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Novel Reconfigurable Loop Antenna for Compact Mobile Phone

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Abstract

In this paper, we proposed a frequency reconfigurable antenna design for loop antenna with dual band resonance frequencies. The current path of the antenna is electronic controlled by PIN diode switch for the desired resonance frequency. The larger/smaller of the current path, the smaller/larger of the resonance frequency can be obtained. The simulation and measurement of resonance frequency and overall efficiency are compared. The trends of results for PIN diode is either in "ON" state or "OFF" state are agreed.

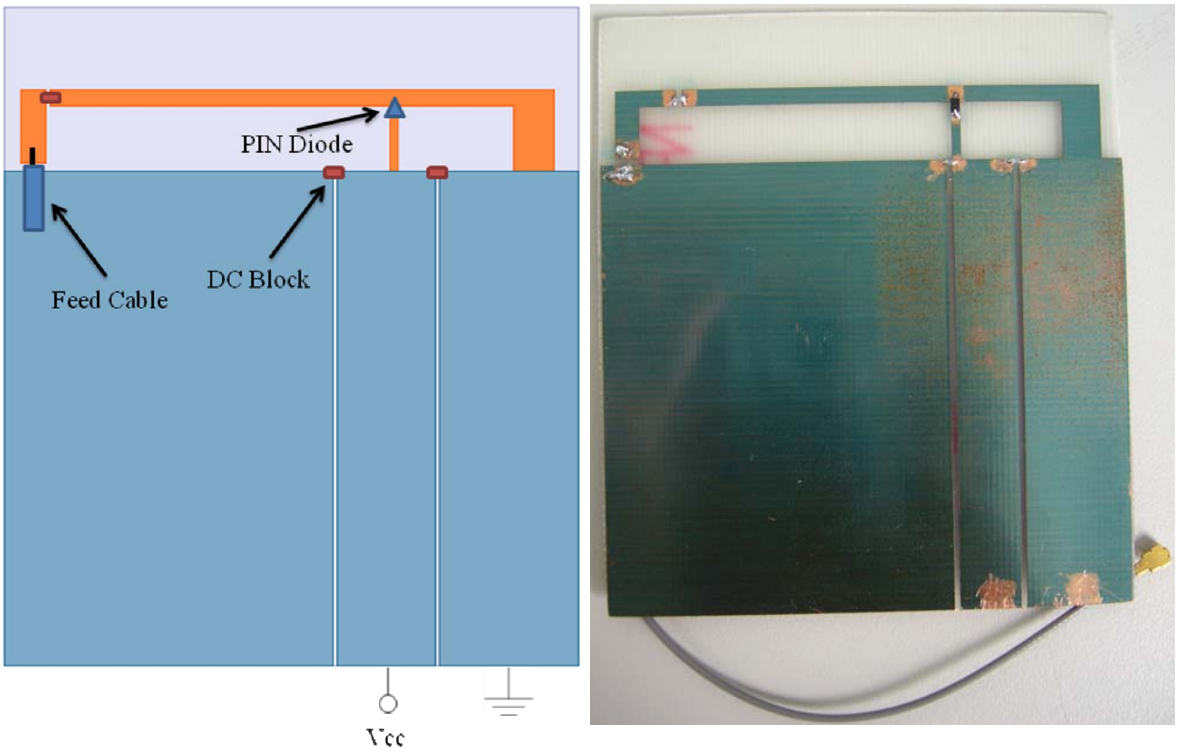
Keywords: Reconfigurable antennas, Loop antenna, PIN diode switch

1. Introduction

In recent years, for wireless communication products are integrating with different antennas for multi-communication systems. In generally, the operating frequency of antenna can be reconfigurable by controlling the reactance for multi-band operation. By using the frequency configurable technique, only one antenna can be used for frequency division multiplexing communication system, but also for improving the quality of signal transmission. By using this reconfigurable technique, the size of wireless mobile communication system can be reduced.

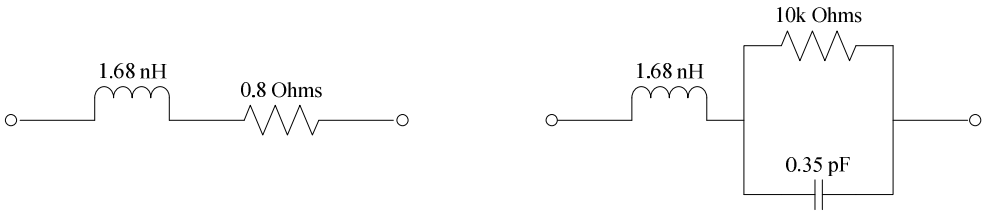
The structure of the proposed reconfigurable antenna is shown in Fig.1. The basic of this reconfigurable antenna is a loop antenna fabricated on the FR4 substrate with size 60mm x 70 mm x 0.8mm. The PIN diodes is placed inside loop and connected to the ground plane. If the PIN diode switch is "OFF", the geometrical of electrical path is a single loop. By changing the voltage on the PIN diode switch it will be"ON", the electrical path of loop will be reconfigured to larger loop and smaller loop. In order to control the PIN diode switch "ON" and "OFF", a Vcc DC bias is applied through the ground plane which was cut two narrow slits. In order to have an impedance match to the desired band and reduced the RF signal to the DC source, a DC block capacitance 100pf is connected among the slit.

The PIN diode (NXP BAP64-03) switch of this article is common used as the frequency reconfigurable antenna design. In order to simulate the PIN diode switch as part of the antenna, the equivalent circuit of the PIN diode switch is shown in Fig. 2. The circuit of the PIN diode switch in "ON" state is equivalent to a lump element with 0.8 ohms resistor series with 1.68nH inductor. The equivalent circuit of PIN diode switch in "OFF" state may consider as 1.67nH series with a parallel circuit of 10KOhms and 0.35pF. Fig.2 shows the equivalent circuit model of this PIN diode in "ON" and "OFF" state. A 100 pF DC block was connected and also for impedance matching of the antenna. The characteristics of this reconfigurable antenna were simulated by the above equivalent circuit either in "ON" or "OFF" state. When the diode is in "OFF" state, the current will flow along the larger loop. That means the resonant frequency will be lower. When the diode is in "ON" state, the major current will flow along the smaller loop and minor current flow along the larger loop. Then the major resonant frequency will be higher. By changing the path of current flow, different resonant frequency can be achieved.



(a) (b)

Fig.1 The frequency configurable antenna structure
(a)Simulation model (b)prototype



(a)ON-state (b)OFF-state

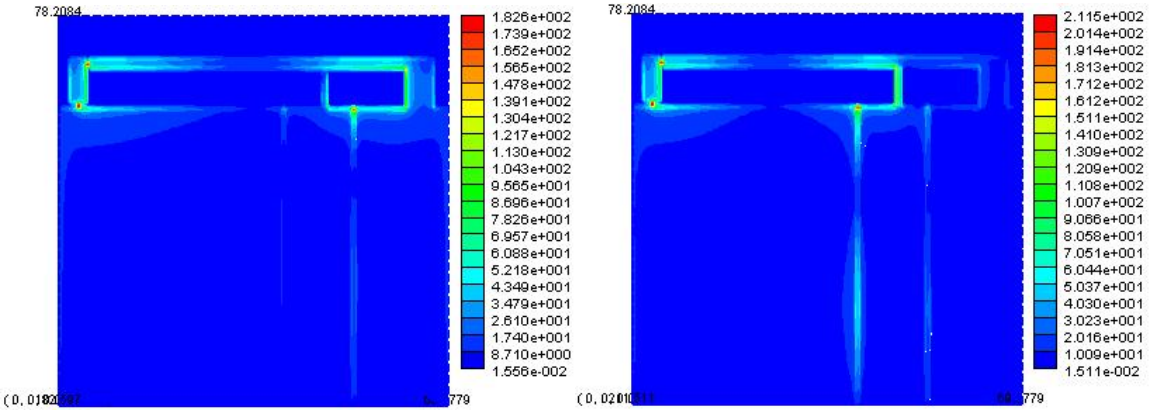
Fig.2 Equivalent circuit ofBAP64-03 PIN diode

2. Comparisons of Simulation and Measurement

The current distribution of this antenna for diode either in “ON” or “OFF” state is shown in figure 3. When the diode is in “ON” state, the major current will flow along the inner loop. The simulated result of resonant frequency and overall antenna efficiency for diode either in “ON” or “OFF” state is shown in figure 4. For the diode is in “OFF” state, the resonant frequency is at 1.8 GHz. For the diode is in “ON” state, the resonance frequency is at 2.4 GHz. The overall antenna efficiency for these two frequencies are about 90%.

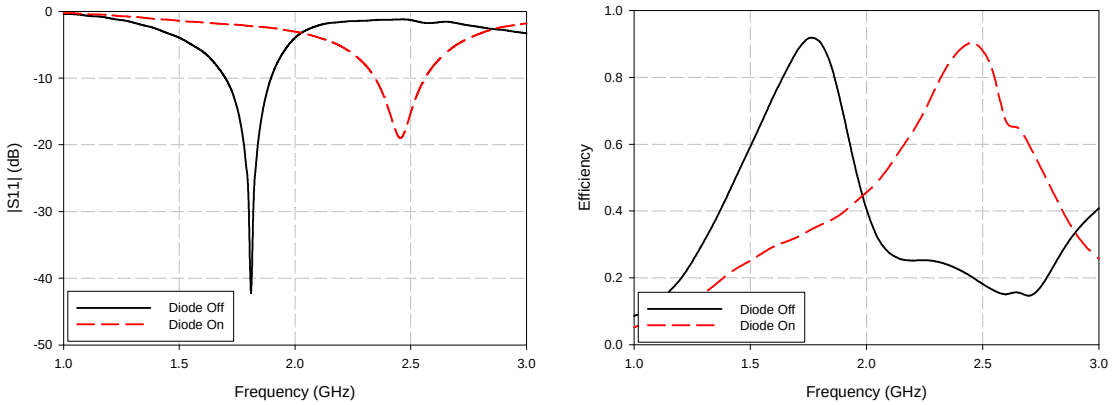
The antenna is fabricated on FR4 substrate with thickness 0.8 mm. The relative permittivity of the substrate is 4.4. The geometry of antenna hardware is shown in figure 1a. Figure 5 shows the resonance frequency and overall efficiency for diode is either in “ON” state or “OFF” state. The measured resonance frequencies are at 1.6 GHz and 2.3 GHz. The efficiency for these two frequencies is about 70%.

From both simulation and measurement, the trend of resonance frequency and overall efficiency for either diode is in “ON” state or in “OFF” state are quite agreed. The difference may be caused be the actual equivalent circuit of diode in “ON” or “OFF” state.



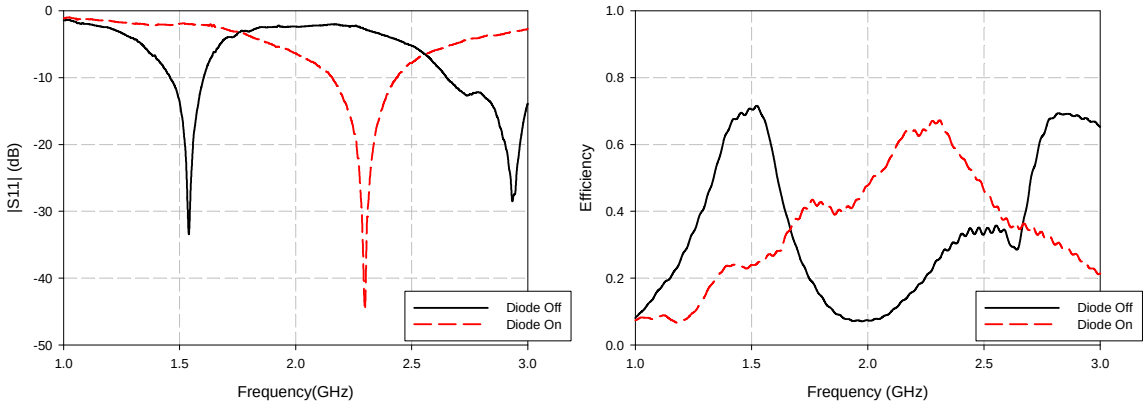
(a) (b)

Fig.3 The current distribution of the high band resonant frequency
(a) Diode in “OFF” state (b) Diode in “ON” state



(a) (b)

Fig.4 Simulation result (a) S11 (b) Overall efficiency



(a) (b)

Fig.5 Measurement result (a) S11 (b) Overall efficiency

3. Conclusion

In this article, a novel frequency reconfigurable antenna employing a tunable loop antenna has been presented. By using the characteristics of equivalent circuit of the PIN diode, the resonance of loop antenna can be reconfigurable by switching the diode either in “ON” or “OFF” state. The trend of both simulation and measurement results are agreed. This type of reconfigurable technique can be used for compact size mobile communication system for different communication purposes.

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