MIMO Antenna with Dual Polarized Slotted Strip for Next Generation Mobile Handsets

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1. Introduction

The demand for high speed and high quality data transmission in wireless mobile communication has been greatly increased, which makes Multiple-Input Multiple-Output (MIMO) technology attractive for its excellent performance in channel capacity without occupying extra spectrum and radiating power [1]. To realize an effective MIMO system, it is necessary to have a sufficient number of uncorrelated antennas at each end of the link. Mutual coupling or isolation between adjacent antennas is a key factor to achieve high antenna performance in the MIMO antenna configuration. For a low mutual coupling, antennas must be separated far enough to minimize the mutual coupling. However, the space for the internal antenna is not enough to obtain low correlation and mutual coupling in the mobile handsets. So far, many investigations on multi-antenna systems using various techniques have been conducted with the goal of improving isolation between the antenna elements. Although several techniques have been reported for high isolation characteristics by employing mushroom-like electromagnetic band gap (EBG) structures [2], defected ground structure (DGS) [3], simple ground plane modification [4] and connecting line facing to the feed point [5], it is still quite difficult for antennas closely located within the limited space in a mobile handset to have good isolation at long term evolution (LTE) band. In MIMO system, the polarization diversity is one of the usually-adopted technologies due to the compactness and low correlation of its radiation system.

In this paper, we propose a MIMO antenna with dual polarized slotted strip for next generation mobile handsets. The proposed MIMO antenna consists of two printed dual-band PIFAs which have dual polarized slotted strip. The input port #1 of the first PIFA is orthogonally disposed with respect to the input port #2 of the second PIFA. The orthogonal placement of the two feed points ensures that the dominant polarization of each of the PIFAs is opposite to each other resulting in good isolation performance. The proposed MIMO antenna can cover LTE band 13 (0.746-0.787 GHz) and mobile worldwide interoperability for microwave access band (M-WiMAX band; 2.5-2.69 GHz) services, simultaneously. Details of the design considerations and experimental results of the dual polarized slot strip dual-band MIMO antenna are presented and discussed.

2. MIMO Antenna Design

The geometry of the proposed dual slotted strip dual-band MIMO antenna for 4G mobile system is shown in Figure. 1. The proposed multiband MIMO antenna consists of two printed dual-band PIFAs. The radiating strip with coupling slot (W_{slot1} = 1mm and W_{slot2} = 1mm) has a length of about 76 mm, which is about 0.2 wavelengths at 0.77 GHz and can easily generate a dual resonant mode to cover LTE band 13 and M-WiMAX bands. In order to improve the isolation characteristic at the LTE and M-WiMAX bands, the directions of excitation each antenna element are different. The input port (port #1) of the first PIFA is orthogonally disposed with respect to the input port (port #2) of the second PIFA. The orthogonal placement of the two feed points ensures that the dominant polarization of each of the PIFAs is opposite to each other resulting in good isolation performance. The overall size of the each printed radiating element is 48×31 mm^2. Two radiating elements with coupling slot are orthogonally placed at the top and bottom sides of a FR4 (ε_r = 4.4) substrate having the volume of 48 × 108 × 0.8 mm^3, which simulates the ground plane of a practical bar type mobile handset.

3. Results and Discussions

Figure. 2 shows the simulated and measured S-parameter characteristics of the proposed MIMO antenna. It is shown that simulated s-parameter characteristics are similar to those of measurement. Good impedance matching over the LTE band 13 and M-WiMAX bands is observed. The measured isolation characteristic is higher than 16 dB over the LTE band 13 (746 - 787 MHz)and is higher than 20 dB over M-WiMAX band (2.5 - 2.69 GHz), which is acceptable for 4G mobile applications. Simulation was carried out with the aid of the commercially available simulation software MWS [5] to optimize the geometric parameters of the proposed antenna. The measured radiation patterns of the designed dual-band MIMO antenna at 770 and 2550 MHz are shown in Figure. 3. From the yz-plane patterns, the main beam direction of each antenna has 150^0 difference, which is good enough to improve the antenna performance for the desired frequency band. From the data in xz-plane, it is confirmed that the antenna has near omni-directional radiation patterns in all frequency bands. To evaluate the performance of the proposed MIMO antenna, key performance parameters such as correlation coefficient (ECC), mean effective gain (MEG), and MEG ratio are analyzed. For diversity and MIMO applications, the correlation between the signals received by the involved antennas at the same side of a wireless link is an important figure of merit for the whole system. Usually, ECC is used to evaluate the diversity capability of a multi-antenna system. This parameter should ideally be computed using the 3D radiation patterns, but this method is quite laborious. Assuming that the antennas are operating in a uniform multi-path environment (XPR = 1 and $P_\theta = P_\varphi = 1/4\pi$), the ECC can be alternatively calculated by using the scattering parameters. The ECC characteristics computed using the scattering parameters are maintained below 0.1. The MEG is a statistical measure of the antenna gain in a mobile environment and is equal to the ratio of the mean received power of the antenna to the total mean incident power. In the case of a uniform propagation environment in which XPR = 1 and $P_\theta = P_\varphi = 1/4\pi$, the MEG is equal to the total antenna efficiency divided by two or −3dB [6]. Moreover, to achieve a good diversity gain, the average received power from each antenna element must be nearly equal; this corresponds to a MEG ratio near unity. Antenna performances such as ECC, total efficiency, MEG, MEG ratio, and actual diversity gain of proposed MIMO antenna are summarized in Table 1. It can be observed that proposed MIMO antenna satisfy the diversity criteria given in [7],

$$ECC < 0.5 \text{ and}$$

$$10 \log \left| MEG_1 / MEG_2 \right| < 3 \ dB \quad (1)$$

4. Conclusions

In this paper, MIMO antenna with dual polarized slotted strip for next generation mobile handsets is proposed. The port #1 of the first PIFA is orthogonally disposed with respect to the port #2 of the second PIFA. The orthogonal placement of the two feed points ensures that the dominant polarization of each of the PIFAs is opposite to each other resulting in good isolation performance. The proposed MIMO antenna provides dual polarization, near omni-directional radiation characteristics and isolation of better than 13 dB across the desired operating bandwidth. With these features, as well as the compact, planar and simple configuration, the proposed MIMO antenna can be a suitable candidate for compact MIMO systems.

Acknowledgments

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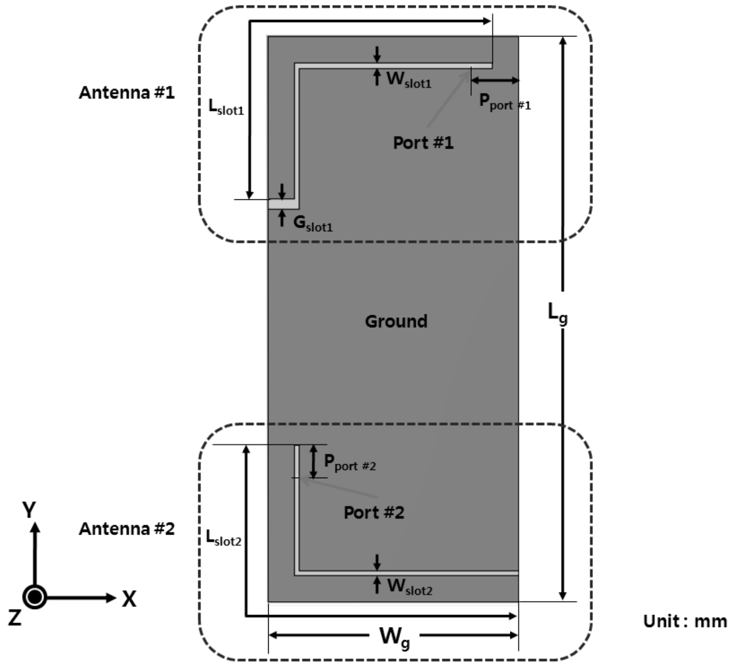

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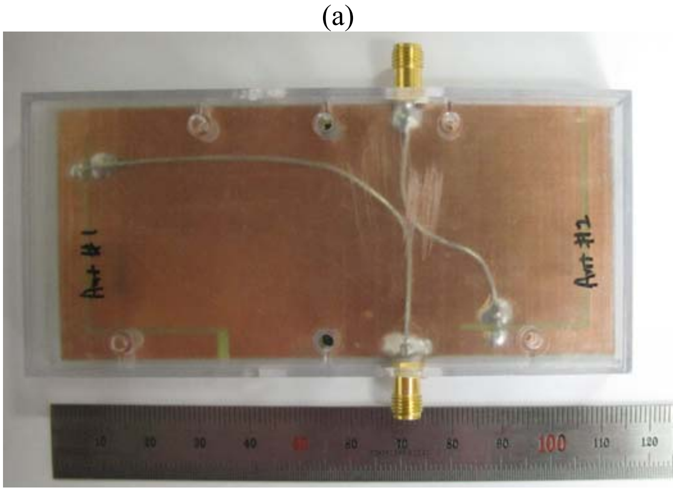
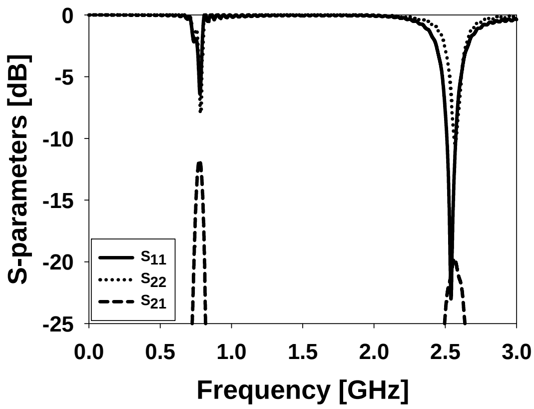


(b)

Figure 1: The proposed dual slotted strip MIMO antenna,
(a) structure of the proposed MIMO antenna and (b) fabricated MIMO antenna.
(Final design parameters; W_g = 48 mm, L_g = 108 mm, W_{slot1} = W_{slot2} = 1 mm, L_{slot1} = L_{slot2} = 76 mm, P_{port1} = P_{port2}= 5 mm and G_{slot1} = 2 mm)



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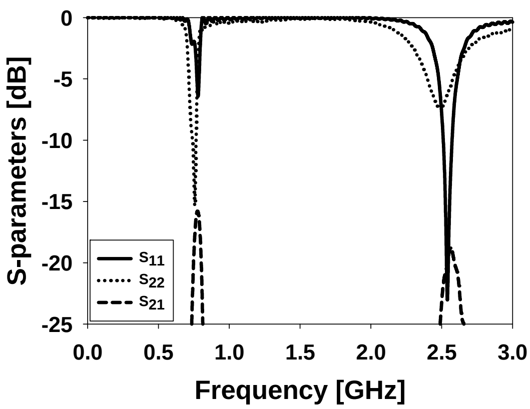

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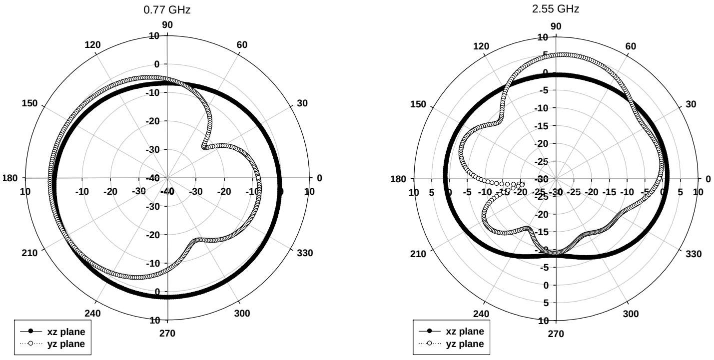
Figure 2: Simulated and measured S-parameter characteristics of the proposed MIMO antenna,
(a) simulated S-parameter characteristics and (b) measured S-parameter characteristics.



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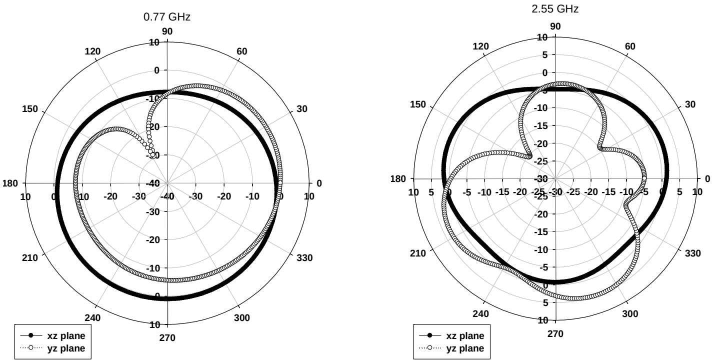

(b)

Figure 3: Measured radiation patterns of the proposed MIMO antenna,
(a) antenna #1 and (b) antenna #2

Table 1: ECC, total efficiency, MEG, MEG ratio, and actual diversity gain

Freq. [GHz]	Isolation [dB]	ECC	Ant #1 Efficiency [%]	Ant #2 Efficiency [%]	Ant #1 MEG	Ant #2 MEG	MEG Ratio	Actual Diversity Gain [dB]
0.77	16	0.15	66.4	70.6	33.2	35.3	0.94	2.22
2.5	20	0.04	74.0	68.2	37.0	34.1	1.08	3.04

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