ISSN: 2348 - 2117

International Journal of Engineering Technology and Computer Research (IJETCR)
Available Online at www.ijetcr.org
Volume 3; Issue 4; July-August-2015; Page No. 105-109

Analysis of Rayleigh, Rician and Nakagami-m fading channel using Matlab Simulation

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Abstract

The fading, which is caused due to multipath propagation in a communication channel, challenges the wireless communication engineer who tries to establish a reliable communication path between transmitter and receiver. An effort has been made to demonstrate the comparison of the Rayleigh , Rician and Nakagami fading channel models by using MATLAB simulation in terms of source velocity and probability density function. We have developed algorithms for above channel, which calculate the Reference signal, Inphase signal ,Quadrature Signal, Envelope Signal, Probability density function . These parameters has play very important role in the performance analysis and design of the digital communication systems over the multipath fading environment..

Keywords: wireless Communication, Rayleigh fading, Rician fading, Nakagami-m fading channel.

INTRODUCTION:

The explosive growth of wireless technology has opened up the implementation of several new path, however, some unavoidable circumstances, the signal attenuation and make a barrier from the system, best results is obtained. Wireless link between the transmitter and the receiver from the simple line of sight to a serious barrier buildings, mountains and etc. However, the mobile channel is due to its randomness from fixed and predictable very different cable channels. There, it determines the behavior of several factors such as terrain features over the years, the speed of transmitter and receiver, between weather conditions, a number of different studies and measurements have been carried out for such a channel and a variety of the position of the model have been proposed indoor and outdoor environments .[1] The instantaneous signal strength at the receiver using conventional large-scale and small-scale model in which the large-scale model predictions depend on the transmitter and receiver. Average received signal strength and small-scale channel model represents the local average signal intensity prediction changes. Effect of mobility is that, channel varies with user's location and time, which results in rapid fluctuations of received power. Less variations will be observed, the slower you move.[2] Channels may be time dispersive or non-dispersive. (Due to the dispersion pulse spreading will be observed, which will result in ISI effect) Channels may be linear or nonlinear & may be fast fading or slow fading, frequency selective or flat fading. There may be different environment for different situation and different weather. There may be different objects in a room or different surrounding conditions. Hence, it is very difficult to predict the number of reflect rays and whether the constructive interference (add inphase) will occur or destructive.[3]

In this article, we have developed an algorithm Rayleigh and Rician and Nakagami-m fading channel in vehicle Environment. In the rest of this article is organized are as follows. Section II discuss the implement of Rayleigh fading model, and proposed algorithms. Section III, Discuss the Rician fading channel models. Section IV, Discuss the Nakagami-m fading channel models and proposed algorithms. Section V concludes the work.

II. Implement of Rayleigh fading channel model

In the urban areas or the existence of a serious non-line of sight between the transmitter and receiver communication, environment, objects attenuation, reflection, refraction and diffraction signal before it reaches the receiver. The propagation environment called Rayleigh fading, and Rayleigh distribution model is a specialized random fading model for this type of fading environment.[4] The transmitted signal at frequency ω_c

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reaches the receiver via a number of paths, the i_{th} path having an amplitude X_i, and a phase Z_i . The received signal X(t) can be expressed as

$$X(t) = \mathrm{Re}\left\{\sum_{i=1}^{N} X_i e^{j(\omega_c t + Z_i)}\right\}$$

$$= \sum_{i=1}^{N} X_i \cos(\omega_c t + Z_i)............(1)$$

Where N is the number of paths. Depending on the phase Z_i path length, a change in the wavelength of the path length is changed by the 2π. Thus, the phase is uniformly distributed in [0,2π]. The Doppler shift of this wave is given by:

$$\omega_{d\,i} = \frac{\omega_c v}{c}\cos\psi_i ....(2)$$

Where v is the speed of the moving object, C is the speed of light, and uniformly distributed ψ_i in [0,2π]. The received signal s (t) can now be written as

$$X(t) = \sum_{i=1}^{N} X_i \cos(\omega_c t + \omega_{d\,i} + Z_i).........(3)$$

Expressing the signal in inphase and quadrature form, eqn. (3) can be written as

$$s(t) = I(t)\cos\omega_c t - Q(t)\sin\omega_c t........(4)$$

where the inphase and quadrature Signal are respectively given as

$$I(t) = \sum_{i=1}^{N} X_i \cos(\omega_{d\,i} t + Z_i)..........(5)$$

$$Q(t) = \sum_{i=1}^{N} X_i \sin(\omega_{d\,i} t + Z_i).........(6)$$

The received signal envelope is given by

$$r(t) = \sqrt{I^2(t) + Q^2(t)}.......(11)$$

Probability density function of the received signal

If N is large enough, by virtue of the central limit theorem, the in-phase and quadrature components I (t) and Q (t) will be independent Gaussian process it can be completely characterized by their mean and autocorrelation function . In this case, I (t) and the means Q (t) is zero. In addition, I (t) and Q (t) will have equal variances σ^2, given by the mean-square value or mean power. Envelopes, r(t), section I (t) and Q (t) from the demodulated signal s (t), as shown in Fig obtained. The received signal envelope is given by the following formula.[5]

$$f(r) = \frac{r}{\sigma^2}\exp\left\{-\frac{r^2}{2\sigma^2}\right\} \qquad r\geq 0..........(7)$$

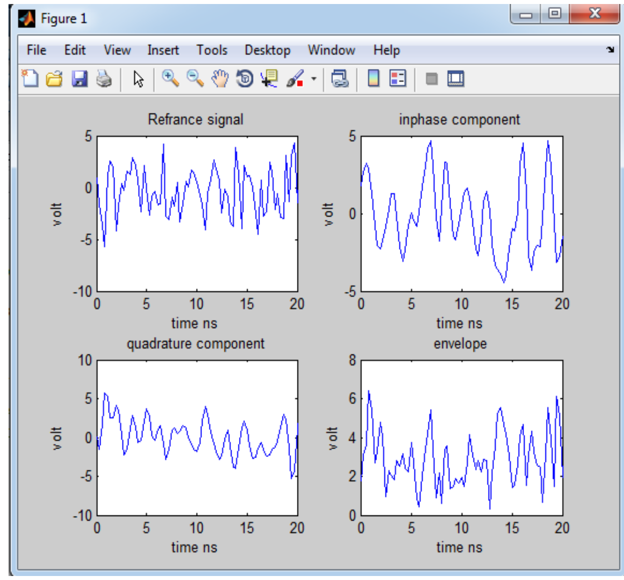

Fig. 1: Simulated radio frequency signal with source velocity 20m/s for Rayleigh fading channel.

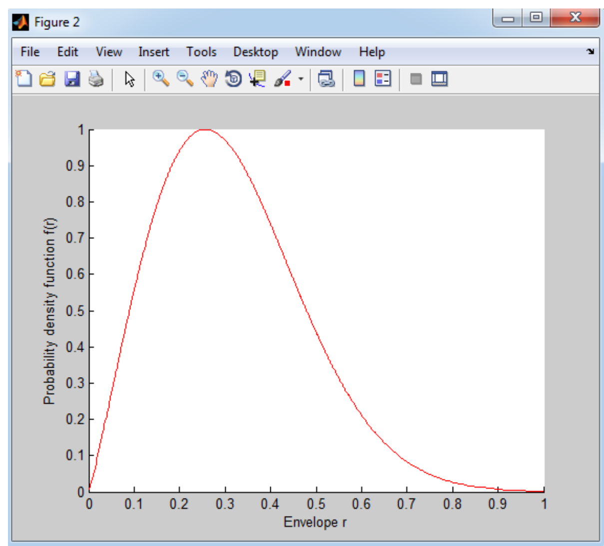

Fig. 2: Simulated PDF signal with source velocity 20m/s for Rayleigh fading channel

III. Rician Fading Channel Model

When Rician fading was selected radio channel process, there is an appropriate model. It is a presence of LOS and a dominant sight path between the transmitter or receiver. In a mobile communication in rural areas, for example typically have a channels Or a dominant component of the line of sight exist. The received signal can be expressed as random multipath components Dominant superimposed signal.[5]

$$X(t)=\sum_{i=1}^{N-1} X_i \cos(\omega_c t+\omega_{d\,i} t+Z_i)+ P_d \cos(\omega_c t+\omega_d t) \ldots\ldots\ldots(8)$$

Where the constant P_d is direct component, ω_d is Doppler shift along line–of sight Path, and Doppler frequency shift along ω_{di} indirect path. In this case, the envelope having a given probability density functions.

$$f(r)=\frac{r}{\sigma^2}\exp\left\{-\frac{r^2+k_d{}^2}{2\sigma^2}\right\} I_o\left(\frac{rk_d}{\sigma^2}\right) \quad .$$

r≥0

Where $I_0()$ is the zeroth-order modified Bessel function of the first kind.

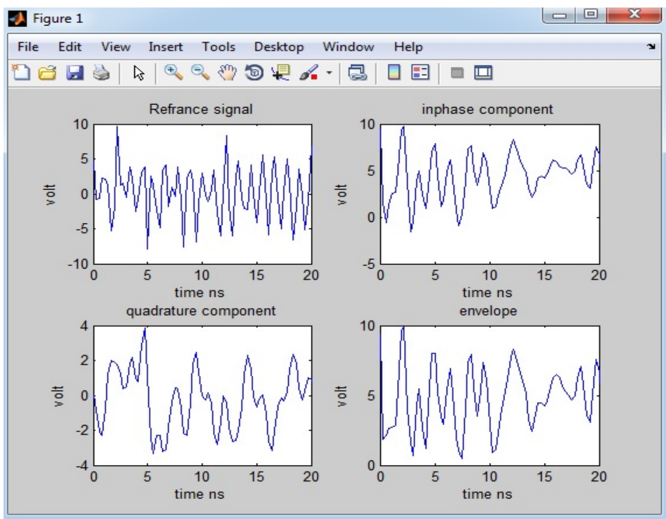

Fig. 3: Simulated radio frequency signal with source velocity 20m/s for Rician fading channel with m= 2.

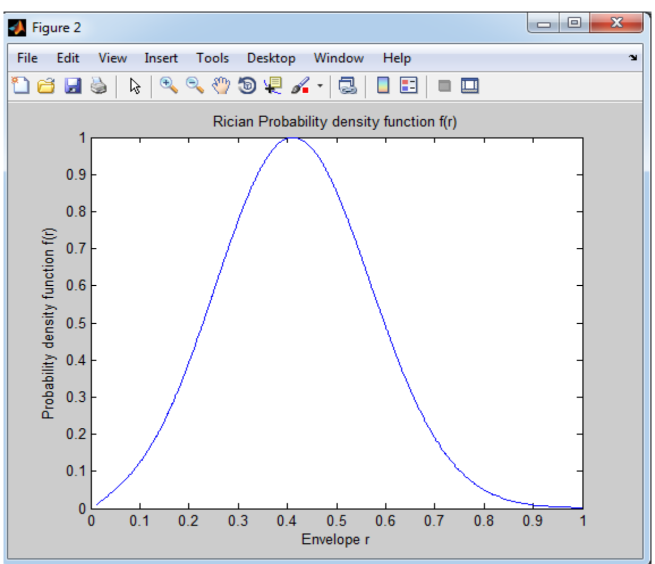

Fig. 4. Simulated PDF signal with source velocity 20m/s for Rician fading channel

IV. Nakagami-m Fading Channel Model

Based on the above model multipath fading channel, the fading channel in use MATLAB to generate fast fading small envelope simulation, parameter m decline relationship between the envelope Assess and compare the results with the Rayleigh and Rician distribution, which helps to better understand the Nakagami-m fading channel statistics, because of the distribution of both Rayleigh and Rice distribution. In this case, when m is large, channel fading qualitatively by (3) adding a leading analog signal, so the combination of the distribution by Rayleigh and Rician distribution, we simulate (3) (8) to generate a Nakagami fading envelope, if Number of channels (NLOS) N is small so the results will be inaccurate.[6] Express the equation inphase and Quadrature from

$$X(t)=\sum_{i=1}^{N} X_i \cos(\omega_{d\,i} t+Z_i)\cos(\omega_c t) -\sum_{i=1}^{N} X_i \sin(\omega_{d\,i} t+Z_i)\sin(\omega_c t) \ldots\ldots.(10)$$

The received signal envelope is given by

$$r(t)=\sqrt{I^2(t)+Q^2(t)} \ldots\ldots.(11)$$

both Rayleigh and Ricean fading envelop are superimposed according to (11) reflected the change of Nakagami parameter m to the impact of signal envelop.

$$R_{Nakagami} = R_{ray}\, e^{1-m} + R_{rice}(1- e^{1-m})$$

The fading model for the received signal envelope, proposed by Nakagami, has the pdf given by

$$f(r)=\frac{2m^m r^{2m-1}}{\Gamma(m)\Omega^m}\exp\left\{-\frac{mr^2}{\Omega}\right\} \qquad r\geq 0$$

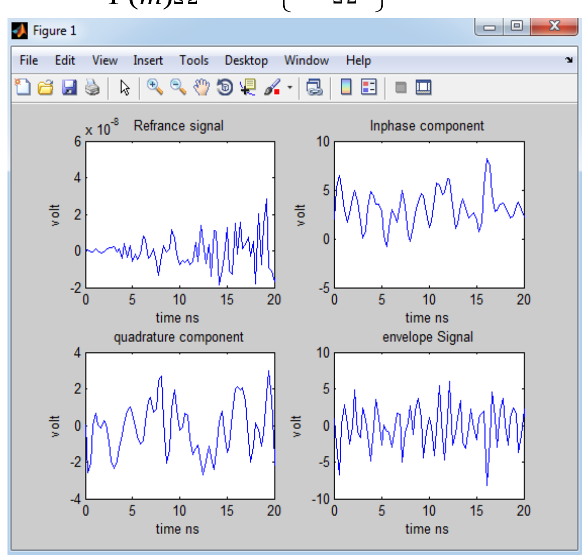

Fig. 5: Simulated radio frequency signal with source velocity 20m/s for Nakagami fading channel

where $\Gamma(m)$ is the Gamma function, and m is the shape factor (with the constraint that $m \geq ½$) given by

$$m = \frac{E^2\{r^2\}}{E\{[r^2 - E(r^2)]^2\}}$$

The parameter Ω controls the spread of the distribution and is given by

$$\Omega = E\{r^2\}$$

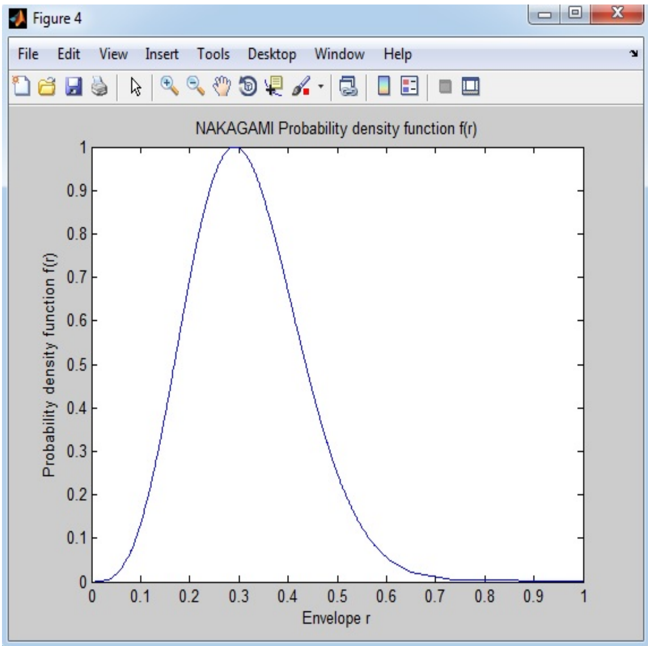

Fig. 6: Simulated PDF signal with source velocity 20m/s for Nakagami fading channel with m=8

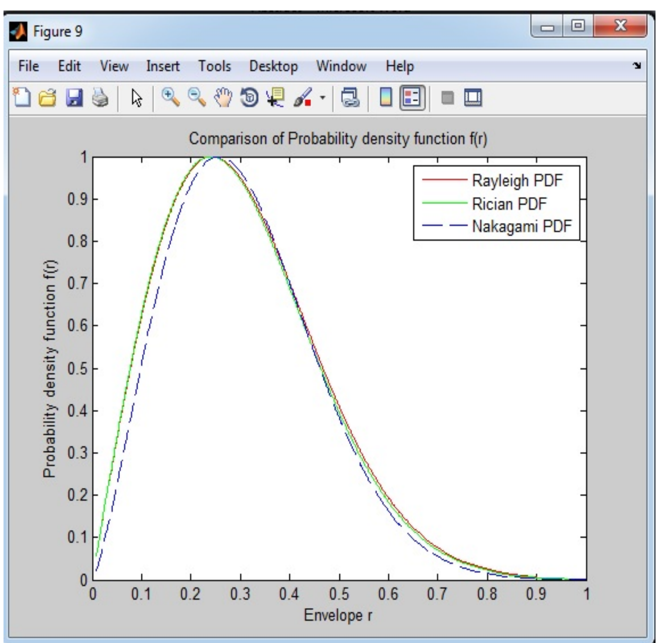

Fig.7: Simulated PDF signal with source velocity 20m/s for Rician fading channel, Rayleigh fading channel, Nakagami fading channel with m=1

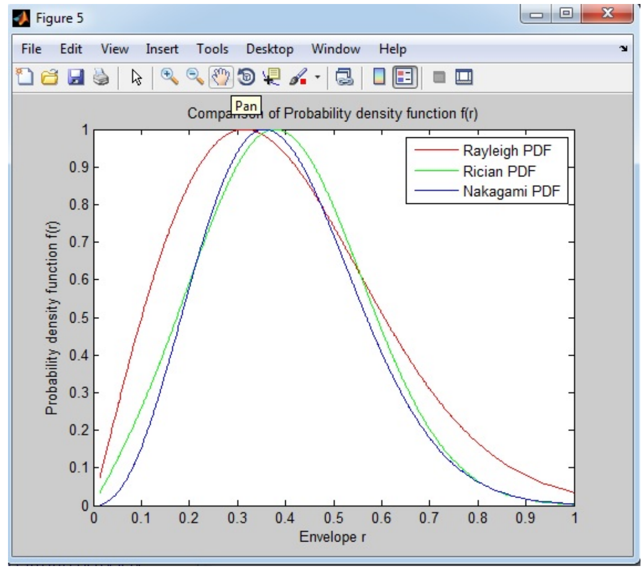

Fig. 8: Simulated PDF signal with source velocity 20m/s for Rician fading channel, Rayleigh fading channel, Nakagami fading channel with m=2

When m = 1, there is no line of sight path between a single MS and BS, at any point in space can be received, the phase of a plane wave, and diagonal arrival by a large number of randomly distributed having an amplitude of the signal by the mobile, and can be caused by move to serious distortion or fading signals received. When M = 2, the presence of LOS path between MS and BS, fading envelope about rician Distribution, which can be seen from figure 8, the depth of fading or fading frequncy is significantly better than fig7.

V. Acknowledgment

Firstly, I would like to thanks my guide Mrs. Anita Chopra (Asst.Prof, ECE), Whose input has been of great significance and helped me towards the successful completion of this work. I am immensely grateful to my family members, particularly to my parents. They have always supported me and taught me the things that matter most in life.

VI. Conclusion

Major objective of our work (for which this research has been carried out) has the major outcome that the probability density function of Nakagami-m fading channel increases with respect to Rayleigh and rician fading channel . In nakagami-m fading channel has sum of multiple independent and identically distributed Rayleigh-fading signals have a Nakagami distributed signal amplitude. The Nakagami-m is generalized channel model which can be converted to Rician distribution , Rayleigh distribution.

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