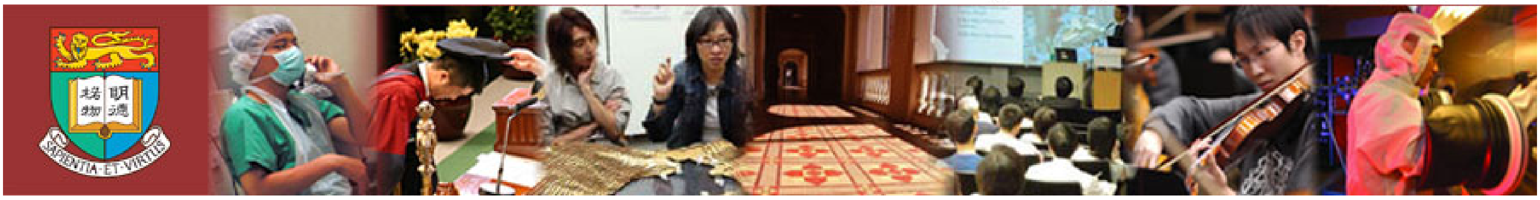

Design of A Printed Multiband MIMO antenna

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***Abstract*—A multiband MIMO antenna using planar technology is proposed for next generation mobile communication system. The antenna consists of two symmetrical monopole elements printed in parallel to each other at the upper and lower corners of a printed-circuit board (PCB) with a size 50×110 mm^2 which is similar to the side of a mobile phone. The two monopoles have two branch strips to generate two frequency bands. By using a parasitic element in each monopole, a much enhanced bandwidth in the upper band can be obtained. A lumped-impedance network is designed to enhance matching at the input ports for the two antenna elements. Computer simulation is used to study, design and optimize the antenna. Results indicate that the proposed MIMO antenna has a very bandwidth enough to cover the LTE (lower band), DCS1800, PCS1900, UMTS-2100, Wibro Band, 2.4G-WLAN, and Wimax (upper band) systems. To enhance the isolation between the two monopole elements within the desirable frequency bands, a slit is cut in the middle on the PCB ground. The MIMO antenna a very low profile and low cost which makes the design very attractive for mobile phone applications.**

Index Terms*—*MIMO antenna; isolation improvement; multiband antenna; wideband antenna; slit element; LTE antenna; WiMAX; WLAN; smart phone antenna

I. Introduction

Multiple-input multiple-output (MIMO) is a radio (RF) communications technology being used in many systems such as the WiFi and LTE (3G long term evolution) systems. It is an effective technology to provide increased link capacity and spectral efficiency combined with improved link reliability using what were seen as interference paths [1]. Nowadays, many future generation protocols including LTE and WiMAX require multiple antennas to implement the MIMO technology in order to achieve higher link gain and hence faster data rates, higher network capacity, and better reliability.

However, designing MIMO antennas for small wireless devices, such as smart phones, USB modems or netbooks, is a big challenging. This is because it is very extremely difficult to install multiple antennas in a small space without having much interfere or mutual coupling between them. Different techniques have been proposed to solve the problem, A common solution for these problems is to keep the antennas farther apart, but this is not practical for small mobile devices [2]. In [3], to enhance the isolation between the antenna elements of the MIMO antenna, a T-shaped grounding element was added between the two inverted-L radiating elements. In [4], a suspended microstrip line was used to link two planar inverted-F antennas to reduce the mutual coupling. In [5], a specific lumped capacitance was added between the two monopoles to achieve a high isolation. However, most of these MIMO antennas design were not designed for uses in the mobile phone applications. Moreover, these antennas could only have a good performance in a single band at about 2.4 GHz or above. The lower band LTE700 operation (which requires a larger antenna size) for the next generation of communication system was not studied.

In this paper, a MIMO antenna designed using planar technology for use in mobile phones is presented. The MIMO antenna is composed of two symmetrical monopoles. A straight slit is cut on the middle on the PCB ground to reduce mutual coupling and increase the isolation between the two monopoles. Simulation results show that the proposed planar MIMO antenna can generate two frequency bands to cover the LTE700 lower band, DCS1800, PCS1900, UMTS-2100, Wibro Band (2.3-2.4 GHz), 2.4-GHz WLAN, and WiMAX (upper band) systems.

II. Antenna Design

Figure 1 shows the configuration of the proposed MIMO antenna for mobile phone applications. The antenna was designed on a FR4 substrate with dielectric constant of ε_r =4.9 and loss tangent of 0.025. The MIMO antenna consisted of two monopole elements printed at the upper and lower corners of a printed-circuit board (PCB) with a volume of 50×110×0.8 mm^3. The two monopole elements were mirror images of each other on the PCB, hence complementing the radiation patterns. An area of 14×45 mm^2 under the two monopole elements was removed from metal ground in order to achieve a good radiation performance. The two monopole elements were printed on the top side of the PCB to achieve a good diversity performance and lower correlation coefficient for the MIMO antenna [6].

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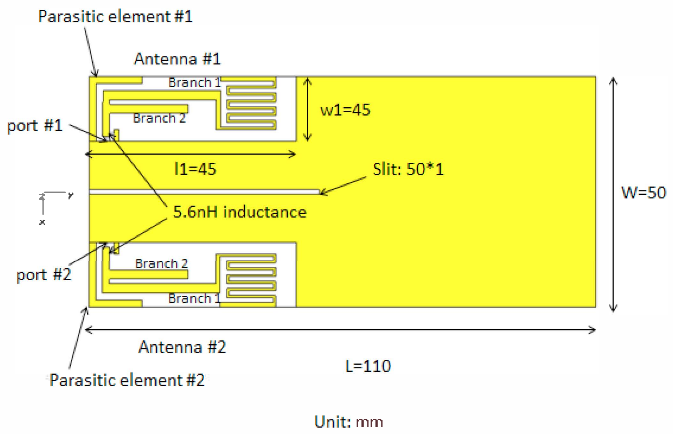


Fig. 1 Geometry of proposed MMO antenna

Figure 2 shows the 2D-layout of the proposed MIMO antenna which consisted of a densely meandered branch (branch 1) and a simple *L*-shaped branch (branches 2). Branch 1 was designed to excite the lower band for the LTE700 band. The second resonant mode of branch 1 at about 1800MHz was used to generate the upper band. Branch 2 was used to generate the high-frequency band at about 2.5 GHz. A parasitic element placed near to each of the monopole elements was used to widen the bandwidth of the upper band. A lumped-impedance network using an inductance of 5.6 nH was used to improve matching for each of the monopole elements at the input ports.

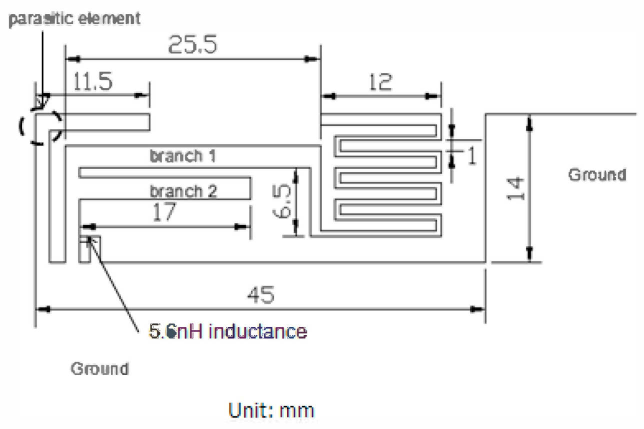


Fig. 2 Structure of radiation element

For a MIMO antenna installed on a space-limited mobile terminal, due to the sharing of the ground plane where surface currents flow, mutual coupling between the antenna elements is an important factor to be considered. In our design, we proposed to cut a slit on the PCB ground between the two monopoles to improve the isolation and reduce the coupling. By doing this, the distribute current on the PCB ground is forced to flow along the slit, which increase the current path on the ground. The currents on the PCB would become much weaker, hence reducing the effects of the mutual coupling between the MIMO elements and also improving the isolation. [7] The dimension the slit needed to be optimized. Computer simulation was used for optimization of the slit in our MIMO antenna design.

III. SIMULATION RESULTS

The proposed MIMO antenna was studied and designed by using the EM simulation software CST. Results are shown in Fig. 3. It can be seen that, since the two antenna elements were placed symmetrically, S11 was identical to S22, and S12 was identical to S21. Here, we only show the results for S11 and S21. It is clear from the simulated results that the antenna had two operation bands, a lower band in the 770-MHz region and a higher band in about the 2-GHz region. In the lower band, a 7-dB return loss was achieved for the LTE700 Bands 13 & 14 (746-798 MHz). For the higher band, the antenna had sufficient bandwidth to cover the DCS1800, PCS1900, UMTS2100, WiBro (2.3-2.4 GHz), 2.4-GHz WLAN, and M-WiMAX (2.5-2.7 GHz) systems. Without the slit on the PCB ground, Figure 3 shows that the isolation between the two input ports of the MIMO antenna was just about -4 dB in the LTE band. With the use of the slit, the isolation was increased from -4 to -13 dB in the LTE700 band, and about 2 or 3dB improvement in the wide upper band. Moreover, the bandwidth of the upper band was also widened by using the slit.

The simulated 3D-radiation patterns of the MIMO antenna at 0.77 GHz, 2 GHz and 2.45 GHz are shown in Figs. 4 and 5. It can be seen that by placing the elements with mirror images of each other, the 3D-radiation patterns of each elements could complement each other. The gains and the efficiencies of the two antenna elements are shown in Table I. It can be seen that the proposed MIMO antenna operated quite well in the working bands.

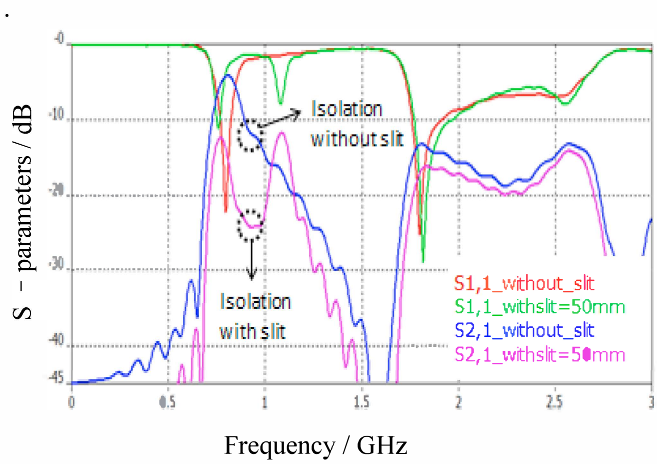


Fig. 3. Simulated S parameters.

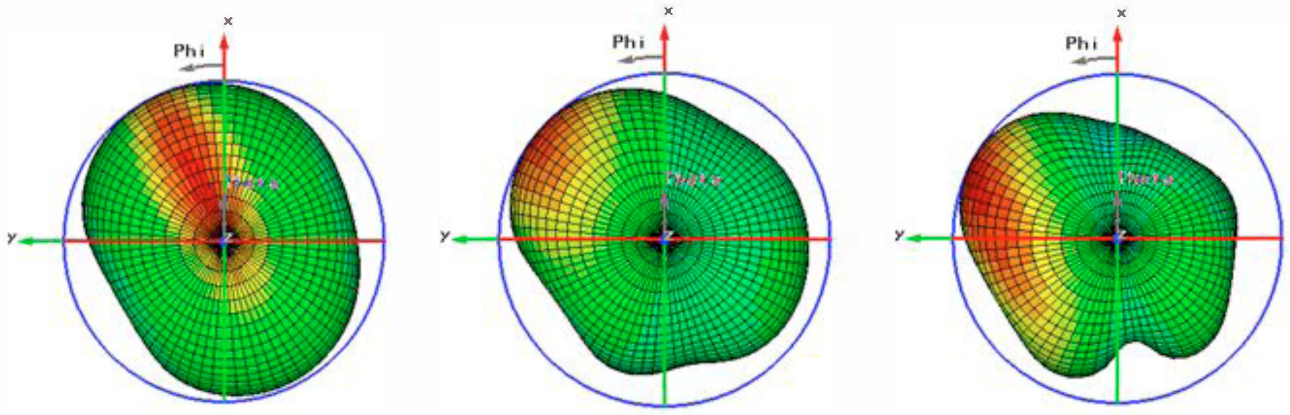
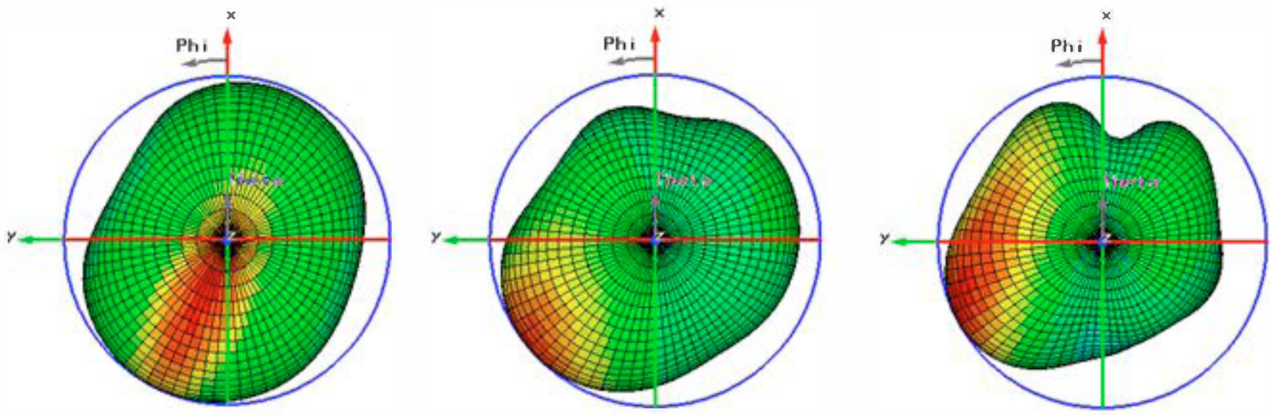


Fig. 4. Port 1 3D radiation pattern simulated.



(a) 770 MHz (b) 1.8 GHz (c) 2.4 GHz

Fig. 5. Port 2 3D radiation pattern simulated.

TABLE 1
SIMULATED GAINS AND EFFICIENCIES

Freq	0.77 GHz	1.8 GHz	2.4GHz	2.6GHz
	Gain			
Ant 1#	0.47 dBi	3.13 dBi	4.32 dBi	3.69 dBi
Ant 2#	0.43 dBi	3.10 dBi	4.23 dBi	3.66 dBi
	Efficiency			
Ant 1#	57.18%	68.60%	57.47%	51.70%
Ant 2#	56.92%	66.49%	57.34%	51.94%

IV. CONCLUSION

A printed wideband MIMO antenna consisted of two monopoles was proposed in this paper. The antenna could be used for multiband operation in the mobile terminals, including the LTE (bands 13 & 14), DCS1800, PCS1900, UMTS-2100, Wibro Band (2.3-2.4 GHz), 2.4 GHz WLAN, and WiMax (2.5-2.7 GHz) systems. A special slit cut on the ground plane was used to reduce the coupling and increase the isolation of the two elements. Results showed that the isolation of the proposed MIMO with slit on the PCB ground was about -13 dB in the LTE band, and -15 dB in the upper band (1.71-2.1GHz).

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