2005 Asia-Pacific Microwave Conference - Volume 4 of 5

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Compact Planar Monopole Antenna for Multi-band Mobile Phones

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Abstract - **A novel planar monopole antenna suitable for mobile handset applications is presented in this paper. The antenna is mainly composed of a rectangular radiating patch with a meandered slot on, and due to the slot three branches are constructed, two resonating branches and a tuning one. The antenna is printed on a FR4 substrate and fed by a 50Ω microstrip line. A prototype has been fabricated and studied. The resulting antenna is able to operate in the GSM, DCS, PCS, UMTS and WLAN bands with a voltage standing wave radio (VSWR) better than 2.5. Both simulated and measured results are presented.**

I. INTRODUCTION

The rapid development of modern wireless communication systems has caused wide interests in designing wide-band and multi-band antennas. A variety of antenna configurations have been reported to be promising candidates for mobile handsets, such as the planar inverted-F antenna (PIFA)[1]-[3], the planar wire antenna[4] ,and the planar monopole antenna[5] - [8]. PIFA usually has a compact size, but its bandwidth is relatively narrow and a sufficient height from the ground plane has to be kept to achieve the acceptable performances. The planar wire antenna exhibits a much wider bandwidth, but its large size and external configuration make it less practicable in mobile applications. The planar monopole antennas proposed in [5] -[8] generally possess compact size, sufficient bandwidth and satisfying radiation patterns. However, their structures are all 3-dimensional instead of 2-dimensional, increasing the manufacture difficulty and cost.

In this paper, a novel planar monopole antenna with a 2-dimensional structure is introduced. Both the structure and the parameters are carefully adjusted to achieve multi-resonances, sufficient bandwidths and convenient profile. Printed on a dielectric board, the antenna consists of three branches. At first, two branches are designed to resonate at certain frequencies, and then another one is added for fine tuning. With a small area of 36×15 mm^2, the antenna meets the demand of the following communication standards: GSM (Global System for Mobile communications, 890-960 MHz), DCS (Digital Communication System, 1710-1880 MHz), PCS (Personal Communication Services, 18 50-1990MHz), UMTS (Universal Mobile Telecommunications System, 1920-2170 MHz), and WLAN (Wireless Local Area Network, 2400-2484 MHz). Details of the design are described in the second section, and measured results of the prototype in the third.

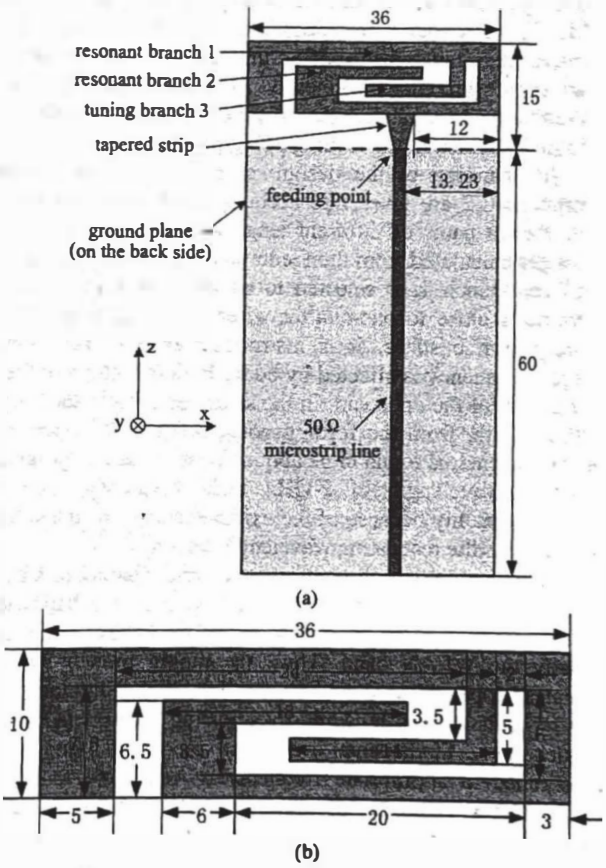

Fig. 1. Configuration of the proposed planar monopole antenna. (a) General view of the antenna. (b) Detailed dimensions of the main radiating element. All dimensions are in millimeter.

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II. ANTENNA DESIGN

The general view of the proposed antenna is shown in Fig. 1(a), and details of the design dimensions in Fig. 1(b). The planar monopole occupies an area of 36×15 mm^2, and is printed on a 0.8-mm FR4 substrate (relative permittivity 4.4). The substrate, 36 mm in width and 75 mm in length, is considered to be the typical system circuit board of a mobile phone. On the back surface of the substrate, a ground plane of 36 mm in width and 60 mm in length is printed and treated as the system ground plane. The monopole is fed by a 50Ω microstrip line, as shown in Fig. 1(a).

The main radiating element is in the shape of a rectangle. With a meandered slot on the patch, three branches are constructed, which are designated as resonant branch 1 (the longer branch), resonant branch 2 (the shorter branch) and tuning branch 3 (the additional inner branch) respectively in Fig. 1. Between the rectangular patch and the feeding microstrip line, a tapered strip of 5-mm length is printed. The width of the strip changes linearly from 1.54 mm at the feeding point to 4 mm at the edge of the patch, improving the impedance matching at the feeding point.

At the beginning of the design, only the two resonant branches 1 and 2 are taken into account, which present two surface current paths of different lengths. The length of the longer path, calculated from the feeding point to the open end of resonant branch 1, is selected to be about 75 mm. This value is very close to one-quarter wavelength of 900-MHz frequency in free space. It is instructive to note that the resonating frequency is affected by both the length of the path and the width of the open end. In the same way, the length of the shorter path, from the feeding point to the open end of resonant branch 2, is found to be about 35 mm, approximately one-quarter wavelength of 2-GHz frequency. The slight difference is mainly because of the existence of the substrate, which shortens the resonating wavelength.

The antenna with only the two resonant branches 1 and 2 is capable of dual-band operation. However, the bandwidth is not sufficient to cover all the five bands listed above, especially the WLAN band. Thus, the tuning branch 3 is added at a proper position on resonant branch 1. Simulation results have shown that by carefully adjusting the dimensions of branch 3, the fundamental and higher modes of branch 1 can be tuned to appropriate frequencies. According to the simulation data, the resonant frequency of the fundamental mode is reduced from 960 MHz to 910 MHz. As for the higher mode, the resonant frequency is changed from higher than 3 GHz to about 2.5GHz. Thus, the antenna with all the three branches is suitable for GSM/DCS/PCS/UMTS/WLAN operation. The simulated return loss of the antennas with and without tuning branch 3 is presented in Fig. 2 for reference. The results are gained through Ansoft HFSS (High Frequency Structure Simulator) software.

III. MEASURED RESULTS

A prototype was constructed according to the design dimensions, and the measured return loss is shown in Fig. 3.

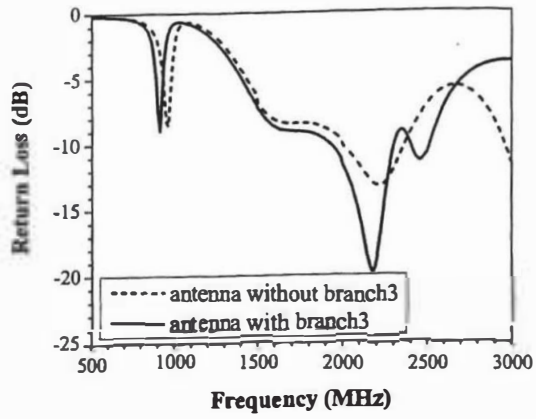

Fig. 2. Simulated return loss of the antennas with and without tuning branch 3.

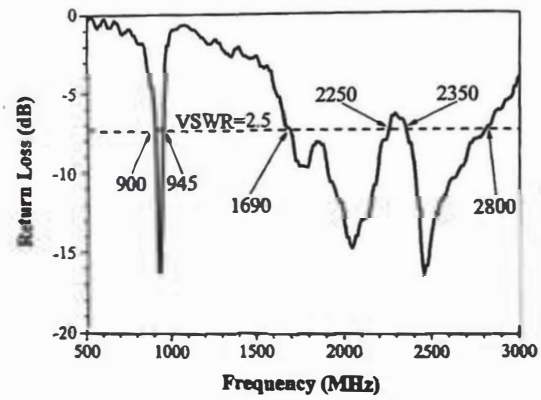

Fig. 3. Measured return loss of the proposed antenna.

Three resonating modes at 920, 2050 and 2460 MHz can be clearly observed. The first impedance bandwidth at 920 MHz is 45 MHz (900-945 MHz) with the VSWR (voltage standing wave ratio) better than 2.5. The second bandwidth at 2050 MHz is 560MHz (1690-2250 MHz), covering the DCS (1710-1880 MHz), PCS (1850-1990 MHz) and UMTS (1920-2170 MHz) bands. The third bandwidth at 2460 MHz is 450 MHz (2350-2800 MHz), covering the WLAN (2400-2484 MHz) band. However, it is observed that the bandwidth of the lowest resonating mode is insufficient to cover the GSM (890-960 MHz) band. More work has to be done to enhance the bandwidth, concentrating on the dimensions of resonant branch 1, the position of the feeding point, and the effects of parasitic elements.

Besides the return loss, the radiation characteristics of the proposed antenna are also studied. The measured radiation patterns in the x-y plane and y-z plane at 920 MHz, 1800 MHz, 2000 MHz and 2400 MHz are depicted in Fig.4. A lack

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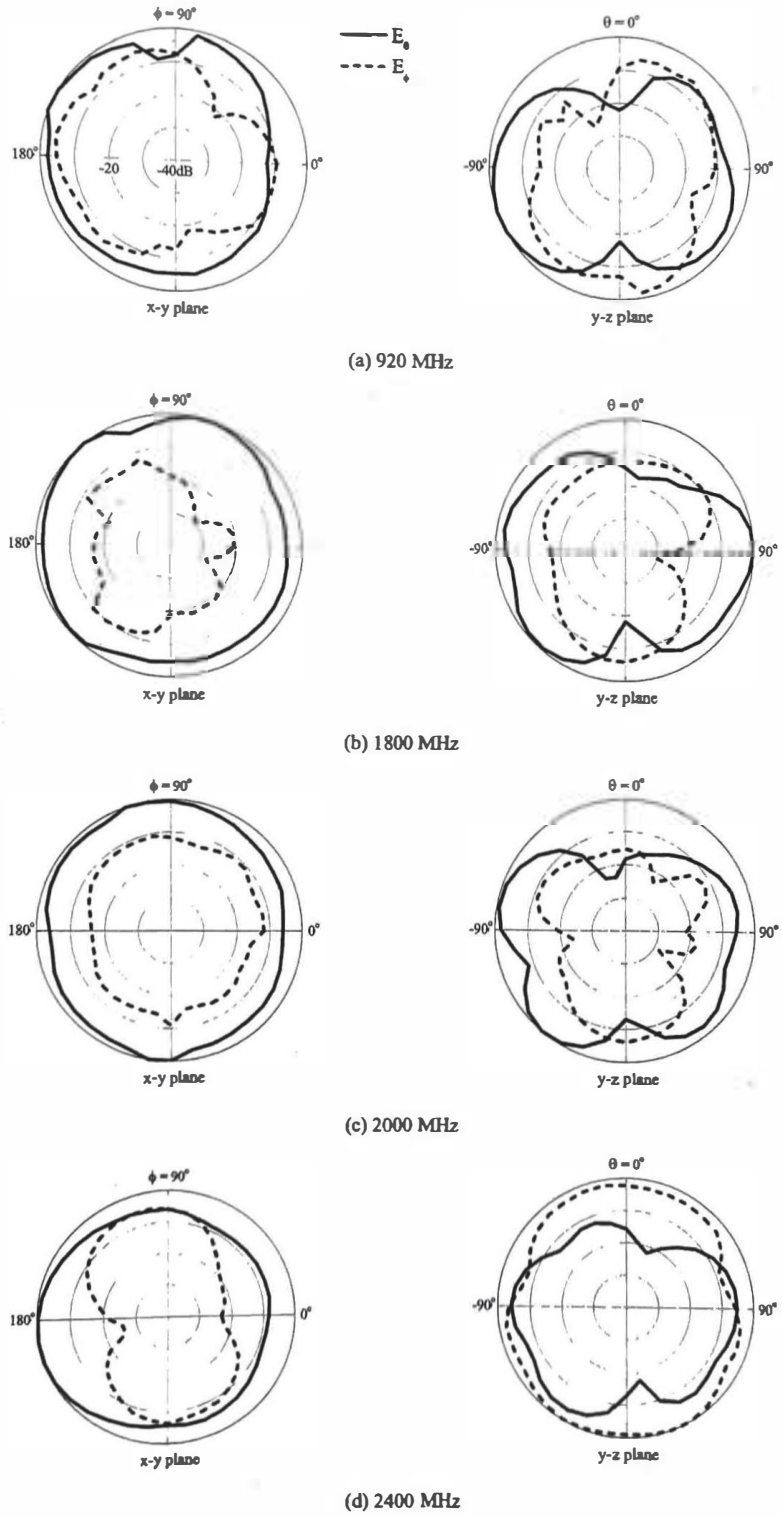

Fig. 4. Measured radiation patterns of the proposed antenna at (a) 920 MHz, (b) 1800 MHz, (c) 2000 MHz and (d) 2400 MHz.

of polarization purity is observed in the figure. As a matter of fact, this is not a drawback since the urban communication environments are so complicated that both vertical and horizontal polarization may exist [9].

IV. CONCLUSIONS

A compact multi-band planar monopole antenna capable of mobile handset applications is proposed in the paper. A prototype is constructed based on the design. Occupying a small area of 36×15 mm^2, the antenna meets the demand of GSM/DCS/PCS/UMTS/WLAN multi-band operation. Good radiation characteristics have been observed. The bandwidth for GSM band is still 25 MHz insufficient, more bandwidth-enhancement work being expected.

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