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Fast Fading Mobile Channel Modeling For wireless Communication

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Abstract

In highly populated urban canyons, the mobile communication signal propagate from the base station and arrives at the mobile station(or mobile phone) as a multitude of partial waves from different directions. This is known as multipath propagation. This effect gives rise to multipath fading. Due to this, received signal strength decreases and sometimes unable to recognise. So characterisation and modelling of wireless channel is important. The received signal strength in terms of power is measured using RF recorder for analysis at the mobile station at certain time intervals and the signal (in dBm) assumed to be received in multipath environment and is composed of fast fading caused by local multipath propagation and slow fading due to shadowing. In this paper, the real time mobile data is analyzed by separating fast fading components using moving average filter and then approximation of its and probability distribution functions (PDF) and cummulative distributions(CDF) are analysed.

Keywords: Fast fading,; PDF; CDF; Rayleigh fading

1. Introduction

The performance of wireless communication systems is mainly governed by the wireless channel environment. In a typical wireless system, RF signal transmission between two antennas commonly suffers from power loss, which affects its performance. In a wireless mobile communication system, a signal can travel from transmitter to receiver over multiple reflective paths; this phenomenon is referred to as multipath propagation. The effect can cause fluctuations in the received signal's phase, angle of arrival and amplitude giving rise to the terminology multipath fading[1].

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The atmosphere reflects, absorbs or scatters radio waves; these waves travel from transmitter to receiver over more number of paths giving rise to multipath fading[1]. Fading is the deviation of the signal attenuation (the gradual loss in intensity). It varies according to the geo-graphical area, time and frequency. It is induced by multipath propagation or by shadowing[2], which increases the error rate of received data. Multipath-fading exhibits dispersion in both time and frequency domains. As the multipath components propagate over different transmission paths having different lengths they reach the receiver with different time delays which gives rise to time dispersion. The straight path from transmitter to receiver is called line-of-sight (LOS) path and remaining all are non line-of-sight (NLOS) paths because of obstacles[3]. These signals from multiple paths may interfere constructively or destructively at the mobile station.

There are many types of fading that may occur in our real life mobile environment today. There are mainly two types of fading effects characterize mobile communication[4]. They are large-scale and small-scale fading.

Large Scale Fading: Large-scale fading represents the average signal power attenuation or path loss due to motion over large areas. This occurs as the mobile moves through a distance of the order of the cell size, and is typically frequency independent. Signal attenuation due to penetration through buildings and walls is called shadowing. Shadow fading is called slow fading because the duration of the fade may last for multiple seconds or minutes.

Small scale fading: If there is a small change in the spatial separation between the receiving station and transmitting station causes dramatic change in the signal's phase and amplitude is referred as small-scale fading. Small scale fading can be statistically described by Rayleigh and Rician fading models[5].

The mobile signal is combination of fast fading component caused by multipath propagation and slow fading component caused by shadowing. Then envelope of the received signal is expressed as

$$S_u(t) = f(t) + s(t) \qquad (1)$$

Where f(t) is the fast fading envelope, which closely follows Rayleigh distribution and s(t) is the slow fading component which is lognormally distributed. The envelope S_u (t) has a Suzuki distribution . The Suzuki distribution is rather complicated and not easy to handle mathematically. It would be very useful to have an approximation by a lognormal distribution.

The statistical properties of received signal are important for the planning of mobile radio networks and development of digital communication systems. The main intention of this paper is to separate slow variations and fast variations from the received mobile signal using a moving average filter in order to perform an independent study of shadowing and multipath effects.

2. Analysis of the received mobile radio propagating signal

In order to analyze the mobile radio propagating signal, the signal is recorded using RF recorder. Data is measured for 2500 seconds. The measured data is under the multipath environment and is shown in Fig.1(a) which illustrates the signal variation at certain time intervals in multipath environment.

In order to normalize the measured data in terms of voltage, first power levels are converted into dBs. To model the voltage, load resistance, R, of 50Ω is assumed, the power and the voltage are related by the following equation

$$v = \sqrt{2RP} \qquad (2)$$

Fig.1(b) shows the received voltage verses elapsed time using equation (2).The received signal is composed of fast fading caused by multipath propagation and slow fading caused by shadowing. In order to study the variations caused by slow and fast fading independently, they are separated by means of a moving average filter.