MIMO Propagation Channel Modeling

Yoshio Karasawa
The University of Electro-Communications
1-5-1 Chofugaoka, Chofu, Tokyo 182-8585, Japan
e-mail: karasawa@ee.uec.ac.jp

ABSTRACT

This paper deals with MIMO propagation channel modeling which might be one of the important study areas realizing effective MIMO communication systems having higher channel capacities. After presenting basic propagation channel models both for narrowband and wideband signals, two recent propagation-related topics on MIMO system, i) MIMO utilizing dual and triple polarization diversity branches, and ii) Tx/Rx weight mismatch problem for open-loop control system such as eigen-beamforming data transmission system, are highlighted.

Multi-Dimensional MIMO Channel

Since MIMO scheme is characterized by advanced diversity scheme, various diversity branches not only for multiple antennas but also for polarization, frequency slots and so on can be utilized. One of the promising method is the use of orthogonal polarizations, namely, MIMO based on space-polarization domain signal processing. By using the developed MIMO experimental system, an experiment at 2.2GHz was carried out in a multipath-rich indoor environment. In the experiment, two-element arrays at both ends where each element has a horizontal polarization branch and a vertical polarization branch were used. The results are compared with those of conventional single-polarization 4-element array (4x4 MIMO).

In order to enrich the polarization utilization, MIMO using a tri-polarized antenna is also experimentally studied. The first two orthogonal polarization ports such as vertical polarization (V) and horizontal polarization (H) has been created on the same patch metal plate. The third one (D) has been added perpendicularly just in the middle on the circular patch where it commonly uses the ground plane but does not contact with the circular patch. We have confirmed that this tri-polarization MIMO, namely, MIMO having three orthogonal polarization branches, works well in multipath-rich environment.

Tx/Rx-Weight Mismatch Problem

For open-loop-controlled MIMO systems, a weight mismatch problem between transmitting and receiving sites will happen in some cases. For example, channel state information (CSI) is obtained separately at both sites when the system is operating with TDD (time-division duplex), estimated eigenvectors at both sides are not always the same due to perturbation factors such as thermal noise. This problem causes significant signal degradation particularly when two eigenvalues, λ_1 and λ_2, become equal, namely, occurrence of degeneration of eigenvalues.

In order to show a typical example of the problem, first, we deal with an inter-vehicle communication system in ITS (Intelligent transport System) where the propagation channel consists of the direct wave and the road-surface reflected wave. Assuming that MIMO of 4x4 (vertical arrangement with element separation of 5cm) and operation frequency of 60 GHz, two non-zero eigenvalues, λ_1 and λ_2, as a function of vehicular distance are obtained. The occurrence of einvalue crossing, degradation of signal transmission at the point, and its countermeasure will be presented.
Next we deal with more general case, i.i.d. Rayleigh fading MIMO channel. The same problem will occur at the point of crossing adjacent eigenvalues, namely, . λ_i and λ_{i+1}. The frequency occurrence of eigenvalue crossing is evaluated through computer simulation. The results show that the crossing between λ_1 and λ_2 for 2x2 and 4x4 will occur onece in two meters at the frequency of 5GHz. Finally, theoretical analysis is carried out to identify the simulation results.