# Improvement of the MIMO Performance of an Antenna Array Using Dielectric Substrates

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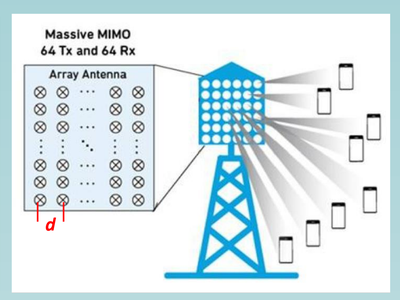
## Introduction

The fading correlation has significant impact on the performance of a MIMO system. And it is directly connected to the diversity gain, antenna gain and multiplexing gain of an MIMO array.




- Aesthetics
- Avoid grating lobes

} The inter-element spacing $d \leq \lambda/2$

Problem I: **Two antenna elements separated at half-wavelength can still be highly correlated.**

For a four-element array, there are six correlation coefficients( $\rho_{ij}$ , $i \neq j$ ) to be characterized in the correlation matrix

$$\mathbf{R} = \begin{pmatrix} \rho_{11} & \cdots & \rho_{14} \\ \vdots & \ddots & \vdots \\ \rho_{41} & \cdots & \rho_{44} \end{pmatrix}$$

Problem II:. **Too many correlation coefficients are messy to use for comparisons of different arrays.**

## Objectives

Proposing an effective method for improving MIMO performance of an antenna array. The method should have the following characteristics

- **Improve the diversity measure and capacity of the existing array**
  - **Diversity measure($\Psi(\mathbf{R})$) is a scalar that can characterize the overall correlation performance of an arbitrary MIMO array**

$$\Psi(\mathbf{R}) = \left( \frac{tr(\mathbf{R})}{\|\mathbf{R}\|_F} \right)^2$$

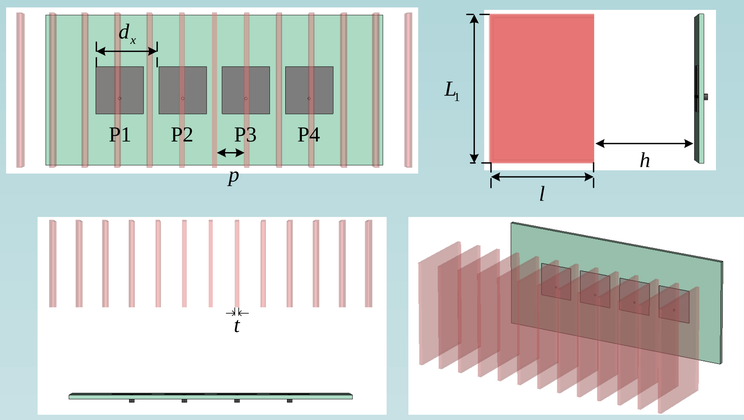
  - **The channel capacity can be calculated as**

$$C = E\left\{ \log_2 \det[\mathbf{I} + \frac{\gamma}{N}\mathbf{H}\mathbf{H}^H] \right\}$$

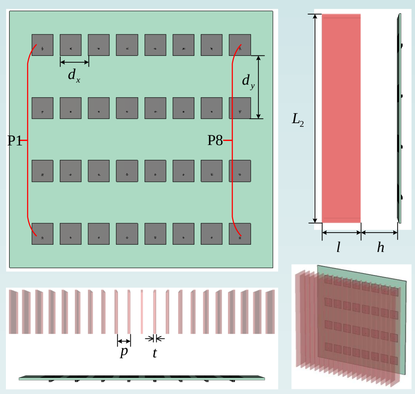
- **The method shouldn't change the structure of the existing array**
  - **The method can be more conveniently applied to the existing equipment, and exists in the form of a radome, etc.**

## Methods

A method of improving the diversity measure and capacity of single-polarized antenna array in non-isotropic multipath environments by loading dielectric substrate array is proposed. The dielectric substrate array, which is made of relatively higher wave impedance dielectric substrate periodically, is placed on top of the antenna array to enrich the wave scattering.

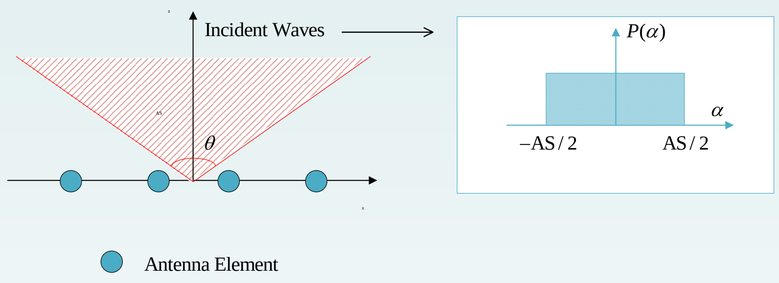



Configuration of the 1×4 microstrip antenna array and the dielectric substrates



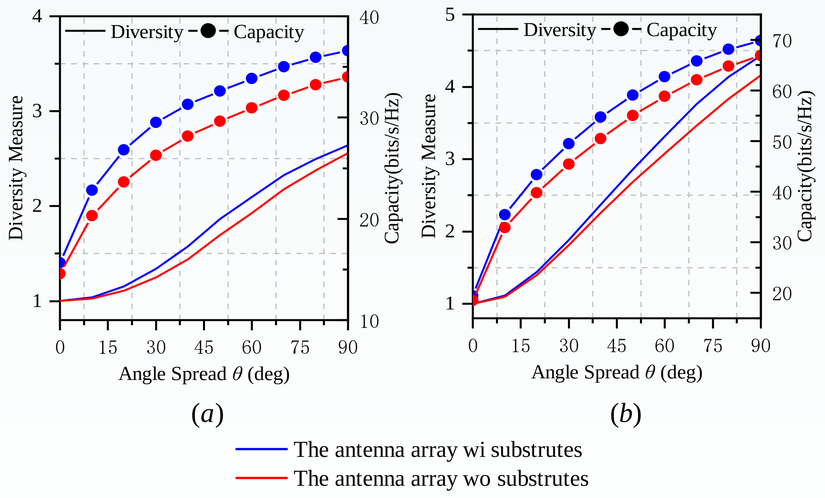

Configuration of the 4×8 microstrip antenna array and the dielectric substrates.

The antennas in the same column are excited simultaneously.




The antenna array is deployed on the receiving side to receive incident waves following uniform angular distribution with different angular spreads(AS).

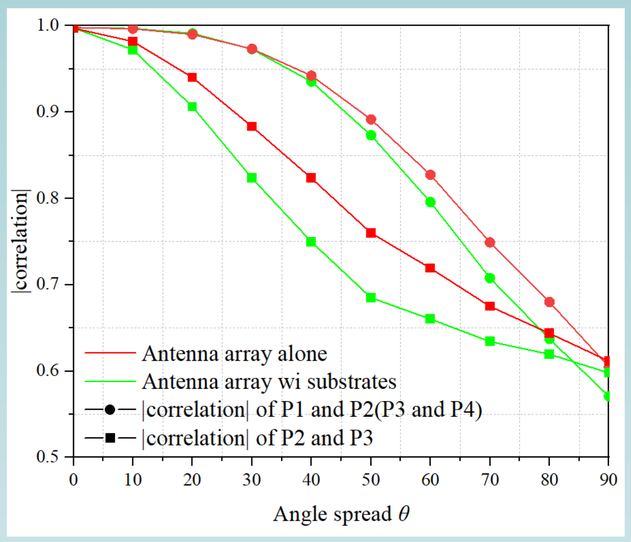
## Simulation Results




Diversity measure and capacity simulated results (without and with the dielectric substrates loaded) of (a) the 1×4 antenna array (b) the 4×8 antenna array.

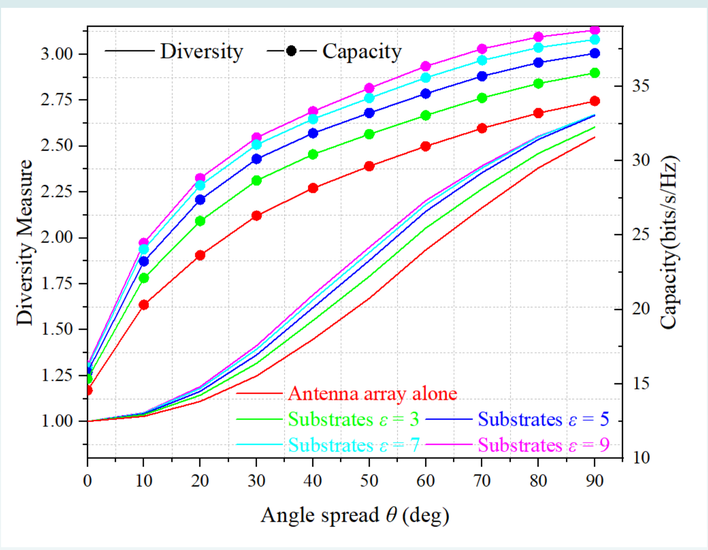
## Conclusion

- The periodic arrangement of dielectric substrates can effectively increase the diversity measure and capacity of the antenna array.
- The decrease of the correlation between adjacent antenna elements is the main reason for the improvement of the diversity measure.




Relationship between the coefficient absolute value of adjacent ports in the 1×4 antenna array and angle spread in horizontal plane.

- The higher the wave impedance of dielectric substrates, the stronger the environment scattering, the more the diversity measure and the capacity are improved.




Diversity measure and capacity of the 1×4 antenna array alone and with dielectric substrates of different permittivity loaded.

## References

[1] M. T. Ivrlac and J. A. Nossek, "Diversity and correlation in Rayleigh fading MIMO channels," IEEE VTC, May 2005, pp. 151-155.

[2] X. Chen, H. Pei, M. Li, H. Huang, Q. Ren, Q. Wu, A. Zhang, and A. A. Kishk, "Revisit to mutual coupling effects on multi-antenna systems," J. Commun. Inf. Netw., in press.

[3] J. B. Andersen and K. I. Pedersen, "Angle-of-arrival statistics for low resolution antennas," IEEE Trans. Antennas Propag., vol. 50, no. 3, pp. 391-395, Mar. 2002.