Source: **Motorola**
Title: **Dual-Polarization Extension for Spatial Channel Model**
Document for: **Discussion**

1. DUAL-POLARIZATION CHANNEL MODEL EXTENSION

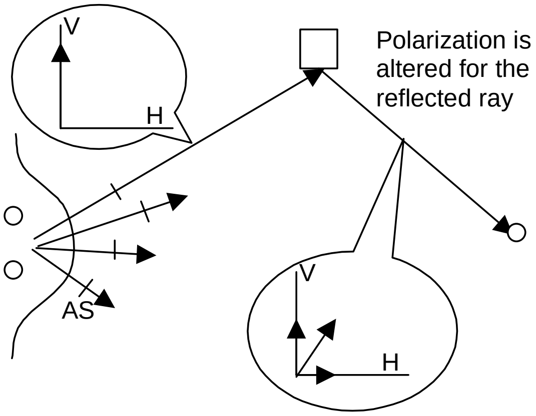
1.1 Introduction

A dual-polarization channel model is proposed based on a simple extension of the single-polarization channel models that are currently being proposed within the 3GPP/3GPP2 Joint Spatial Channel Modeling Ad-hoc discussion [1-3]. This model is based largely on the empirical results reported in the literature which indicate that the mean delay, RMS delay spread, mean azimuth, and azimuth spread is virtually identical for both polarizations [4,5].

1.2 Model Overview

The dual-polarization channel model essentially extends the single-polarization model by allowing each ray to be depolarized by the scattering environment. This is illustrated in Figure 1, where the rays generated in the typical single-polarization scenario are reflected at different polarizations than they were originally transmitted.

Figure 1. Depolarization Example



In the proposed dual-polarization model, the channel models currently under discussion in the 3GPP/3GPP2 Joint Spatial Channel Modeling Ad-hoc group would be extended as follows:

1. The channel models currently under discussion would be used to generate the channel model for the polarization of the transmitting antenna.
2. A second channel model would then be generated to model the channel corresponding to the polarization orthogonal to the transmitting polarization. This second channel model would have the identical number of rays and subrays, identical delays, and identical angles of arrival at the node B and node UE. However, it would have different amplitude characteristics which would be set based on measured branch power ratio.

1.3 Computation of the Complex Channel Impulse Response

Computation of the channel impulse response between the j^{th} transmit antenna and the k^{th} receive antenna is performed in a manner similar to that used for the single-polarization scenario, with the exception of two important differences. First, the impact of the orthogonal polarization $P_{j\perp}$ must be included in the calculation in addition to the transmitted polarization P_j. Second, the impact of the different antenna orientations must be included in the computation. This has the effect of producing azimuth-dependent attenuation of the subray amplitudes due to non-vertical orientation.

The process typically used to account for this azimuth dependent attenuation consists of decomposing the transmitted and orthogonal polarizations into vertically-polarized (V) and horizontally-polarized (H) components [6]. As an example, consider the dual-polarized system illustrated in Figure 2. It consists of a node UE array consists of a pair of antenna elements (UE_1 and UE_2) installed in the XY plane slantwise relative to the vertical direction (Y) at angles of α_{T1} and α_{T2} (measured counter-clockwise with w.r.t. the Y-axis), respectively. Similarly, the node B array consists of a pair of antenna elements (BS_1 and BS_2) installed slantwise relative to the vertical direction at angles of α_{R1} and α_{R2}, respectively. Some examples of typical dual-polarized antennas are the slant-45° configuration (i.e., $\alpha_{T1}=45^o$ and $\alpha_{T2}=-45^o$) and the V-H configuration (i.e., $\alpha_{T1}=90^o$ and $\alpha_{T2}=0^o$).

For subray i that is transmitted from the jth transmit antenna via the transmitting polarization ($h_{jk,i}$), the contribution at the kth receive antenna is computed by first decomposing the subray into its vertical and horizontal components as follows:

$$h_{jk,i,V}= h_{jk,i}\cos(\alpha_{Tj}) \qquad (1)$$

and

$$h_{jk,i,H}= h_{jk,i}\sin(\alpha_{Tj}) \qquad (2)$$

where the additional subscripts V and H indicate the horizontal and vertical components of the transmitted subray. This is similarly done for the orthogonal polarization ($h_{jk,i\perp}$) as follows:

$$h_{jk,i,\perp,V}= h_{jk,i}\cos(\alpha_{Tj}-\pi/2) \qquad (3)$$

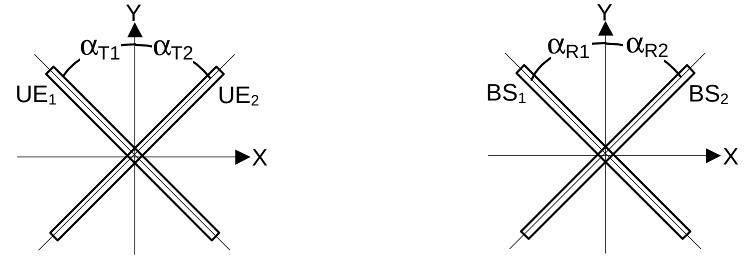
and

$$h_{jk,i,\perp,H}= h_{jk,i}\sin(\alpha_{Tj}-\pi/2) \qquad (4)$$

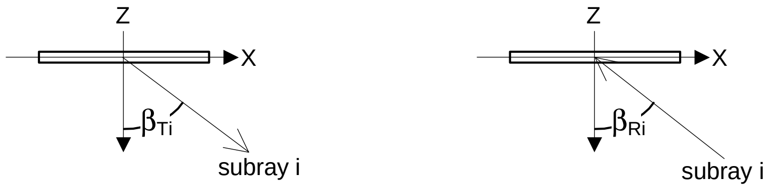
where the $\perp$ indicates the contribution of the identical subray in the orthogonal polarization to the transmit polarization. At the kth receive antenna, the contribution of this subray to the composite channel between antennas j and k ($h_{jk,i,total}$) is then added based on its receive orientation, and the impact of the angle of arrivals at the node B and node UE are included. This is performed as follows:

$$h_{jk,i,total} = (h_{jk,i,V}+ h_{jk,i,\perp,V})\cos(\alpha_{Rk})+ (h_{jk,i,H}+h_{jk,i,\perp,V})\sin(\alpha_{Rk})\cos(\beta_{Ti})\cos(\beta_{Ri}). \qquad (5)$$

Figure 2. Dual Polarization Example



A. XY Plane at node UE ($\beta_T=0^o$) B. XY Plane at node B ($\beta_R=0^o$)



C. XZ Plane at node UE D. XZ Plane at node B

2. CONCLUSION

In this contribution, a dual-polarization channel model has been presented that is compatible with the current models under discussion.

3. REFERENCES

[1] Motorola, "Correlated Spatial Channel Model", SCM-029, Conference Call, June 4th 2002.
[2] Motorola, "System Level Channel Model and Simulation", TSGR1#24(02)0407, Orlando, Florida, January 18-22, 2002.
[3] Motorola, "Correlated Spatial Channel Model", SCM-020, Conference Call, May 3rd, 2002.
[4] Klaus I. Pedersen, Preben E. Mogensen, and Bernard H. Fleury, "Dual-Polarized Model of Outdoor Propagation Environments for Adaptive Antennas," Vehicular Technology Conference, 1999, pp. 990-995.
[5] P. Eggers, J. Toftgaard, A. Oprea, "Antenna Systems for Base Station Diversity in Urban Small and Micro Cells," IEEE Journal on Selected Areas in Communications, Vol. 11, No. 7, pp. 1046-1057, September 1993.
[6] S. Kozono, T. Tsuruhara, M. Sakamoto, "Base Station Polarization Diversity Reception for Mobile Radio," IEEE Transactions on Vehicular Technology, Vol. VT-33, No. 4, November 1984, pp. 301-306.