Performance Analysis of Wireless Communication System in the Presence of Gamma Shadowing, Nakagami-m Multipath Fading and Cochannel Interference

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Abstract: - Wireless communication system working over Gamma shadowed Nakagami-*m* multipath fading channel in the presence of cochannel interference exposed to Nakagami-*m* short term fading and Gamma long term fading is investigated in this work. In interference limited channel, the ratio of desired signal envelope and interference is important performance measure. For considered model signal to interference ratio can be calculated as the ratio of two products of square rooted Gamma random variable and Nakagami-*m* random variable. In this paper, the closed form expression for probability density function (PDF), moments and moment generating function (MGF) of output SIR will be calculated. The influences of Nakagami-*m* short term fading severity parameter and Gamma long term fading severity parameter on moments of the first and the second order will be discussed.

Key-Words: -Cochannel interference; Gamma shadowing; moments; probability density function; Nakagami-m fading

1 Introduction

In interference limited environments, cochannel interference power is significantly higher than Gaussian noise power, so Gaussian noise effects on the outage probability and bit error probability of wireless communication system can be ignored [1]. In these channels, the ratio of desired signal envelope and cochannel interference envelope is important performance measure. Refraction, diffraction, reflection and scattering of electromagnetic waves cause small scale fading resulting in signal envelope variation. With the other hand, large obstacles between transmitter and receiver cause shadowing which resulting in signal envelope average power variation. Desired signal and cochannel interference are subjected to long term fading and short term fading.

A plurality of distribution is used to describe signal envelope variation in short term fading channels and to describe signal envelope average power variation in long term fading channels [2].

Nakagami-*m* statistical model describes signal envelope in non line of sight (LOS), linear multipath fading channel where signal propagates with one, two or more clusters [3]. Nakagami-*m* distribution has severity parameter *m* and signal envelope average power Ω. The parameter *m* is is greater than 0.5. When parameter *m* is equal to one, Nakagami-*m* distribution reduces to Rayleigh distribution; when parameter *m* tends to 0.5, Nakagami-*m* statistical model turn into one sided Gaussian statistical model and when parameter *m* goes to infinity, Nakagami-*m* multipath fading channel becomes no fading channel.

Signal envelope average variation in long term fading channels can be described by using log-normal distribution or Gamma distribution. When signal envelope is modeled with Gamma distribution, probability density function and cumulative distribution function of output signal to interference ratio can be obtained as the closed form expressions.

There are more works in aveilable technical literature, considering performance of wireless communication system in the presence of short term fading and cochannel interference and performance of wireless systems operating over shadowed short term fading environments. In [4], wireless communication system working over Weibull multipath channel with SC receiver in the presence of cochannel interference affected to Weibull multipath fading is evaluated. Probability density function, cumulative distribution function, moments, outage probability and bit error probability for several modulation schemes are calculated in the paper.

Outage performance of multi-branch SC receiver over correlated Weibull channel in the presence of correlated Rayleigh co-channel interference is determined in [5].

Macrodiversity system including macrodiversity SC receiver and two microdiversity SC receivers is considered in [6]. Received signal experiences long term fading and short term fading. Microdiversity SC receivers reduce Rayleigh fading effects on system performance and macrodiversity SC receivers mitigate Gamma shadowing effects on system performance. The closed form expressions for level crossing rate of system output signals envelopes are calculated.

Macrodiversity system with macrodiversity SC receiver and two maximal ratio combining (MRC) receivers operating over Gamma shadowed Rician multipath fading channel is analyzed in [7]. Average level crossing rate and average fade duration are evaluated.

In [8], the authors presented novel exact expressions and accurate closed-form approximations for the level crossing rate (LCR) and the average fade duration (AFD) of the double Nakagami-m random process. These results are useful for studying the second order statistics of multiple input multiple output (MIMO) keyhole fading channels. Numerical and computer simulation examples validate the accuracy of the presented mathematical analysis and show the tightness of the proposed approximations.

The problems of products and ratios of random variables with different distributions, as well as their application in wireless telecommunication systems are considered in [9]-[12]. The application in performance analysis of multi-hop relaying communications over fading channels is presented in [9] and [10]. Statistical characteristic of ratio of product of two random Rayleigh variables and Rayleigh random variable and its application in performance analysis of wireless communication systems are derived in [11], and statistics for ratios of Rayleigh, Rician, Nakagami-*m*, and Weibull distributed random variables is given in [12].

In this work, wireless communication system functioning over Gamma shadowed Nakagami-*m* multipath fading in the presence of cochannel interference subjected to Nakagami-*m* short term fading is examined. Signal envelope to cochannel interference envelope ratio of considered wireless system can be calculated as ratio of two products of square rooted Gamma random variable and Nakagami-*m* random variable. In this paper, probability density function and moments of signal to interference ratio are derived. The influence of fading channel parameters on system performance is analyzed.

2 Performance of Output Signal to Interference Ratio

2.1 Probability Density Function of Output Signal to Interference Ratio

Signal to interference ratio at the output of wireless communication system is:

$$w = \frac{x \cdot y}{z \cdot t} . \tag{1}$$

Then, random variable x is:

$$x = \frac{wzt}{y} . \tag{2}$$

Random variable x is also:

$$x_1 = x^2, \ \frac{dx_1}{dx} = 2x \tag{3}$$

where x_1 is Gamma random variable:

$$p_{x_1}\left(x_1\right) = \frac{1}{\Gamma\left(c_1\right)\beta_1^{c_1}} x_1^{c_1-1} e^{-\frac{1}{\beta_1}x_1} , \ x_1 \geq 0 \tag{4}$$

with a shape parameter c_1 and a scale parameter β_1.

Probability density function of x is:

$$p_x\left(x\right) = \left|\frac{dx_1}{dx}\right| p_{x_1}\left(x^2\right) = \frac{2}{\Gamma\left(c_1\right)\beta_1^{c_1}} x^{2c_1-1} e^{-\frac{1}{\beta_1}x^2} \tag{5}$$

Random variable y has Nakagami-*m* distribution [13]:

$$p_y\left(y\right) = \frac{2}{\Gamma\left(m_1\right)} \left(\frac{m_1}{\Omega_1}\right)^{m_1} y^{2m_1-1} e^{-\frac{m_1}{\Omega_1}y^2} , \ y \geq 0 \tag{6}$$

whereas $\Gamma(.)$ is the Gamma function, Ω_1 is the average signal power:

$$\Omega_1 = \frac{\overline{y^2}}{m_1}$$

and m_1 represents the inverse normalized variance y^2, which must satisfy $m_1 \geq 1/2$, describing the fading severity.

Random variable z is square root of Gamma variable. PDF of z is:

$$p_z(z)=\frac{2}{\Gamma(c_2)\beta_2^{c_2}}z^{2c_2-1}e^{-\frac{1}{\beta_2}z^2},\ z\ge 0 \tag{7}$$

Nakagami-*m* random variable *t* has Nakagami-*m* distribution [13]:

$$p_t(t)=\frac{2}{\Gamma(m_2)}\left(\frac{m_2}{\Omega_2}\right)^{m_2}t^{2m_2-1}e^{-\frac{m_2}{\Omega_2}t^2},\ t\ge 0 \tag{8}$$

Probability density function of *w* is therefore:

$$p_w(w)=\int_0^\infty dy\int_0^\infty dz\int_0^\infty dt\cdot\frac{z}{y}t\cdot p_x\left(\frac{wzt}{y}\right)p_y(y)\,p_z(z)p_t(t)=$$

$$=\frac{2}{\Gamma(c_1)\beta_1^{c_1}}w^{2c_1-1}\frac{2}{\Gamma(m_1)}\left(\frac{m_1}{\Omega_1}\right)^{m_1}\frac{2}{\Gamma(m_2)}\left(\frac{m_2}{\Omega_2}\right)^{m_2}\frac{2}{\Gamma(c_2)\beta_2^{c_2}}$$

$$\int_0^\infty dy\cdot y^{-2c_1+1-1+2m_1-1}\int_0^\infty dz\,z^{2c_1-1+1+2c_2-1}\int_0^\infty dt\,t^{1+2c_1-1+2m_2-1}$$

$$\cdot e^{-\frac{1}{\beta_1}\frac{w^2z^2t^2}{y^2}-\frac{m_1}{\Omega_1}y^2-\frac{1}{\beta_2}z^2-\frac{m_2}{\Omega_2}t^2} \tag{9}$$

Let us introduce integral J_1 as:

$$J_1=\int_0^\infty dt\,t^{2c_1+2m_2-1}\cdot e^{-\left(\frac{1}{\beta_1}\frac{w^2z^2}{y^2}+\frac{m_2}{\Omega_2}\right)t^2}=$$

$$=\frac{1}{2}\beta_1^{c_1+m_2}\Omega_2^{c_1+m_2}\frac{y^{2c_1+2m_2}}{\left(w^2z^2+m_2y^2\right)^{c_1+m_2}}\Gamma(c_1+m_2) \tag{10}$$

Similarly, let is integral J_2:

$$J_2=\int_0^\infty dy\,y^{2m_1-2c_1-1+2c_1+2m_2}\cdot e^{-\frac{m_1}{\Omega_1}y^2}\cdot$$

$$\cdot\int_0^\infty dz\frac{1}{\left(w^2z^2+m_2y^2\right)^{c_1+m_2}}z^{2c_1+2c_2-1}e^{-\frac{1}{\beta_2}z^2} \tag{11}$$

Now, it is valid:

$$y^2=y_1,\ z^2=z_1. \tag{12}$$

The derivatives are:

$$ydy=\frac{1}{2}dy_1\quad\text{and}\quad zdz=\frac{1}{2}dz_1. \tag{13}$$

From expression (12) we have:

$$y=y_1^{1/2},\ z=z_1^{1/2}.$$

After substituting, the expression for J_2 becomes:

$$J_2=\int_0^\infty dy_1\,y_1^{m_1+m_2-1}\cdot e^{-\frac{m_1}{\Omega_1}y_1}\cdot$$

$$\cdot\frac{1}{2}\int_0^\infty dz_1\,z_1^{c_1+c_2-1}e^{-\frac{1}{\beta_2}z_1}\cdot\frac{1}{\left(w^2z_1+m_2y_1\right)^{c_1+m_2}} \tag{14}$$

By using the formula [14]:

$$\int_0^\infty ds_1\,s_1^{p_1-1}\cdot e^{-\alpha_1 s_1}\cdot\int_0^\infty d\Omega_1\,\Omega_1^{p_2-1}e^{-\alpha_2\Omega_1}\cdot\frac{1}{\left(a\Omega_1+bs_1\right)^n}=$$

$$=\frac{b^{p_2-n}}{a^{p_2}}\Gamma(p_2)\left(\frac{a}{\alpha_2 b}\right)^{p_1+p_2-n}\frac{\Gamma(p_1+p_2-n)\Gamma(p_1)}{\Gamma(p_1+p_2)}\cdot$$

$$\cdot{}_2F_1\left(p_1+p_2-n,p_1,p_1+p_2,1-\frac{\alpha_1 a}{\alpha_2 b}\right), \tag{15}$$

precursory expression ensues:

$$J_2=\frac{1}{4}\frac{m_2^{c_1+c_2-c_1-m_2}}{w^{2(c_1+c_2)}}\Gamma(c_1+c_2)\left(\frac{w^2\beta_2}{1\cdot m_2}\right)^{m_1+m_2+c_1+c_2-c_1-m_2}$$

$$\cdot\frac{\Gamma(m_1+c_2)\Gamma(m_1+m_2)}{\Gamma(m_1+m_2+c_1+c_2)}\cdot$$

$$\cdot{}_2F_1\left(m_1+c_2,m_1+m_2,m_1+m_2+c_1+c_2,1-\frac{m_1w^2}{\Omega_1}\frac{\beta_2}{m_2}\right). \tag{16}$$

After substituting the expression for J_2 in the expression for the PDF of *w*, it becomes:

$$p_w(w)=\frac{2}{\Gamma(c_1)\beta_1^{c_1}}\cdot\frac{2}{\Gamma(c_2)\beta_2^{c_2}}w^{2c_1-1}\cdot$$

$$\cdot\frac{2}{\Gamma(m_1)}\left(\frac{m_1}{\Omega_1}\right)^{m_1}\frac{2}{\Gamma(m_2)}\left(\frac{m_2}{\Omega_2}\right)^{m_2}\cdot$$

$$\cdot\Gamma(c_1+m_2)\frac{1}{2}\beta_1^{c_1+m_2}\Omega_2^{c_1+m_2}\frac{1}{4}\cdot$$

$$\frac{m_2^{c_2-m_2}}{w^{2(c_1+c_2)}}\Gamma(c_1+c_2)\frac{w^{2(m_1+c_2)}\beta_2^{m_1+c_2}}{m_2^{m_1+c_2}}$$

$$\cdot\frac{\Gamma(m_1+c_2)\Gamma(m_1+m_2)}{\Gamma(m_1+m_2+c_1+c_2)}\cdot$$

$$\cdot{}_2F_1\left(m_1+c_2,m_1+m_2,m_1+m_2+c_1+c_2,1-\frac{m_1}{\Omega_1}\frac{\beta_2}{m_2}w^2\right). \tag{17}$$

2.2 Moments of Output Signal to Interference Ratio

Moment of n-th order of ratio of two products of square rooted Gamma random variable and Nakagami-m random variable is:

$$m_n = \overline{w^n} = \int_0^\infty dw\, w^n p_w(w) =$$

$$= \frac{2}{\Gamma(c_1)\beta_1^{c_1}} \cdot \frac{2}{\Gamma(c_2)\beta_2^{c_2}} \cdot \frac{2}{\Gamma(m_1)}\left(\frac{m_1}{\Omega_1}\right)^{m_1} \frac{2}{\Gamma(m_2)}\left(\frac{m_2}{\Omega_2}\right)^{m_2} \cdot$$

$$\cdot \frac{1}{8}\Gamma(c_1+m_2)\beta_1^{c_1+m_2}\Omega_2^{c_1+m_2} \cdot m_2^{c_2-m_2}\,\Gamma(c_1+c_2)\frac{\beta_2^{m_1+c_2}}{m_2^{m_1+c_2}} \cdot$$

$$\cdot \frac{\Gamma(m_1+c_2)\Gamma(m_1+m_2)}{\Gamma(m_1+m_2+c_1+c_2)} \cdot \int_0^\infty dw\, w^{n+2m_1-1}$$

$$\cdot {}_2F_1\left(m_1+c_2, m_1+m_2, m_1+m_2+c_1+c_2, 1-\frac{m_1}{\Omega_1}\frac{\beta_2}{m_2}w^2\right). \tag{18}$$

By using replacement:

$$\frac{m_1}{\Omega_1}\frac{\beta_2}{m_2} w^2 = s\,, \tag{19}$$

it follows:

$$w^2 = \frac{\Omega_1 m_2}{m_1\beta_2} s\,,\ \ wdw = \frac{1}{2}\frac{\Omega_1 m_2}{m_1\beta_2} ds\,. \tag{20}$$

After substituting, the expression for m_n becomes:

$$m_n = \frac{2}{\Gamma(c_1)\beta_1^{c_1}} \cdot \frac{2}{\Gamma(c_2)\beta_2^{c_2}} \cdot$$

$$\cdot \frac{2}{\Gamma(m_1)}\left(\frac{m_1}{\Omega_1}\right)^{m_1} \frac{2}{\Gamma(m_2)}\left(\frac{m_2}{\Omega_2}\right)^{m_2} \cdot \frac{1}{8}\Gamma(c_1+m_2)\beta_1^{c_1+m_2}\Omega_2^{c_1+m_2} \cdot$$

$$\cdot m_2^{c_2-m_2}\,\Gamma(c_1+c_2)\frac{\beta_2^{m_1+c_2}}{m_2^{m_1+c_2}} \cdot$$

$$\cdot \frac{\Gamma(m_1+c_2)\Gamma(m_1+m_2)}{\Gamma(m_1+m_2+c_1+c_2)} \cdot \int_0^\infty ds\, s^{\frac{n}{2}+m_1-1}$$

$$\cdot {}_2F_1(m_1+c_2, m_1+m_2, m_1+m_2+c_1+c_2, 1-s) \tag{21}$$

Now, by using the formula:

$${}_2F_1(a,b,c,-z)z^{-s-1} = \frac{\Gamma(a+s)\Gamma(b+s)\Gamma(c)\Gamma(-s)}{\Gamma(a)\Gamma(b)\Gamma(c+s)},$$

previous expression will be:

$$m_n = \frac{2}{\Gamma(c_1)\beta_1^{c_1}} \cdot \frac{2}{\Gamma(c_2)\beta_2^{c_2}} \cdot$$

$$\cdot \frac{2}{\Gamma(m_1)}\left(\frac{m_1}{\Omega_1}\right)^{m_1} \frac{2}{\Gamma(m_2)}\left(\frac{m_2}{\Omega_2}\right)^{m_2} \cdot \frac{1}{8}\Gamma(c_1+m_2)\beta_1^{c_1+m_2}\Omega_2^{c_1+m_2} \cdot$$

$$\cdot m_2^{c_2-m_2}\,\Gamma(c_1+c_2)\frac{\beta_2^{m_1+c_2}}{m_2^{m_1+c_2}} \cdot$$

$$\cdot \frac{\Gamma(m_1+c_2)\Gamma(m_1+m_2)}{\Gamma(m_1+m_2+c_1+c_2)} \frac{1}{2}\left(\frac{\Omega_1 m_2}{m_1\beta_2}\right)^{\frac{n}{2}+m_1}$$

$$\cdot \frac{\Gamma\left(m_1+c_2-\frac{n}{2}-m_1\right)\Gamma\left(m_1+m_2-\frac{n}{2}-m_1\right)\Gamma(m_1+m_2+c_1+c_2)\Gamma\left(\frac{n}{2}+m_1\right)}{\Gamma(m_1+c_2)\Gamma(m_1+m_2)\Gamma\left(m_1+m_2+c_1+c_2-\frac{n}{2}-m_1\right)} \tag{22}$$

2.3 Moment generating function of Output Signal to Interference Ratio

Moment generating function (MGF) of output SIR is:

$$M_w(s) = \overline{e^{sw}} = \int_0^\infty dw\, e^{sw} p_w(w) =$$

$$= \frac{2}{\Gamma(c_1)\beta_1^{c_1}} \cdot \frac{2}{\Gamma(c_2)\beta_2^{c_2}} \cdot \frac{2}{\Gamma(m_1)}\left(\frac{m_1}{\Omega_1}\right)^{m_1} \frac{2}{\Gamma(m_2)}\left(\frac{m_2}{\Omega_2}\right)^{m_2} \cdot$$

$$\cdot \frac{1}{8}\Gamma(c_1+m_2)\beta_1^{c_1+m_2}\Omega_2^{c_1+m_2} \cdot m_2^{c_2-m_2}\,\Gamma(c_1+c_2)\frac{\beta_2^{m_1+c_2}}{m_2^{m_1+c_2}} \cdot$$

$$\cdot \frac{\Gamma(m_1+c_2)\Gamma(m_1+m_2)}{\Gamma(m_1+m_2+c_1+c_2)} \cdot \int_0^\infty dw\, w^{2m_1-1} e^{sw}$$

$$\cdot {}_2F_1\left(m_1+c_2, m_1+m_2, m_1+m_2+c_1+c_2, -\frac{m_1}{\Omega_1}\frac{\beta_2}{m_2}w^2\right) =$$

$$= \frac{2}{\Gamma(c_1)\beta_1^{c_1}} \cdot \frac{2}{\Gamma(c_2)\beta_2^{c_2}} \cdot \frac{2}{\Gamma(m_1)}\left(\frac{m_1}{\Omega_1}\right)^{m_1} \frac{2}{\Gamma(m_2)}\left(\frac{m_2}{\Omega_2}\right)^{m_2} \cdot$$

$$\cdot \frac{1}{2}\Gamma(c_1+m_2)\beta_1^{c_1+m_2}\Omega_2^{c_1+m_2} \cdot m_2^{c_2-m_2}\,\Gamma(c_1+c_2)\frac{\beta_2^{m_1+c_2}}{m_2^{m_1+c_2}} \cdot$$

$$\cdot \frac{\Gamma(m_1+c_2)\Gamma(m_1+m_2)}{\Gamma(m_1+m_2+c_1+c_2)} \cdot \sum_{k_1=0}^\infty \frac{s^{k_1}}{k_1!} \int_0^\infty dw\, w^{2m_1-1+k_1} \cdot$$

$$\cdot {}_2F_1\left(m_1+c_2, m_1+m_2, m_1+m_2+c_1+c_2, 1-\frac{m_1}{\Omega_1}\frac{\beta_2}{m_2}w^2\right) \tag{23}$$

Now, let us introduce the integral J_3:

$$J_3 = \int_0^\infty dw\, w^{2m_1-1+k_1} \cdot$$

$$\cdot {}_2F_1\left(m_1+c_2, m_1+m_2, m_1+m_2+c_1+c_2, -\frac{m_1}{\Omega_1}\frac{\beta_2}{m_2}w^2\right) \tag{24}$$

By dint of exchange introduced by formulas (19) and (20):

$$\frac{m_1}{\Omega_1}\frac{\beta_2}{m_2}w^2 = s\ ,\ w^2 = \frac{\Omega_1 m_2}{m_1\beta_2}s\ ,\ wdw = \frac{1}{2}\frac{\Omega_1 m_2}{m_1\beta_2}ds\ ,$$

and after replacing the integral J_3 will be:

$$J_3 = \frac{1}{2}\left(\frac{\Omega_1 m_2}{m_1\beta_2}\right)^{m_1+\frac{k_1}{2}} \cdot \int_0^\infty ds\, s^{m_1+\frac{k_1}{2}-1} \cdot$$

$$\cdot {}_2F_1\left(m_1+c_2, m_1+m_2, m_1+m_2+c_1+c_2, -s\right) =$$

$$= \frac{1}{2}\left(\frac{\Omega_1 m_2}{m_1\beta_2}\right)^{m_1+\frac{k_1}{2}} \cdot$$

$$\cdot\frac{\Gamma\left(c_2-\frac{k_1}{2}\right)\Gamma\left(m_2-\frac{k_1}{2}\right)\Gamma\left(m_1+m_2+c_1+c_2\right)\Gamma\left(-m_1-\frac{k_1}{2}\right)}{\Gamma\left(m_1+c_2\right)\Gamma\left(m_1+m_2\right)\Gamma\left(m_1+m_2+c_1+c_2-m_1-\frac{k_1}{2}\right)} \qquad (25)$$

3 Numerical Results

The first moment of w (mean value $\overline{w}$) is given in the first four figures, and the second moment of w (squared average value $\overline{w^2}$) in the second four figures.

In Fig. 1, the main value $\overline{w}$ versus average signal power Ω_1 for Gamma long scale parameters β_1=β_2=1, Nakagami-m fading severity parameters m_1=m_2=2, Gamma fading severity parameters c_1=c_2=2 and variable interference signal power Ω_2 is presented. The first moment of w versus interference signal power Ω_2 for β_1= β_2=1, m_1= m_2=2, c_1= c_2=2 and changeable average desired signal power Ω_1 is shown in Fig. 2.

It is obvious from Fig. 1 that mean value $\overline{w}$ increases with increasing of average signal power Ω_1. The mean value is bigger for smaller values of average interference signal power Ω_2 for the same other parameters. One can see from Fig. 2 that the first moment of w decreases with enlarging of average interference power. This decline is more pronounced for small values of Ω_2.

In Fig. 3 and 4, the mean value $\overline{w}$ versus Gamma long term scale parameters β_1 and β_2, respectively, is plotted. In Fig. 3, the graph is drawn for m_1=m_2=2, c_1=c_2=2 and variable average signal power Ω_1, average interference power Ω_2 and scale parameter β_2. It is possible to see from this figure that the first moment of w rises with enlargement of Gamma long term fading parameter β_1. This is more expressed for bigger values of Gamma large scale fading parameter β_2.

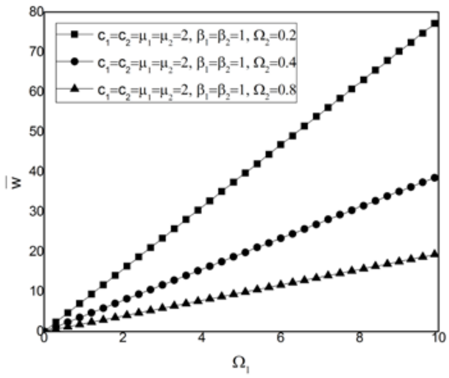

Fig. 1. Mean value $\overline{w}$ versus average desired signal power Ω_1 for Gamma long scale parameters β_1=β_2=1, Nakagami-m fading severity parameters m_1= m_2=2, Gamma fading severity parameters c_1=c_2=2 and variable average interference signal power Ω_2.

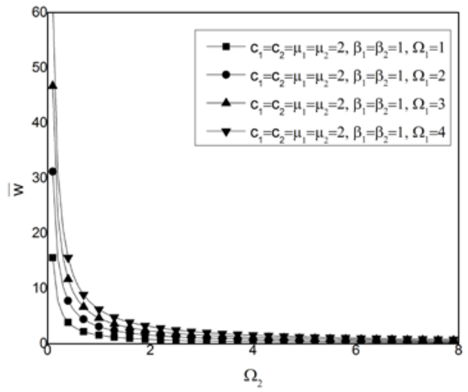

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Fig.2. The first moment of w versus average interference power Ω_2 for β_1= β_2=1, m_1= m_2=2, c_1= c_2=2 and changeable average desired signal power Ω_1.

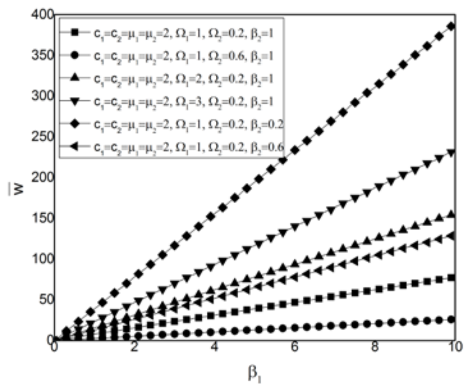

Fig.3. Mean value $\overline{w}$ versus Gamma long term scale parameter β_1 for m_1= m_2=2, c_1= c_2=2 and variable average signal power Ω_1, average interference power Ω_2 and scale parameter β_2.

From Fig. 4, it is visible that the first moment of w abates with an increase of Gamma long term parameter β_2. This is more expressed for smaller values of Gamma large scale fading parameter β_2. The mean value is bigger for bigger values of Ω_1 and smaller for larger value of Ω_2.

The second moment of w is introduced in Fig. 5 versus average signal power Ω_1 for $m_1=m_2=2$, $c_1=c_2=2$ and variable average interference power Ω_2 and scale parameters $\beta_1=\beta_2=1$. The squared average value $\overline{w^2}$ is presented in Fig. 6 versus interference power Ω_2 for $m_1=m_2=2$, $c_1=c_2=2$ and variable average interference signal power Ω_2 and scale parameters $\beta_1=\beta_2=1$.

It can be seen from these two figures that squared average value grows with rise of signal power and reduction of interference power. The least values are for bigger interference power Ω_2 and small signal power Ω_1.

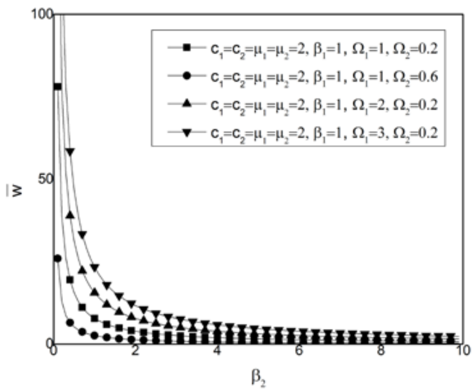

Fig. 4. The first moment of w versus scale parameter β_2 for $m_1=m_2=2$, $c_1=c_2=2$ and scale parameter $\beta_1=1$ and variable average signal power Ω_1 and average interference power Ω_2.

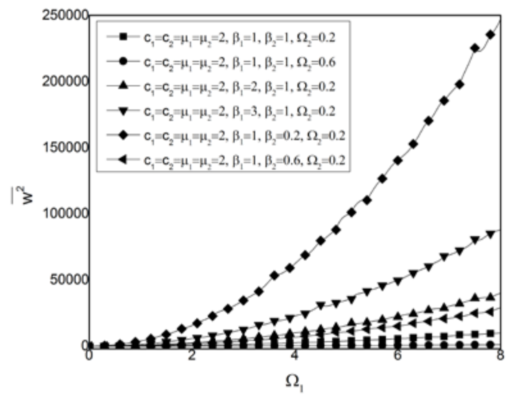

Fig.5. The squared average value $\overline{w^2}$ versus average signal power Ω_1 for $m_1=m_2=2$, $c_1=c_2=2$ and variable average interference power Ω_2 and scale parameters $\beta_1=\beta_2=1$.

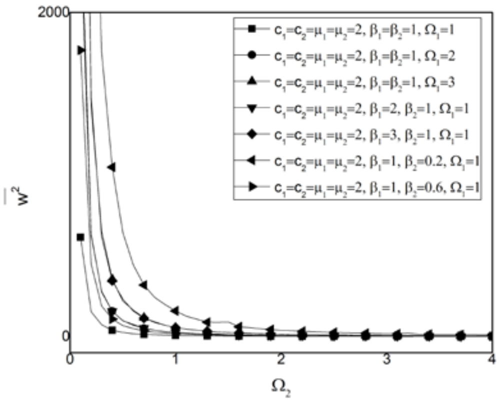

Fig.6. The second moment of w versus average interference power Ω_2 with $m_1= m_2=2$, $c_1= c_2=2$ and variable scale parameters β_1 and β_2 as well as average signal power Ω_1.

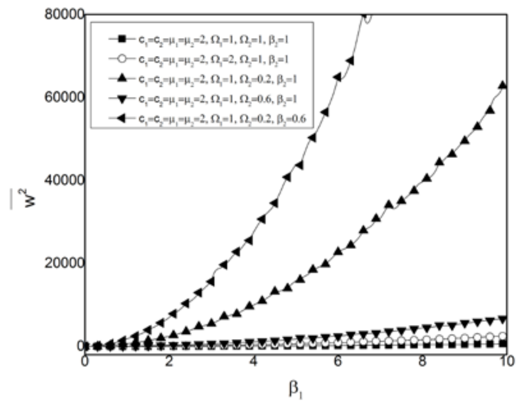

Fig. 7. The second moment of w versus scale parameter β_1 for changeable average signal power Ω_1, interference signal power Ω_2, and scale parameter β_2, with $m_1= m_2=2$, $c_1= c_2=2$.

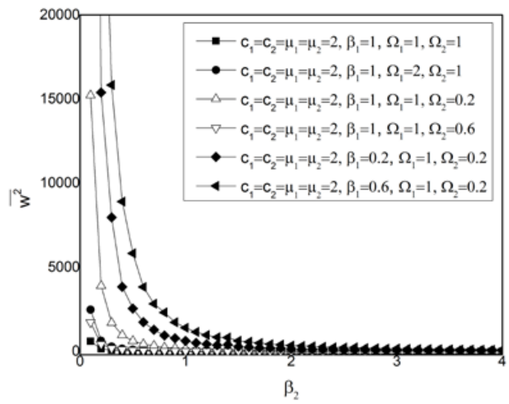

Fig.8. The second moment of w versus scale parameter β_2 for some values of average signal power Ω_1 and average interference signal power Ω_2, with $m_1= m_2=2$, $c_1= c_2=2$ and variable scale parameter β_1.

The second moment of w versus scale parameter β_1 for changeable average signal power Ω_1, interference power Ω_2, and scale parameter β_2, with $m_1 = m_2 = 2$, $c_1 = c_2 = 2$, is shown in Fig. 7. The squared average value $\overline{w^2}$ is plotted in Fig. 8 versus scale parameter β_2 for different values of average signal power Ω_1 and average interference power Ω_2, with $m_1 = m_2 = 2$, $c_1 = c_2 = 2$ and variable scale parameter β_1.

If scale parameter β_1 aggrandizes, the second moment of w also increases. The second moment declines with increment of scale parameter β_2. One can see from Figs. 7 and 8 that the squared average value has growth especially for big scale parameters β_1 for smaller β_2. The changes are more prominent for low values of β_2.

4 Conclusion

Wireless communication system operating over shadowed short term fading channel in the presence of cochannel interference affected to shadowed multipath fading is considered. Desired signal experiences Gamma long term fading and Nakagami-*m* short term fading and cochannel interference subjected to Gamma shadowed Nakagami-*m* multipath fading. In proposed model, desired signal envelope can be represented as product of square root of Gamma random variable and Nakagami-*m* random variable. Also, interference envelope can be represented as product of square root of Gamma random variable and Nakagami-*m* random variable. Signal to interference ratio can be calculated as the ratio of two products of square rooted Gamma random variable and Nakagami-*m* random variable.

For parameter m=1, Gamma shadowed Nakagami-*m* multipath fading channel becomes Gamma shadowed Rayleigh multipath fading channel. When parameter m goes to infinity, Gamma shadowed Nakagami-*m* multipath fading channel ensues pure Gamma long term fading channel. When Gamma shadowing severity parameter tends to be infinite, Gamma shadowed Nakagami-*m* multipath fading channel turns into pure Nakagami-*m* multipath fading channel. In a situation where both, Nakagami-*m* parameter m and Gamma shadowing severity parameter tend to infinity, Gamma shadowed Nakagami-*m* multipath fading channel is no fading channel.

In this paper, probability density function, moments and moment generating function of signal to interference ratio at the output of considered wireless communication system are calculated. By using these formulas, the outage probability and bit error probability can be calculated.

The first moment and the second moment increase as Nakagami-m parameter and Gamma long term fading parameter increase. The system performance are better for higher values of moments.

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