz	ALL OFF	-8.38	2.23
2.2GHz	D1 ON	-9.63	1.98
2.1GHz	D2 ON	-8.87	2.12
1.9GHz	D3 ON	-9.25	2.06



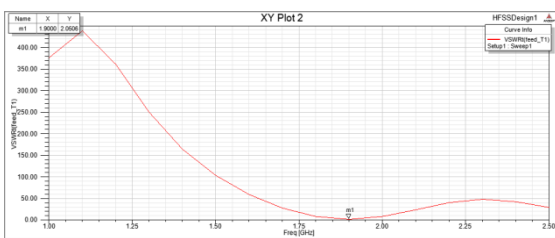
(a) When all diodes are OFF



(b) When D1 is ON



(c) When D2 is ON



(d) When D3 is ON

Fig.5 shows the simulated result of VSWR against frequency (a) 2.4 GHz (b) 2.2 GHz (c) 2.1 GHz (d) 1.9 GHz

The VSWR of the antenna is closely related to the return loss. VSWR value is below 2.5 for all the frequency bands.

### VI. CONCLUSION

In this paper frequency reconfigurable Yagi Uda shaped micro-strip patch antenna for multimode mobile communication is presented. The proposed antenna can work on different wireless standards like Bluetooth, Wi-Fi, WLAN, 3G, UMTS, WCDMA, GSM, CDMA etc. three pin diodes are use to switch frequency between different standards. the proposed structure is very simple to fabricate due to planar structure, small in size, have radiation characteristics like return loss and VSWR.

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