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Performance evaluation of wireless multipath/shadowed *G*-distributed channel

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In wireless communication the effect of multipath as well as shadowing takes place simultaneously over the channel and this phenomena leads to composite fading. G-distribution is frequently encountered distribution in wireless fading environment. Combination of multipath fading and shadowing model are used as composite fading model. This composite fading model is named as G-distribution. G-distribution is a combination of the Inverse-Gaussian distribution and the distribution. In this paper the Pade approximation approach is used to analyze the performance of composite multipath/shadowed fading channel. This distribution is used to approximate any system in form of closed form solution as well as for accurate approximation in several shadowing conditions. The Pade approximation is applied over the general expression that is given in terms of moment generating function and results are obtained by varying shadowing parameters as well as signal to noise power threshold ratio. Our study start by deriving the moment generating function of the G-distribution and approximate them by using the Pade approximation for the calculation of bit error rate and outage probability for different values of average Signal to noise ratio (SNR). All simulations are done using Maple-13 software tool and results are obtained for outage probability and bit error rate versus average SNR.

Key words: Pade's approximation, G-distribution, moment generating function, inverse Gaussian distribution, Nakagami distribution and composite distributions, average signal to noise ratio, outage probability, bit error probability.

INTRODUCTION

Wireless is the fastest growing communication system for communication that provides high data rates and lesser complexity for global coverage. In wireless communication multipath fading and shadowing phenomenon are encountered in different scenario. Multipath fading and shadowing reduces the performance of wireless communication system. In this case receiver does not mitigate the effect of multipath fading as well as shadowing.

The composite distribution is used for the perfect modeling for these channels. In case of outdoor communication an electromagnetic signal experiences the effect of reflection, diffraction, scattering as well as path loss and shadowing. These effects can be modeled in terms of composite multipath/shadowing fading distribution (Jeffrey and Goldsmith, 2004; Homayoun, 1993). One of the best known distributions is shadowed Nakagami fading distribution (Ho and Stuber, 1993). This is the generalized distribution of combined Rayleigh-Lognormal distribution model (also called Suzuki model)

(Suzuki, 1977; Amine et al., 2009).

The main drawback of this distribution is that the probability density function (PDF) of this distribution does not provide closed form solution for performance evaluation of communication channel such as bit error probability, outage probability and channel capacity. So this log-normal distribution is substituted by the closed form gamma distribution function and obtained the K-distribution (Abdi and Kaveh, 1998). In K-fading log-normal distribution is substituted with Inverse-Gaussian pdf and this composite Rayleigh-Inverse Gaussian distribution approximate more accurately as compared to K-distribution. There are several composite fading models that have been presented in literature (Stüber, 1996).

In this paper, we constraint a very general form of distribution function which is combination of general Nakagami-Inverse Gaussian model considered as a composite distribution model. We demonstrated that this combination gives birth to a closed form composite distribution called the G-distribution (Homayoun, 1993; Amine et al., 2009). This distribution is used to approximate any system in form of closed form solution as well as for accurate approximation in several shadowing conditions. We approximate the G-distributed function using the Pade approximation and evaluate the bit error rate and outage probability performance of single user communication system using different modulation schemes.

Our analysis starts from closed form expression for composite pdf and then, the moment generating function has been solved. The outage probability and bit error rate for different values of SNR have been analyzed by using the relation of outage probability versus moment generating function and bit error rate versus moment generating function.

PADE APPROXIMATION (PA)

To analyze the performance of wireless fading channel we always deal with different complicated mathematical function like infinite power series, exponential function, Bessel's functions and Gamma functions etc., which are not easy to handle by simple mathematical approaches. So we require an alternative approach to work with infinite power series functions. PA is a well known method that is used to approximate infinite power series that are either not guaranteed to converge, converge very slowly or for which a limited number of coefficients is known. The approximation is given in terms of a simple rational function of arbitrary numerator and denominator orders (Mahmoud and Mustafa, 2006). Let $g(s)$ be an unknown function given in terms of a power series in the variable $s \in \mathbb{C}$, the set of complex numbers, namely (Mahmoud and Mustafa, 2006; Baker, 1971).

$$g(s) = \sum_{n=0}^{\infty} c_n s^n, \quad c_n \in \mathbb{R} \tag{1}$$

where $\mathbb{R}$ is the set of real number. There are several reasons to look for a rational approximation to a series, the series might be divergent or converging too slowly to be of any practical use. PA gives result in a transfer function form thus it can be used easily for any computation and one of the major reasons is that only few coefficients of the series may be known and that is why a good approximation is needed which represents the properties of the function.

The one point PA of order $[N_p/N_q]$, $P^{[N_p/N_q]}(s)$, is defined from the series $g(s)$ as a rational function by (Hansen and Mano, 1977).

$$P^{[N_p/N_q]}(s) = \frac{\sum_{n=0}^{N_p} a_n s^n}{\sum_{n=0}^{N_q} b_n s^n} \tag{2}$$

Where the coefficients $\{a_n\}$ and $\{b_n\}$ are defined such that,

$$\frac{\sum_{n=0}^{N_p} a_n s^n}{\sum_{n=0}^{N_q} b_n s^n} = \sum_{n=0}^{\infty} c_n s^n + \mathcal{O}(s^{N_p+N_q+1}) \tag{3}$$

Where $\mathcal{O}(s^{N_p+N_q+1})$ representing the term of order higher than N_p/N_q. For better approximation the value of Np should be lesser than the value of Nq. It is straightforward to see that the coefficients $\{a_n\}$ and $\{b_n\}$ can be easily obtained by matching the coefficients of like powers on both sides of the above Equation. Specifically, taking $b_0=1$, without loss of generality, one can find that the values of all coefficients (Mahmoud and Mustafa, 2006).

G- DISTRIBUTION

The probability density function of the composite multipath/shadowing channel is given by (Amine et al., 2009)

$$f_X(x) = \int_0^{+\infty} f_{X/Y}(x/Y = y) f_Y(y) dy, \tag{4}$$

where $f_{X/Y}$ is the Nakagami-m multipath fading distribution and it is given by

$$f_{X/Y}(x/Y = y) = \frac{2m^m x^{2m-1} \exp\left(\frac{-mx^2}{y}\right)}{\Gamma(m) y^m}, \quad x > 0 \tag{5}$$

And $f_Y(y)$ is the inverse- Gaussian (IG) distribution which is given by

$$f_Y(y) = \sqrt{\frac{\lambda}{2\pi}} y^{-\frac{3}{2}} \exp\left(-\frac{\lambda(y-\theta)^2}{2\theta^2 y}\right), \quad y > 0 \tag{6}$$

On substituting (5) and (6) in (4) the closed form of composite envelope is expressed as follows

$$f_X(x) = \left(\frac{\lambda}{\theta^2}\right)^{m+\frac{1}{2}} \sqrt{\frac{\lambda}{2\pi}} \frac{4m^m x^{2m-1} exp\left(\frac{\lambda}{\theta}\right)}{\Gamma(m)\left(\sqrt{g(x)}\right)^{m+\frac{1}{2}}} K_{m+\frac{1}{2}}\left(\sqrt{g(x)}\right) \quad (7)$$

Where $g(x) = \frac{2\lambda}{\theta^2}\left(mx^2 + \frac{\lambda}{2}\right)$ and $K_v(\bullet)$ is the modified Bessel (Gradshteyn and Ryzhik, 1994) function of the second kind of order v. At $m = 1$, this distribution reduces to the Rayleigh-Inverse Gaussian.

The probability density function of the instantaneous composite signal to noise power ratio $f_\gamma(\gamma)$ can be easily deduced from (7) as

$$f_\gamma(\gamma) = A \frac{\gamma^{m-1}}{\left(\sqrt{\alpha+\beta\gamma}\right)^{m+\frac{1}{2}}} K_{m+\frac{1}{2}}\left(b\sqrt{\alpha+\beta\gamma}\right) \quad (8)$$

Terms used in Equation (8) can be expressed as:

$$A = \frac{(\lambda\gamma)^{\frac{1+2m}{4}}}{\Gamma(m)} \sqrt{\frac{2\lambda}{\pi\theta}} \exp\left(\frac{\lambda}{\theta}\right)\left(\frac{m}{\gamma}\right)^m , \quad b = \frac{1}{\theta}\sqrt{\frac{\lambda}{\gamma}} , \alpha = \lambda\bar{\gamma}, \beta = 2m\theta$$

From (Abdi and Kaveh, 1998), $\gamma = \frac{\gamma}{E[x^2]}x^2$, where γ represents instantaneous SNR, $\bar{\gamma}$ represents average SNR, $E[\bullet]$ is the expectation operator and λ, θ are the shadowing parameters.

Moment generating function

In probability theory and statistics, the MGF of any random variable is an alternative definition of its probability distribution. Thus, it provides the basis of an alternative route to analytical results compared with working directly with probability density functions or cumulative distribution functions. There are particularly simple results for the moment-generating functions of distributions defined by the weighted sums of random variables. The moment-generating function does not always exist even for real-valued arguments, unlike the characteristic function. There are relations between the behavior of the moment-generating function of a distribution and properties of the distribution, such as the existence of moments. Thus, MGF is nothing but the Laplace transform of the PDF with argument reversed in sign.

The MGF of an CRV, $\gamma > 0$ is defined as (Mahmoud and Mustafa, 2006; Athanasios, 1989)

$$M_\gamma(s) = E(e^{-s\gamma}) = \int_0^\infty e^{-s\gamma}f_\gamma(\gamma)d\gamma \quad (9)$$

Where $M_\gamma(s\bullet)$ is the moment generating function and $f_\gamma(\gamma)$ is the probability density function (PDF) of γ. Using the Taylor series expansion of $e^{-s\gamma}$ the MGF can be expressed as (Mahmoud and Mustafa, 2006)

$$M_\gamma(s) = \sum_{n=0}^\infty \frac{(-1)^n}{n!} E[\gamma^n] s^n \quad (10)$$

For composite PDF the n_{th} moment is given by Equation (11) and on using the power series expansion for Bessel function (Gradshteyn and Ryzhik, 1994, Equation 8.468)

$$E[\gamma^n] = \sqrt{\frac{2\lambda}{\pi\theta}} e^{\frac{\lambda}{\theta}} \left(\frac{\gamma}{m}\right)^m \frac{\Gamma(m+n)}{\Gamma(m)} K_{n-\frac{1}{2}}\left(\frac{\lambda}{\theta}\right) \quad (11)$$

$$K_{n-\frac{1}{2}}\left(\frac{\lambda}{\theta}\right) = \sqrt{\frac{\pi\theta}{2\lambda}} e^{-\frac{\lambda}{\theta}} \sum_{k=0}^{n-1} \frac{(n+k-1)!}{k!\left(n-K_{n-\frac{1}{2}}\left(\frac{\lambda}{\theta}\right)=k-1\right)!\left(\frac{2\lambda}{\theta}\right)^k} \quad (12)$$

On substituting (11) and (12) in (10), the moment generating function for specific number of numerator and denominator order is given by

$$M_\gamma(s) = \sum_{n=0}^{N_p+N_q+1} \left[\frac{(-1)^n}{n!}\left(\frac{\gamma}{m}\right)^m \frac{\Gamma(m+n)}{\Gamma(m)} \sum_{k=0}^{n-1} \left(\frac{(n+k-1)!}{k!(n-k-1)!\left(\frac{2\lambda}{\theta}\right)^k}\right) s^n\right] \quad (13)$$

On solving the Equation (12) for the value of $m = 5$ in case of frequent heavy shadowing MGF is represent in power series which is order of N_p+N_q+1. Pade approximation of this power series is represent by the Equation (14)

$$P^{\left[\frac{5}{5}\right]}(s,m,\bar{\gamma}) = \frac{1+14.93\,\bar{\gamma}S+74.51\,\bar{\gamma}^2S^2+143.23\,\bar{\gamma}^3S^3+82.97\,\bar{\gamma}^4S^4-6.59\,\bar{\gamma}^5S^5}{1+15.93\bar{\gamma}S+89.29\,\bar{\gamma}^2S^2+215.98\,\bar{\gamma}^3S^3+220.85\,\bar{\gamma}^4S^4+76.17\,\bar{\gamma}^5S^5+2.29\,\bar{\gamma}^6S^6} \quad (14)$$

Table 1 shows the value of coefficient at the nominator and denominator for different fading parameter. As we change the value of fading parameter the value of coefficient is also changed. Coefficient of approximation for different fading parameter value (m=1, 2, 4, 5) are given in Table 1.

Outage probability

For reliable wireless communication the received power level should be greater than the minimum power level which is required for uninterrupted communication between transmitter and receiver. This minimum level is

Table 1. Value of coefficient of nominator and denominator in moment generating function for different fading parameter (m).

Shadowing	Numerator coefficients (a_n), (a_0=1)	Denominator coefficients (b_n), (b_0=1)
Frequent heavy shadowing		
m=1	{53.786, 966.572, 6970.783, 18904.747, 13580.563}	{54.78, 1019.44, 7891.57, 25156.42, 28532.05, 7965.94}
m=2	{26.775, 223.313, 602.796, 36.947, -867.123}	{27.7748, 249.65, 815.69, 571.43, - 913.44, - 698.914}
m=5	{14.934, 74.507, 143.239, 82.976, -6.591}	{15.9337, 89.292, 215.976, 220.8524, 76.175, 2.295}
Average shadowing		
m=1	{6.8597, 18.0859, 22.8953, 13.9043, 3.2379}	{7.8597, 24.919, 40.829, 36.487, 16.8715, 3.1550}
m=2	{2.9102, 3.0314, 1.3226, 0.1992, 2.3447}	{3.9102, 6.172, 5.02539, 2.22, 0.50517, 0.04609}
m=4	{1.0846, 0.286, -0.000262, 0.000021, -0.000001015}	{2.0846, 1.7296, 0.730, 0.16503, 0.0189, 0.00085}
m=5	{0.46227, 0.016074, -0.0010309, 0.00005115, -0.0000014938}	{1.463, 0.8625, 0.2638, 0.0444, 0.00394, 0.000147}

known as received power threshold. Due to the effect of fading received signal value fluctuates therefore it is important to calculate the probability of outage of any communication system when the received power level goes below then the certain threshold level. In terms of moment generating function the outage probability is given by (Karagiannidis, 2004).

$$P_{out} = \frac{1}{2\pi j} \int_{\varepsilon-j\infty}^{\varepsilon+j\infty} \frac{[\mathcal{M}_\gamma(s)]}{s} \, e^{s\gamma} \, ds \tag{14}$$

or in the terms of Laplace transform this is given by (8, 17)

$$P_{out} = \mathcal{L}^{-1}\left(\frac{\mathcal{M}_\gamma(-s)}{s}\right)\Big|_{\gamma_{th}} \tag{15}$$

On using Pade approximation it can be solved for fixed number of numerator and denominator coefficients and which is as follows

$$\mathcal{M}_\gamma(s) = \frac{\sum_{n=0}^{Np} a_n s^n}{1+\sum_{n=1}^{Nq} b_n s^n} = \sum_{n=1}^{Nq} \frac{\lambda_n}{s+p_n} \tag{16}$$

$$P_{out} = 1 - \sum_{n=1}^{Nq} \frac{\lambda_n}{p_n} e^{-p_n\gamma_{th}} \tag{17}$$

where p_n are the poles of the approximated result and λ_n are the residue (Stüber, 1996; van Nee et al., 1992). By using Pade approximated MGF we plotted the result for outage probability versus normalized outage threshold that is, $\frac{\gamma_{th}}{\gamma}$ in later section (Karagiannidis, 2004).

Table 2 shows the value of coefficient at the nominator and denominator for different fading parameter for calculation of outage probability. As we change the value of fading parameter the value of coefficient is also changed.

Amount of fading

Amount of fading is a statistical characterization of fading environment. On varying the fading parameter m for a particular range the effectiveness of fading can be measured through the wireless channel. AF = 0 (for higher values of m) represents ideal Gaussian channel and AF = ∞ (for very small values of m) represents severe fading environment.

$$AF = \frac{E[\gamma^2]}{E[\gamma]^2} - 1 \; ; \tag{18}$$

On using (11) and (12) it represents by following Equation

$$AF = \frac{\Gamma(m+2)\,\Gamma(m)}{\Gamma^2(m+1)}\left(1+\frac{\theta}{\lambda}\right) - 1 \tag{19}$$

Bit error rate

Bit error rate or bit error probability (BEP) is an important performance analysis measurement of any digital communication system. Compute of bit error rate for any system is very difficult as compare to other parameter. BEP is one of the most relevant methods to show about the nature of any system (Mahmoud and Mustafa, 2006). Moment generating function plays a key role for evaluating the average BEP for several modulation schemes. For differently coherent detection of binary phase shift keying (DPSK) and non coherent frequency shift keying (FSK), the average BEP is given as (Simon and Alouini, 2004).

$$P_b(E) = C_1 \mathcal{M}_\gamma(a_1) \tag{20}$$

Where M(•) is moment generating function and c_1 and a_1 are constant depend on the modulation scheme

$$p^{[4/5]}(s, m, \bar{\gamma}) = \frac{1+4.385\bar{\gamma}s+3.984\bar{\gamma}^2}{1+5.384\bar{\gamma}s+8.2739\bar{\gamma}^2s^2+3.9137\bar{\gamma}^3s^3+.4395\bar{\gamma}^4s^4} \tag{21}$$

Table 2. Value of coefficient of nominator and denominator in outage probability for different value of fading parameter (m).

Shadowing	Residue of the approximated MGF (λ_n)	Poles of the approximated MGF (p_n)
Frequent heavy shadowing		
m=1	{4.91×10⁻⁹, 1.460, 3.05×10⁻⁶,0.231, 3.25×10⁻⁴, 0.0123}	{0.039, 2.448, 0.066, 0.658, 0.119, 0.248}
m=2	{ .0012, 5.77 ×10⁻⁸, 0.0027, 3.22 ×10⁻⁵, 1.151, 0.0846}	{-1.014, 0.074, 0.224, 0.124, 1.418, 0.478}
m=5	{ 1.365, -4.447, 2.59x10⁻⁴, 7.51×10⁻⁷,0.0127, 0.197}	{ 1.645, 30.098, 0.229, 0.146, 0.376, 0.697}
Average shadowing	**Residue of the approximated MGF (λ_n)**	**Poles of the approximated MGF (p_n)**
m=1	{0.4602, 0.421, 0.0729, 8.878 ×10⁻⁷, 0.0018, 0.0699}	{1.153, 0.929, 0.752, 0.445, 0.6023, 1.464}
m=2	{0.039, 3.475, 0.918, -0.675, 1.444 ×10⁻⁴, -3.757}	{1.172, 1.722, 1.426, 3.166, 0.938, 2.534}
m=4	{-7.767, 5.5×10⁻⁴, 1.204, 27.224, 214.88, -235.55}	{7.286, 1.593, 2.141, 2.643, 4.372, 4.0
m=5	{45.447, 0.687,-0.625-j4.68, -0.625+j4.68, -22.44+j52.36, - 22.44-j52.36 }	{2.972, 2.379, 6.48-j3.06, 6.48+j3.06, 4.23-j0.85, 4.23+j0.85 }

After putting the value of $s=a_1$

$$P_b(E) = C_1\left(\frac{1+4.385\gamma a_1+3.984\gamma^2 a_1{}^2}{1+5.384\gamma a_1+8.2739\gamma^2 a_1{}^2+3.9137\,\gamma^3 a_1{}^3+.4395\gamma^4 a_1{}^4}\right) \quad (22)$$

Where C_1=1/2 and a_1=1 for coherent DPSK and $C_1 = \frac{1}{2}$ and a_1=1/2 for noncoherent FSK.

The average BER for BPSK/BFSK modulation scheme

is given as (Simon and Alouini, 2004; Vivek and Ghanshyam 2011)

$$P_b(E) = \frac{1}{\pi}\int_0^{\frac{\pi}{2}} M_\gamma\left(\frac{g}{\sin^2\theta}\right)d\theta \quad (23)$$

By putting $\sin^2\theta = x^2$ and simply (23) for pade's approximation $P^{[2/5]}$ is expressed as

$P_b(E)$

$$= \frac{1}{\pi}\int_0^1 \frac{.1857}{\bar\gamma\left(\frac{g}{x^2}\right)+.651}\times\frac{1}{\sqrt{1-x^2}}dx + \frac{1}{\pi}\int_0^1 \frac{.003}{\bar\gamma\left(\frac{g}{x^2}\right)+.3203}\times\frac{1}{\sqrt{1-x^2}}dx + \frac{1}{\pi}\int_0^1 \frac{2.015}{\bar\gamma\left(\frac{g}{x^2}\right)+6.163}\times\frac{1}{\sqrt{1-x^2}}dx + \frac{1}{\pi}\int_0^1 \frac{1.826}{\bar\gamma\left(\frac{g}{x^2}\right)+1.77}\times\frac{1}{\sqrt{1-x^2}}dx \quad (24)$$

where g=1/2 for BFSK and g=1 for BPSK and g=.715 for coherent BFSK with minimum correlation.

$$P_b(E) = \frac{.1857}{\pi}\left(2.4134 - \frac{2.99153}{\sqrt{1.53644+\frac{1}{\gamma}}}\right) + \frac{.003}{\pi}\left(4.9029 - \frac{8.6621}{\sqrt{3.1213+\frac{1}{\gamma}}}\right) - \frac{2.01519}{\pi}\left(.254857 - \frac{.102656}{\sqrt{.162247+\frac{1}{\gamma}}}\right) + \frac{1.8261}{\pi}\left(.887262 - \frac{.66683}{\sqrt{.5648+\frac{1}{\gamma}}}\right) \quad (25)$$

RESULTS AND DISCUSSION

Figure 1 shows the outage probability for different fading environment frequent heavy $(\lambda = 0.03019,\ \theta = 0.02762)$ shadowing and average $(\lambda = 34.38756,\ \theta = 0.902993)$ shadowing for different pade approximated function. These models were widely used in wireless environment (van Nee et al., 1992; Chau and Sun, 1996). From this figure we notice that as we move for higher order rational function, the proposed method provides best match to reference (Amine et al., 2009). In all approximation, N_p has chosen to be equal to $(N_q - 1)$ as these guarantees the convergence of Pade approximation (Mahmoud and Mustafa, 2006). In this paper, we took N_q such that it

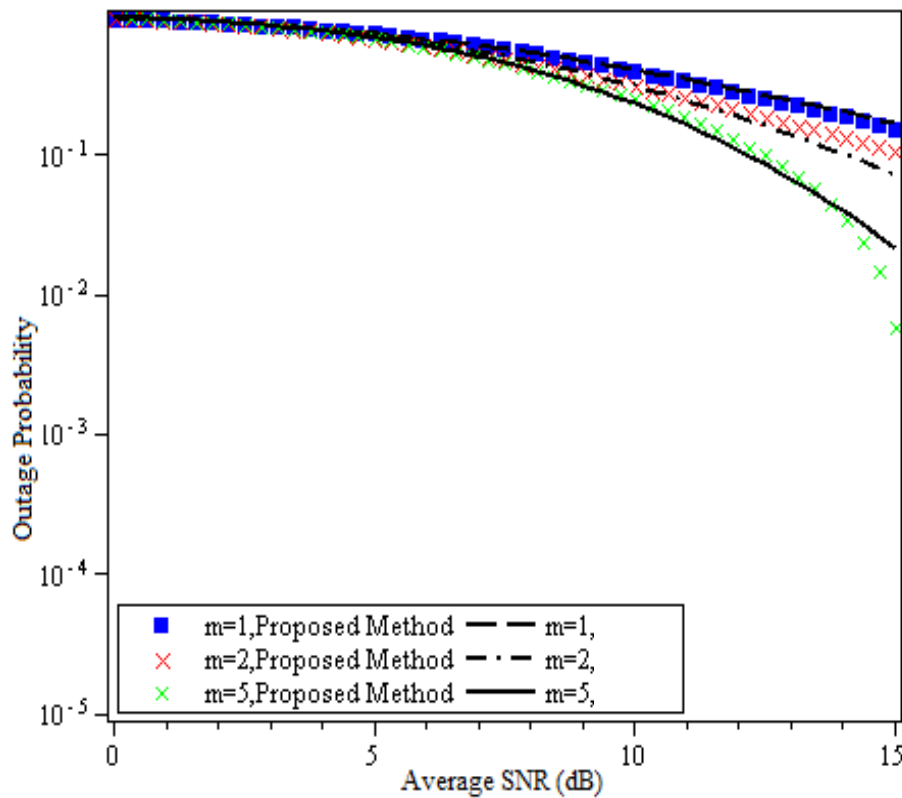guarantees the uniqueness of the all approximations and that is given at $N_p = (N_q - 1)$.

Figure 2 shows the plot between outage probability versus average SNR for different values of fading parameter 'm'. In this case of frequent heavy shadowing we take $\mu = -3.914$ and $\sigma = 0.806$ (Amine et al., 2009). Result depicts that as the value of fading parameter 'm' increase, the value of outage probabilty get reduce for higher values of average SNR. In Figure 3 we draw a plot between outage probability and average SNR for different values of threshold SNR. Plot depicts that as the threshold SNR increase then the value of outage probability also increases. In Figure 4 plots are shown for average shadowing environment by using $\mu = -0.115$ and $\sigma = 0.161$. It reflects that as the value of

‘m’ increase the value of outage probabilty reduces rapidly after the 5 dB average SNR value.

Figure 5 provides best match between proposed method results and reference (Amine et al., 2009).

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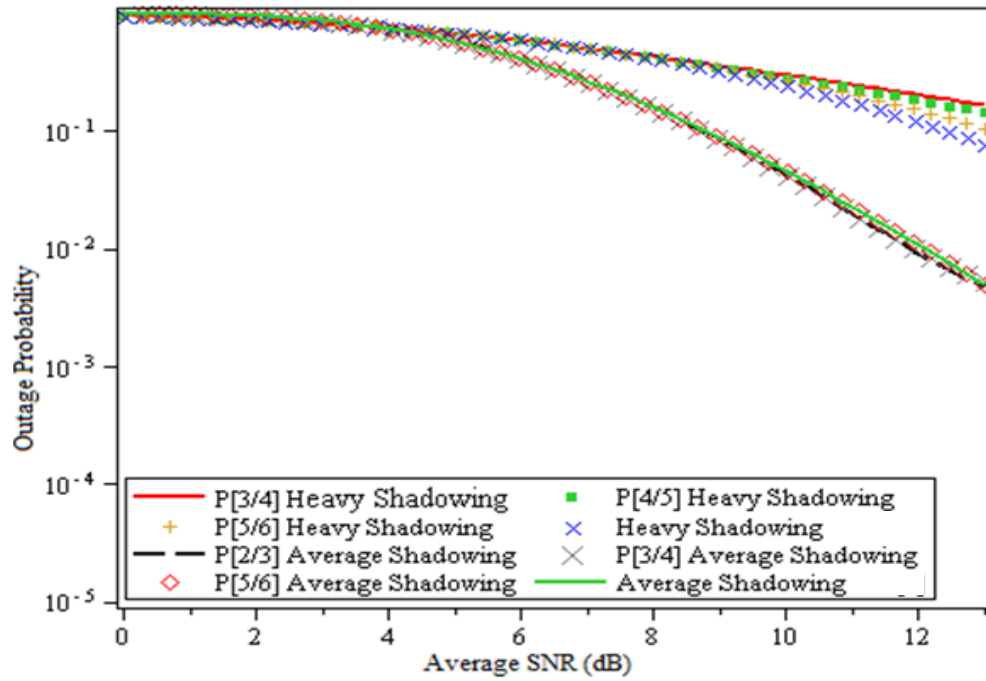
Figure 1. Outage probability for different Pade approximations with $m = 4$ and $\gamma_{th} = 5dB$ in frequent heavy shadowing and average shadowing environment.

Figure 2. Outage probability for P[5/6], $\gamma_{th} = 5dB$ in frequent heavy $(\lambda = 0.03019,\ \theta = 0.02762)$ shadowing environments using different value of fading parameter m.

Figure 3. Outage probability for P[5/6], $m = 1$ in heavy $(\lambda = 0.03019,\ \theta = 0.02762)$ shadowing environments using different value of γ_{th}.

Figure 4. Outage probability for P[5/6], $\gamma_{th} = 5dB$ in average $(\lambda = 34.38756, \theta = 0.902993)$ shadowing environments using different value of fading parameter m.
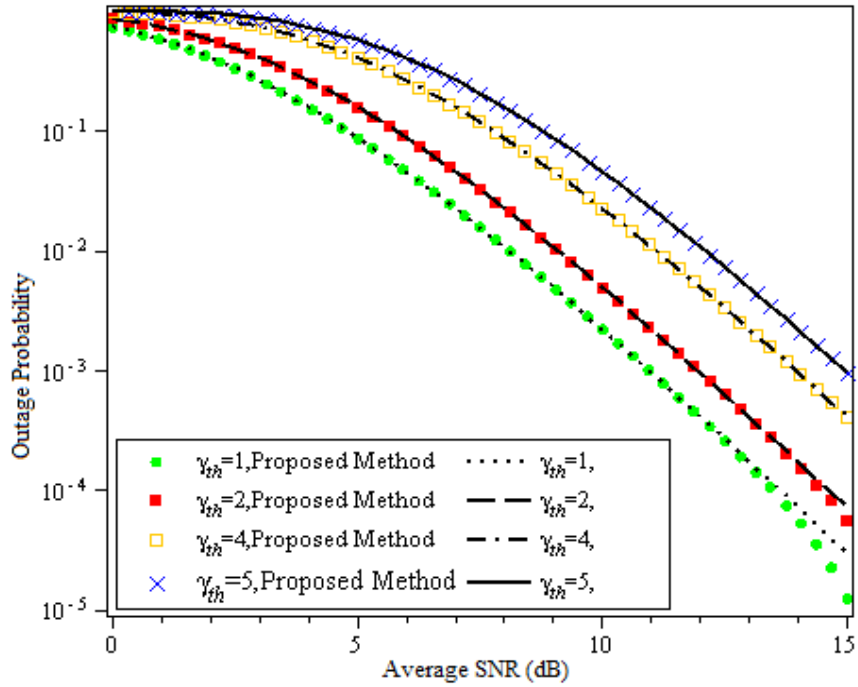
Figure 5. Outage probability for P[5/6], $m = 4$ in average $(\lambda = 34.38756, \theta = 0.902993)$ shadowing environments using different value of γ_{th} .
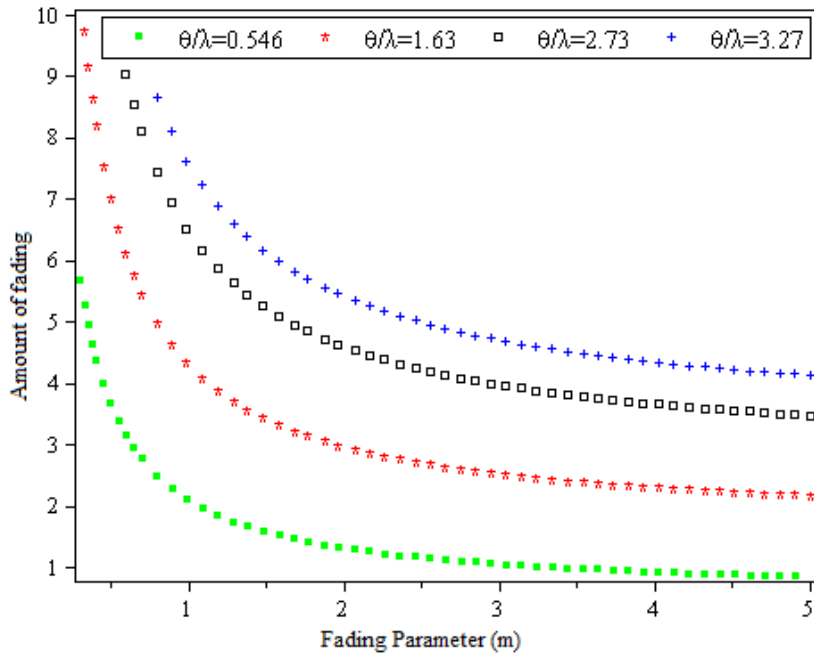

**Figure 6.** Amount of fading as a function of m for different values of θ/λ.

results. As γ_{th} increase, it reflects an increment in the value of outage probability. The impact of fading parameter m over amount of fading is shown in Figure 6. From this figure it can be notice that as the value of

fading parameter approaches to infinity then the fading severity approaches to zero. So this figure reflects the results over different fading and shadowing situation by varying the value of µ and σ and fading parameter 'm'.
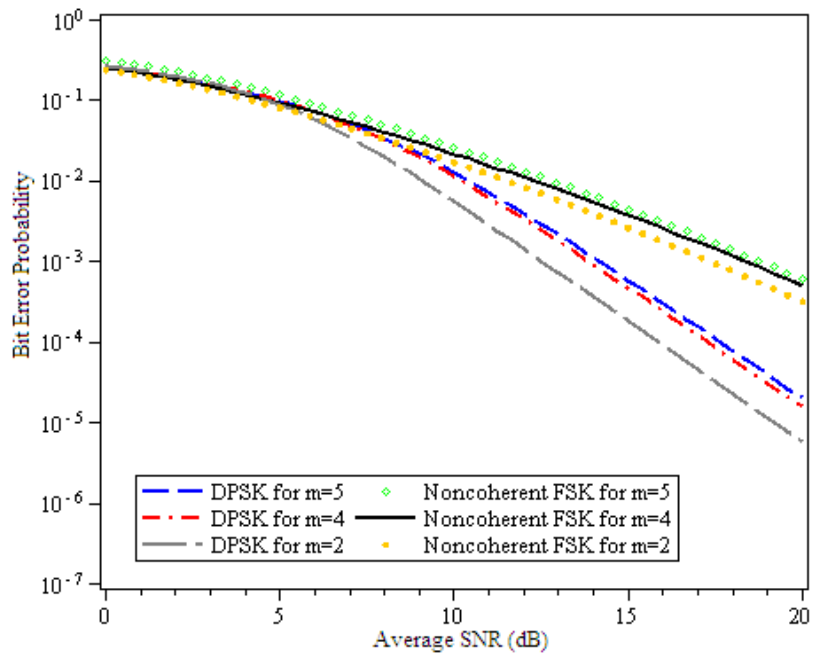
Figure 7. Average bit error probability for BFSK, BPSK and noncoherent BFSK for different value of fading parameter(m=7 and m=4) in frequent heavy shadowing environment (µ= -3.914 and σ= 0.806).
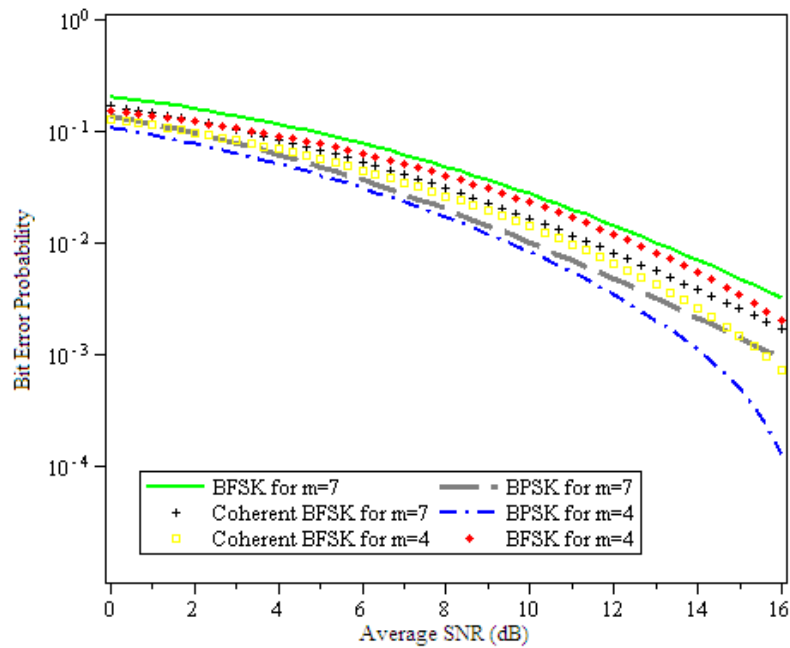
Figure 8. Average bit error probability for DPSK and noncoherent FSK for different value of fading parameter(m=5, m=4 and m=2) in frequent heavy shadowing environment (µ= -3.914 and σ= 0.806).

Figure 7 shows the plot between bit error probability and average SNR for different modulaton scheme for different fading parameter. From this we analysis that as we increase the value of fading parameter the bit error probability is also increases for a value of average SNR and also conclude that when we move from BFSK to BPSK and than coherent BFSK modulation system performance is also enhanced. Figure 8 shows the plot

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between bit error probability and average snr curve for DPSK and noncoherent FSK modulation scheme and estimate the performance of system that in which modulation scheme system performance is better. From plot we conclude that as DPSK modulation scheme is better as compare to Noncoherent FSK because in DPSK bit error rate is less.

Conclusion

From the whole analysis we concluded that the Pade approximation provide a best match to the reference results. In this paper we have done the composite analysis of Nakagami- Inverse Gaussian model and calculate the outage probability and bit error rate using Pade approximation. By using the Pade approximation method calculation is much easier as compare to analytical expression. As we know that to analyze the performance of wireless channel we deal with different PDF function that contains complex mathematical function like Bessel function of different kinds and orders, exponential function, Gamma function and other mathematical infinite series which makes the analysis very difficult. Hence Pade approximation provides a simple solution to this problem and it creates a way to very easy system modeling. There is a lot of work has been done using Pade approximation over the different areas like finance, image theory etc and now it also has been used in performance analysis of short term faded wireless channels but in this paper we are suggested this method to performance analysis over the composite (multipath/shadowed) wireless fading channels. For future analysis this method can be used for approximation of other wireless channel which also have the consideration of diversity, equalization etc. This analysis concludes that the Pade approximation provides a better approximation as compare to other approximation method.

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