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An Approximation of a Frequency-Selective Fading Rician Channel for OFDM Systems

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***Abstract*—As the Rician channel model expresses out-door wireless channel environment, performance analysis of communication systems under Rician channel model has been widely performed. However, the performance analysis with a frequency-selective fading channel requires additional memories and complexity for frequency domain statistics. In this respect, an approximation of the two-ray Rician frequency-selective fading channel coefficient is proposed and it is verified by simulation.**

Keywords*— BER; Frequency-selective fading channel; Rician channel

I. Introduction

The multipath wireless channel environment which has strong line-of-sight (LOS) components can be modeled by the Rician channel model. As out-door wireless channel environment is assumed to have significant LOS components, performance analysis of the Rician channel model for commercialized wireless communication systems and terrestrial broadcasting systems has been performed [1]. In specific, the performance analysis of orthogonal frequency division multiplexing (OFDM) technique, which is chosen as the modulation scheme for various wireless communication systems, under the Rician frequency-selective fading channel has been also performed [2]. However, the performance analysis of the Rician frequency-selective fading channel for the OFDM systems requires large complexity and memory. In this respect, this paper proposes an approximated two-ray Rician channel model. The simulation results verifies the validity of the approximation.

II. An Approximation of the Frequency-Selective Fading Rician Channel Coefficient

The channel coefficient of the frequency-selective two-ray Rician fading channel for the nth subcarrier of the OFDM symbol, $h(n)$, can be written as

$$h(n) = \sqrt{\frac{K}{K+1}} h_{LOS} + \sqrt{\frac{1}{K+1}} e^{-j\frac{2\pi\tau fn}{N}} h_{NLOS} \quad (1)$$

where h_{LOS} and h_{NLOS} denote the constant value for the line-of-sight (LOS) and the random variable for the scattering component, respectively, and the Rician factor K indicates the power ratio of two components. The random variable indicates the multipath component with time delay, τ, and the corresponding phase distortion is expressed as shown in the exponential function of (1). When the frequency-selective fading channel is considered like (1), the statistical distribution of (1) requires to collect trials of the random variable with every subcarrier number, n. It requires n times more memories and larger amount of complexity.

In order to reduce the analysis complexity, this paper approximate the channel equation of (1) by using the statistical property of the random variable component of (1). In detail, it is known that the magnitude of the complex Gaussian random variable component, h_{LOS}, has Rayleigh distribution and the phase shows uniform distribution. Considering (1), since the phase of the exponential component multiplied by h_{LOS} is uniformly distributed along the range of 0 to 2π, the phase of the resultant multiplied variable still exhibits the uniform distribution. Therefore, in the sense of the statistical distribution, the channel equation of (1) can be approximated as

$$h' = \sqrt{\frac{K}{K+1}} h_{LOS} + \sqrt{\frac{1}{K+1}} h_{NLOS} . \qquad (2)$$

III. Simulation Results

The probability density functions of the approximated channel model of (2) and the original (1) are the same as shown in Fig. 1. In Fig. 1, A and α denote $\sqrt{K/(K+1)}h_{LOS}$ and $\sqrt{1/(K+1)}h_{NLOS}$, respectively.

The uncoded BER performance of an OFDM system curves with the channel equation (1) and (2) are plotted in Fig. 2. In the simulation, 16-QAM symbol modulation was used, the Rician K factor was 1 that the power of the constant and the random variable components was identical. According to the simulation results, the uncoded BER of an OFDM system with an approximated channel coefficient of (2) exhibits is the same with that with the original channel coefficient of (1).

IV. Conclusion

This paper has proposed an approximated channel coefficient equation for the two-ray frequency-selective Rician fading channel and verified that the probability density functions and the uncoded BER performances with the original and an approximated channel coefficient channel equations are the same. With these results, it is expected that the approximation can be used for performance analysis of OFDM systems going through the Rician channel model with reduced memory and complexity. As a further research, approaches to approximate multipath channel environment, which has larger number of multipath components than two-ray model, can be performed.

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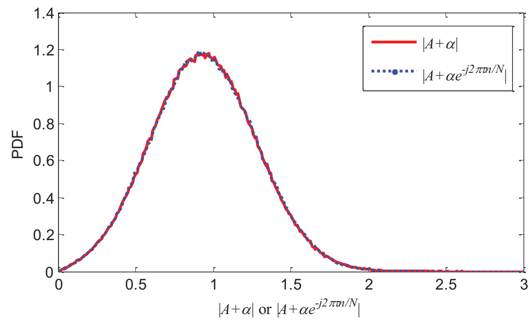

Fig. 1. The probability density function of (1) and (2).

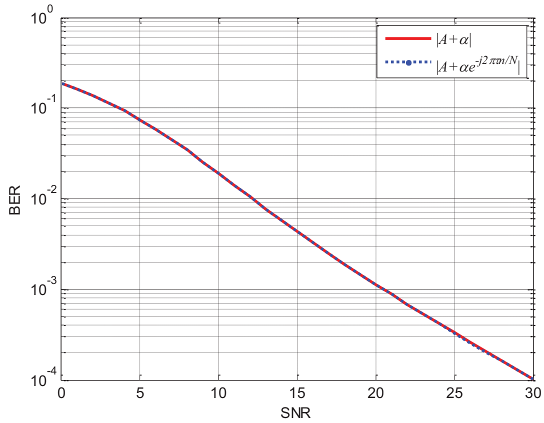

Fig. 2. Uncoded BER performance with (1) and (2).