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Design and Analysis of a PIN diode biased Reconfigurable Antenna for Wireless Communications

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Abstract: *Using ANSYS HFSS and Circuit Design in ANSYS Electronics Desktop, A frequency bandof 1.8GHz-5.2GHz reconfigurable Planar Inverted F Antenna(PIFA) designed. Primary radiator of the antenna consists of a concertic three split-ring(SR) resonators and twelve metallic loadings. Metallic loadings are placed between the split-ring resonators. The compact design is fed by vertical probe provides independent frequency band of operations by means of integrated switches inserted between the rings. By using PIN diodes as switches the resonant frequencies can be varied by changing the mode of the switches into ON or OFF conditions.*
A band of 1.8GHz-5.2GHz frequency reconfigurable operation of antenna will be studied and demonstrated for GSM at 1.8 GHz, DCS at 1.9 GHz, WiMAX at 3.8 GHz, 2.2 GHz at LTE and WLAN at 4.6 GHz, 5.2 GHz applications.
Keywords: *Planar Inverted F antenna (PIFA), Split-ring(SR) resonators.*

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I. Introduction

In wireless communication, the design of a new compact antenna is of great demand to support multiple applications with available less space in the device. The portable antenna technology has precise features like low power consumption, improved transmission and reception, energy efficiency etc. The reconfigurable antenna is an antenna has capability of modifying dynamically its frequency and radiation properties. It has the ability to radiate more than one pattern at different frequencies and polarizations [1].

Reconfigurable antennas has many advantages over their traditional counterparts, it reduces the hardware size and cost. The reconfiguration can be achieved by switching parts of antenna structure using electronic switches, by adjusting the loading of an antenna externally and by changing the antenna geometry by mechanical movement. Switching can be achieved by means of PIN diodes [2-3].

There is a rapid development in WLAN and Bluetooth applications for fast and uninterruptable access to information. PIFA is a compact multifunction antenna which plays an important role in communication networks with high system performance. PIFA with three concentric split-ring resonators and twelve metallic loadings. These metallic loadings are placed between the rings, the conductive switches are used for the operation. Independent band performances are provided depending on the switch being in ON or OFF states. Frquency band of operation at switch ON state will be at 1.8 GHz for GSM, 2.2 GHz for LTE and 4.6 GHz for WLAN. And at switch OFF state 1.9 GHz for DCS, 3.8 GHz for WIMAX and 5.2 GHz for WLAN applications are performed using single antenna. The applications of PIFA are light weight, planar and also cost inexpensive. Ansoft HFSS V.15 is used to design a PIFA. The return loss and radiation pattern/gain results for the proposed PIN diode biased reconfigurable antenna were achieved [4-5].

II. Planar Inverted F Antenna (Pifa)

For rapid development of cellular communication an antenna which meets the requirement of a mobile phone user is very demanding. Monopole λ/2 antenna was used earlier to face these challenges. Half wavelength monopole antennas have high radiation towards user head, easy to physical damage and unable to produce multi resonance frequencies. Later monopole antenna is replaced by Planar Inverted F Antenna (PIFA). It has advantages of desired cross polarization in order to receive both horizontal and vertical polarization, easy feedig, simple to fabricate and easy to plae in mobile terminal as its size is less (λ/4).

It has less spurious radiation towards user head. Planar Inverted F antenna is a radiating element shorted at one end from patch to ground. This shorting plate makes the PIFA to resonate at λ/4. In present scenario minimum size of the antenna is challenging one. For PIFA with λ/4 resonance, same basic properties can be obtained as that of normal half wavelength patch antenna. PIFA is used as a basic antenna for the applications of GSM 850, 900, DCS 1800, PCS 1900, WLAN, WiBro, Bluetooth, UMTS, 4GLTE.

III. Proposed Split Ring Antenna

The proposed antenna is designed on Rogers RO3006(tm) dielectric substrate with dielectric constant of ε_r = 6.15. The substrate thickness is 0.64mm. The radiating top plate consists of three concentric split-ring resonators and twelve metallic loadings (s_1 – s_{12}) placed between the rings. Frequency band operation is performed using two switches. In switch off state inductance is applied to the switch one, resistance and capacitance are applied to the switch two.

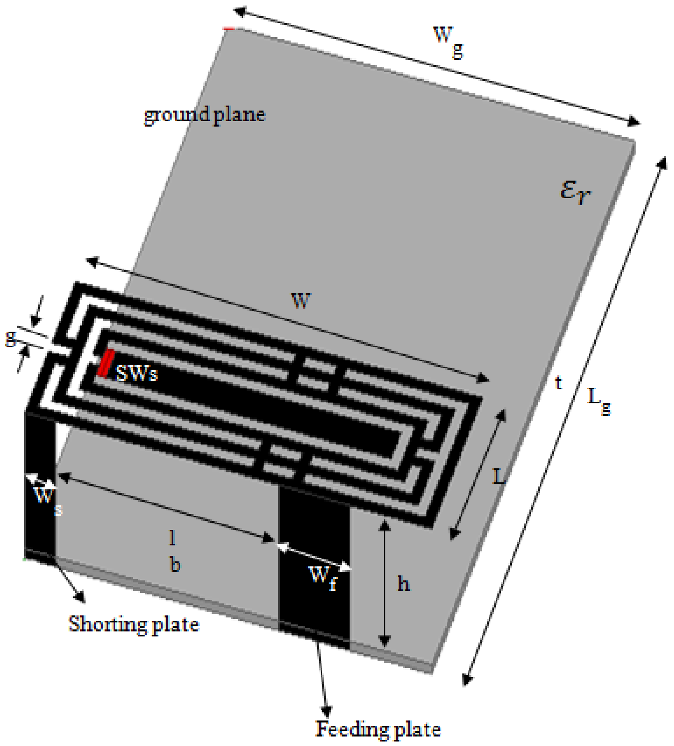


Figure.1: Design parameters of proposed antenna: W_g = 40, L_g = 60, W = 40, L = 20, w_s = 3, w_f = 7, lb = 22, g = 1, h = 10, t = 0.64, $s_1 – s_{12}$ = 1×1 (all are in mm), ε_r = 6.15

In switch ON state inductance is applied to switch one and resistance is applied to switch two.When the switch is in OFF state, a frequency band operation at 1.9GHz, 3.8GHz and 4.6GHz. On the other hand, the antenna provides frequency band performance at 1.8GHz, 2.2GHz and 5.2GHz when the switch is in ON state. Hence, the proposed antenna covers 1.9GHz for DCS, 3.8GHz for WIMAX and 5.2GHz for WLAN bands when switch is in OFF state. And 1.8GHz for GSM, 2.2GHz for LTE, 4.6GHz for WLAN bands are covered when switch in ON state. The simulated radiation pattern for reconfigurable PIFA antenna for both switch ON and OFF conditions were given below.

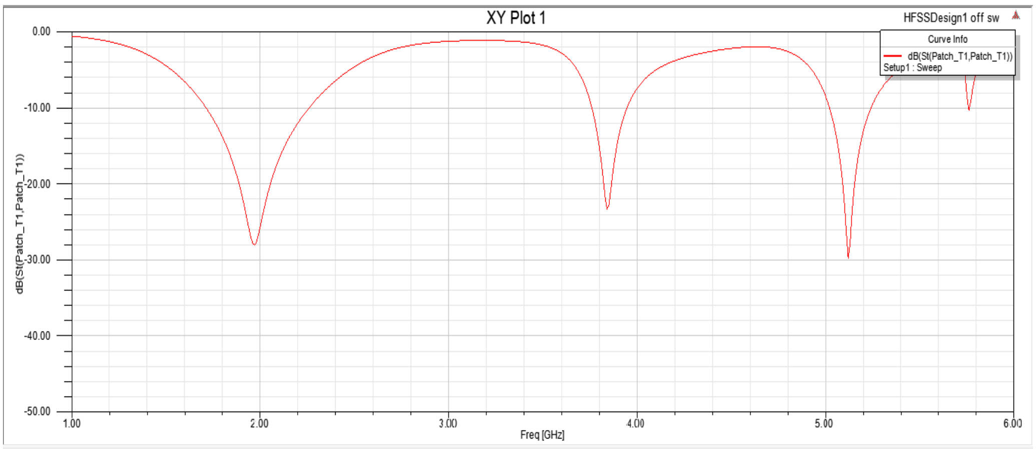


Figure.2: Return loss for proposed antenna at switch OFF state

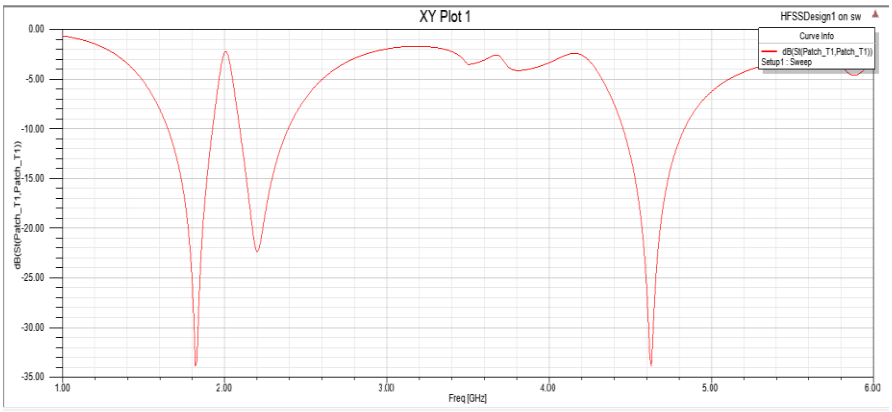
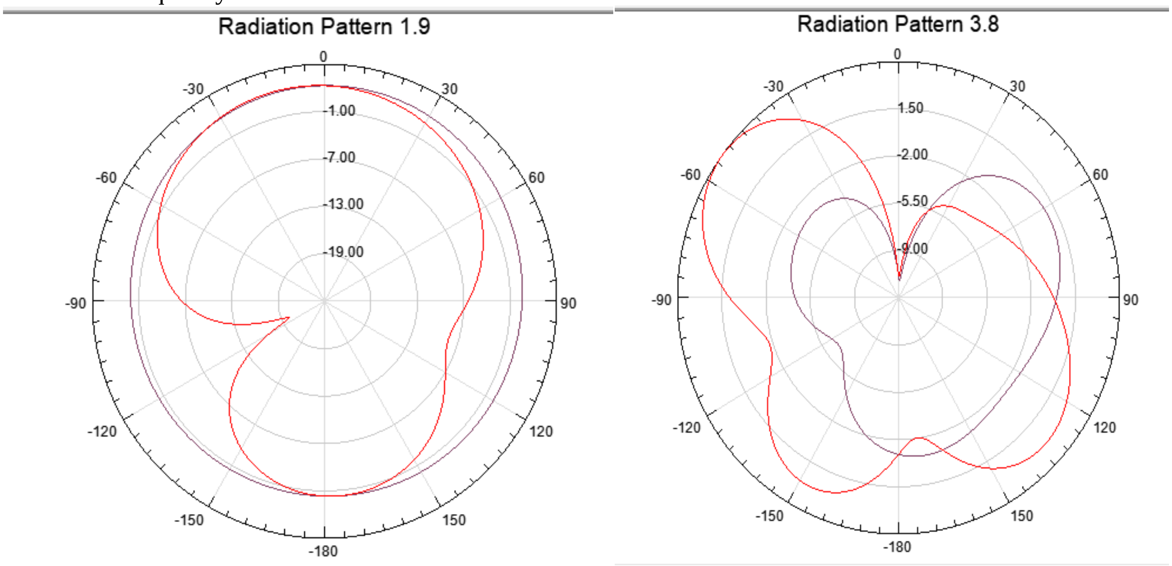
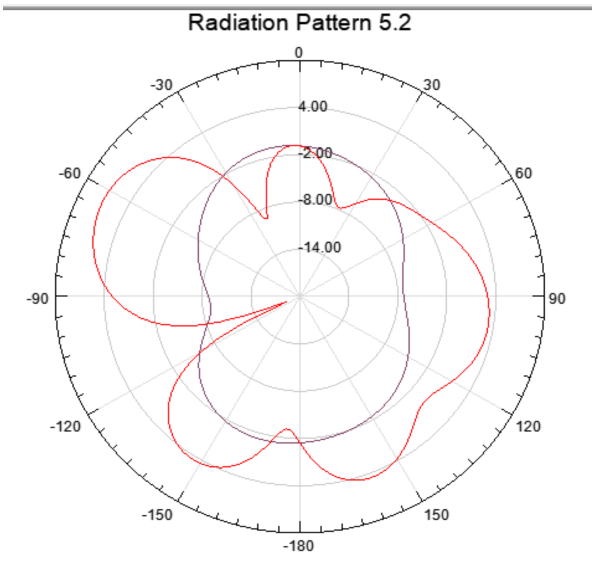


Figure.3: Return loss for proposed antenna at switch ON state

The Return loss plots for both switch OFF and switch ON conditions are obtained by taking the return loss at the X-axis and frequency at Y-axis.



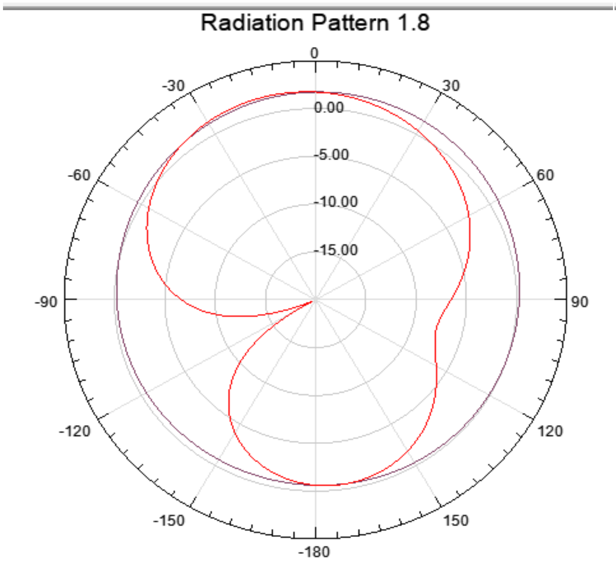
(a) (b)



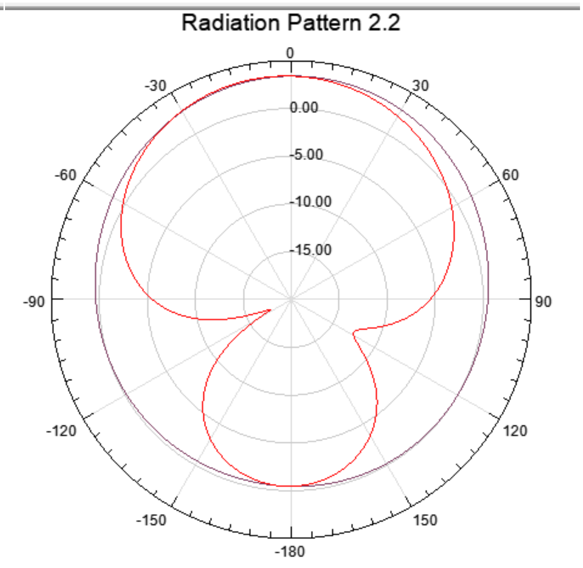
(c)

Figure.4: 2D pattern for the proposed antenna. (a) f = 1.9 GHz, (b) f = 3.8 GHz, (c) f = 5.2 GHz at switch OFF condition

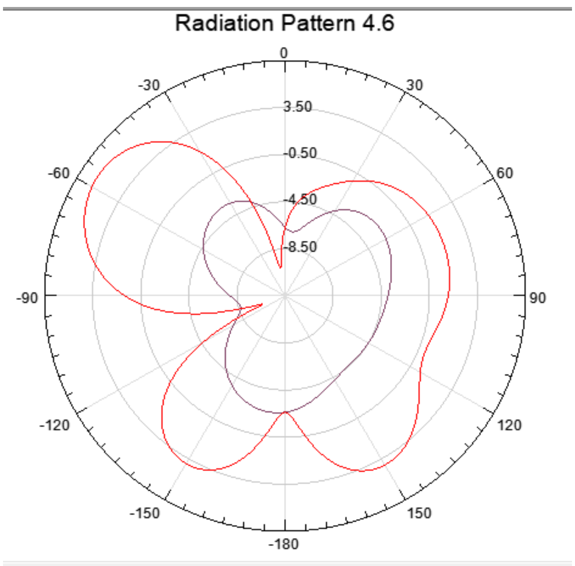
The figures show the radiation patternsat switch OFF state for the proposed antenna. The radiation pattern at 0º the plot has maximum gain 2.3502 dB and at 90º the plot has maximum gain 2.3026 dB for f = 1.9 GHz. At 0º the plot has maximum gain 4.9935 dB and at 90º the plot has maximum gain 0.8231 dB for f = 3.8 GHz. At 0º the plot has maximum gain 6.9975 dB and at 90º the plot has maximum gain -0.7857 dB for f = 5.2 GHz.Thus the maximum gain values are obtained at frequencies of switch OFF state in the radiation pattern plots.



(a)



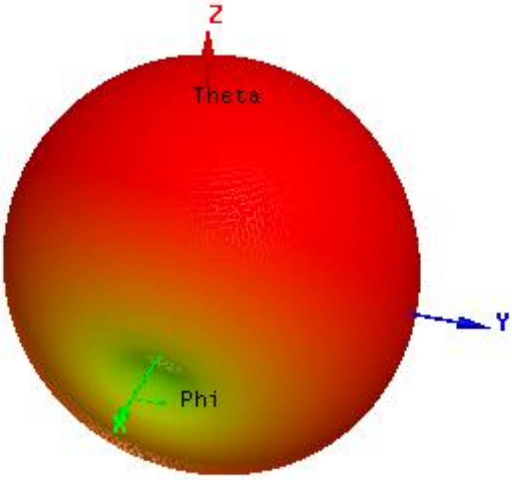
(b)



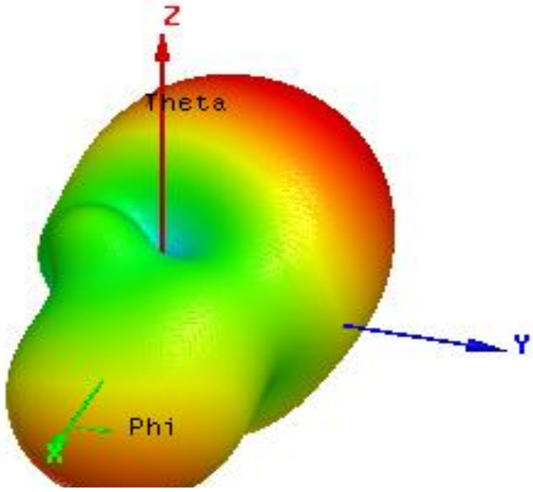
(c)

Figure.5: 2D pattern for the proposed antenna. (a) f = 1.8 GHz, (b) f = 2.2 GHz, (c) f = 4.6 GHz at switch ON condition

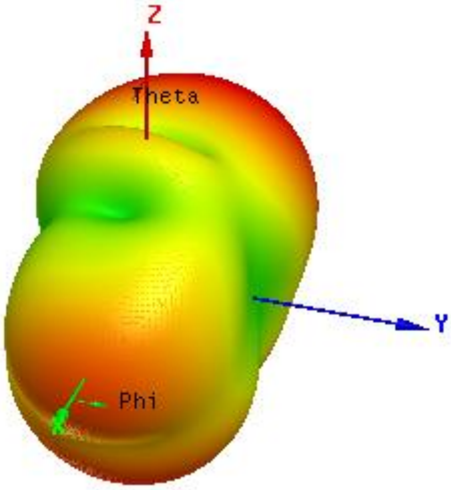
The figures show the radiation patterns at switch ON state for the proposed antenna. The radiation pattern at 0º the plot has maximum gain 1.8238 dB and at 90º the plot has maximum gain 1.7435 dB for f = 1.8 GHz. At 0º the plot has maximum gain 3.4124 dB and at 90º the plot has maximum gain 3.3885 dB for f = 2.2 GHz. At 0º the plot has maximum gain 6.0873 and at 90º the plot has maximum gain -2.5412 dB for f = 4.6 GHz. Thus the maximum gain values are obtained at frequencies of switch ON state in the radiation pattern plots.



(a)

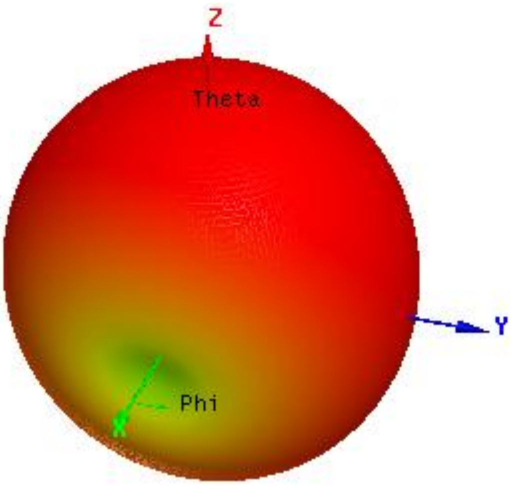


(b)

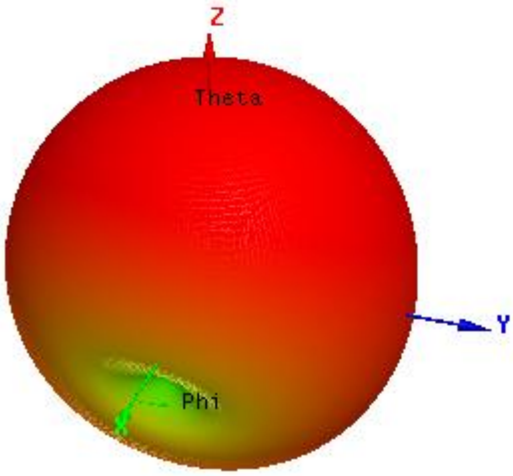


(c)

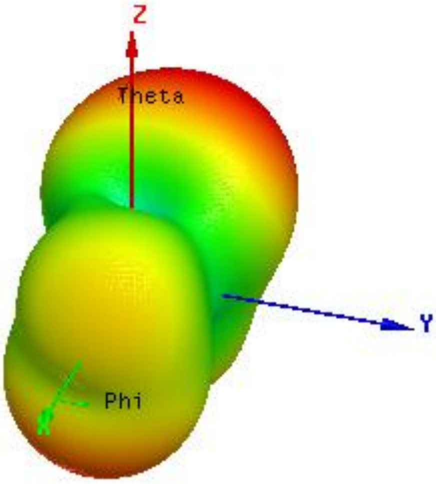
Figure.6: 3D polar plots for the proposed antenna. (a) f = 1.9 GHz, (b) f = 3.8 GHz, (c) f = 5.2GHz at switch OFF condition



(a)



(b)



(c)

Figure.7: 3D polar plots for the proposed antenna. (a) f = 1.8 GHz, (b) f = 2.2 GHz, (c) f = 4.6 GHz at switch ON condition

These are the 3D polar plots obtained for both switch OFF state and switch ON state at different frequencies.

IV. Conclusion

The frequency band of 1.8GHz -5.2GHz reconfigurable planar inverted F antenna is designed by using ANSOFT HFSS. The frequency reconfigurable PIFA with three split rings and twelve metallic loadings and two switches are provided to cover different band of frequencies at both switch ON and OFF conditions, radiation pattern and gain performance were achieved at 1.8GHz for GSM, 2.2GHz for LTE and 4.6GHz for WLAN applications in switch ON condition. Similarly 1.9GHz for DCS, 3.8GHz for WIMAX and 5.2GHz for WLAN applications are achieved in switch OFF condition respectively.

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