Level crossing rate of L-branch SC receiver over *α-k-μ* fading channel in the presence *α-k-μ* co-channel interference

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Abstract: - Wireless communication system operating over interference limited, *α-k-μ* multipath fading channel is considered. Closed form expressions for cumulative distribution function and level crossing rate of the ratio of two *k-μ* random variables and the ratio of the two *α-k-μ* random variables are calculated. These expressions are used for evaluation level crossing rate of wireless communication system with L-branches, SIR based SC receiver operating over. *α-k-μ* multipath fading environment in the presence of co-channel interference affected to *α-k-μ* multipath fading. Numerical results are plotted to show Rice factor affects and *α-k-μ* fading severity parameter affects on level crossing rate.

Key-Words: - Average fade duration, *α-k-μ* distribution, co-channel interference, level crossing rate.

1 Introduction

Small scale fading and co-channel interference degrade system performance and limit channel capacity. Received signal experiences short term fading resulting in signal envelope variation. There are more distributions can be used to describe small scale signal envelope variation. The *k-μ* distribution can be used to describe small scale signal envelope variation in linear, line-of sight multipath fading environment. This distribution has two parameters. The parameter *k* is Rice factor. Rice factor is defined as the ratio of dominant components power and scattering components power [6]. The parameter *μ* is related to the number of clusters in propagation environment. Reyleigh, Rician, Nakagami-m distribution can be obtained from *k-μ* distribution as special cases. By setting $k=0$ the *k-μ* distribution reduces to Nakagami-m distribution and Rician distribution can be derived from *k-μ* distribution by setting μ=1. By setting $\mu=1$ and $k=0$, the *k-μ* distribution approximates Reyleigh distribution [8], [11].

In this paper, wireless communication system with L-branches SIR based SC diversity receiver operating over *α-k-μ* multipath fading environment in the presence of co-channel interference subjected to *α-k-μ* multipath fading is considered. The *α-k-μ* distribution can be used to describe small scale signal envelope variation in non-linear and line-of-sight fading environment. The parameter *α* is related to nonlinearity of system. The *α-k-μ* is general distribution. By setting α=2, the *α-k-μ* distribution reduces to *k-μ* distribution, and the *α-μ* distribution can be obtained from *α-k-μ* distribution by setting k=0. By setting *α=2* and *k=0*, the *α-k-μ* distribution approximates Nakagami-m distribution.

There are several diversity combining techniques that can be used to reduce fading affects and influence of co-channel interference on outage probability, bit error probability and system capacity [7]. In this paper, SC diversity combining techniques is used to reduce *α-k-μ* fading affects and co-channel interference affects on average level crossing rate and average fade duration. In interference limited environment the SC receiver selects and outputs the branch with the highest SIR. There are more works considered first and second order statistics of wireless communication system in open technical literature [4], [5], [9], [10].

In papers [1], [13], level crossing rate of SC receiver operating over Rician multipath fading channel in the presence of co-channel interference subjected to Reyleigh multipath fading is calculated.

In paper [2], second order statistics of wireless system with SC receiver operating over Nakagami-m multipath fading environment are evaluated. In this paper, the ratio of two *k-μ* random variables and ratio of two *α-k-μ* random variables are considered. The joint probability density function of the ratio of two *k-μ* random variables and the first derivative of the ratio of two *k-μ* random variables is calculated. This expression is used for calculating the joint probability density function of the ratio of two *α-k-μ* random variables and it's the first derivative and level crossing rate of ratio of two *α-k-μ* random variables. Closed form expression for level crossing rate and average fade duration of wireless system with L-branches SC receiver operating over *α-k-μ* multipath fading environment in the presence of co-channel interference subjected to *α-k-μ* multipath fading are derived.

2 Level crossing rate of two *k-μ* random variables

The ratio of two *k-μ* random variables is:

$$z = \frac{x}{y} \tag{1}$$

where *x* and *y* follow *k-μ* distribution [8].

$$p_x(x) = \frac{2\mu(k+1)^{\frac{\mu+1}{2}}}{k^{\frac{\mu+1}{2}} e^{\mu k}\Omega_1^{\mu+1}} x^{\mu} e^{-\frac{\mu(1+k)x^2}{\Omega_1}} \cdot I_{\mu-1}\left(\frac{2\mu\sqrt{k(k+1)}}{\Omega_1}x\right), x \geq 0 \tag{2}$$

$$p_y(y) = \frac{2\mu(k+1)^{\frac{\mu+1}{2}}}{k^{\frac{\mu+1}{2}} e^{\mu k}\Omega_2^{\mu+1}} y^{\mu} e^{-\frac{\mu(1+k)y^2}{\Omega_2}} \cdot I_{\mu-1}\left(\frac{2\mu\sqrt{k(k+1)}}{\Omega_2}y\right), y \geq 0 \tag{3}$$

The first derivative of ratio of two *k-μ* random variables is:

$$\dot{z} = \frac{\dot{x}}{y} = \frac{x\dot{y}}{y^2} \tag{4}$$

Squared *k-μ* random variable *x* is:

$$x^2 = x_1^2 + x_2^2 + \cdots + x_{2\mu}^2 \tag{5}$$

The first derivative of *k-μ* random variable *x* is:

$$\dot{x} = \frac{1}{x}\left(x_1\dot{x}_1 + x_2\dot{x}_2 + \ldots + x_{2\mu}\dot{x}_{2\mu}\right) \tag{6}$$

Squared *k-μ* random variable *y* and the first derivative of *k-μ* random variable *y* are:

$$y^2 = y_1^2 + y_2^2 + \cdots + y_{2\mu}^2 \tag{7}$$

$$\dot{y} = \frac{1}{y}\left(y_1\dot{y}_1 + y_2\dot{y}_2 + \cdots + y_{2\mu}\dot{y}_{2\mu}\right) \tag{8}$$

After substituting (6) and (8) in (4) expression for the first derivative of the ratio of two *k-μ* random variables becomes:

$$\dot{z} = \frac{1}{y}\frac{1}{x}\left(x_1\dot{x}_1 + x_2\dot{x}_2 + \ldots + x_{2\mu}\dot{x}_{2\mu}\right) - \frac{x}{y^3}\left(y_1\dot{y}_1 + y_2\dot{y}_2 + \ldots + y_{2\mu}\dot{y}_{2\mu}\right) \tag{9}$$

The main of $\dot{z}$ is zero. The variance of $\dot{z}$ is:

$$\delta_{\dot{z}}^2 = \frac{1}{x^2y^2}\left(x_1^2\delta\dot{x}_1^2 + x_2^2\delta\dot{x}_2^2 + \cdots + x_{2\mu}^2\delta\dot{x}_{2\mu}^2\right) + \frac{x^2}{y^6}\left(y_1^2\delta\dot{y}_1^2 + y_2^2\delta\dot{y}_2^2 + \cdots + y_{2\mu}^2\delta\dot{y}_{2\mu}^2\right) \tag{10}$$

where:

$$\delta\dot{x}_1^2 = \delta\dot{x}_2^2 = \cdots = \delta\dot{x}_{2\mu}^2 = \delta_1^2\pi^2 f_m^2\delta_x^2 = f_1^2 and$$
$$\delta\dot{y}_1^2 = \delta\dot{y}_2^2 = \cdots = \delta\dot{y}_{2\mu}^2 = \delta_2^2\pi^2 f_m^2\delta_y^2 = f_2^2 \quad (11)$$

After substituting, the expression for variance of $\dot{z}$ becomes:

$$\delta_{\dot{z}}^2 = \frac{1}{x^2y^2} f_1^2\left(x_1^2 + x_2^2 + \cdots + x_{2\mu}^2\right) + \\ + \frac{x^2}{y^6} f_2^2\left(y_1^2 + y_2^2 + \cdots + y_{2\mu}^2\right) = \\ = \frac{f_1^2}{x^2y^2}x^2 + \frac{x^2}{y^6} f_2^2 y^2 = \\ = \frac{f_1^2}{y^2} + \frac{z^2 f_2^2}{y^2} = \frac{1}{y^2}\left(f_1^2 + z^2 f_2^2\right) \quad (12)$$

The joint probability density function of z, $\dot{z}$ and y is:

$$p_{z\dot{z}y}\left(z\dot{z}y\right) = p_{\dot{z}}\left(\dot{z}/zy\right)\cdot p_{zy}\left(zy\right) = \\ = p_{\dot{z}}\left(\dot{z}/zy\right) p_y\left(y\right) p_z\left(z/y\right) \quad (13)$$

Where is:

$$p_z\left(z/\mathrm{y}\right) = \left|\frac{d\mathrm{x}}{dz}\right| p_{\mathrm{x}}\left(zy\right)$$

The first derivative of x respect to z is:

$$\frac{d\mathrm{x}}{dz} = y$$

After substituting, the expression for joint probability density function z, $\dot{z}$ and y becomes:

$$p_{z\dot{z}y}\left(z\dot{z}y\right) = yp_x\left(zy\right) p_y\left(y\right) p_{\dot{z}}\left(\dot{z}/zy\right) \quad (14)$$

The joint probability density function of z and $\dot{z}$ can be calculated by integrating previously expression respect to y:

$$p_{z\dot{z}}\left(z\dot{z}\right) = \int_0^\infty dyyp_x\left(zy\right) p_y\left(y\right) p_{\dot{z}}\left(\dot{z}/zy\right) \quad (15)$$

Level crossing rate of ratio of two k-μ random variable can be calculated as the average value of the first derivative of ratio of two k-μ random variable:

$$N_z = \int_0^\infty d\dot{z}\dot{z}p_{z\dot{z}}\left(z\dot{z}\right) = \int_0^\infty dyyp_x\left(zy\right) p_y\left(y\right)\cdot \\ \cdot\int_0^\infty d\dot{z}\dot{z}p_{\dot{z}}\left(\dot{z}/zy\right) = \int_0^\infty dyyp_x\left(zy\right) p_y\left(y\right)\cdot\frac{\delta_z^2}{\sqrt{2\pi}} = \\ = \frac{1}{\sqrt{2\pi}}\sqrt{f_1^2 + z^2 f_2^2}\int_0^\infty dyyp_x\left(zy\right) p_y\left(y\right) \quad (16)$$

The expression for level crossing rate of two k-μ random variable can be used in performance analysis of wireless communication system operating over k-μ multipath fading environment in the presence k-μ co-channel interference.

3 Level crossing rate of ratio of two *α-k-μ* random variable

The α-k-μ random variable z_1 and the first derivative of α-k-μ random variable $\dot{z}_1$ are:

$$z_1 = z^{\frac{2}{\alpha}}, z = z_1^{\frac{2}{\alpha}}$$
$$\dot{z}_1 = \frac{2}{\alpha} z_1^{\frac{2}{\alpha}-1}\dot{z}, \dot{z} = \frac{\alpha}{2} z_1^{\frac{\alpha}{2}-1}\dot{z}_1 \quad (17)$$

where z is k-μ random variable and $\dot{z}$ is the first derivative of k-μ random variable

The joint probability density function of α-k-μ random variable z_1 and it's the first derivative $\dot{z}_1$ is:

$$p_{z_1\dot{z}_1}\left(z_1\dot{z}_1\right) = \left|J\right| p_{z\dot{z}}\left(z_1^{\frac{\alpha}{2}}, \frac{\alpha}{2} z_1^{\frac{\alpha}{2}-1}\dot{z}_1\right) \quad (18)$$

where:

$$J = \begin{vmatrix} \frac{\partial z}{\partial z_1} & \frac{\partial z}{\partial \dot{z}_1} \\ \frac{\partial \dot{z}}{\partial z_1} & \frac{\partial \dot{z}}{\partial \dot{z}_1} \end{vmatrix} = \begin{vmatrix} \frac{\alpha}{2} z_1^{\frac{\alpha}{2}-1} & 0 \\ & \frac{\alpha}{2} z_1^{\frac{\alpha}{2}-1} \end{vmatrix} - \frac{\alpha^2}{2} z_1^{\alpha-2} \quad (19)$$

By substituting (19) in (18), the joint probability density function of z_1 and $\dot{z}_1$ becomes:

$$p_{z_1\dot{z}_1}\left(z_1\dot{z}_1\right) = \frac{\alpha^2}{2} z_1^{\alpha-2} p_{z\dot{z}}\left(z_1^{\frac{\alpha}{2}}, \frac{\alpha}{2} z_1^{\frac{\alpha}{2}-1}\dot{z}_1\right) = \\ = \frac{\alpha^2}{2} z_1^{\alpha-2}\int_0^\infty dyyp_x\left(z_1^{\frac{\alpha}{2}} y\right) p_y\left(y\right) p_{\dot{z}}\left(\frac{\alpha}{2} z_1^{\frac{\alpha}{2}-1}\dot{z}_1 \middle/ y\right) \quad (20)$$

Level crossing rate of z_1 is:

$$N_{z_1}=\int_0^\infty d\dot{z}_1\dot{z}_1 p_{z_1\dot{z}_1}\left(z_1\dot{z}_1\right)=$$
$$=\frac{1}{\sqrt{2\pi\pi}}\sqrt{f_1^2+z_1^\alpha f_2^2}\int_0^\infty dy\,p_x\left(z_1^{\frac{\alpha}{2}}y\right)p_y\left(y\right) \tag{21}$$

After substituting (2) and (3) in (20), the expression for level crossing rate of the ratio of two α-k-μ random variable becomes:

$$N_z=\frac{1}{\sqrt{2\pi}}\frac{4\mu^2\left(k+1\right)^{\mu+1}}{k^{\mu-1}e^{2\mu k}(\Omega_1\Omega_2)^{\mu+1}}\sqrt{f_1^{2\alpha}+z^2 f_2}\cdot$$
$$\cdot\sum_{i_1=0}^{\infty}\left(\frac{\mu\sqrt{k(1+k)}}{\Omega_1}\right)^{2i_1+\mu-1}\frac{1}{i_1!\Gamma\left(i_1+\mu\right)}z^{\alpha(i_1+\mu-\frac{1}{2})}\cdot$$
$$\cdot\sum_{i_2=0}^{\infty}\left(\frac{\mu\sqrt{k(1+k)}}{\Omega_2}\right)^{2i_2+\mu-1}\frac{1}{i_2!\Gamma\left(i_2+\mu\right)}\cdot$$
$$\cdot\frac{1}{2}\left(\frac{\Omega_1^2\Omega_2^2}{\mu\left(1+k\right)\left(z^2\Omega_2^2+\Omega_1^2\right)}\right)^{2\mu+i_1+i_2-1/2}\cdot$$
$$\cdot\Gamma\left(2\mu+i_1+i_2-1/2\right) \tag{22}$$

Cumulative distribution function of ratio of two α-k-μ random variables is:

$$F_z\left(z_1\right)=\int_0^{z_1}dt\,p_{z_1}\left(t\right)=\frac{4\mu^2\left(k+1\right)^{\mu+1}}{k^{\mu-1}e^{\mu k}\left(\Omega_1\Omega_2\right)^{\mu+1}}\cdot$$
$$\cdot\sum_{i_1=0}^{\infty}\left(\frac{\mu\sqrt{k(1+k)}}{\Omega_1}\right)^{2i_1+\mu-1}\frac{1}{i_1!\Gamma\left(i_1+\mu\right)}\cdot$$
$$\cdot\sum_{i_2=0}^{\infty}\left(\frac{\mu\sqrt{k(1+k)}}{\Omega_2}\right)^{2i_2+\mu-1}\frac{1}{i_2!\Gamma\left(i_2+\mu\right)}\cdot$$
$$\cdot\frac{1}{2}\left(\frac{\Omega_1^2\Omega_2^2}{\mu\left(1+k\right)}\right)^{2\mu+i_1+i_2}\Gamma\left(2\mu+i_1+i_2\right)\cdot$$
$$\frac{1}{2}\Omega_1^{-2\left(2\mu+i_1+i_2\right)}\left(\frac{\Omega_1}{\Omega_2}\right)^{2\left(\mu+i_1\right)}B_{z_1}(\mu+i_1,\mu+i_2) \tag{23}$$

where:

$$z_2=\frac{\Omega_2^2 z_1^\alpha}{\Omega_1^2+\Omega_2^2 z_1^\alpha}$$

4 Level crossing rate of SC receiver output SIR

Wireless communication system with L-branch, SIR based SC receiver operating over α-k-μ multipath fading channel in the presence of co-channel interference subjected to α-k-μ multipath fading is considered. The SIR's at inputs of SC receiver are denotes with $z_1,z_2,\ldots,z_L$ and SC receiver output SIR is denoted with z. The joint probability density function of SC receiver output SIR z, and its first derivative $\dot{z}$ is:

$$p_{z\dot{z}}\left(z\dot{z}\right)=p_{z_1\dot{z}_1}\left(z\dot{z}\right)F_{z_2}\left(z\right)F_{z_3}\left(z\right)\cdots F_{z_L}\left(z\right)+$$
$$+p_{z_2\dot{z}_2}\left(z\dot{z}\right)F_{z_1}\left(z\right)F_{z_3}\left(z\right)\cdots F_{z_L}\left(z\right)+$$
$$\cdot p_{z_L\dot{z}_L}\left(z\dot{z}\right)F_{z_1}\left(z\right)F_{z_2}\left(z\right)\cdots F_{z_{L-1}}\left(z\right) \tag{24}$$

For identical α-k-μ fading, the previously expression becomes:

$$p_{z\dot{z}}\left(z\dot{z}\right)=L\cdot p_{z_1\dot{z}_1}\left(z\dot{z}\right)\left(F_{z_1}\left(z\right)\right)^{L-1} \tag{25}$$

Where $p_{z\dot{z}}\left(z\dot{z}\right)$ is given by (20) and $F_{z1}(z)$ is given with (23).

The level crossing rate of SC receiver output SIR can be calculated as average value of the first derivative of SC receiver output SIR:

$$N_z=\int_0^\infty p_{z\dot{z}}\left(z\dot{z}\right)\dot{z}d\dot{z}=2\left(F_{z_1}\left(z\right)\right)^{L-1}\cdot$$
$$\cdot\int_0^\infty p_{z\dot{z}}\left(z\dot{z}\right)\dot{z}d\dot{z}=2\left(F_{z_1}\left(z\right)\right)^{L-1}\cdot N_{z_1}\left(z\right) \tag{26}$$

where $N_{z1}(z)$ is given with (22).

The outage probability of SC receiver is:

$$p_o=F_z\left(z\right)=F_{z_1}\left(z_1\right)\cdot F_{z_2}\left(z_2\right)\cdots F_{z_L}\left(z\right)=$$
$$=\prod_{i=1}^{L}F_{z_1}\left(z\right)=\left(F_{z_1}\left(z\right)\right)^2 \tag{27}$$

The average fade duration of SC receiver can be calculated as ratio of outage probability and level crossing rate of SC receiver output SIR:

$$AFD=\frac{p_o}{N_z}=\frac{\left(F_{z_1}\left(z\right)\right)^2}{2\left(F_{z_1}\left(z\right)\right)^{L-1}N_{z_1}\left(z\right)}=\frac{F_{z_1}\left(z\right)}{2N_{z_1}\left(z\right)} \tag{28}$$

For $L=2$, the expression for level crossing rate of SC receiver output SIR is:

$$N_z=2F_z\left(z\right)N_{z_1}\left(z\right) \tag{29}$$

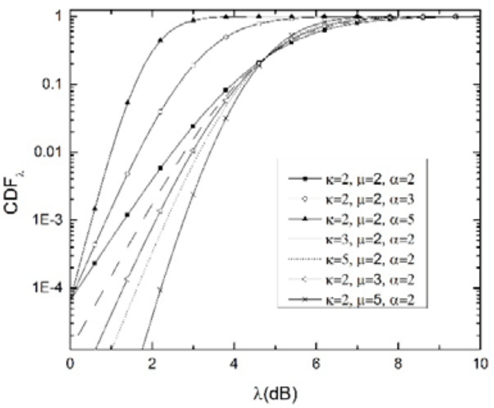

Fig.1. CDF versus SC output SIR for different parameters *á, k, ì* and *$\Omega_1=3$, $\Omega_2=1$*.

At Figure 1, the cumulative distribution function is presented versus SC receiver output SIR for several values of fading parameters α, k and μ and constant values powers of desired signal and co-channel interference. As parameters k and μ increase the CDF decreases. The influence of parameter μ of SC output SIR for performance improvement, regarding CDF is greater. As parameter α increases, CDF increases.

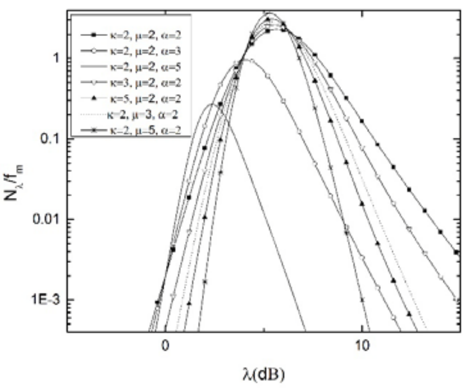

Fig.2. Normalized LCR versus SC output SIR for different parameters *á, k , ì* and *$\Omega_1=3$, $\Omega_2=1$*.

At Figure 2, the LCR versus SC receiver output SIR is shown. For lower values of SC receiver output SIR, the LCR increases as SC receiver output SIR increases and for higher values of SC receiver output SIR, LCR decreases as output SIR increases. The curves for LCR have maximum, which depends on parameters α, k and μ.

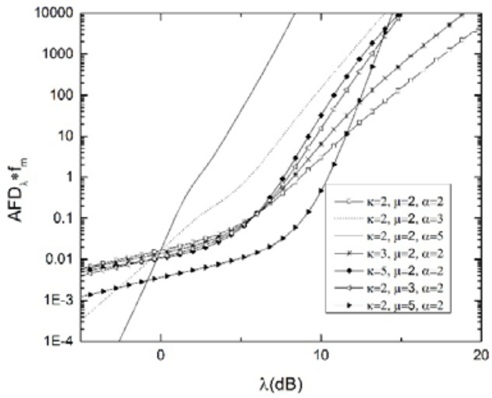

Fig.3. Normalized AFD versus SC output SIR for different parameters *á, k , ì* and *$\Omega_1=3$, $\Omega_2=1$*.

In Figure 3, the average fade duration is presented in term of SC output SIR for various values of fading parameters and constant values of desired signal envelope power and co-channel interference envelope power. The influence of fading parameters on average fade duration cannot be ignored. As SC output SIR increases, the average fade duration is greater. As parameter μ increases, average fade duration decreases and improves system performances. For greater values of parameter α, the system performance degrade.

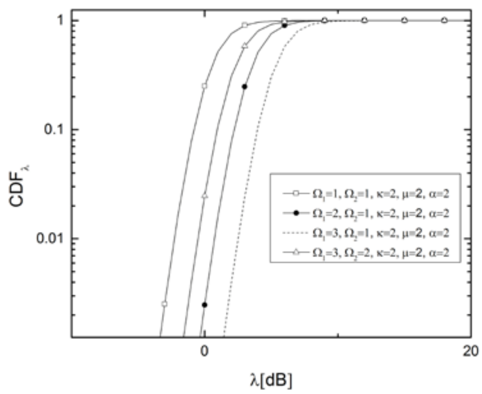

Fig.4. CDF versus SC output SIR for different parameters Ω_1 and Ω_2, and *á, k, ì=2*.

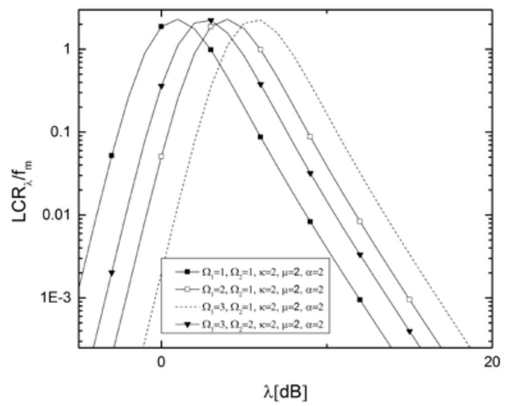

Fig.5. Normalized LCR versus SC output SIR for different parameters Ω_1 and Ω_2, and *á, k, ì=2.*

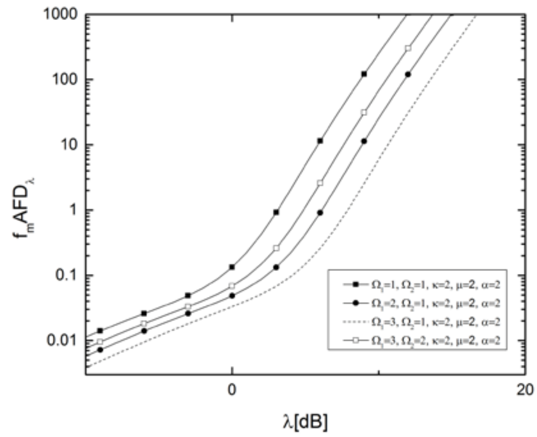

Fig.6. Normalized AFD versus SC output SIR for different parameters Ω_1 and Ω_2, and *á, k, ì=2.*

In figure 4, cumulative distribution function of SC receiver output SIR versus SC receiver output for several values of average desired signal envelope power and average co-channel interference envelope power SIR is plotted. Cumulative distribution function increases as SC receiver output SIR increases. CDF, also, increases as desired signal envelope power decreases and CDF decreases as co-channel interference envelope power increases. The system performance is better as CDF of SC output SIR decreses. In figure 5, normalized level crossing rate of SC receiver output SIR versus SC receiver output SIR for several values of average desired signal envelope power and average co-channel interference power is shown. For lower values of SC receiver output SIR the system performance is better for lower values of level crossing rate. LCR decreases as average desired signal envelope increases but also LCR decreases as average co-channel envelope decreases. In figure 6, normalized average fade duration of proposed system versus SC receiver output SIR versus SC receiver output SIR for different values of average signal envelope and co-channel interference powers is shown. The system performance is better for lower values of average fade duration. AFD decreases as average signal envelope power increases or average co-channel envelope power decreases

5 Conclusion

Wireless communication system with L-branches, SIR based SC receiver operating over multipath fading channel in the presence of co-channel interference is considered. System performance are analysed in interference limited environment. Desired signal experiences α-k-μ small scale fading resulting in signal envelope variation. Co-channel interference is subjected to α-k-μ multipath fading. LCR and AFD are second order performance measure of wireless communication system. Closed form expressions for probability density function, cumulative distribution function and average level crossing rate of the ratio of two k-μ random variables and the ratio of two α-k-μ random variables are calculated. Those expressions are used for evaluation of average level crossing rate and average fade duration of SC receiver output SIR of wireless communication system. The average level crossing rate of the ratio of two α-k-μ random variables is calculated as average value of the first derivative of the ratio of two α-k-μ random variables. The average fade duration of considered system is determined as the ratio of outage probability and level crossing rate. In interference limited environment outage probability is defined as the probability that SC receiver output SIR falls below the predetermined threshold. Numerical results are presented graphically to show α-k-μ fading parameter affects on average level crossing rate and average fade duration.

References:

[1] A. S Panajotovic, M. C Stefanovic. D. LJ Draca, N. M Sekulovic, Average Level Crossing Rate of Dual Selection Diversity in Correlated Rician Fading with Rayleigh Cochannel Interference, IEEE COMMUNICATIONS LETTERS, vol. 14, No. 7, July 2010.

[2] Dusan Stefanovic, Stefan R. Panic, Petar Spalevic „Second-order statistics of SC macrodiversity system operating over Gamma

shadowed Nakagami-m fading channels“,AEU - International Journal of Electronics and Communications, Volume 65, Issue 5, May 2011, Pages 413–418 (M 23);

[3] S. Jovkovic, D. Milic, D. Djosic, S. Panic, S. Veljkovic, C. Stefanovic “Second order statistics of SC receiver output SIR in the presence of α-k-μ multipath fading and co-channel interference”, Procedeeings of the 2014 International Conferences on Communications, Signal Processings and Computers (CSCP 2014) Interlaken, Switzerland, February 22-24, 2014, pp 27-31. ISBN 978-1-61804-215-6

[4] M. Stefanovic, D. Krstic, S. Panic, J. Anastasov, D. Stefanovic, S. Minic”SC and SSC diversity reception over correlated Nakagami-m fading channels in the presence of CCI” WSEAS TRANSACTIONS on COMMUNICATIONS, Volume 10 Issue 12, December 2011

[5] P. Spalevic, M. Stefanovic, D. Stefanovic, S. Panic “Selection Combining Receiver in the Presence of Ricean fading”, WSEAS TRANSACTIONS on COMMUNICATIONS, Volume 8 Issue 6, June 2009 Pages 505-514

[6] Sekulovic Nikola M, Stefanovic Mihajlo C, Milovic Daniela M, Stanojcic Selena Z “ Second-order statistics of system with N-branch microdiversity and L-branch macrodiversity operating over gamma shadowed Nakagami-m fading channels”, INTERNATIONAL JOURNAL OF COMMUNICATION SYSTEMS, (2014), vol. 27 br. 2, str. 390-400.

[7] Mitrovic Zlatko J Djordjevic Goran T Nikolic Bojana Z Stefanovic Mihajlo C Milic Dejan N “Performance of partially coherent selection combining receiver in alpha-mu fading channel ”JOURNAL OF COMMUNICATIONS TECHNOLOGY AND ELECTRONICS, (2013), vol. 58 br. 12, str. 1251-1256.

[8] M. K. Simon, M. S. Alouini, Digital Communication over Fading Channels, USA, New York: Wiley, 2005.

[9] E.Mekic, N.Sekulovic, M.Bandjur,M. Stefanov ic, P. Spalevic, " The distribution of ratio of random variable and product of two random variables and its application in performance analysis of multi-hop relaying communications over fading channels PRZEGLAD ELEKTROTECHNICZNY, (2012), vol. 88 br. 7A, str. 133-137.

[10] A. Matovic, E. Mekic, N. Sekulovic, M. Stefanovic, M. Matovicand C. Stefanovic,”The distribution of the ratio of the products of two independent a-μ variates and its application in the performance analysis of relaying communication systems”, MATHEMATICAL PROBLEMS IN ENGINEERING, (2013).

[11] J. Proakis, “Digital Communications”, 4thed. New York: McGraw-Hill, 2001.

[12] I. Gradshteyn, I, Ryzhik. Tables of Integrals, Series, and products. Academic Press, New York 1994.

[13] A. Panajotovic, N. Sekulovic, M. Stefanovic, D. Draca,”Average Level Crossing Rate of Dual Selection Diversity over Correlated Unbalanced Nakagami-m Fading Channels in the Presence of Cochannel Interference (Article)”, IEEE COMMUNICATIONS LETTERS, (2012), vol. 16 br. 5, str. 691-693.