A Multi-band Printed Monopole Antenna

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Abstract— **In this paper, we present an antenna design for multi-band applications which can cover the GSM 900 (890-960 MHz), DCS (1710– 1880 MHz) and PCS (1850–1990 MHz), UMTS (1920–2170 MHz), and WLAN2.4GHz (2400-2484MHz) frequency bands. A prototype is built and measured. Results of return loss, radiation patterns, and efficiency are given. The antenna is small, cheap to manufacture, has a low profile and would be suitable for wearable applications, mobile phones and base stations.**

I. INTRODUCTION

With the development of wireless communications, integration becomes a trend to accommodate the rapidly increasing amount of electronic components. To reduce the complexity and cost of the integration, devices which can fulfil many roles are becoming popular. Multi-band antennas are such a solution for this trend as they increase the flexibility and functionality of devices. Many different designs of multi-band antennas can be found in [1] - [4]. Printed monopoles have wideband performance and nearly omni-directional radiation patterns which are suitable for mobile phones, base stations, and other personal communications.

II. ANTENNA DESIGN

The size and shape of the ground plane affects the monopole antenna's performance [5]. However, in practice the shape of the monopole has more a dominant effect. In [6], the author presented a printed triangular monopole which had a bandwidth of 32.5%. In [7], the authors analyzed the performance of a rectangular monopole by changing the size of a rectangular monopole and its distance above the ground plane. Therefore, adjusting the shape of a monopole is very important technique to achieve the desired results.

In our design, a rectangular monopole was used as the initial design. The dimensions are shown in Fig. 1(a). A FR4 board with permittivity 4.5 was used as the substrate. All the simulations were done with Microstripes 3D electromagnetic simulation software. The rectangular antenna has a bandwidth from 2.5GHz to 3.1GHz (about 23.3%) which is located in the antenna's anti-resonance region, see Fig.2. While due to the low real part and capacitive imaginary part of the impedance caused by the small ground plane, the resonance area (1.6GHz-2.1GHz) has a worse match. To counteract this effect without increasing the ground plane size or adding an extra matching circuit, two 12mm long wings are added to the ground plane. See Fig. 1(b). The two resonant modes of the simulated return loss of the "winged" monopole have been combined together and its bandwidth is increased to cover the range 1.31GHz to 2.46GHz (61%), see Fig.2. To further extend its applications to a lower band at 900MHz, two slots were added to the rectangular monopole to increase its electrical length without increasing the overall size of the antenna, shown in Fig. 1(b). By tuning the size and position of the slots, a strong current can be excited along the slots to resonate around 900MHz.

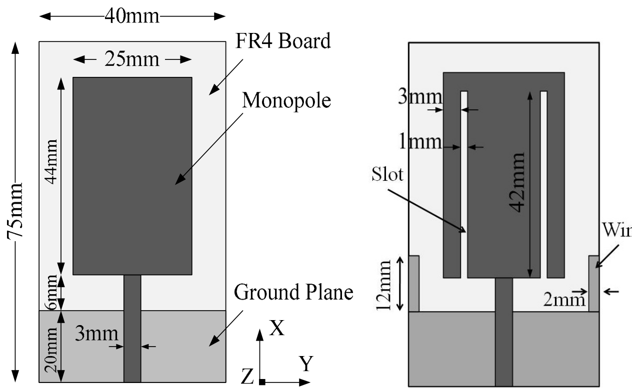

Fig.1. (a) Rectangular monopole and (b) with added wings and slots

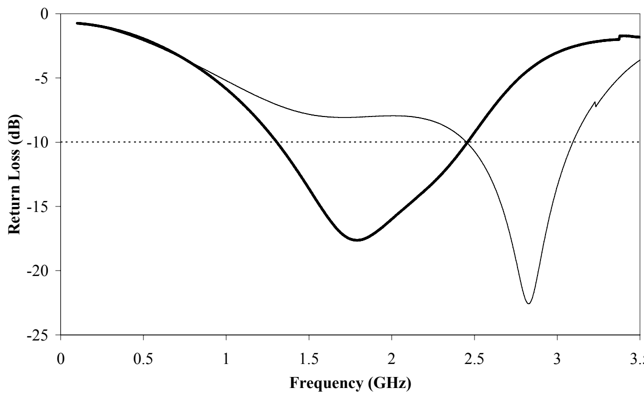

Fig.2. Simulated results comparing a rectangular monopole (grey) and a "winged" rectangular monopole (black). These results are before the slots have been added

III. SIMULATION AND MEASUREMENT RESULTS

Using the dimensions in Fig. 1(b), a prototype antenna was built. Its simulated and measured return losses are shown in Fig. 3. The effect of adding the slots can be seen by comparing the differences around 900MHz in Fig.2 and Fig.3. The slots produce a working band for GSM 900MHz (simulation: 0.87GHz-1GHz, measurement: 0.90-1.04GHz). The small difference between simulation and measurement can be further reduced by tuning the slots. In addition, it is found that the wings have improved the return loss at 900MHz, see Fig.3. Furthermore, due to the effects of the slots, the higher working band has been slightly shifted up to a higher frequency band (simulation: 1.68GHz-2.53GHz, measurement: 1.62GHz-2.58GHz) and now covers the DCS, PCS, UMTS, and WLAN2.4GHz applications.

Monopole antennas have omni-directional radiation patterns which are suitable for base station or indoor applications. For this multi-band monopole, omni-directional radiation patterns are observed from both simulations and measurements of the prototype at all five frequency bands. Six measured patterns, at 900MHz, 1.8GHz, 2.4GHz, are shown in Fig.4 and Fig.5. The 900MHz pattern was isotropic in the YZ plane, while there were minor nulls in the ±Y direction at higher frequencies. The efficiency measured in the RF anechoic chamber is 53.68%, 69.24%, 69.06% for 900MHz, 1.8GHz, and 2.4 GHz respectively.

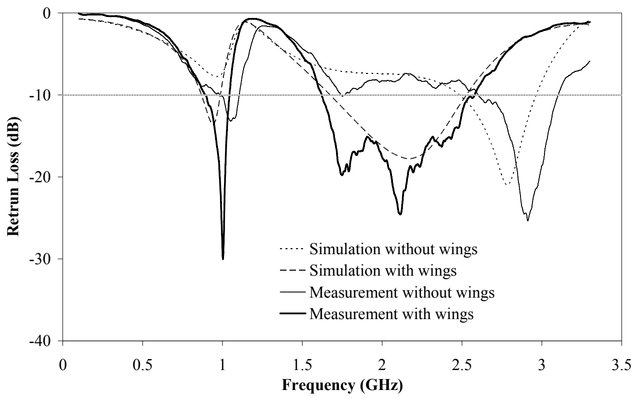

Fig. 3. Return losses for the multi-band monopole with slots and with/without wings

IV. CONCLUSION

In this paper we introduce a novel method to design a multi-band monopole antenna. By adding two slots to a rectangular monopole and two wings to the ground plane, an antenna which can cover GSM 900 (880–960 MHz), DCS (1710– 1880 MHz) and PCS (1850–1990 MHz), UMTS (1920–2170 MHz), and WLAN 2.4GHz (2400-2484MHz) is simulated and measured. This antenna has omni-directional radiation patterns and good efficiency which make it suitable in many communication applications.

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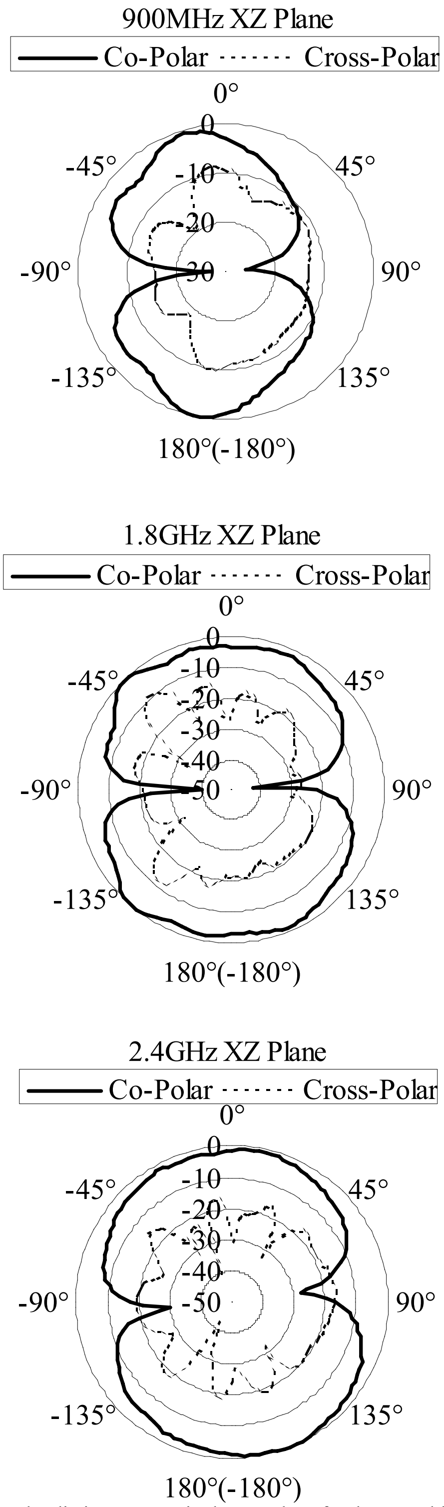

Fig. 4. Measured radiation patterns in the XZ plane for the wearable multi-band antenna in free space at (a) 900MHz, (b) 1.8GHz and (c) 2.4GHz

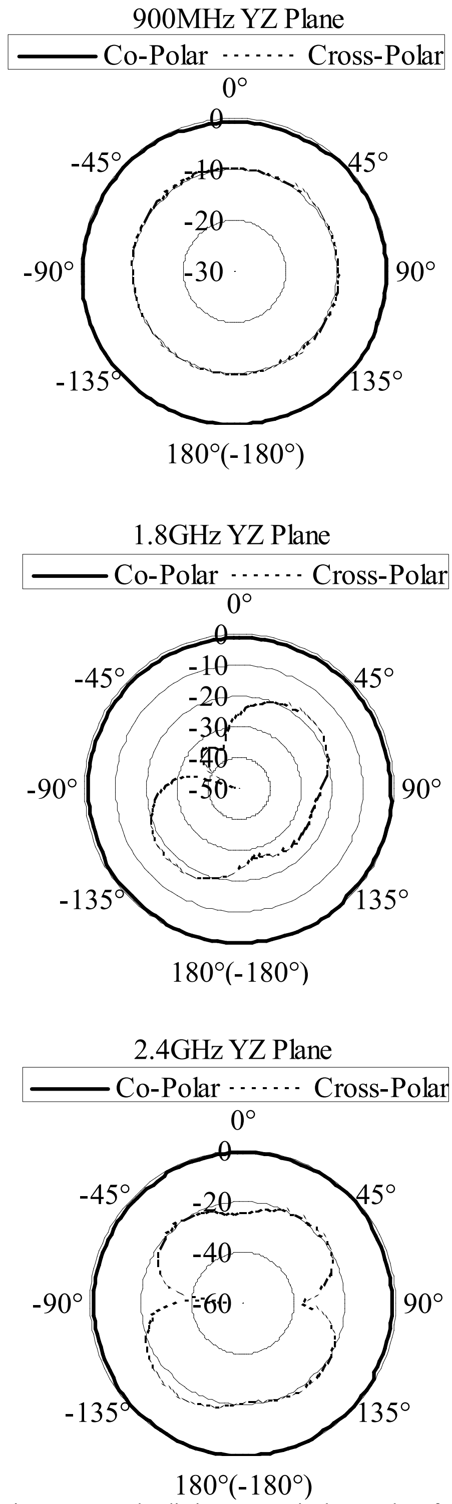

Fig. 5. Measured radiation patterns in the YZ plane for the wearable multi-band antenna in free space at (a) 900MHz, (b) 1.8GHz and (c) 2.4GHz