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Performance analysis in non-Rayleigh and non-Rician communications channels

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Abstract

This paper investigates the probability of erasure for mobile communication channels containing limited number of scatterers. Two kinds of channels with and without line of sight are examined. The resultant data is depicted by graphs to express the differences in existing theoretical models more clearly. The results indicate that the probability of erasure is different from that of predicted by both Rayleigh and Rician models for small number of scatterers.

Keywords: Fading; Mobile communications; Non-Rayleigh and non-Rician channel

1. Introduction

Propagation models in mobile communications are very useful tools to design cellular systems. Carrier-to-interference ratio (CIR) and fading depth are key parameters to determine the cell size. CIR depends on the cell configuration that varies with respect to the distance used for the same frequencies. The fading depth, however, mostly depends on terrain effects. It is possible to find many works related to fading calculation in literature. These studies are generally classified into two groups which based on theoretical [1–3] and experimental models [4–6]. Due to difficulties in determining the parameters of theoretical models, system designers have faced some difficulties to calculate fade depth although they have so many such models. Another problem arises from experimental models since they can give results only in the regions where the measurements are taken. Due to the problems mentioned above, the use of these models becomes difficult in many

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cases. Therefore additional models and approaches are required to be developed for this sort of problems.

Statistical models are developed as alternative approaches to determine fading depth. It is clear that, the amplitude fluctuations in received signals over mobile radio channels are modeled by either Rayleigh for channels without line of sight (LOS) component or Rician model for channels with LOS component [7]. Both of these models are based on statistical approaches. If there is a large number of multipath signals, where all signal contributions are on the same order of magnitude, the received signal is determined by the Rayleigh model. In the case where signal contributions are in different order of magnitude and there is a large number of multipath signals, then Rician model is used to predict the received signal. In practice, the scatterer numbers of communication channels are generally big enough so that either Rayleigh or Rician model can be used to determine the signal fluctuations. These models assume that the number of scatterer is infinitive. However, in some cases, the channel may contain only small number of scatterers. For examples, due to low traffic and building density, the scatterer numbers are expected to be lower in rural and suburban areas. In this case, neither Rayleigh nor Rician is an appropriate model to be used in computing the received signal correctly because of the considerable faults caused by these models. The resultant channel performances of the proposed approach are compared with those of obtained using Rayleigh and Rician channels.

A novel approach is developed here in order to determine the received signals where the scattering sources are limited with small numbers compared to the ones in urban areas where Rayleigh and Rician models are used. The results of the proposed approach are compared. In this study the number of scatterers are changed between 2 and 10 while calculating received signal in the cases with and without LOS.

2. Received signal simulations

In mobile communication systems, the received signal includes the multipath signals that are scattered from scatterers existing on active scatterers radius (ASR) [7–9]. The phaser sum of these multipath signals causes fading on the received signal.

Rayleigh and Rician models are widely used to calculate the received signal in mobile communication systems. These models are given as [7,10]:

$$p_r(r) = \begin{cases} \frac{1}{\sigma^2} r \exp(-r^2/2\sigma^2), & r \geqslant 0 \\ 0, & \text{other} \end{cases} \tag{1}$$

for Rayleigh model,

$$p(r) = \begin{cases} \frac{r}{\sigma^2} \exp\left(-\frac{(r^2+a_0^2)}{2\sigma^2} \right) I_0\left(\frac{a_0 r}{\sigma^2}\right), & r \geqslant 0 \\ 0, & \text{other} \end{cases} \tag{2}$$

for Rician model, where $p_r(r)$ is probability density function, r is the random variable, σ is standard deviation, a_0 is the amplitude of LOS component, and I_0 is first order zero degree Bessel function in both Eqs. (1) and (2).