International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161
Available at http://inpressco.com/category/ijcet

Research Article

Channel modeling for Urban and Hilly terrain using Jakes, Gaussian and Flat spectrum for Ad-hoc network

Swatantra Kumar Singh†*, Ashish Xavier Das† and A.K. Jaiswal†

†E&C Department, SHAITS, Allahabad, India

Accepted 29 Aug 2015, Available online 31 Aug 2015, **Vol.5, No.4 (Aug 2015)**

Abstract

The radio channel places fundamental limitations on the performance of mobile ad hoc wireless networks. In the mobile radio environment, fading due to multipath delay spread impairs received signals. The purpose of this thesis is to develop a radio channel model and examine the effect of various parameters on channel behaviour that is representative of environments in which mobile ad hoc wireless networks operate. The various physical phenomena considered are outdoor environments, fading and multipath propagation, type of terrains, and mobility (Doppler shift).In this paper we are analysing channel model performance of ad-hoc network in terms of number of taps mobile Velocity and Doppler Spectrum and improve the performance of wireless network using jakes spectrum.

Keywords: *Channel modeling, number of taps mobile Velocity, Gaussian spectrum, Flat spectrum and Doppler Spectrum.*

1. Introduction

A wireless network is a rising new technology that will permit users to access services and information by electronic means, irrespective of their geographic location. Wireless networks can be divided in two kinds: infrastructure network and Infrastructure less (ad hoc) networks. Infrastructure wireless network is a network with fixed and wired gateways. A mobile host interrelates with base station within its communication radius. The mobile device move frequently when it is communicating with other mobile devices. As radio waves propagate through space, multiple corruptions due to morphology, temperature and humidity of the environment through which they are traveling can occur. As a consequence, mobile radio transmissions usually suffer large fluctuations in both time and space. A major limitation on the performance of a mobile communications system is the attenuation undergone by the signal as it travels from the transmitter to the receiver. The path (from the transmitter to the receiver) taken by the signal can follow the Line-of- Sight (LOS) in which the signal loss may not be severe. In typical operational surroundings, indirect paths also exist and the signal reaches the receiver through the processes of reflection, diffraction, refraction, and scattering from buildings, structures, and other obstructions in the path. These are examples of Non-Line-of-Sight (NLOS) propagation. The ultimate performance limits of any communication system are determined by the channel modeling (Molisch *et al*, 2005). Realistic channel models are thus of utmost importance for system design and testing. In addition to exponential power path-loss, wireless channels suffer from stochastic short term fading (STF) due to multipath, and stochastic long term fading (LTF) due to shadowing depending on the geographical area. STF corresponds to severe signal envelope fluctuations and occurs in densely built-up areas filled with lots of objects like buildings, vehicles, etc. On the other hand, LTF corresponds to less severe mean signal envelope fluctuations, and occurs in sparsely populated or suburban areas (Proakis *et al*, 2000). In general, LTF and STF are considered as superimposed and may be treated separately (stiber *et al*, 2001).

However, the mobile radio channel places fundamental limitations on the performance of mobile wireless networks. In the mobile radio environment, fading due to multipath delay spread impairs received signals. Movement of the receiver causes the multipath components as well as their phase and propagation delays to vary with time, and the speed of motion impacts how rapidly the signal level fades. Reliable operation of a wireless communications system is dependent upon the propagation channel over which the system operates as the channel is the primary contributor to many of the problems and limitations that plague wireless communications systems (Tabbane *et al*, 2000). This has prompted a need for a deeper understanding of the wireless channel characteristics. Such an understanding will lead to developing viable solutions to such problems as dropped or lost packets, interference, and coverage.

*Corresponding author: **Swatantra Kumar Singh**

The focus of channel modeling in this paper is studied based on the following physical phenomena like multipath propagation, type of terrains, and Doppler shift due to motion of the mobile. The purpose this paper is to evaluate the performance of a radio channel model and examine the effect of various parameters on the channel behavior that is representative of environments in which mobile wireless networks operate.

2. Wireless channel characteristics

Reliable operation of a wireless communications system is dependent upon the propagation channel over which the system operates.

2.1 Operating environment

The operating environment of wireless communications usually encompasses indoor or outdoor forms where a radio transmitter or receiver is capable of moving.

1. Types of Terrain

Propagation characteristics differ with the environment through and over which the radio waves travel. Depending on the type of environment, the signal will be reflected or absorbed by the obstacles it encounters. The above-mentioned parameters are important considerations in a operating environment, e.g., a command vehicle carrying mobile command posts moving through an area where the radio wave could be reflected by any kind of obstacle, such as a mountain or building. In this paper, there are two models urban areas and hilly terrain widely used for evaluation of channel characteristic.

2. Multipath propagation

For most practical channels, where signal propagation takes place in the atmosphere and near the ground, the free-space propagation model is inadequate to describe the channel .In a wireless mobile communications system, a signal can travel from the transmitter to the receiver over multiple reflective paths; this phenomenon is known as multipath propagation. This effect can cause fluctuations in the received signal's amplitude, phase, and angle of arrival, known as multipath fading. Fading is caused by interference between two or more versions of the transmitted signal that arrive at the receiver at slightly different times there are two main types of fading effects that characterize mobile communications, large-scale fading and small-scale fading. A mobile radio roaming over a large area must process signals that experience both types of fading, small-scale fading superimposed on large-scale fading.

3. Mobility

For mobile radio applications, the channel is time-varying because motion between the transmitter and receiver results in propagation path changes. The Doppler effect is a phenomenon caused by the relative velocity between the receiver and the transmitter. When a wave source and a mobile are moving relative to one another, the motion leads to a frequency variation, df, of the received signal known as Doppler shift and can be written.

$$f_d = \frac{1}{2\pi}\frac{\Delta\phi}{\Delta t} = \frac{v}{\lambda}\cos\theta$$

From the equation Doppler shift to the mobile velocity and the spatial angle between the direction of motion of the mobile unit and the direction of the wave can be determine. If the mobile receiver is moving towards the direction of arrival of the wave, the Doppler shift is positive. However, if the mobile is moving away from the direction of arrival of the wave, the Doppler shift is negative. Multipath components from a Continuous Wave signal that arrives from different directions contribute to the Doppler spreading of the received signal, thus increasing the signal bandwidth.

4. Effects of weather

For most practical channels in which the signal propagates through the atmosphere, the free-space propagation channel assumption is usually not enough. The first effect that must be included is the atmosphere, which causes absorption, refraction and scattering. Signal attenuation through the atmosphere is mainly due to molecular absorption by oxygen for frequencies ranging between 60 and 118 GHz and due to water vapor in the 22, 183 and 325-GHz bands .Rain has the most significant impact since the size of the rain drops is on the order of the wavelength of the transmitted signal. It results in energy absorption by the rain drops themselves, and as a secondary effect, energy is scattered by the drops.

5. Additive White Gaussian Noises

In addition to the impairments experienced by the signal as a result of the multipath propagation phenomena, a channel can also be affected by Additive White Gaussian Noise (AWGN). It can be considered one of the limiting factors in a communications system's performance. AWGN affects each transmitted symbol independently. The term "additive" means that the noise is superimposed or added to the signal and there are no multiplicative mechanisms involved.

6. Doppler Power Spectrum

The common Doppler spectral shape is an even function of frequency, meaning that only a real-valued filter is necessary to do the shaping. Therefore, the shaping filter's amplitude transfer function can be expressed as

$$H(f) = \sqrt{S(f)}$$

Where s(f) is the Doppler power spectrum of the filter? Depending on the physical environment, three Doppler spectra can be specified flat, Gaussian and Jakes.

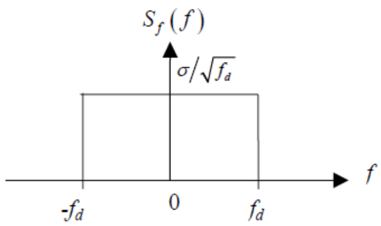
Flat Spectrum

The flat spectrum has a rectangular shape.In order to obtain the desired process bandwidth, proper scaling and band limiting is required. The flat spectrum is described by

$$S_f(f) = \begin{cases} \sigma^2/f_d, & -f_d < f < f_d \\ 0, & \text{otherwise} \end{cases}$$

Where σ^2 is the total signal power and f_d is the maximum Doppler frequency. After substitution into Equation, the filter response is given by

$$H_f(f) = \begin{cases} \sigma/\sqrt{f_d}, & -f_d < f < f_d \\ 0, & \text{otherwise} \end{cases}$$

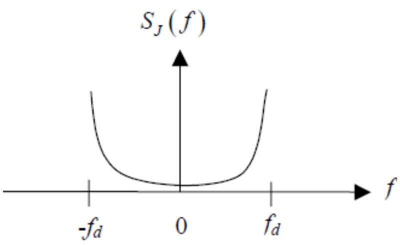


Jakes Spectrum

The classical Jakes Doppler spectrum was used by Jakes and others at Bell Laboratories to derive the first comprehensive mobile radio channel model for Doppler effects. The Jakes spectrum that characterizes a mobile radio channel is described by

$$S_j(f) = \begin{cases} 1\Big/\pi f_d\sqrt{1-(\frac{f}{f_d})^2} & f \le f_d \\ 0 & \text{otherwise} \end{cases}$$

A plot of the Jakes power spectrum which shows that most of the energy is concentrated around the maximum Doppler shift, fd.

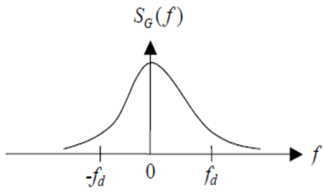


Gaussian Spectrum

The Gaussian spectrum is illustrated in Figure 16 and is mathematically described by

$$S_G(f) = (2\sigma^2/\sqrt{\pi}(f_d)^2)\exp\{-f/f_d\}$$

Where $\sigma^2$the total is signal power and fd is the maximum Doppler frequency. The corresponding shaping filter response function is given by



3. Simulation Parameters

The key to successful channel characterization depends on whether the chosen parameters are closely related to the performance of the system under consideration. Therefore, a number of choices and considerations must be taken into account when building the model. In general, for a TDL model, the following parameters and functions must be specified: the number of taps, the Doppler spectrum of each tap, the Ricean factor K, and the power distribution of each tap. Simulations were conducted for five different sets of parameters values consisting of number of taps, velocity in miles per hour (mph), frequency in GHz, terrain and the power spectrum as given in Table 1.0. For scenario, the Doppler spectrum were plotted.

The simulation is performed by using the network simulator MATLAB for evaluating the performance of channel characteristic of mobile wireless network.

Table.1 Simulation parameter

Taps No.	Velocity	Frequency (GHz)	Terrain	Power spectrum
14	90	2.5	Urban and Hilly	Jakes/Flat /Gaussian

4. Result and Discussions

4.1 Doppler spectrum

Figure 4.1(A) shows the Jakes spectrum at a carrier frequency of 2.5 GHz and a mobile speed at 90 mph for urban area with 14 taps.

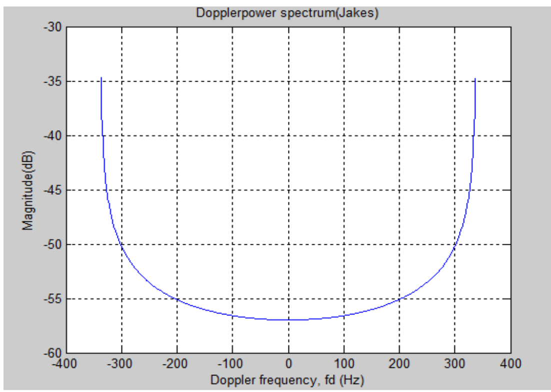


Figure 4.1(a) Jakes Doppler power spectrum at a mobile speed of 90 mph and a carrier frequency of 2.5 GHz

Two related representations of flat and Gaussian spectra were also implemented in the simulation and are shown in Figures 4.1(B) and 4.1(C), respectively, for the carrier frequency of 2.5 GHz and a mobile speed at 90 mph. Note that as the Jakes spectrum suppresses the low frequencies, the Gaussian spectrum is predominantly low frequency in nature.

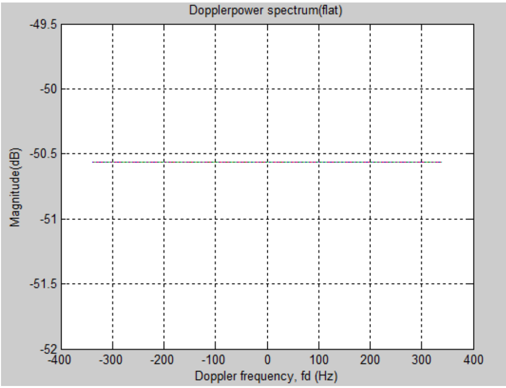


Figure 4.1.1(b) Flat Doppler spectrum at a mobile speed of 90 mph and a carrier frequency of 2.5 GHz

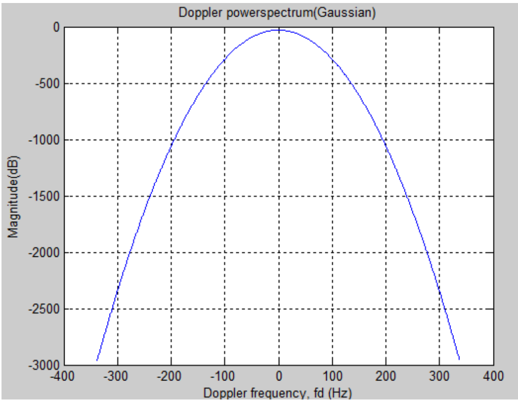


Figure 4.1(C) Gaussian Doppler spectrum at a mobile speed of 90 mph and a carrier frequency of 2.5 GHz.

The simulation results also showed that the flat spectrum is not suitable for both operating environments of urban and hilly terrains, and it suffers the most distortion. The Jakes spectrum was found to be suitable for the high-speed urban areas, and the Gaussian spectrum was appropriate for the low-speed urban areas and the hilly terrain.

4.2 Number of Taps

Simulations were performed assuming an urban environment, a carrier frequency of 2.5 GHz, keeping the velocity at 90 mph and 14 numbers of filter-taps. The filter-taps are computed for the three different Doppler spectra: Jakes, flat and Gaussian. The PSD at the filter output using the Jakes spectrum is shown in Figure 4.2(a). Depending on the type of power spectrum used, it can be seen that the envelope corresponds to the shape of the respective power spectrum used. Figure4.2 (b) and Figure 4.2(c) show the PSD at the filter output for the flat and the Gaussian spectrum, respectively; the shape of both differs considerably from that of Jakes.

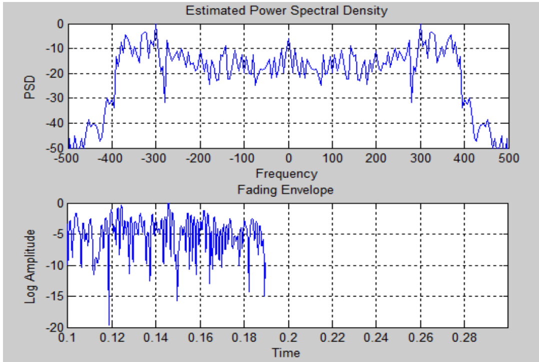


Figure 4.2(a) PSD at the filter output using Jakes spectrum

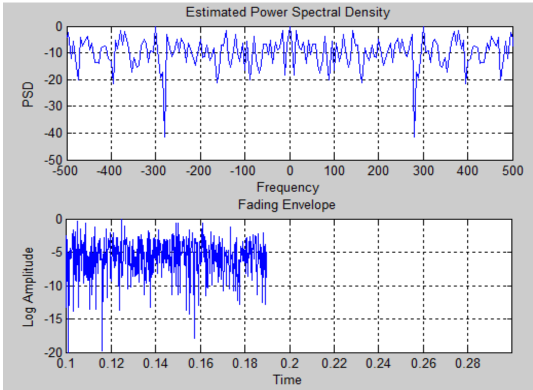


Figure 4.2(b) PSD at the filter output using flat spectrum.

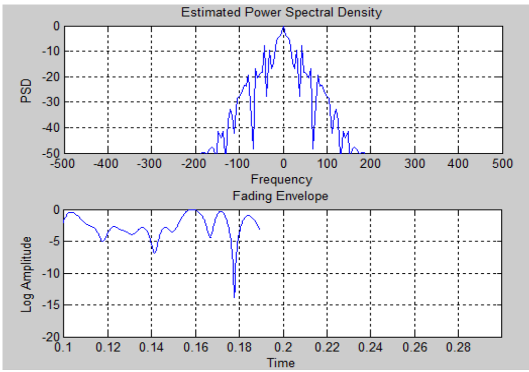


Figure 4.2(c) PSD at the filter output using Gaussian spectrum

4.3 Mobile Velocity and Doppler Spectrum

In this simulation, the carrier frequency is set at 2.5 GHz and, from the previous section, the number of taps for the TDL model was chosen to be 14.

(A) Velocity at 90 mph

The signal constellation plots for a mobile traveling at a speed of 90 mph are shown in Figures shows the transmitted signal through a channel with a shaping filter using the Jakes spectrum, flat and Gaussian spectrum for Urban and hilly terrain.

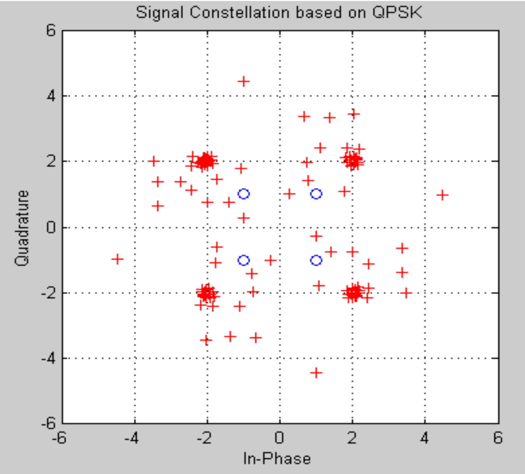


Figure 4.3 (a) Signal constellation for a Channel model with the following parameter settings: 2.5 GHz, 90 mph, urban area, and Jakes spectrum

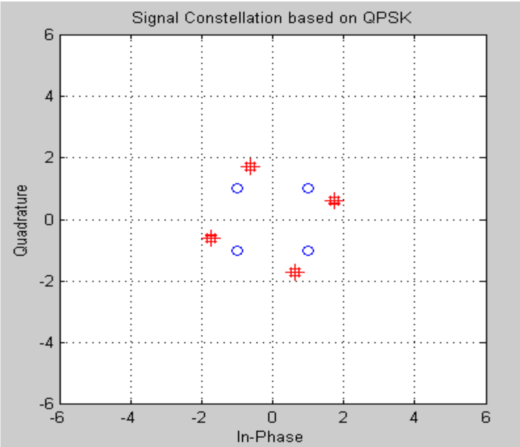


Figure 4.3(b) Signal constellation for a Channel model with the following parameter settings: 2.5 GHz, 90 mph, Hilly area, and Jakes spectrum

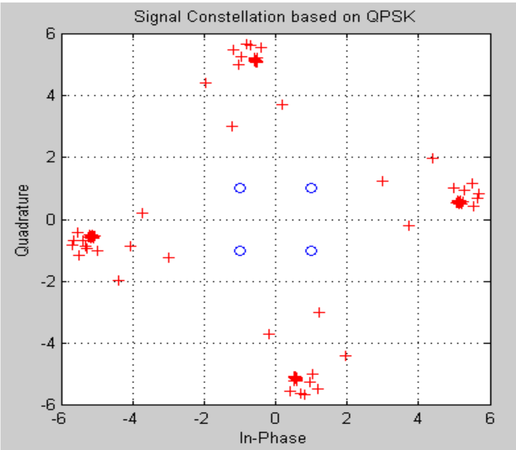


Figure 4.3 (c) Signal constellation for a Channel model with the following parameter settings: 2.5 GHz, 90 mph, urban area, and flat spectrum

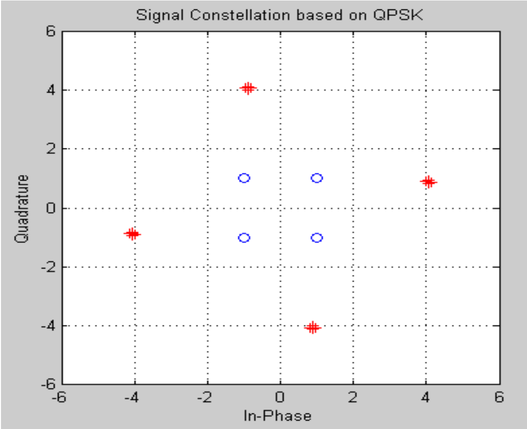
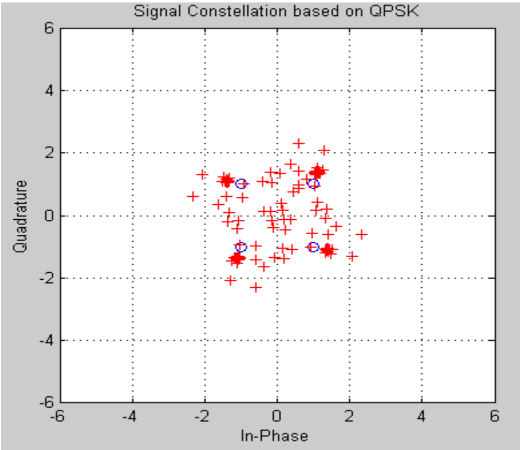
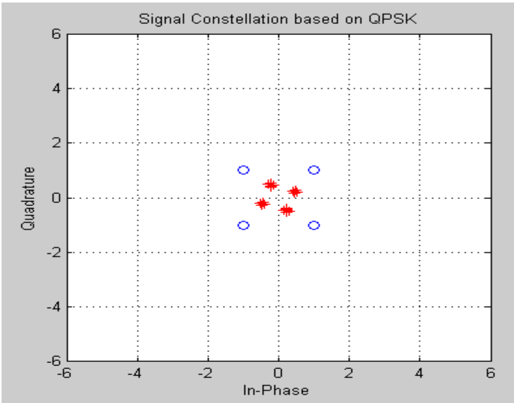


Figure 4.3 (d) Signal constellation for a Channel model with the following parameter settings: 2.5 GHz, 90 mph, Hilly area, and flat spectrum



4.3 (e) Signal constellation for a Channel model with the following parameter settings: 2.5 GHz, 90 mph, urban area, and Gaussian spectrum.



4.3 (f) Signal constellation for a Channel model with the following parameter settings: 2.5 GHz, 90 mph, Hilly area, and Gaussian spectrum

The simulations results indicate that the number of tap gains of the TDL channel model should generally be small since higher-order tap gain values are not significant. In addition, it was noticed that the results obtained for carrier frequencies of 2.5 GHz As Doppler shift is directly proportional to speed, mobile speeds of 90 mph were used in the simulation, representing a high mobility scenario, respectively. The simulation results indicate that the Gaussian and Jakes are more suitable Doppler spectra for mobile radio channels than the flat spectrum.

Lastly, two types of environments (i.e., urban and hilly terrain) were considered in this work. The Jakes Doppler spectrum should be used in urban environments with high mobility; the Gaussian Doppler spectrum is the choice for low mobility urban environments and for the hilly terrain under both low and high mobility

Conclusion

After observing the results it can be concluded that the objective of the dissertation was achieved with following observation.

- The simulation results indicate that the Gaussian and Jakes are more suitable Doppler spectra for mobile radio channels than the flat spectrum.
- The simulation results also showed that the flat spectrum is not suitable for both operating environments of urban and hilly terrains, and it suffers the most distortion. The Jakes spectrum was found to be suitable for the high-speed urban areas, and the Gaussian spectrum was appropriate for the low-speed urban areas and the hilly terrain
- The Jakes Doppler spectrum should be used in urban environments with high mobility; the Gaussian Doppler spectrum is the choice for low mobility urban environments and for the hilly terrain under both low and high mobility

References

F. Molisch (2005), Wireless communications. New York: IEEE Press/ Wiley.

J. Proakis (2000), Digital communications, McGraw Hill, 4th Edition.

G. Stüber (2001), Principles of mobile communication, Kluwer, 2nd Edition.

T.S. Rappaport (2002), Wireless communications: Principles and practice, Prentice Hall, 2nd Edition.

S. Tabbane (2000), Handbook of Mobile Radio Networks, Artech House Publishers, Norwood, MA.