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A unified approach to average LCR and AFD performance of SC diversity in generalized fading environments

Joy Iong-Zong Chen*

Department of Communication Engineering, Da Yeh University, 112 Shan -Jeau, Rd. Da-Tsuen, Chang-Hua 51505, Taiwan, ROC

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Abstract

The average level crossing rate (LCR) and average fading duration (AFD) criterions are applied to analyze the selection combining (SC) diversity for wireless communication systems over correlated-Rayleigh and correlated-Rice fading in this paper. The scenarios of the fading channel models are characterized as 4 generalized and experimental distributions, e.g., Rayleigh, Rice, Nakagami-*m*, and Weibull distributed statistics. Moreover, both of independent and correlated proprieties between branches are also involved for consideration. For purpose of unifying and clarifying the average LCR and AFD performance formulas results from the evaluation for SC diversity, it is not only the results from our research presented, but some of the published results are also cited and illustrated by numerical evaluation again in this study.

Keywords: AFD; LCR; Nakagami-*m*; Rayleigh; Rice; SC diversity; Weibull fading channel

1. Introduction

It is well known that the received signal at the receiver output would have the appearance of the shadowing and fading effect caused by the influence of many terrains when the signals are transmitted in the mobile communication systems. The local average power of a received signal at output of a receiver will fluctuate randomly from place to

*Tel.: +886 48 511888; fax: +886 48 511245.
E-mail address: jchen@mail.dyu.edu.tw.

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place in a mobile radio system due to the instantaneous power averaged over a distance is changing rapidly. This phenomenon is generally referred as a shadowing fading [1]. In general, the log-normal probability density function (PDF) is the most popular and proper model used to describe the shadowing effect which results from diffraction. There exists a lot of path, called multipath, are caused by many physical phenomenon such as reflection, refraction and scatter between the transmitter and the receiver station over wireless communication systems. The major reasons of linear distortion and inter-symbol interference (ISI) are not only generated by the multipath, but the power of received signal will also be destabilized. It is worth noting that one of the reasons that the fading channel is assumed characterized by Weibull statistic distribution in this paper is that it can be regarded as an approximation to the generalized Nakagami-*m* distribution of same order. Furthermore, according to many experimental measurements, it is a demonstration that the characteristic of Nakagami-*m* distribution is better than Rayleigh and Rice distribution in the urban area and includes the characteristics both of one-sided Gaussian and Rayleigh distribution [2–4]. There are some diversity-combining methods to mitigate fading and multipath experienced in wireless communication systems. Traditionally, in selective combining (SC) diversity, choosing a branch at output of the combiner with the highest signal-to-noise ratio (SNR), which corresponds to the strongest signal if noise power among different branches are assumed all same [5,6].

In this paper, the performance of communication systems with both of the average level crossing rate (LCR) and average fade duration (AFD) criterions are investigated, and most of the generalized and experimental fading channel models are applied for evaluation. For comparison purpose, not only some of new LCR and AFD formulas were derived, for example, the case of correlated-Rayleigh and correlated-Rice channel, but the published results were cited and illustrated again. The average LCR and AFD are two quantities, which statistically characterize a fading communication channel. When the transmitted signals are affected by multipath, the envelope of the signals will be degraded to a threshold level R_{th}, which is preset. As long as the distance between transmitter and receiver are made a little movement, then envelope and phase of the transmitted signal will variate a lot. Especially, the magnitude of the signal will agitate irregular in envelope such that the envelope of a fading channel crosses a given value in positive or negative direction. Hence the average LCR can be defined as number of times per unit duration that the envelope of a fading channel crosses a given value in the positive or negative direction [7]. The AFD corresponds to average length of time the envelope remains under a threshold level R_{th} once the transmitted signals cross R_{th} in positive or negative directions [8].

The average LCR and AFD have found a variety of applications in modeling and designing of the wireless communication systems, such as Patzold analyzed and simulated the average LCR and AFD with the aid of computer over independent Rice fading channels [9]. The performance evaluation of LCR and AFD for time diversity working in independent Rayleigh fading channel is presented in [10]. In [11] where Yang studied the LCR and AFD performance for SC diversity scheme and the correlated Rayleigh fading environments were assumed. The authors Dong et al. in [12] evaluated the LCR and AFD for SC diversity and considered both of the independent of branch when it is working in Rayleigh, Rice and Nakagami-*m* fading channel models. In paper [13] Tjhung assumed that the transmitted signal is operating over Nakagami–log-normal fading channels and analyzed the LCR and AFD for SC receipt system. The dual-branch correlated Weibull