# The realization and analysis of polarization diversity in WiBro MIMO antenna

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## Introduction

Multi-Input Multi-Output (MIMO) communication systems have received a great attention because it increases the channel capacity by using multiple transmitter and receiver [1]. However, the spatial correlation between antennas causes the loss of spectral efficiency. To reduce the spatial correlation, the space, polarization, and pattern diversity techniques are most widely used.
The polarization of PIFA can be changed by different feed ports [2]. By using techniques of vertical and horizontal feeding, this paper proposed polarization diversity system by two array antenna which can apply wireless broadband (WiBro) application in US and Canada. Also, the analysis of the polarization diversity in the view point of capacity is presented. The CST Micro Wave Studio(MWS) is employed to simulate the scattering parameters and radiation patterns in this paper.

## Theoretical background

The instananeous channel capacity of MIMO has been shown to be [1]

$$C(H) = \log_2(I + \frac{P}{\sigma_N{}^2} HH^\dagger) \tag{1}$$

Note that because H is random, the capacity is also random. Thus we can characterize the capacity by cumulative distribution function (CDF).
In case of correlated channel, channel matrix H can be factorized in form as follows:[3]

$$H = (\Psi^R)^{\frac{1}{2}} W (\Psi^T)^{\frac{1}{2}} \tag{2}$$

where $\Psi^R$ and $\Psi^T$ are the correlation matrix of transmit antennas and receive antennas and the entries of $W$ are independent and identically distributed (i.i.d). In this paper, we assume that transmit antennas are uncorrelated.
If we assume the incident wave is uniform, the entries of $\Psi^R$ can be obtained by following equation [4]

$$\Psi_{ij} = \frac{1}{\sigma_i \sigma_j} \int P_{\theta i}(\theta,\phi) P_{\theta j}{}^*(\theta,\phi) + P_{\phi i}(\theta,\phi) P_{\phi j}{}^*(\theta,\phi) d\Omega \tag{3}$$

where $P_\theta(\theta,\phi)$ and $P_\phi(\theta,\phi)$ are complex antenna patterns for both polarizations $\theta$ and $\phi$. Also, $\sigma_i$ and $\sigma_j$ are the standard deviations of received signal.

## The proposed polarization diversity system

Fig. 1 shows the structure of vertically and horizontally excited antennas, respectively. As shown in Fig. 2, the measured center frequency is slightly increased compare to those of the simulation. In the comparison between horizontal excitation and vertical excitation, the return loss characteristic is not much different. However, as shown in Fig. 3, the radiation pattern of vertical excitation is different from horizontal excitation case. Although the shapes of pattern $E_\theta$ and $E_\phi$ in both cases are similar, the dominant components are changed. In case of vertical excitation, $E_\theta$ is dominant while $E_\phi$ is dominant in horizontal excitation. Thus, we can conclude that the vertical polarization is achieved by vertical excitation.

By applying these properties, we proposed the two antenna array as shown in Fig. 4 (a). Each antenna's polarization differs from each other. To analyze the effect of polarization diversity, we also designed another antenna array whose elements have same polarization characteristics (Type 2). In both antenna arrays, the ground is slotted to reduce the mutual coupling.

Fig. 4(c) and (d) shows the scattering parameters of two antenna arrays. As shown in Fig. 4, since the isolations between antenna elements are similar, we can ignore the effect of mutual coupling on the variation of spatial correlation.

Spatial correlation can be calculated from radiation pattern by using the equation (3). In case of Type 1, the calculated correlation coefficient between two antennas is 0.78. However, in case of Type 2, the correlation coefficient is 0.57. Thus, we can notice that correlation coefficient decreases due to the polarization diversity.

Also, from the correlation matrix, we can calculate the capacity at each random value of H by using equation (4). Then, we obtained the complementary CDF of capacity and mean capacity versus signal noise to ratio and plotted in Fig.5 (a) and Fig.5 (b), respectively. In both graph, the Type 2 shows better performance.

## Conclusion and Discussion

The polarization diversity is easily achieved by horizontal and vertical feeding. The proposed polarization diversity system shows the decrease of spatial correlation and increase of the capacity compare to co-polarized antenna array.

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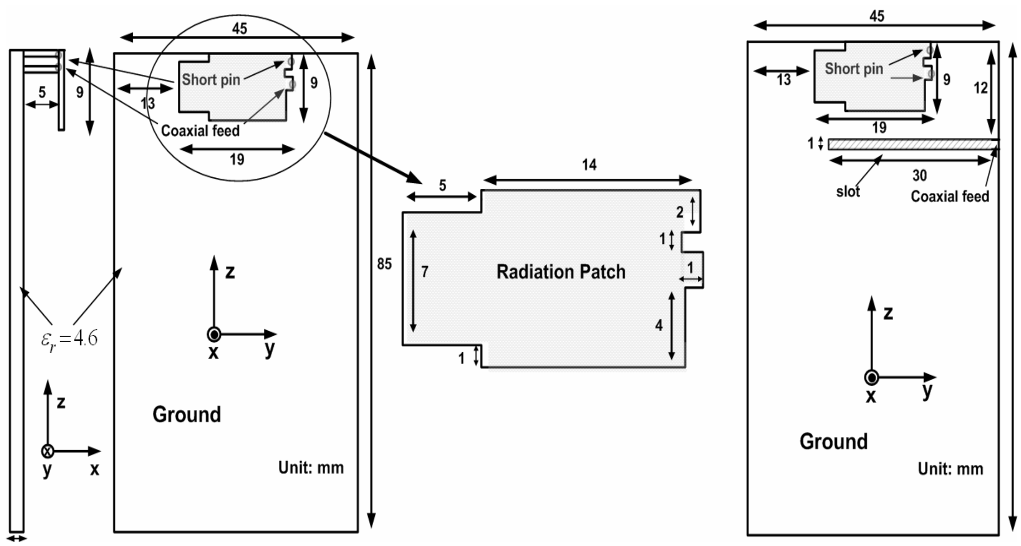



(a) The horizontal excited antenna (b) The vertical excited antenna

Fig. 1 Geometries and dimensions of the proposed antennas

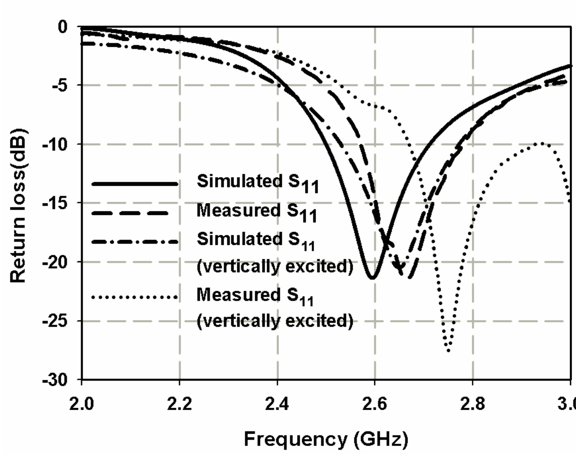
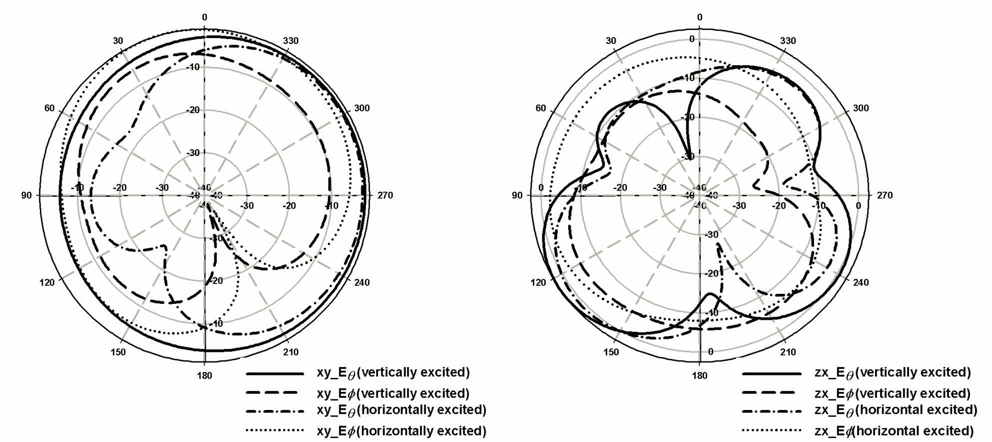



Fig. 2 Simulated and measured return loss for the proposed antennas




(a) x-y plane (b) z-x plane

Fig. 3 Comparison of radiation patterns for the proposed antennas at 2.6GHz

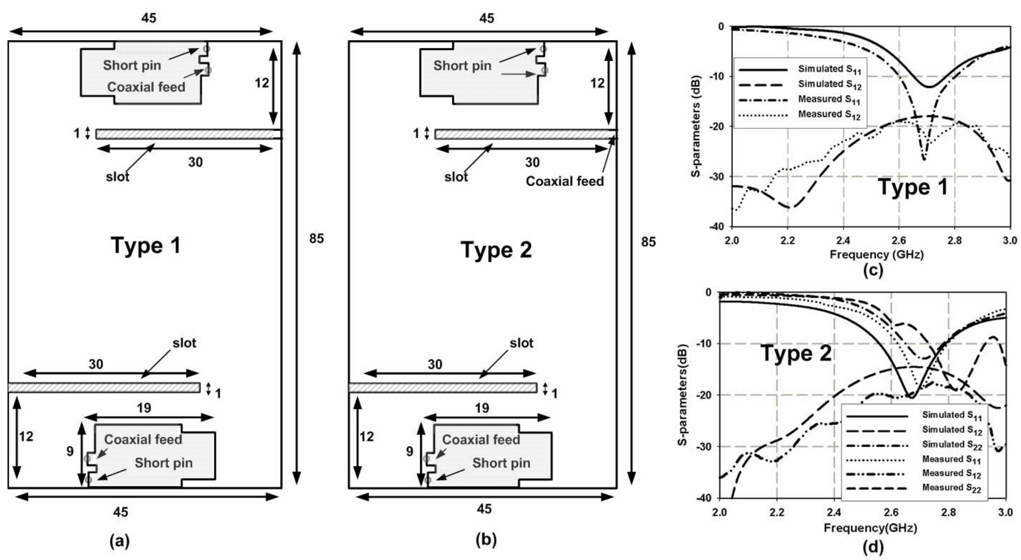
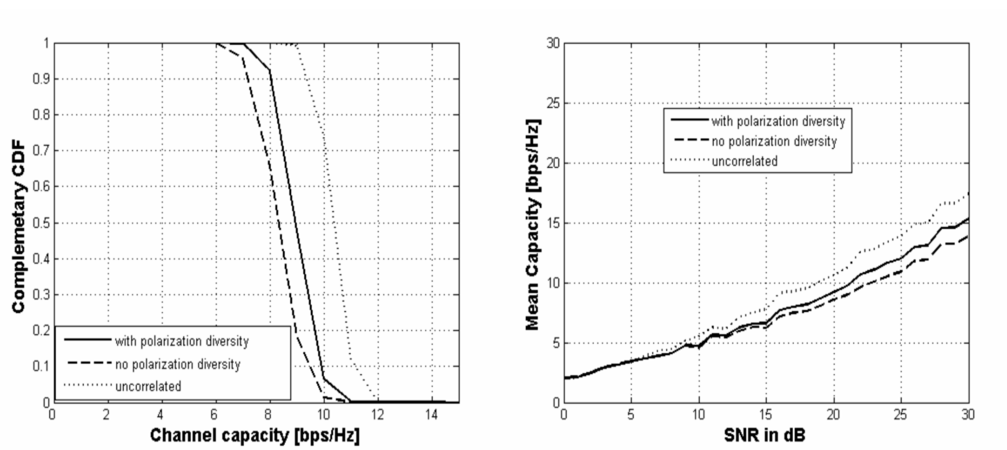



Fig. 4 The proposed two antenna array and S-parameters




(a) Complement CDF of capacity (b) Mean capacity versus SNR

Fig. 5 Complement CDF of capacity and Mean capacity versus SNR