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DESIGN OF FREQUENCY RECONFIGURABLE ANTENNA FOR MOBILE COMMUNICATION

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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 to 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 reconfigurability. The antenna is simulated on Ansoft HFSS software. The simulated results give return loss lower than -6dB and VSWR below 2.5.
KEYWORDS: Frequency Reconfigurable Antenna, Mobile Antenna, Patch Antenna, Yagi Uda Antenna

I. INTRODUCTION

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 application [1-2] such as GSM 900 (880-960MHz), GSM 1800 (1.71-1.88GHz), PCS 1900 (1.859-1.99 GHz) and UMTS (1.9-2.17 GHz) DCS 1800, 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 restrictions and compromise regarding polarization, radiation efficiency, bandwidth, and furthermore increases the sensitivity to manufacturing tolerances. 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 6 dB 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 systems. Most current multiband antenna designs used for mobile devices can be categorized into three types: planar inverted-F antenna (PIFAs), monopole antennas and slot-type antennas [7-16]. Among different antennas multiband, planar inverted-F antenna (PIFA) antenna are mostly used for mobile handset 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 Saidatul et al. add fractal apertures to increase the resonant path and 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 two long slots for dual band operation [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 which degrade the signal quality and its 3D structure which may be challenging in fabrication [16]. Although size of these antenna are small but at the cost of other important antenna parameter like radiation efficiency, gain etc. To access multimode communication we need such an antenna which has a wider input impedance bandwidth and can easily be fabricated. Multiple band antennas should dynamically alter their 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 designs of antenna structure which are capable of providing these facilities but also manage the interference among wireless standards 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 on frequency reconfigurable microstrip patch antenna for mobile communication standards summarized in [20].One of the merits of frequency reconfigurable antennas 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 greatly reduced [20]. Reconfigurable antennas have more advantages for example, saving energy; reducing the number of antennas thus reducing the mutual interferences between them 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 bands. 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. There for present work is focused on design of an 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 switches. This may results in reduction in number of antennas on wireless equipment hence saves the area and power requirement. In this paper a novel frequency reconfigurable Yagi Uda shaped antenna which can switch its resonating frequency for different standards like Bluetooth,wifi,WLAN,3G,UMTS,WCDMA,GSM,CDMA with high isolation and within 2.5:1 voltage standing wave ratio (VSWR) has been proposed.

II. ANTENNA DESIGN

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 substrate with the dielectric constant of 4.4 and the substrate thickness of 1.57 mm. In this work, inset microstrip feeding technique is used. The location of inset cut point is adjusted to match with its input impedance (usually 50 ohm). 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.

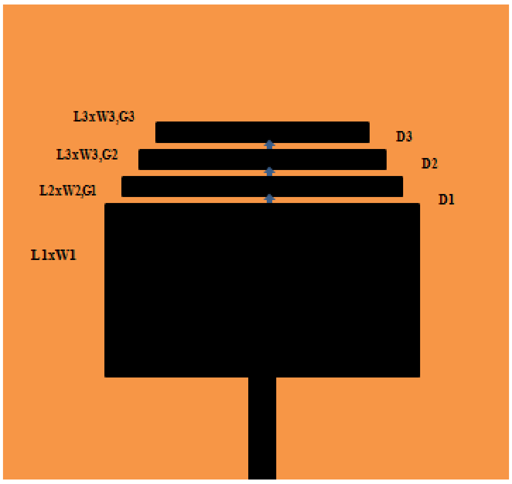


Fig1: Yagi Uda shaped frequency Reconfigurable Microstrip Antenna

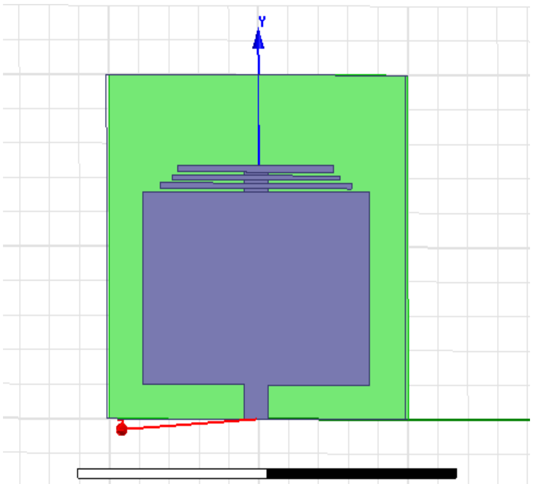


Fig2: Simulated Yagi Uda shaped Frequency Reconfigurable microstrip Antenna.

The optimized parameters of proposed antenna are: length=50mm, width =50 mm on a ground 50x50mm. The four parasitic patches on the top patch metallization are properly placed and its length, width and gap were optimized for desired frequency range as shown in Table below.

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

Antenna is fed by micro strip transmission line with a metal strip of width 3mm and length 30mm.Three PIN diodes are introduced in between the gap of parasitic patch to connect and disconnect them. According to the state of PIN diode; electrical length of the 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.

III. MODELLING OF PIN DIODE

The ON and OFF conditions 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 characteristic 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.2. If diode is forward biased it can be modelled as a resistor of 0.01 ohm and if diode is in reverse biased, it can be modelled as a parallel combination of 0.1pF capacitor and 1Kohm resistor.

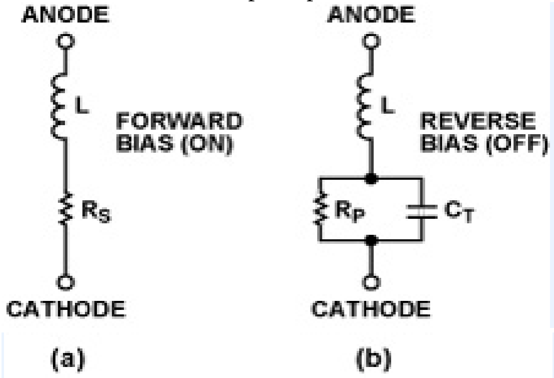
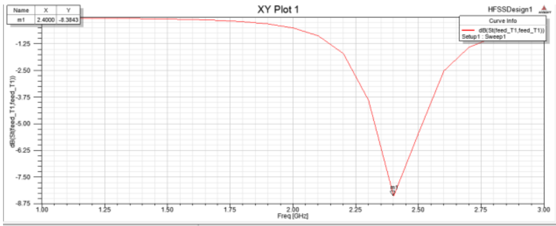


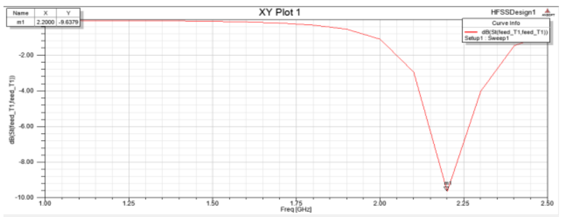
Fig3: PIN diode under (a) forward (b) reversed biased condition

IV. RESULT AND DISCUSSION

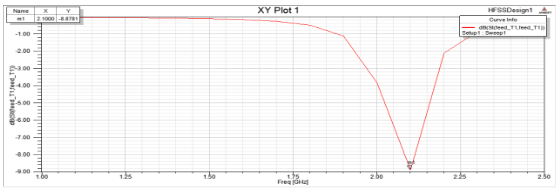
The performance of proposed antenna is characterized by two electrical properties, which include VSWR and return loss.



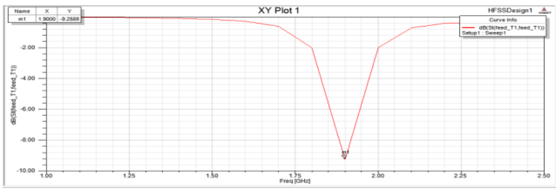
(a)



(b)



(c)



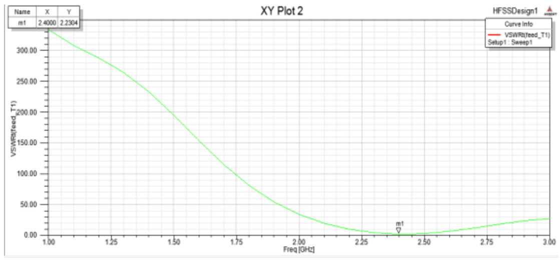
(d)

Fig. above shows the simulated results for return loss of this antenna (a) 2.4Ghz (b) 2.2Ghz (c) 2.1Ghz (d) 1.9Ghz

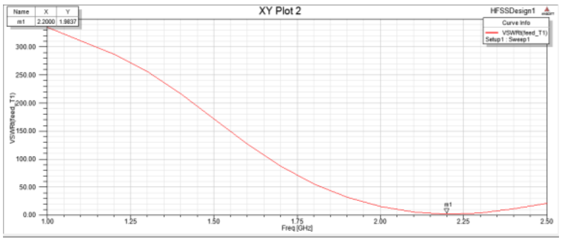
The overall goal of the proposed antenna design is to achieve good performance in the return loss below 6dB. When no diode is switch ON antenna have first resonance in a frequency range of 2.36-2.41GHz (Blue tooth802.15.1, Wi-Fi, WLAN).

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

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 a frequency range of 2.22-2.28 GHz [3G,ITM (1.885-2.2 GHz)]. 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].



(a)



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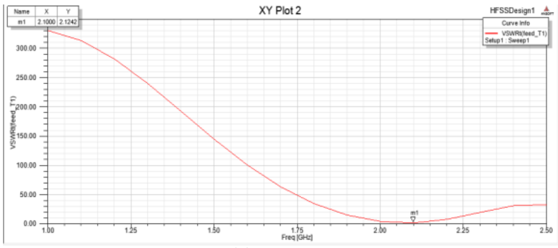
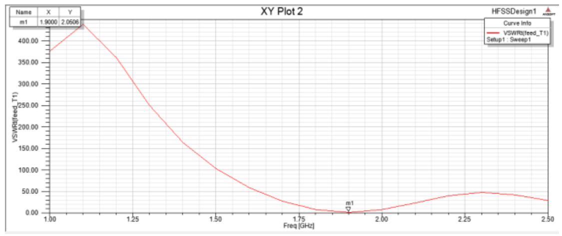


(c)



(d)

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

V. CONCLUSION

In this paper frequency reconfigurable Yagi Uda shaped microstrip patch antenna for multimode mobile communication is presented. The proposed antenna can work on different wireless standards like Bluetooth, wifi, WLAN, 3G, UMTS, WCDMA, GSM, CDMA etc. Three PIN diodes are used to switch the frequency between different standards. The proposed structure is very simple to fabricated due to planner structure, small in size, have good radiation characteristics like return loss and VSWR.

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