Frequency Tunable PIFA Design Based on Meander Line Elements

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Burcin Ramazan[1], and S. Cumhur Basaran[2]

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[1,2]Akdeniz University, Department of Electrical-Electronics Engineering, 07058 Antalya, Turkey

burcinrmzn@gmail.com, cbasaran@akdeniz.edu.tr

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Abstract

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A novel design of dual-band frequency tunable Planar Inverted F Antenna (PIFA) is proposed in the paper. Primary radiator of the antenna consists of unsymmetrical meander line (ML) elements. The compact design fed by vertical probe provides two independent operations by means of an integrated switch inserted between two meander lines. Frequency tunable operation of antenna is studied and demonstrated for WLAN at 2.4/5.2 GHz and WiMAX at 2.6 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.15.

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1. Introduction

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Reconfiguring an antenna is achieved through deliberately changing its frequency, polarization, or radiation characteristics. 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 bandwidth, changes in operating frequency, polarization, and radiation pattern). Reconfigurability has become an important and desired feature of modern, agile, radio-frequency (RF) systems for wireless and satellite communications, sensing, and imaging. There is a shift toward incorporating smart, cognitive, and agile RF devices that can both sense the surrounding RF environment and communicate at the same time in any contested/congested environment. Some of the new desired capabilities include frequency-agile, software defined, and cognitive radios to cope with extendable and reconfigurable multiservice, multistandard, and multiband operation, as well as with efficient spectrum and power utilization. These concepts can significantly reduce the number of components and thus hardware complexity, and cost compared to today's radio technology, which relies on incompatible communications systems with inflexible hardware [1]. Within this context, various types of reconfigurable and tunable antenna design have been proposed in the literature [2–5].

In this paper, we propose a novel frequency tunable PIFA design based on printed meander line elements. Since PIFA designs derived from a quarter-wave half-patch antenna are resonant at a quarter-wavelength, they are electrically smaller than typical patch antennas. On the other hand, meander line radiator itself occupies a very small volume, it can make whole dimensions of a typical patch antenna reduce. That's why, meander line chip monopole antenna [6], as well as compact modified pentaband meander line (ML) antenna [7] was also investigated to achieve miniature antenna design having multiband or wideband operation. The proposed antenna design is typical PIFA configuration and primary radiator of the design consists of unsymmetrical ML elements as seen in Fig.1. The tunable meander line (TML) antenna is fed 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 meander line elements. The proposed design provides two independent operations depending on the switch being in ON or OFF states. When the switch is ON state, the antenna provides a dual-band performance at 2.4 GHz and 5.2 GHz WLAN bands. On the other hand, a single wideband operation at 2.8 GHz WiMAX band achieved when the switch is OFF state. Analysis and design of the antenna is carried out by means of Ansoft HFFS v.15. Here, we present predicted return loss and radiation pattern/gain results for the proposed TML-PIFA. The actual antenna performance is going to be discussed in the conference.

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2. Tunable Meander Line PIFA Design

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The proposed design with novel configuration is depicted in Fig.1.

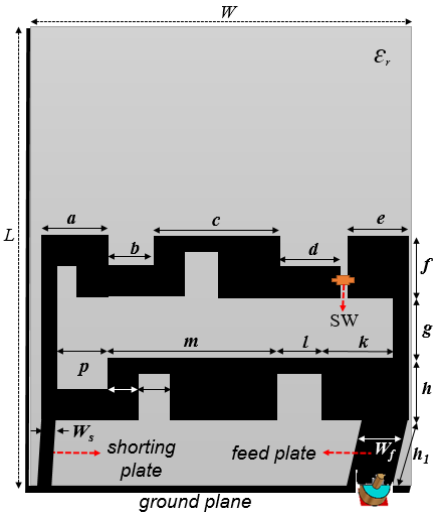


Fig. 1. Configuration of proposed TML-PIFA with its design parameters

A series of parametric studies were carried out to achieve desired antenna performance, particularly for tuning the resonant frequencies and return loss characteristics. In this design process, substrate's thickness and permittivity, dimensions of the meander line elements, position and

dimensions of the shorting pin and the feed-line were varied. The proposed design is performed with a commercial electromagnetic tool, namely Ansoft HFSS v.15, and the final dimensions are achieved as follows: *W=25, L=30, Ws=1,Wf=4, a=5, b=3, c=8, d=3.6, e=5, f=g=h=p=4, k=5, l=3, m=7, h1=10, h2=8.36*, h_g=0.76 (all in mm), ε_r=6.15.

The antenna in Fig.1 is fabricated on the Rogers RO3006(tm) substrate with 0.64mm thickness and dielectric constant of εr=6.15. Radiating top plate consists of unsymmetrical meander line elements. The antenna height is 10mm, and the space between the top plate and the substrate is filled with air. While the shorting plate width dimension is 3mm, width of feed plate dimension is 4mm.The shorting plate is placed under the top corner of the top plate. The horizontal distance between shorting and feed plates is 20mm. The proposed antenna is fed by a current-probe placed in the feeding plate in the simulations. In addition, a conductive switch, implemented as a small metallic pad in the numerical design, is integrated into meander line elements.

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 ON state, a dual band operation at 2.47 GHZ and 5.2 GHz with 6% bandwidths of the both bands is achieved. On the other hand, when the switch is the OFF state, the antenna provides a single band performance at 2.95 GHz with 24% bandwidth.

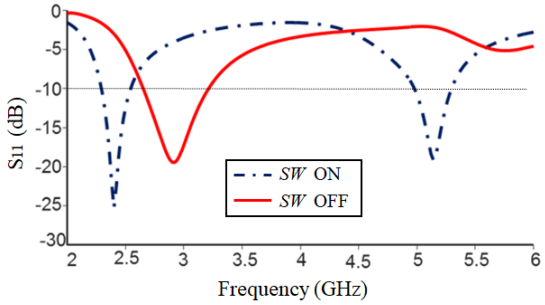
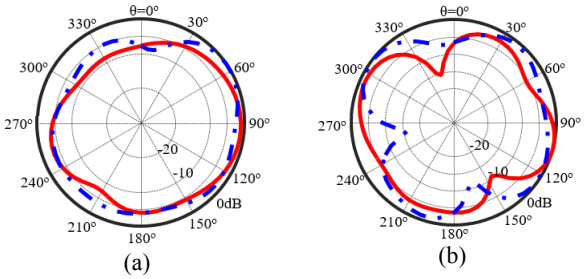


Fig. 2. Return loss of the dual-mode -PIFA

The simulated radiation patterns on the *E*- plane and *H*- plane of the TML-PIFA design for ON status of the switch at 2.4 GHz and 5.2 GHz, OFF state of the switch at 2.7 GHz are shown in Fig. 3(a), (b), (c), respectively. As seen, the TML-PIFA exhibits relatively uniform radiation pattern at the desired frequency bands.



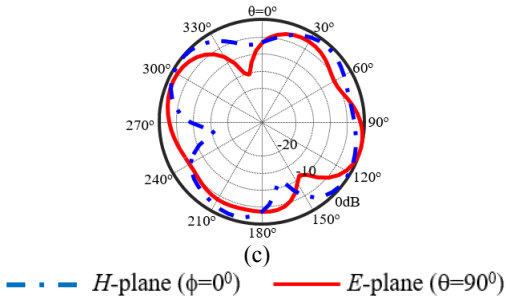


Fig. 3. Radiation patterns of the proposed antenna. (a) *f*=2.4 GHz, switch ON (b) *f*=5.2 GHz, switch ON (c) *f*=2.7 GHz, switch OFF.

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3. Conclusions

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We presented a novel frequency tunable PIFA for WLAN and WiMAX applications. In order to keep the antenna size small, unsymmetrical meander line resonator is used as main radiator of the proposed antenna. The antenna provides either a dual band operation at 2.4/5.2 GHz WLAN bands or single band coverage of the 2.6 GHz WiMAX band by means of an integrated switch appropriately placed between two meander line elements. In addition, a good radiation pattern as well as gain performance is achieved for the frequency bands considered.

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4. References

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