# A Frequency Reconfigurable PIFA Design for Wireless Communication Applications

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**Abstract**— A novel design of dual-band reconfigurable Planar Inverted F Antenna (PIFA) is proposed in the paper. Primary radiator of the antenna consists of concentric split-ring (SR)resonators and metallic loadings appropriately placed between the rings. The compact design fed by vertical probe provides two independent dual-band operations by means of an integrated switch inserted between the rings. Dual-band reconfigurable operation of antenna is studied and demonstrated for GPS at 1.575 GHz, DCS at 1.8 GHz, WiMAX at 3.5 GHz and WLAN at 5.2 GHz applications. Also, the proposed design exhibits uniform radiation patterns at the frequency band of interests. Analysis and design of the antenna is carried out Ansoft HFSS v.13.

## 1. INTRODUCTION

Reconfigurable antennas, with the ability to radiate more than one pattern at different frequencies and polarizations, are necessary in modern wireless telecommunication systems. Compared to conventional wideband antennas that can cover multiple communications bands, reconfigurable antennas have become an important and desired feature of modern, agile, radio-frequency systems for wireless communications, sensing, and imaging. In addition, they provide much needed agility to dynamically tune into sub-bands for improved noise, crosstalk, and jamming suppression without using external filters, thus also reducing the size, cost, and power requirements of wireless mobile devices. Thus, various types of reconfigurable antenna design have been proposed in the literature [1–4].

In this paper, we propose a novel frequency reconfigurable PIFA design based on printed split-ring elements. As it well known, PIFA is evolved from a quarter-wavelength monopole antenna and is now widely used in mobile and portable applications due to its simple design, lightweight, low cost, conformal nature, attractive radiation pattern, and reliable performance [5, 6]. On the other hand, split-ring resonators were introduced as the building blocks of metamaterial structures and they were utilized in various electrically small antenna designs [7–9] thanks to their resonant behavior. The proposed antenna in this study has typically PIFA structure and primary radiator of the antenna consists of two concentric split-ring resonators and six metallic loadings appropriately placed between the rings as depicted in Fig. 1. The antenna is fed by a current-probe placed in between the feeding plate and the ground plane in the simulations. In addition, a conductive switch standing for SW in Fig. 1, implemented as a small metallic pad in the numerical design, is integrated between a straight patch and inner split-ring element. The proposed design provides two independent dual-band performances depending on the switch being in ON or OFF states. When the switch is ON state, the antenna provides a dual-band performance at 1.8 GHz and 5.2 GHz. On the other hand, a dual band operation at 1.75 GHz and 3.65 GHz is achieved when the switch is OFF state. Analysis and design of the antenna is carried out by means of Ansoft HFFS v.13. Here, we present predicted return loss and radiation pattern/gain results for the proposed frequency reconfigurable antenna while the actual antenna performance is going to be discussed in the conference.

## 2. FREQUENCY RECONFIGURABLE SPLIT RING PIFA DESIGN

The proposed design with novel configuration is depicted in Fig. 1. As seen, the antenna is fabricated on the Rogers RO3006(tm) substrate with 0.64 mm thickness and dielectric constant of $\varepsilon_r = 6.15$. The radiating top plate consists of two concentric split-ring elements and six metallic loadings ($s_1$–$s_6$) appropriately placed between the rings. The antenna height is 10 mm, and the space between the top plate and the substrate is filled with air. The shorting plate has dimensions of 3 mm, and the feed plate has dimensions of 7 mm. The shorting plate is placed under the top corner of the top plate. The horizontal distance between shorting and feed plates is 22 mm. The proposed antenna is fed by a current-probe placed between the feeding plate and the ground plane in the simulations.

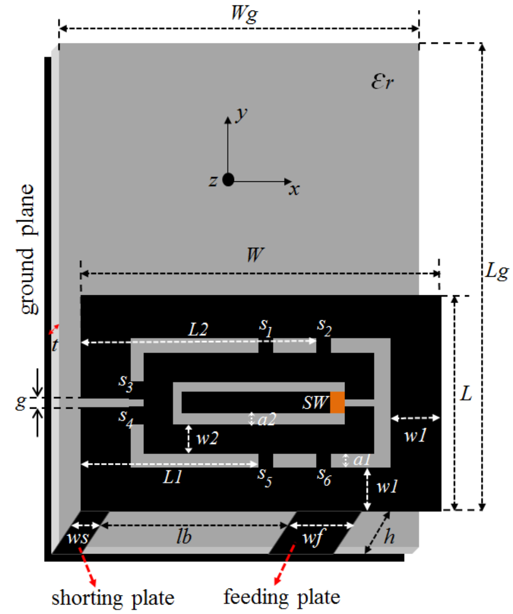


Figure 1: Configuration of proposed antenna with its design parameters: $W_g = 40$, $L_g = 60$, $W = 40$, $L = 20$, $w_1 = 4$, $w_2 = 3$, $w_s = 3$, $w_f = 7$, $lb = 22$, $a = 1$, $g = 1$, $h = 10$, $L1 = 22$, $L2 = 26$, $t = 0.64$, $S_1 - S_6 = 1 \times 1$ (all in mm), $\varepsilon_r = 6.15$.

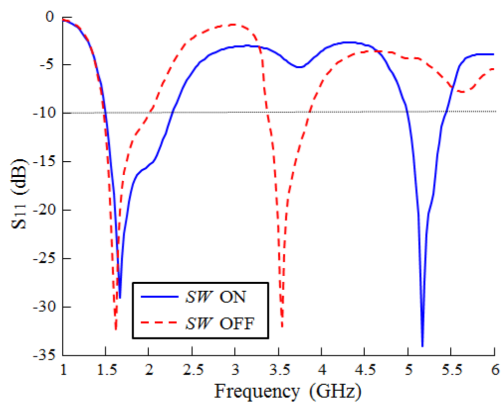


Figure 2: Return loss of the dual-mode SR-PIFA.

In addition, a conductive switch, implemented as a small metallic pad in the numerical design, is integrated into astraight patch and inner split-ring element.

Computed return loss characteristic of the proposed antenna is shown in Fig. 2 for the two states of the switch ($SW$). When the switch is in OFF state, a dual band operation at 1.75 GHz and 3.65 GHz with 28% and 18% bandwidths, respectively is achieved. On the other hand, the antenna provides a dual band performance at 1.85 GHZ and 5.2 GHz with 38% and 8% bandwidths, respectively when the switch is the ON state. Hence, the proposes antenna covers 1.575 GHz GPS/1.8 GHz DCS/5.2 GHz WLAN bands or 1.575 GHz GPS/3.5 GHz WiMAX bands depending on switch being in ON or OFF state, respectively.

The simulated radiation patterns on the $y$-$z$ plane and $x$-$y$ plane of the SR-PIFA design for OFF and ON statuses of the switch at 1.5 GHz, OFF state of the switch at 3.5 GHz and ON state of the switch at 5.2 GHz are shown in Figs. 3(a), (b), (c) and (d), respectively.As seen, the SR-PIFA exhibits relatively uniform radiation pattern at the desired frequency bands. Computed realized antenna gains of the antenna in the $H$-plane are also displayed in Fig. 4. As seen, when the switch is OFF state, the predicted gain at 1.5 GHz and 3.5 GHz are about 3 and 1 dBi, respectively. When the diode is ON state, the gain at the frequencies 1.5 GHz and 5.2 GHz are about 6 and 7 dBi, respectively

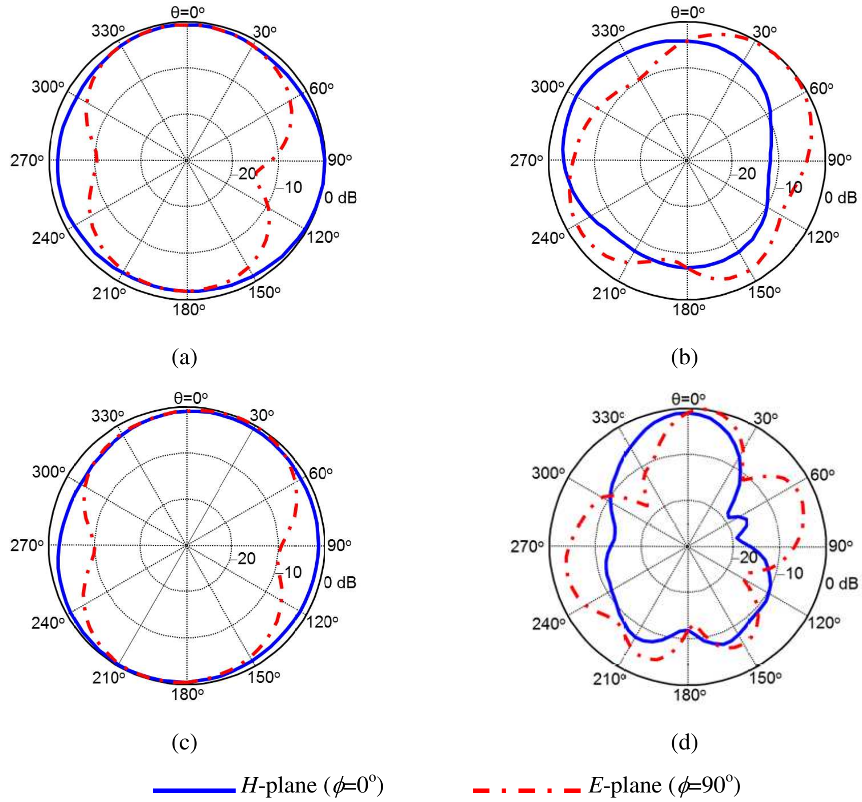


Figure 3: Radiation patterns of the proposed antenna. (a) $f = 1.5$ GHz, switch OFF, (b) $f = 3.5$ GHz, switch OFF, (c) $f = 1.5$ GHz, switch ON, (d) $f = 5.2$ GHz, switch ON.

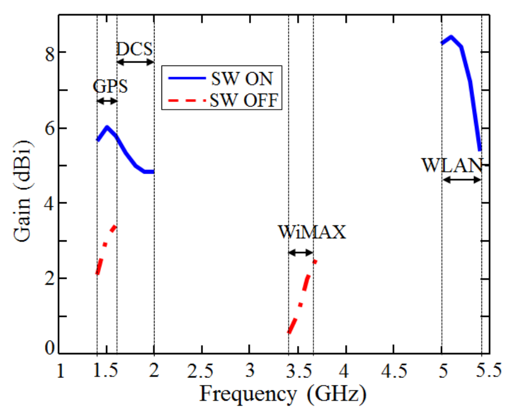


Figure 4: Predicted realized gain of the proposed antenna for frequency across.

## 3. CONCLUSION

We presented a novel frequency reconfigurable PIFA for wireless communication applications. In order to keep the antenna size small, two concentric split ring resonators are used as main radiator of the proposed antenna. The antenna provides either a dual band operation at 1.5/3.5 GHz or dual-band coverage of the 1.5 GHz and 5.2 GHz bands by means of an integrated switch placed between one of the split ring elements and the microstrip line being between the inner rings. In addition, a good radiation pattern as well as gain performance is achieved for the frequency bands considered.

## ACKNOWLEDGMENT

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