Multiband Antenna with Parasitic Element for Wireless Applications

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Abstract

A square loop printed antenna with inverted F-shaped parasitic strip capable of operating in five frequency bands was developed and analyzed to support wireless applications such as PCS (1.85-1.99 GHz), UMTS (1.92-2.17 GHz), IMT (1.9-2.2 GHz), WLAN (2.40-2.483 GHz), WiMAX (3.49-3.79 GHz) and WLAN (5.725-5.825 GHz). The properties of the proposed antenna are studied through simulation and measurement.

Introduction

Recently, wireless communication has grown exponentially worldwide [1] and due to the space constraints, multiband antennas are becoming more and more favorable [2]. Traditionally microstrip antennas operate at single or dual bands, thus different antennas are required for different applications. Increasing the number operating frequency bands is one of the major challenges that antenna design engineers face. Various promising techniques have been investigated to solve these problems and one of best techniques is by adding parasitic strip to the microstrip antenna [3-6]. In this paper, a square loop printed antenna with inverted F-shaped parasitic strip operating in five frequency bands has been investigated.

Antenna Design

The geometry of the square loop printed antenna with an inverted F-shaped parasitic strip is shown is Figure 1. The antenna was simulated using the commercial software package CST Microwave Studio. This antenna is fed by 50 Ω co-planar waveguide (CPW) transmission line and etched on a 1.59 mm thick FR4 substrate with relative permittivity 4.4. The total volume of the antenna is 40 × 45 × 1.59 mm^3 including the feeding structure.

The geometrical parameters of the antenna are: t = 3 mm, W_1 = 2.85 mm, g = 0.35 mm, L_1 = 4 mm, L_2 = 4 mm, L_3 = 26mm, L_4 = 20 mm, L_5 = 25 mm, L_6 = 4 mm, L_7 = 24.5 mm, L_8 = 7 mm, L_9 = 7 mm, h = 1.59 mm, W = 40 mm, L = 45 mm, Θ = 90 degrees.

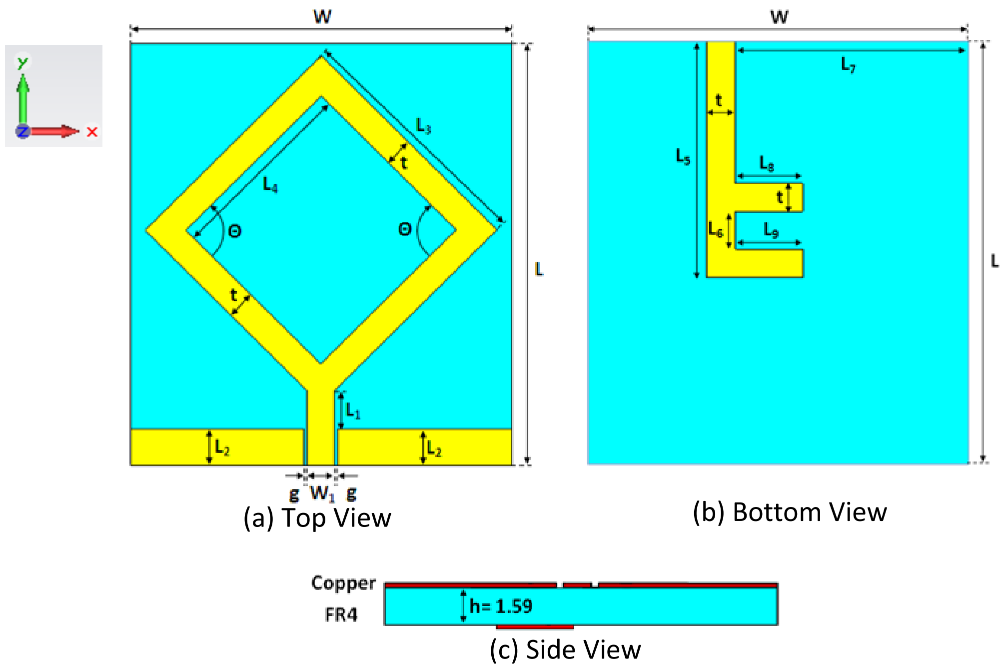

Figure 1: Geometry of the proposed square loop antenna with inverted F-shaped parasitic strip.

Parametric Study and Discussion

Figure 2 shows the reflection coefficient against frequency of the proposed square loop antenna with and without inverted F-shaped parasitic strip. As it can be seen from Figure 2, without parasitic strip, considering a reflection coefficient criterion of better than -10 dB, the antenna has only two operating frequency bands. With parasitic strip, the antenna has three operating frequency bands.

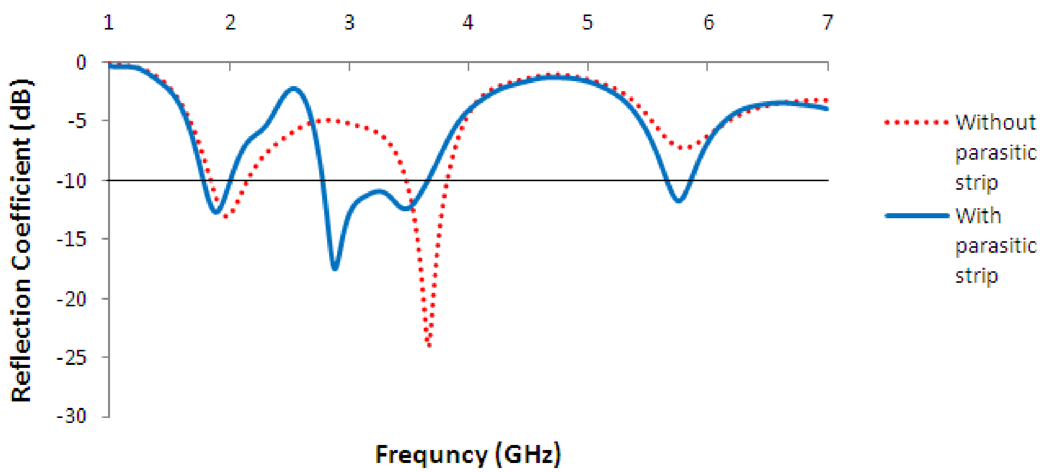

Figure 2: Simulated reflection coefficient versus frequency of the antenna with and without parasitic strip.

Effect of Parasitic Strip:

In order to investigate the effect of parasitic strip on the resonant modes, the parameters of the inverted F-shaped parasitic strip were varied. When the value of L_8 is increased from 7 mm to 17 mm, three operating frequency bands were still observed and for brevity this results is not shown.

It can be seen from Figure 3, when the value of L_9 is between 7 mm and 9.5 mm, three resonant modes were observed. As L_9 is increased from 9.5 mm to 14.5 mm, four operating frequency bands were observed with second resonant frequency reduces. First, third and fourth resonant modes were almost stable with slight change in reflection coefficient magnitude as L_9 is increased. When the value of L_9 is between 14.5mm and 17mm, only three frequency modes were observed.

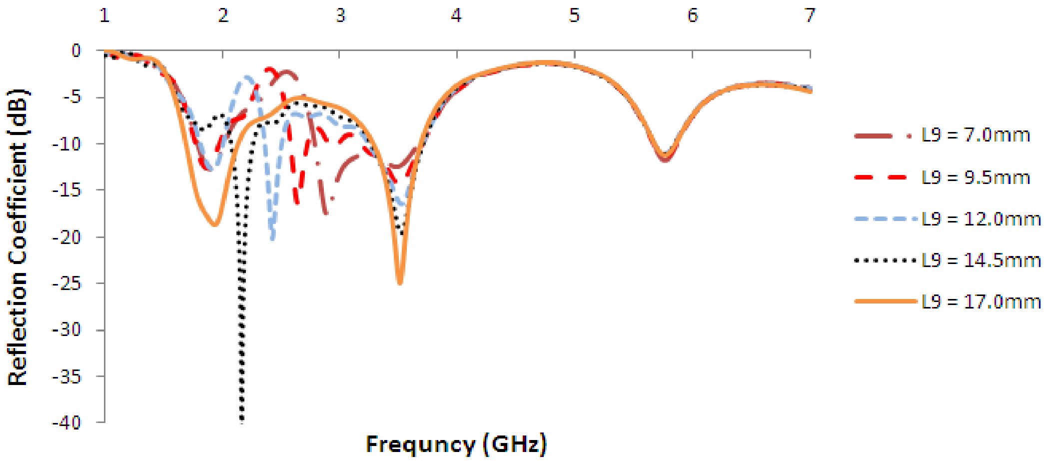

Figure 3: Simulated reflection coefficient versus frequency for various L_9.

When both L_8 and L_9 are between 7 mm and 12 mm, four operating frequency bands were observed; whereas five operating frequency bands were observed when L_8 and L_9 are increased from 12 mm to 14.5 mm. In this study, when both L_8 and L_9 are between 7 mm and 17mm, both fourth and fifth resonant modes remained and therefore the zoomed version of only the first three bands is depicted in Figure 4.

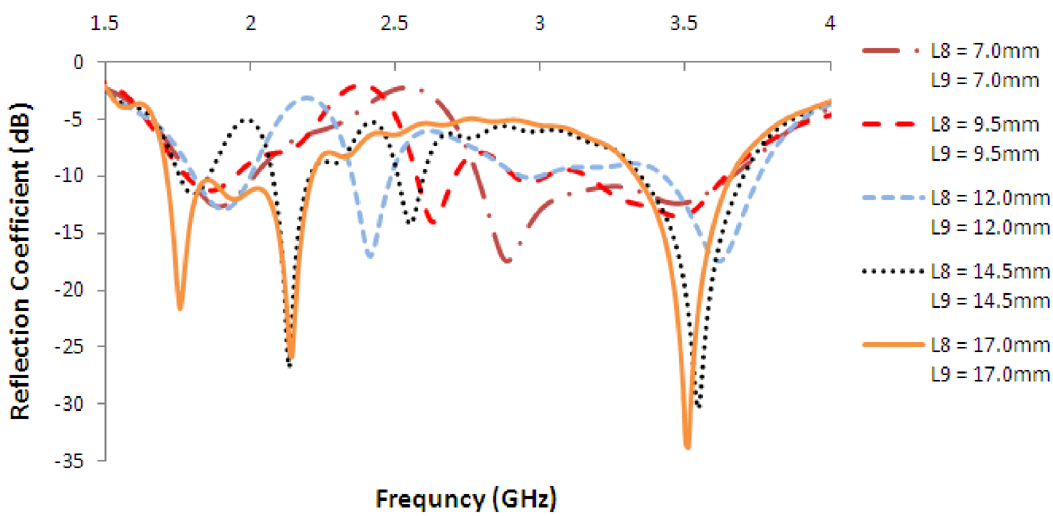

Figure 4: Simulated reflection coefficient versus frequency for various L_8 and L_9.

In order to obtain five operating frequency bands suitable for wireless applications, both L_8 and L_9 are varied between 11 mm and 14 mm. When L_8 = 13 mm and L_9 = 11.5 mm the antenna produced five resonant frequencies close to 1.9 GHz, 2.431 GHz, 2.845 GHz, 3.61 GHz and 5.752 GHz which meets the specifications of wireless applications such as Personal Communication System (PCS), Universal Mobile Telecommunication System (UMTS), International Mobile Telecommunications-2000 (IMT), Wireless

Local Area Network (WLAN) and Worldwide Interoperability for Microwave Access (WiMAX). Simulated and measured reflection coefficient versus frequency are compared and plotted in Figure 5.

The radiation pattern at the resonant frequencies have been simulated and depicted in Figure 6. Radiation pattern measurement is still undergoing and will be presented at the conference.

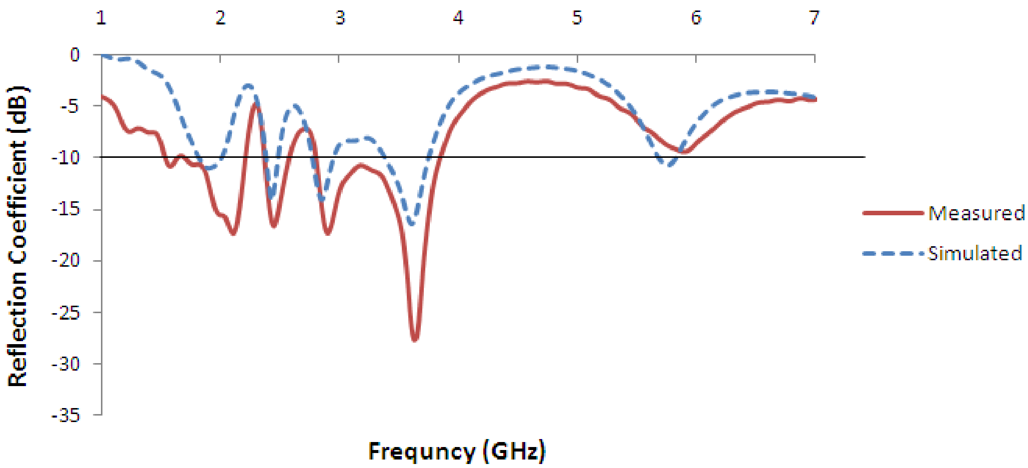

Figure 5: Measured and simulated reflection coefficient versus frequency (when L_8 = 13mm and L_9 = 11.5mm).

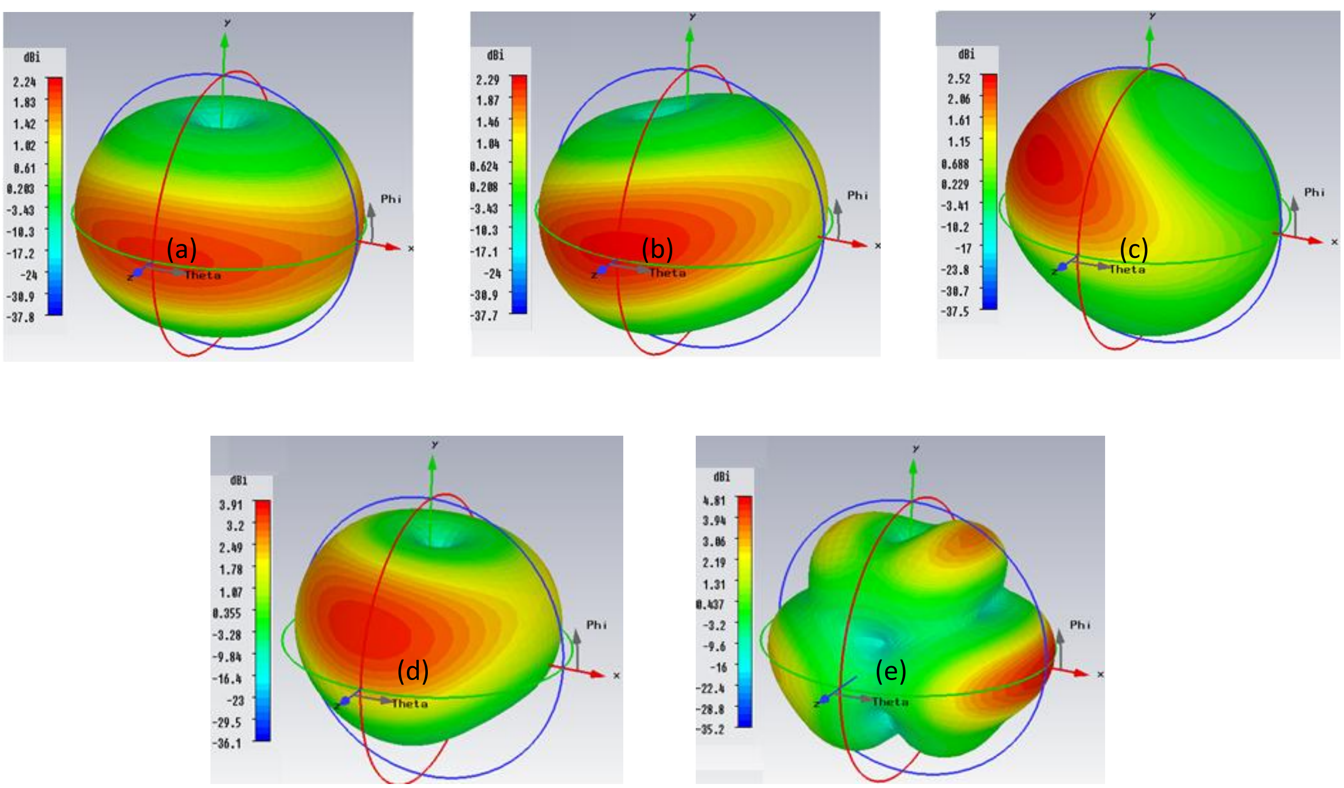

Figure 6: Simulated radiation pattern at (a) 1.9 GHz (b) 2.431 GHZ (c) 2.845GHz (d) 3.61 GHz and (e) 5.752GHz.

(a) Top View (b) Bottom View

Figure 7: Photograph of the proposed square loop antenna with inverted F-shaped parasitic strip (when L_8 = 13mm and L_9 = 11.5mm).

Conclusion

A five-band printed antenna with parasitic element has been designed and studied. The operating frequency bands are suitable for wireless applications such as PCS, UMTS, IMT, WLAN and WiMAX.

Reference

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