Design of a Dual-Band MIMO Antenna with Orthogonal Bi-directional Radiation Patterns

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Abstract **- Recently, MIMO (Multi-Input Multi-Output) transmission technique is one of the most promising technique as it can satisfy the demand for exponential data traffic in mobile communications, especially for multipath-rich environment. In this paper, we proposed an antenna design which can operate in the 2.6 GHz and 3.5 GHz bands and produce an orthogonal bi-directional radiation pattern. Antenna performances of reflection coefficient (S_{11}), transmission coefficient (S_{21}) and far-field radiation pattern are simulated and evaluated using the FDTD (finite-difference time-domain) method. As a result, dual-band operating to cover 2.6 GHz and 3.5GHz bands with desired S_{11}<-10dB, and S_{21} between the two antenna elements for each frequency band is lower than -15 dB. Moreover, the MIMO performance can probably be improved because the difference between the two directional gain levels is achieved by approximately 15 dB when four slits are etched into the ground plane.**

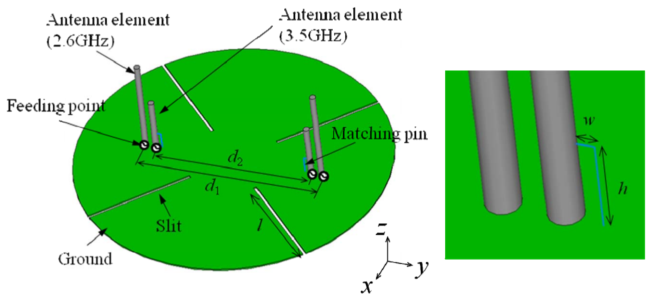
Index Terms **— Indoor Antennas, Base Station Antennas, MIMO, Dual-band.**

1. Introduction

Recently, the MIMO (Multi-Input Multi-Output) transmission technique is one of the most promising technique as it can satisfy the demand for the exponential data traffic in mobile communications, especially for multipath-rich environment. In general, diversity reception on the base station is used for minimizing the effect of Rayleigh fading on the received signal. Polarization spatial diversity techniques are the most common forms of diversity reception [1]. Angular diversity techniques are also effective at mitigating multipath situations [2], since multiple antennas are oriented in different directions. However, multiple antennas are required to form such system. That will be difficult to be used for indoor base station, since the device are constrained to be compact.

A number of studies on indoor base station antennas have been published in journals and conference papers. According to [3], in 1997 the main design target for an indoor base station antenna and the effect of the ground plane were introduced. A design for a cylindrical monopole antenna was proposed to reduce the physical antenna size [4]. In order to enhance the bandwidth, a dual-sleeve antenna structure and the use of a shorting wire were proposed [5] and [6].

In this paper, we propose a indoor base station antenna for dual-band operation of 2.6 GHz and 3.5 GHz. The performances of S_{11} and S_{21} fulfill the requirement of S_{11}<-10dB and S_{21}<-15dB for MIMO system [7] and [8]. Moreover, the proposed antenna produces an orthogonal bi-directional radiation pattern for each frequency band, which means that angular diversity gains could be realized to a practically useful extent in a multipath-rich environment. The MIMO performance can probably be improved since the difference between the two directional gain level can be achieved by approximately 15 dB to reduce the overlapping on the orthogonal bi-direction radiation pattern when we etched four slits into ground plane. The simulation was performed with CST Microwave STUDIO [9].

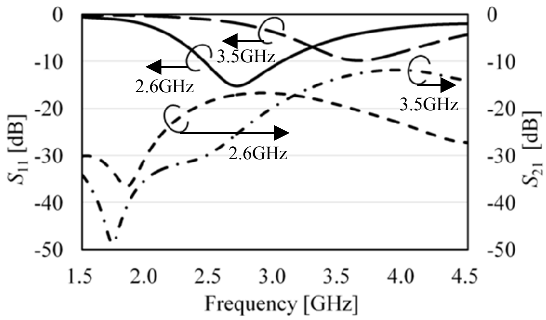


(a) Overview (b)Matching pin

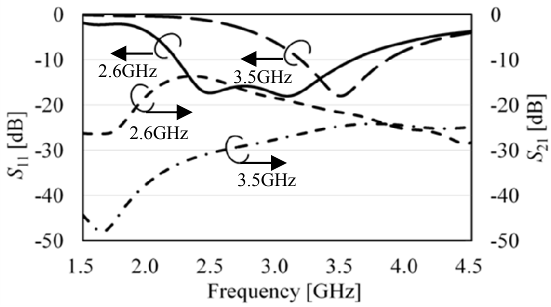
Fig. 1 Geometry of the proposed antenna structure.

2. Antenna Design

Fig. 1 (a) shows the geometry of the proposed antenna that is symmetric with respect to the x-axis. The proposed antenna consists of two pairs of monopole antennas both with a diameter of 2 mm that are mounted on a ground plane and located along the y-axis. The distance d_1 and d_2 between these antenna elements are set to be 0.5 λ for 2.6 GHz and 0.59 λ for 2.6 GHz. The diameter and thickness of the circular ground plane are set to 100 mm and 0.5 mm. In addition, to improve the input impedance matching, a matching-pin that is designed to connect the monopole antenna of 3.5 GHz with the ground plane as shown in Fig. 1(b) is added and the height (h) and distance (w) between matching-pin and monopole antenna are 5.5 mm and 1 mm. For improving the MIMO performance, four slits are etched into the ground plane and symmetrically arranged to reduce the overlapping on the orthogonal radiation pattern. The width and length of each slit are 1 mm and 35 mm. Gap feeding is set at the bottom of each antenna element. The chosen material of the proposed antenna is PEC (Perfect electric conductor).

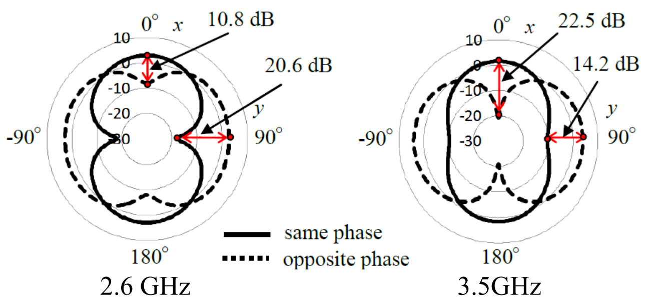


(a) w/o matching-pin

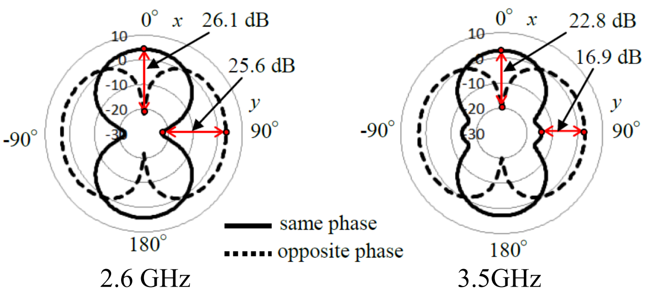


(b) w/o matching-pin

Fig. 2 Simulation result of *S*-parameter.



(a) w/o four slits



(a) with four slits

Fig. 3 Orthogonal bi-directional radiation pattern

3. Simulation Result and Discussion

The *S*-parameters of the proposed antenna is shown in Fig. 2 (a) and (b). From the result of (a), it can be seen that S_{11} does not satisfy the demanded value of -10 dB in 3.5 GHz band, when the matching-pin is not used. possibly because the antenna element at 3.5 GHz is close to antenna element at 2.6 GHz each other and the coupling between them becomes strong. S_{21} between 2.6 GHz antenna elements at 2.6 GHz is -17 dB, which satisfies the -15 dB requirement, but at 3.5 GHz S_{21} between 3.5 GHz antenna elements is -13 dB and needs to be improved. Fig. 2 (b) presents the result with the matching-pin, S_{11} in 3.5 GHz band can be improved to fulfills the demanded value of -10 dB, and moreover S_{21} at the 2.6 GHz and 3.5 GHz is -15 dB and -24 dB, which satisfies the required -15 dB.

Fig. 3 (a) plots the radiation pattern of the proposed antenna without four slits. From the result of (a), even though the proposed antenna seems to have an orthogonal bi-directional radiation pattern, for 2.6 GHz the difference between the two directional gain levels in the *x* direction and *y* direction are 10.8 dB and 20.6 dB, for 3.5 GHz the levels are 22.5 dB and 14.2 dB, therefore some results need to be improved to fulfill the demanded value of 15 dB. Fig. 3 (b) shows the radiation pattern with four slits. From the result, the difference between the two directional gain levels in *x* direction and *y* direction are 26.1 dB and 25.6 dB, for 3.5 GHz the levels are 22.8 dB and 16.9 dB, all results fulfill the 15 dB requirement by adding four slits. For the opposite phase case at 2.6 GHz the difference between two directional gain levels in the *y* direction has been improved from 10.8 dB to 26.5 dB, the amount of improvement is approximately 15 dB.

4. Conclusion

In this article, an indoor antenna with an orthogonal bi-directional radiation pattern for dual-band operation of 2.6 GHz and 3.5 GHz has been presented. As the result, the S_{11} in the 3.5 GHz band can be improved using a matching-pin, and moreover, the difference between the two directional gain levels is achieved by approximately 15 dB when four slits are etched into the ground plane, that meaning the overlapping on the radiation pattern can probably be reduced to improve the MIMO performance. In future work, the MIMO capacity and an experiment will be estimated and carried out to confirm the simulated results presented here for the proposed antenna.

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