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Compact Fork-shaped Monopole Antenna for Bluetooth, WLAN and Wi-MAX Applications

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Abstract

This paper presents a fork-shaped monopole antenna (FSMA) with compact size. The proposed FSMA consisting a fork-shaped radiator and a partial ground plane with L-shaped and rectangular slits. The size of the proposed FSMA is 34 × 18 × 1.6 mm^3 which is fed by 50Ω microstrip line. The L-shaped slit is introduced in the ground plane to enhance the bandwidth impedance of the proposed FSMA. The proposed antenna achieved 10 dB return loss bandwidth of 120% (1.97–7.90) GHz with stable radiation pattern. The obtained result shows that proposed antenna is suitable for wide band applications like WLAN, Wi-MAX, Bluetooth and ISM band.

Keywords: Bluetooth, monopole antenna, rectangular ring, WLAN, WiMAX

INTRODUCTION

The rapid development in wireless communications system, the requirement of wide band antennas that support different technologies is also increasing rapidly. In satellite communication, in air crafts or in missile application wherever mass heaviness, volume, and budget performances are most essential for antennas [1]. Technologies such as WLAN and WiMAX are used in wireless networking systems. The WLAN is required to transfer data from one point to another without cables and it uses in infrared radio and microwaves for transmission.

Printed monopole antennas (PMAs) are good for broadband wireless technology due to their wide impedance bandwidth. PMA has radiation pattern identical to that of dipole antenna and they are truly planner. These antennas are commonly manufactured on the FR4 epoxy substrate and it is cost effective. PMAs are preferably suited for wide band technology based low cost system. The characteristic features of PMAs have low value, light weight, less fragile, low profile and easy manufacturing apart from the compact size [2].

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There are several antennas [2–7] which are supposed for wide band applications such as, according to Li et al. [2], a triple band monopole antenna is satisfying the necessity of LAN and Wi-MAX applications. According to Prasanna et al. [1], T-shaped monopole antenna is proposed which is excited by 50Ω inset feed techniques on FR4 substrate which is applicable for WLAN, the obtained S parameter of the antenna is 2.256–2.656 GHz**.** According to Sharma et al. [3], monopole antenna is designed with *L*-shaped radiating patch and it operates over a bandwidth of 250–850 MHz. Further, a monopole antenna [4] with square patch is proposed and achieved a frequency range of 2.89–11.43 GHz. As per Kamma et al. [5], the antenna with dual split ring slots is proposed and the

bandwidth range of the proposed split ring antenna is in the range up to 5.1–5.8 GHz. The directional monopole antenna presented by Golezani et al. [6] having parabolic shape ground plane is proposed and it covers 4–9 GHz bandwidth range. According to Dissanayake et al. [7], a printed monopole antenna with partial ground plane is proposed which have VSWR<2 and impedance bandwidth in the range up to 2–7 GHz.

A compact fork-shaped monopole antenna is presented in this paper, which consists a fork shaped radiating patch with partial ground plane having *L*-shaped and rectangular slits. The proposed FSMA is excited by 50Ω microstrip line and fabricated on the substrate that's FR4 (glass epoxy) with relative permittivity (ε_r) of 4.4. In this proposed design, an *L*-shaped slit is inserted into the ground to enhance the 10 dB return loss (RL) bandwidth of proposed FSMA. The FSMA is simulated with the help of Ansys Electronics Desktop 3D EM wave simulator.

Antenna Design

Figure 1 depicts the layout of the optimized design of proposed FSMA. The proposed design comprises a fork-shaped radiator and ground with L shaped and rectangular slits which is excited by 50Ω microstrip line that is connected with the compact radiator. The proposed antenna of size as 18 × 34 × 1.6 mm^3 and is fabricated on the substrate that's FR4 epoxy and having relative permittivity (ε_r) of 4.4, loss tangent of 0.02 and thickness (*h)* = 1.6.

The design evolution of the proposed FSMA is depicted in Figure 2, and their simulated reflection coefficient $|S_{11}|$ is represented in Figure 3. Antenna 1 is a fork-shaped monopole antenna with partial ground plane is taken by Li et al. [2] which operated in three bands are as 2.4–2.71 GHz, 3.32–3.72 GHz and 4.96–5.32 GHz, respectively. Then, a horizontal rectangular slit is inserted in the ground plane as shown in Antenna 2 due to which the proposed antenna achieved a single wide band of bandwidth 114% in frequency range 1.90–7.02 GHz. In Antenna 3, a vertical slit is introduced and form a *L*-shaped slit, which enhance the impedance bandwidth up to 120% (1.97–7.90 GHz).

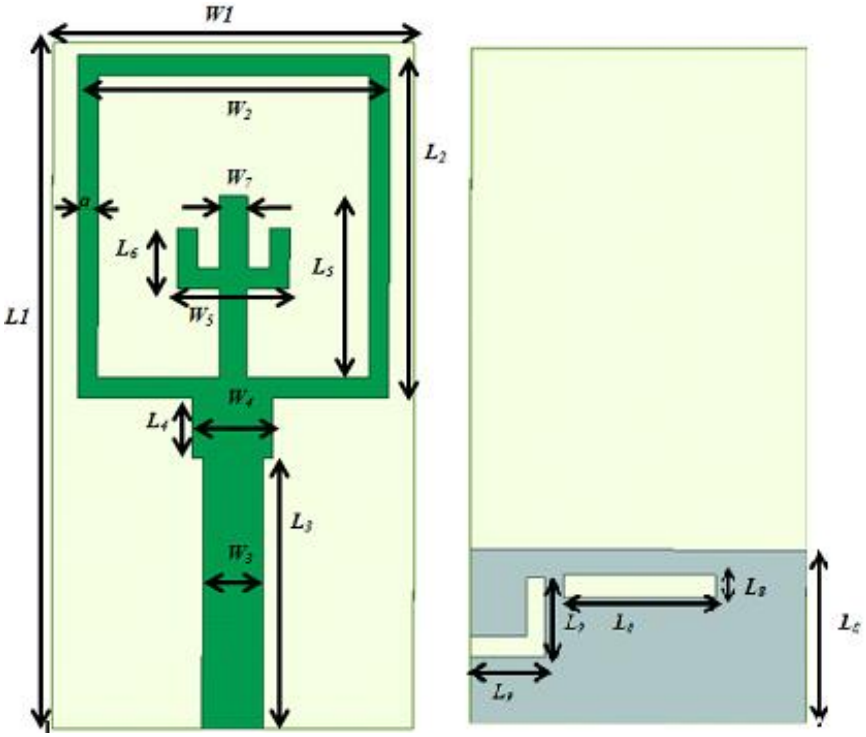


Figure 1. Layout of the optimized design of proposed FSMA: (L_1 = 34, L_2 = 1, L_3 = 13, L_4 = 3, L_5 = 9, L_6 = 2, L_8 = 1.2, L_9 =4, *Ls* = 8.2, *h* = 1.6, W_1 = 18, W_2 = 15.4, W_3 = 3, W_4 = 4, W_5 = 5.6, W_7 = 1.4, W_8 = 8.2, W_9 = 4, *a* = 1, units: mm).

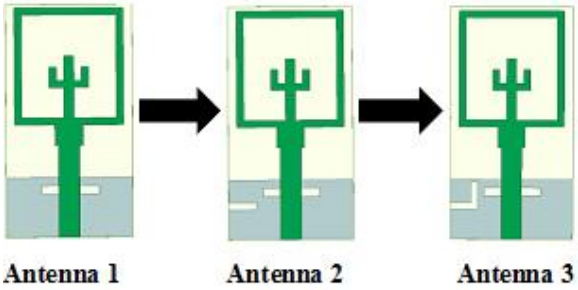


Figure 2. Evolution steps of the proposed FSMA.

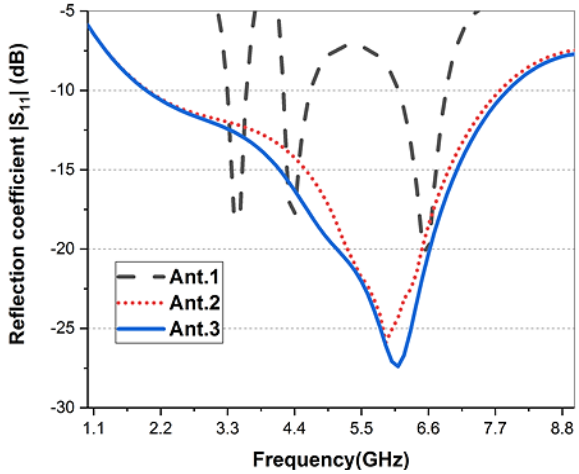


Figure 3. Simulated $|S_{11}|$ of evolution antennas.

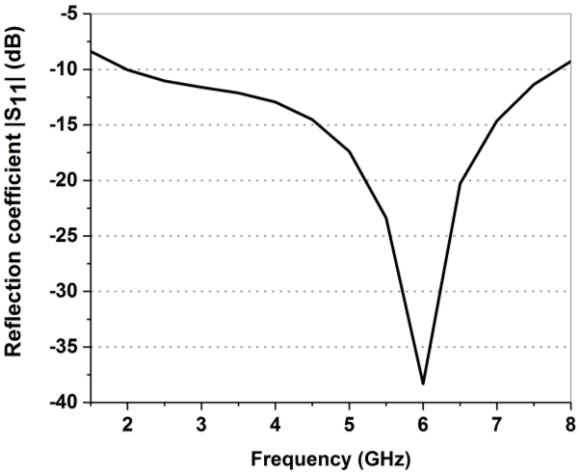


Figure 4. Simulated Reflection Coefficient in dB of the proposed FSMA.

RESULTS AND DISCUSSIONS

The simulated characteristic of reflection coefficient |S11| dB of the fork-shaped monopole antenna is shown as Figure 4. The proposed FSMA radiate with -10 dB impedance bandwidth of 120% over the frequency range of 1.97–7.90 GHz. The observed -10 dB impedance bandwidth shows that the proposed FSMA is suitable for Bluetooth, WLAN and Wi-MAX, ISM band applications.

To understand the radiation phenomenon of this proposed FSMA, a surface current distribution at frequency 6 GHz is shown in Figure 5. The surface current distribution of FSMA shows that the maximum current is concentrated in the feed of the radiating patch and it is near about the *L*-shaped slit.

The simulated radiation characteristics (*yz*-plane and *xz*-plane) of the proposed FSMA at 2.45, 3.6, 5.8, and 6 GHz on respectively are shown in Figure 6, which shows that the copolar of E-plane is seems almost bi-directional pattern and the levels of cross-polar is less than 20 dB whereas the copolar of H-plane is seems almost omnidirectional pattern and the levels of cross-polar is less than 20 dB in entire band. The observed result shows that the proposed FSMA is well suited for applications such as WLAN, Wi-MAX, Bluetooth and ISM band.

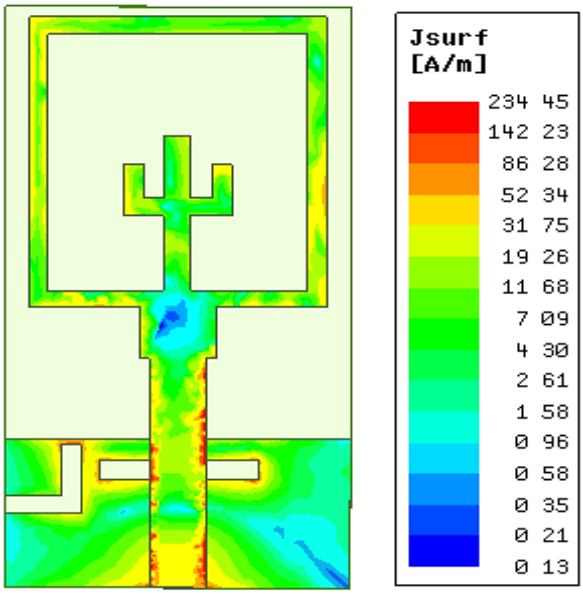
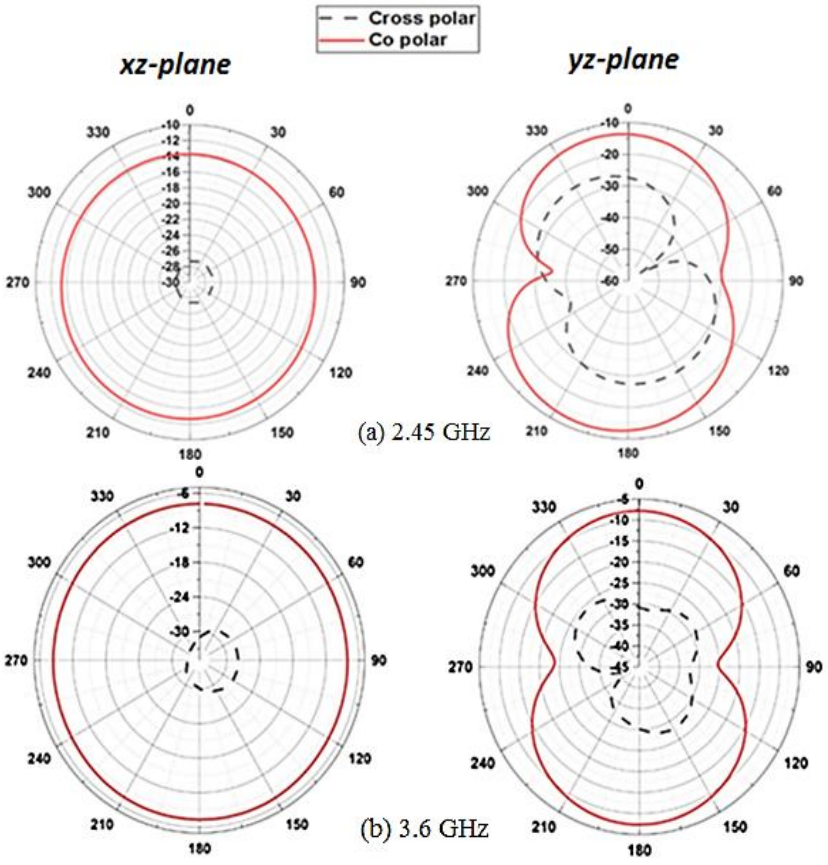


Figure 5. The simulated surface current distribution on the feed line of proposed FSMA at 6 GHz.



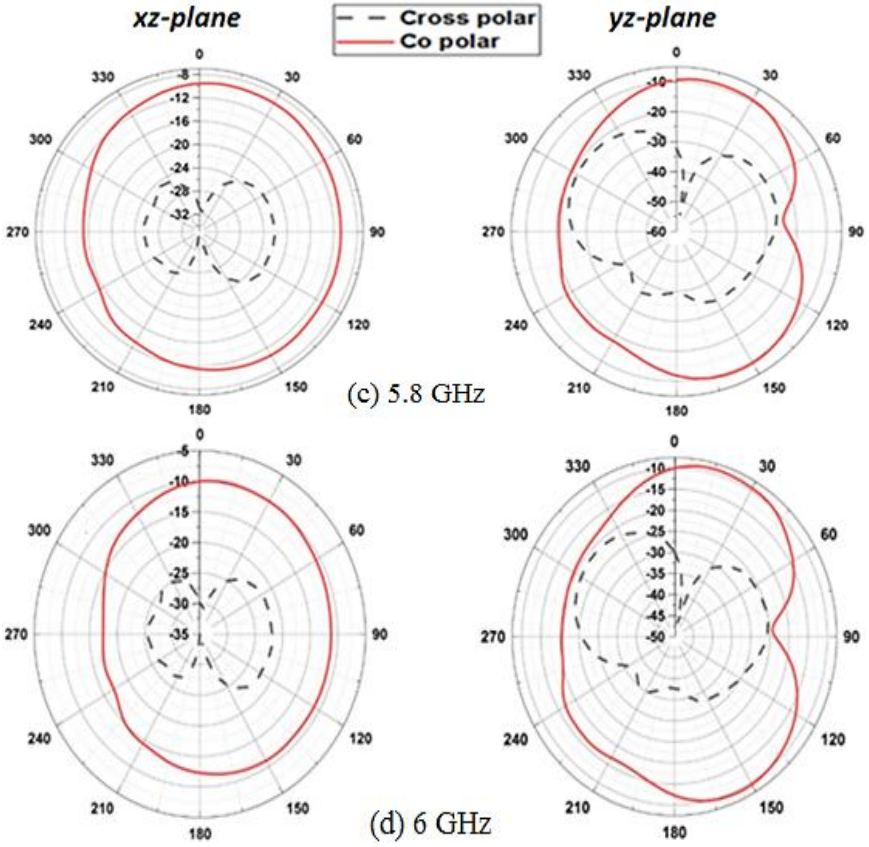


Figure 6. Simulated radiation patterns (*yz*-plane and *xz*-plane) of proposed FSMA.

CONCLUSION

A low profile fork-shaped antenna is designed and proposed for wide band characteristics are presented in this paper. The proposed FSMA constitute a compact fork-shaped radiating patch and a defected ground plane with *L*-shaped and rectangular slits. The *L*-shaped slit is introduced to enhance the -10 dB impedance bandwidth of the proposed antenna due to which the proposed FSMA radiate with 10 dB return loss bandwidth of 120% in frequency range 1.97–7.90 GHz with stable radiation pattern. The proposed FSMA is compact in size and it is easy to fabricate. All these characteristics make an antenna well suited for applications like WLAN/WiMAX as well as Bluetooth.

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