Chapter 4.18
Stochastic Modeling of Narrowband Fading Channels with Three Dimensional Diffuse Scattering

Petros Karadimas
University of Patras, Greece

ABSTRACT

This chapter studies a composite stochastic model, in which the diffuse component arises from three dimensional (3-D) multipath scattering. That case occurs especially in dense scattering environments, in which the tall obstacles cause arrival of multipath power in the elevation plane, besides that arriving in the azimuth one. Also the multipath components are assumed to arrive at the mobile receiver in specific angular sectors at the azimuth receiver's plane. The last is physically justified by multipath power blocking due to the channel obstacles (shadow fading), or/and lack of scattering objects at specific angular directions, or/and directional antennas utilization. An extended Suzuki model, where the Rician process for the diffuse scattering component is multiplied by a lognormal one, is considered as an appropriate composite model. The most important metrics of the model are presented, according to its assumptions. More specifically, from the closed form autocorrelation function, the Doppler power spectral density (PSD) of the diffuse component can be analytically derived. Afterwards exact solutions for the envelope and phase probability density functions (PDF's) are presented. Exact solutions are also derived for the second order statistics, i.e. the level crossing rate (LCR) and the average duration of fades (ADF's). An efficient deterministic simulation scheme will be presented, which implements the analytical model on a digital computer. Finally a curve fitting of the LCR to real world data, drawn from channel

measurements, will demonstrate the flexibility and usefulness of the extended Suzuki model.

I. INTRODUCTION

The transmission performance of wireless services is strongly influenced by the rapid amplitude and phase fluctuations of the received signal. Those fluctuations result from the constructive and destructive nature of the arriving multipath components at the receiver. In turn multipath components can arrive at the elevation plane, besides those arriving at the azimuth receiver's plane, due to 3-D electromagnetic wave propagation. Moreover an important contribution to the received signal variability arises from the shadowing mechanisms of the channel, causing time varying attenuation of the received signal mean value.

In order to model the slow term variations, due to shadow fading and incorporate them in the rapid short term variations, arising from multipath propagation, two basic models have been proposed. Each of them represents a different concept for the wireless mobile channel modeling. The first one was proposed by Suzuki [Suzuki, 1977] and Hansen and Meno [Hansen, 1977], the so called Suzuki process. This model is obtained by multiplying a Rayleigh process with a lognormal one. The second was proposed by Loo [Loo, 1985], [Loo, 1991]. This model resembles a Rician model, with the additional property that the amplitude of the line of sight (LOS) component is no more constant, as this happens in the Rician model, but it is a random stochastic process following a lognormal PDF. Loo model arises by summing a lognormally distributed random phasor and a Rayleigh phasor. In international bibliography the term "modified" applies to the case where the inphase and quadrature Gaussian components generating the Rayleigh part are correlated, whereas the term "extended" refers to the case where a specular component of constant amplitude has been added to the diffuse one. Thus we obtain modified Suzuki processes [Krantzik, 1990], extended Suzuki processes, [Corazza, 1994; Patzold, 1998 A; Patzold, 1997; Li, 1996], [Patzold, pp. (157-208), 2002] and modified Loo models [Patzold, 1998 B], [Patzold, pp. (218-240), 2002]. By adopting modified models we force the Doppler PSD of the diffuse scattering component to obtain an asymmetrical shape, in contrast to the classical symmetrical PSD, arising from two dimensional (2-D) propagation and given by Clarke [Clarke, 1968]. Thus, it is a simple technique to model sectored arrival of multipath power. By adopting extended Suzuki processes we increase the flexibility and usefulness of the channel model, as this extension enables us to incorporate in it a LOS component, if a specific channel configuration implies its existence (e.g. an open environment). Apart from the already cited works, Suzuki models have been employed in several publications, in both single state (stationary) and multiple states (non-stationary) models. In [Vatalaro, 1995] and [Vatalaro, 2002] a generalized Rice-lognormal channel was studied, in which Suzuki model constitute a special case of it. In [Tjhung, 1999] the second order statistics of the Nakagami-lognormal channel were derived, whereas in [Xie, 2000] the received signal envelope and power PDF's of the Beckmann-lognormal model were investigated. Finally in [Lutz, 1991] a two states model was employed, where a Suzuki process occupies one state and a Rician the other one.

In order to account for multipath propagation in three dimensions, combined with shadow fading, we adopt in this chapter an extended Suzuki model, where the diffuse component arises from both 3-D scattering and partial arrival of multipath power [Karadimas, 2008 A]. Apart from [Karadimas, 2008 A], where the PSD was analytically calculated, 3-D multipath scattering has been the topic of several publications. In [Aulin, 1979] a PDF for the elevation angles

15 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage:
www.igi-global.com/chapter/stochastic-modeling-narrowband-fading-channels/49443

Related Content

Changing Middle School Science through STEAM
Teresa Franklin, David Chelbergand Chang Liu (2011). *Gaming and Simulations: Concepts, Methodologies, Tools and Applications (pp. 645-667).*
www.irma-international.org/chapter/changing-middle-school-science-through/49410

A Review on Semantic Text and Multimedia Retrieval and Recent Trends
Ouzhan Menemencioluand lhami Muharrem Orak (2015). *International Journal of Multimedia Data Engineering and Management (pp. 54-74).*
www.irma-international.org/article/a-review-on-semantic-text-and-multimedia-retrieval-and-recent-trends/124245

Digital Watermarking Based on Neural Network Technology for Grayscale Images
Jeanne Chen, Tung-Shou Chen, Keh-Jian Maand Pin-Hsin Wang (2005). *Encyclopedia of Multimedia Technology and Networking (pp. 204-212).*
www.irma-international.org/chapter/digital-watermarking-based-neural-network/17247

UML as an Essential Tool for Implementing eCRM Systems
Calin Gurau (2009). *Encyclopedia of Multimedia Technology and Networking, Second Edition (pp. 1453-1463).*
www.irma-international.org/chapter/uml-essential-tool-implementing-ecrm/17570

Robust Duplicate Detection of 2D and 3D Objects
Peter Vajda, Ivan Ivanov, Lutz Goldmann, Jong-Seok Leeand Touradj Ebrahimi (2010). *International Journal of Multimedia Data Engineering and Management (pp. 19-40).*
www.irma-international.org/article/robust-duplicate-detection-objects/45753