A Compact Triple-Band Fork-Shaped Printed Slot Antenna for GSM, Bluetooth and UWB Applications

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***Abstract*—A Compact triple-band fork-shaped printed slot antenna for GSM, Bluetooth and UWB Applications is proposed. Triple-band operations covering the UWB frequency range (3.1–10.6 GHz), GSM band, at frequencies of 1.8 GHz, and Bluetooth band, at frequencies of 2.4 GHz, are obtained by creating quarter-wavelength stubs in the ground plane of fork shaped printed slot antenna. The proposed antenna is fabricated on FR4 substrate and measured results are presented and discussed. The antenna has a compact size, 35×35×1.6 mm^3, stable radiation pattern and return loss of better than 10 dB over the whole of the triple bands.**

Keywords-Multiband; printed slot antenna; ultrawideband (UWB)

I. Introduction

Due to rapid development of wireless communication systems, the design of ultrawideband (UWB), dual-band, and multiband antennas are desirable. Printed antennas are good candidates for being used in these systems because of wide impedance bandwidth, omnidirectional radiation pattern, low cost, and ease of fabrication. Among planar printed antennas, printed slot antenna is one of the most suitable candidates for UWB applications. Design of a small-size printed slot antenna that covers the UWB frequency band and also be suitable for use with portable communication systems is highly desirable. Several papers have been reported [1]-[4] that have used different shapes of printed microstrip-fed wide slot antennas to obtain UWB performance.

Recently, adding an extra Bluetooth band to a UWB printed antenna is desirable. In the literature, few works have been reported UWB antenna with added Bluetooth band such as adding a narrow L-shaped strip to the middle part of a UWB printed monopole [5], attaching quarter-wavelength strip to the high concentrated current area in the ground plane [3], adding T-shaped resonance path to the base U-shaped patch [4], and fork shaped monopole antenna [6]. However In [3]-[6], only a single frequency band is added to the UWB antenna.

In this paper, a compact triple-band printed slot antenna suitable for GSM, Bluetooth, and UWB applications is proposed. Two extra resonant bands are obtained by removing a section from the ground and in effect creating two elliptic-shaped stubs in the ground plane. The elliptic-shaped stubs are of quarter-wavelength and act independent of each other.

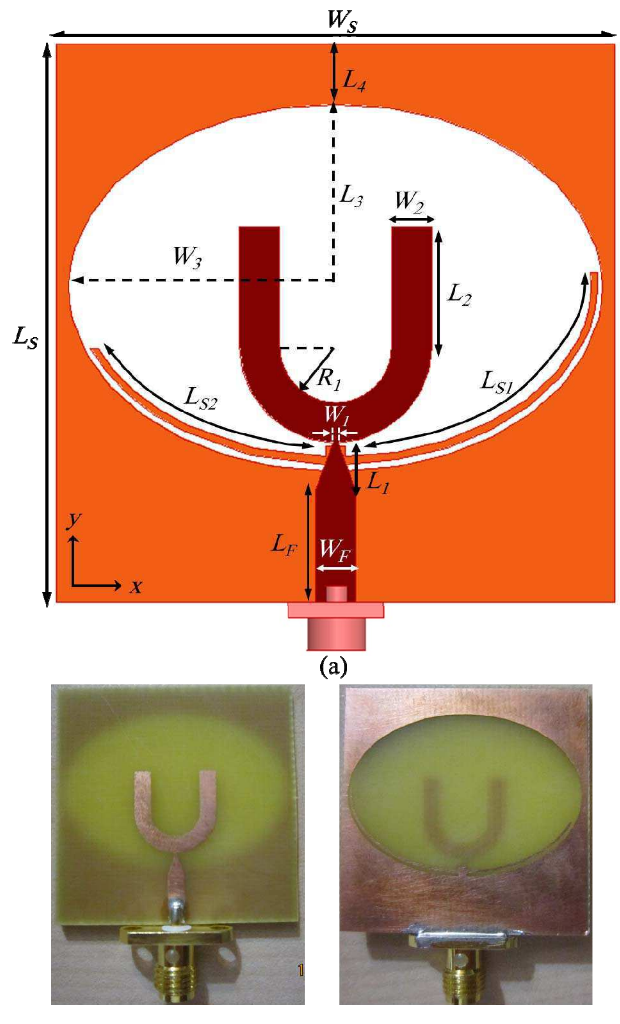

Fig. 1. Configuration of the proposed triple-band printed slot antenna. (a) dimensions, (b), and (c) the fabricated antenna at top and bottom layer, respectively.

The simulation results are carried out using a commercially available software package HFSS, and the measured results are presented and discussed.

II. ANTENNA DESIGN

The geometry of the proposed printed slot antenna is shown in Fig. 1. The antenna is fabricated on FR4 substrate with a size of 35×35×1.6 mm^3, relative permittivity of 4.4, and loss tangent of 0.02. The radiating patch is in the shape of a fork and the slot, in the ground plane, has an elliptic shape. The printed slot antenna covers the UWB frequency range. By using elliptic-shaped quarter-wavelength stub in the ground plane, other practical frequency bands such as GSM band or Bluetooth band can be created.

The total length of the elliptic-shaped stub can be obtained approximately from the following formula:

$$L = \frac{c}{4f\sqrt{\frac{\varepsilon_r + 1}{2}}} \qquad (1)$$

where ε_r, c, and f are dielectric constant, the velocity of light in free space, and the center frequency of the added band, respectively.

By using two protrudent stubs in the ground plane, two additional tunable bands are created below the UWB band. Through optimization, the dimensions of the stubs can be obtained as follows:

L_{S1}= 22 mm (stub length related to GSM band), and L_{S2} = 17 mm (stub length related to Bluetooth band).

The final dimensions of the proposed triple-band slot antenna, as shown in Fig. 1 (a), are obtained as follows:

R_1 = 3.5 mm, W_S = 35 mm, W_F = 2.5 mm, W_1 = 0.3 mm, W_2 = 2.5 mm, W_3 = 16.7 mm, L_F = 7 mm, L_S = 35 mm, L_1 = 3 mm, L_2 = 7 mm, L_3 = 10.6 mm, L_4 = 3.8 mm, and L_{S1} = 22 mm, and L_{S2} = 17 mm.

III. RESULTS AND DISCUSSION

The simulated reflection coefficient of the proposed UWB printed slot antenna with and without the presence of elliptic-shaped stubs is shown in Fig. 2. As it can be seen the antenna without the elliptic-shaped stubs shows a good UWB response from 3.1 to 10.6 GHz. As shown in this figure, by creating an elliptic-shaped stub in the ground plane a new resonance is occurred below the UWB frequency range at 1.8 GHz (GSM band). Also by creating two elliptic shaped stubs two independent resonances can be created at frequencies of 1.8 GHz and 2.4 GHz (Bluetooth band) besides the UWB frequency band. The measured reflection coefficient of the proposed UWB printed slot antenna is shown in Fig. 3 as a comparison the simulated reflection coefficient is also shown in this figure. Good agreement between simulation and measurement results are observed.

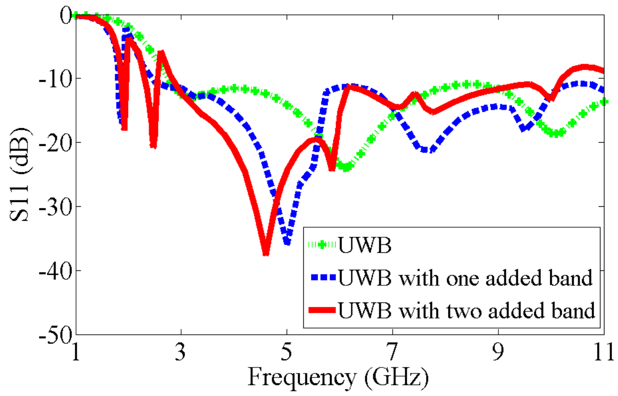

Fig. 2. Simulated S-parameters of the single band (UWB) antenna, dual band (UWB and one added band), and triple band proposed printed slot antenna.

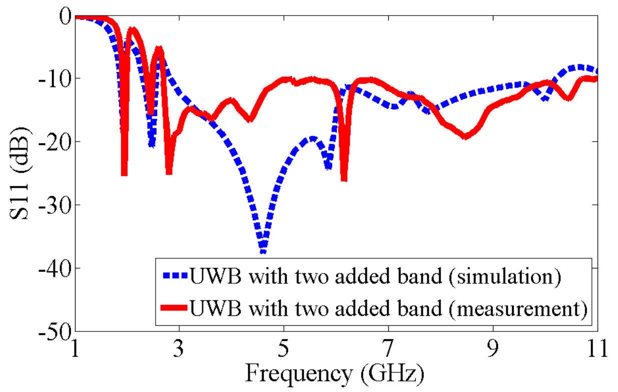

Fig. 3. Simulated and measured S-parameters of the proposed triple-band printed slot antenna.

For better understanding of the proposed antenna behavior, the current distribution on the antenna at frequencies of 1.8 GHz, 2.45 GHz, and 8 GHz is presented in Fig. 4. It is seen that at frequencies related to the added bands (e.g. 1.8 and 2.45 GHz) the current distribution is significantly high on the desired stubs. It is also seen from Fig. 4 (a), and (b) that the current distribution is maximum at one end and minimum at the other end of the stubs, proving the stubs are quarter-wavelength and confirms the validity of equation (1). On the other hand, one can see when one stub is activated the other stub is inactivated which shows the independency of added bands.

The measured radiation pattern of the proposed antenna in both E- and H-planes at three frequencies of 2.45, 4.5, and 6 GHz is shown in Fig. 5. As shown in Fig. 5, the antenna has almost stable omnidirectional radiation pattern in H-plane (*x-z* plane), and stable bidirectional radiation patterns in E-plane (*y-z*). The radiation patterns in both E- and H-planes are stable along the pass band frequencies. The simulated antenna radiation efficiency is shown in Fig. 6. It is seen that the antenna has good radiation efficiency in whole pass bands.

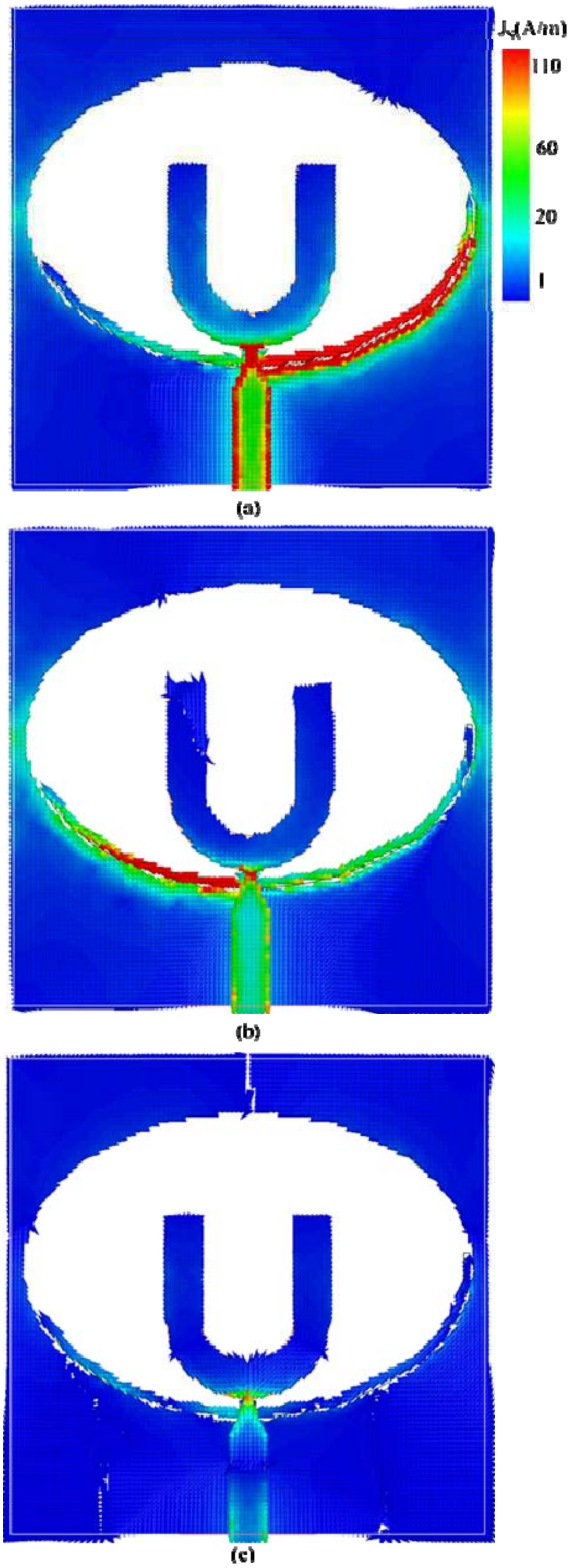

Fig. 4. Simulated current distribution proposed triple-band printed slot antenna at frequencies of (a) 1.8 GHz, (b) 2.45 GHz, and (c) 8 GHz.

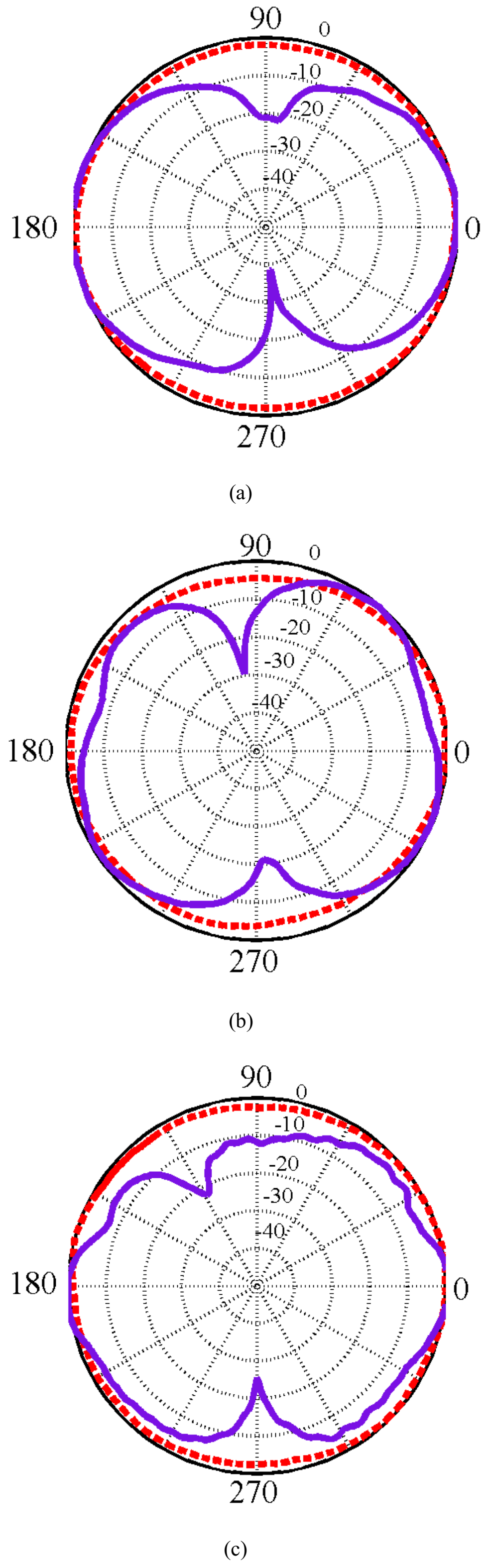

Fig. 5. Measured radiation pattern (dB) of the proposed antenna at frequencies of (a) 2.45 GHz, (b) 4.5 GHz, and (c) 6 GHz. Dashed line represents H-plane (x–z plane), and solid line represents E-plane (y–z plane).

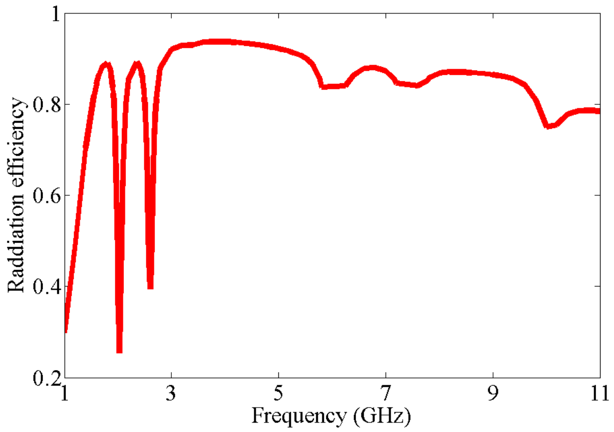

Fig. 6. The simulated antenna radiation efficiency

IV. CONCLUSION:

A Compact triple-band fork-shaped printed slot antenna for GSM, Bluetooth and UWB Applications is presented. The antenna has a compact size, stable radiation pattern and return loss of better than 10 dB over the whole of the triple bands.

References

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