Macrodiversity Outage Performance in the Presence of Weibull Short Term Fading, Gamma Long Term Fading and α-κ-μ Co-channel Interference

Dragana S. Krstic, Siniša G. Minić, Srdjan Milosavljevic, Bojana Milosavljević, and Mihajlo C. Stefanovic

Abstract**—**Macrodiversity reception containing of macrodiversity selection combining (SC) receiver and two microdiversity SC receivers in the presence of short term fading, long term fading and co-channel interference is considered in this article. Desired signal experiences Weibull short term fading, correlated Gamma long term fading and co-channel interference experiences α-κ-μ short term fading and correlated Gamma long term fading. In this article, probability density function and cumulative distribution function of Weibull random process and α-κ-μ random process ratio are evaluated. Theses expressions are used for evaluation cumulative distribution function of signal to interference ratio at outputs of microdiversity SC receivers and cumulative distribution function of macrodiversity SC receiver output signal to interference ratio. Outage probability can be evaluated from cumulative distribution function. The influence of Weibull short term fading nonlinearity parameter, α-κ-μ short term fading severity parameter, α-κ-μ short term fading nonlinearity parameter, α-κ-μ short term fading Rician factor, Gamma long term fading severity parameter and Gamma long term fading correlation coefficient are analyzed.

Keywords**—**α-κ-μ short term fading, Gamma fading, macrodiversity reception, microdiversity reception, outage probability, selection combining (SC), Weibull short term fading.

I. INTRODUCTION

SHORT term fading, long term fading and co-channel interference degrade outage probability, average bit error probability, system capacity, level crossing rate and average fade duration of wireless mobile communication radio system [1]. Macrodiversity technique reduces short term fading effects, long term fading effects and co-channel interference effects on outage probability. Macrodiversity SC receiver selects microdiversity SC receiver with higher signal envelope average power at inputs resulting in Gamma long term fading reduction and microdiversity SC receiver selects the branch with the highest signal to interference ratio resulting in short term fading effects reduction and co-channel interference effects reduction [1] - [3].

There are several distributions that are used to describe signal envelope in fading channels including Weibull distribution and α-κ-μ distribution [4]. Weibull distribution can describe small scale signal envelope variation in nonlinear, non line of sight multipath fading channel. This distribution has parameter α related to nonlinearity of environment. For α=2, Weibull distribution reduces to Rayleigh distribution; for α goes to infinity Weibull fading channel becomes no fading channel.

The α-κ-μ distribution has three parameters [5]. The parameter α is nonlinearity parameter; κ is Rician factor and can be evaluated as a ratio of dominant component power and scattering components powers; and μ is short term fading severity parameter [6] [7]. The α-κ-μ distribution is general distribution and a few distributions can be derived from this distribution as special cases. For α=2, the α-κ-μ distribution reduces to κ-μ distribution; for κ=0, the α-κ-μ reduces to α-μ distribution; for κ=0 and μ=1, the α-κ-μ distribution reduces to Weibull distribution; for α=2 and μ=1, the α-κ-μ distribution reduces to Rician distribution; for α=2 and κ=0, the α-κ-μ distribution reduces to Nakagami-*m* distribution and for α=2, κ=0 and μ=1, the α-κ-μ distribution reduces to Rayleigh distribution.

The analysis of wireless communication system performance in α-k-μ fading channel subjected to shadowing is done in [8]. Second-order statistics for the envelope of α-κ-μ fading channels are derived in [9].

There are more works in open literature considering macrodiversity system performance in the presence of large scale fading, small scale fading and co-channel interference. In [10], macrodiversity system with macrodiversity SC receiver and two microdiversity SC receivers operating over Gamma shadowed Weibull multipath fading channel in the presence of Weibull co-channel interference is considered and

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level crossing rate is evaluated. Outage probability of macrodiversity reception in the presence of Rayleigh short term fading and co-channel interference subjected to Rayleigh small scale fading is evaluated in [11].

Outage probability of macrodiversity with two microdiversity SC receiver in the presence of Nakagami-*m* short term fading, Gamma long term fading and co-channel interference is efficiently evaluated as expression in the closed form in [12].

In this paper, macrodiversity system is applied to reduce short term fading effects, long term fading effects and co-channel interference effects on system performance. Desired signal is subjected to Weibull short term fading and Gamma long term fading and co-channel interference experiences α-κ-μ short term fading and Gamma long term fading. Outage probability of Weibull random variable and α-κ-μ random variable ratio is evaluated and this expression is used for calculation outage probability of microdiversity SC receivers and macrodiversity SC receiver. The results, derived in this paper, can be used in performance analysis of macrodiversity reception in the presence of short term fading, long term fading and co-channel interference.

II. Ratio of Weibull Random Variable and α-κ-μ Random Variable

The Weibull random process and α-κ-μ random process ratio is:

$$z_1 = \frac{x_1}{y_1} = \frac{x^{\frac{2}{\alpha}}}{y^{\frac{2}{\alpha}}},$$

$$y_1 = z_1 x_1,\ \frac{x}{y} = z_1^{\frac{2}{\alpha}},\ x = y \cdot z_1^{\frac{2}{\alpha}} \tag{1}$$

where x_1 follows Weibull distribution [4]:

$$p_{x_1}(x_1) = \frac{\alpha}{\Omega_1} \cdot x_1^{\alpha-1} e^{-\frac{1}{\Omega_1} x_1^{\alpha}},\ x_1 \geq 0\,; \tag{2}$$

α is Weibull short term fading nonlinearity parameter.

The random variable x is Rayleigh distributed:

$$p_x(x) = \frac{2x}{\Omega_1} \cdot e^{-\frac{x^2}{\Omega_1}},\ x \geq 0 \tag{3}$$

Ω_1 is average power of x.

Random variable y_1 follows α-κ-μ distribution [6]:

$$p_{y_1}(y_1) = \frac{\alpha\mu(k+1)^{\frac{\mu+1}{2}}}{k^{\frac{\mu-1}{2}} e^{k\mu}\, \Omega_2^{\frac{\mu+1}{2}}} \cdot \sum_{i_1=0}^{\infty} \left(\mu \frac{\sqrt{k(k+1)}}{\Omega_2}\right)^{2i_1+\mu-1} \frac{1}{i_1!\Gamma(i_1+\mu)}$$

$$y_1^{\alpha i_1+\alpha\mu-1} \cdot e^{-\frac{\mu(k+1)}{\Omega_2} y_1^{\alpha}},\ y_1 \geq 0 \tag{4}$$

κ is Rician factor; α is nonlinearity parameter; Ω_2 is average power of y_1; y follows κ-μ distribution:

$$p_y(y) = \frac{2\mu(k+1)^{\frac{\mu+1}{2}}}{k^{\frac{\mu-1}{2}} e^{k\mu}\, \Omega_2^{\frac{\mu+1}{2}}} \cdot \sum_{i_2=0}^{\infty} \left(\mu \frac{\sqrt{k(k+1)}}{\Omega_2}\right)^{2i_2+\mu-1} \frac{1}{i_2!\Gamma(i_2+\mu)},$$

$$y^{2i_2+2\mu-1} e^{-\frac{\mu(k+1)}{\Omega_2} y^2},\ y \geq 0 \tag{5}$$

Probability density function of z_1 is:

$$p_{z_1}(z_1) = \int_0^{\infty} dy_1 \cdot y_1 p_{x_1}(z_1 y_1)\, p_{y_1}(y_1) =$$

$$= \frac{\alpha}{\Omega_1} z_1^{\alpha-1} \cdot \frac{\alpha\mu(k+1)^{\frac{\mu+1}{2}}}{k^{\frac{\mu-1}{2}} e^{k\mu}\, \Omega_2^{\frac{\mu+1}{2}}} \cdot \sum_{i_1=0}^{\infty} \left(\mu \frac{\sqrt{k(k+1)}}{\Omega_2}\right)^{2i_1+\mu-1} \frac{1}{i_1!\Gamma(i_1+\mu)}$$

$$\int_0^{\infty} dy_1 y_1^{1+\alpha-1+\alpha i_1+\alpha\mu-1} \cdot e^{-y_1^2\left(\frac{z_1^{\alpha}}{\Omega_1}+\frac{\mu(k+1)}{\Omega_2}\right)} =$$

$$= \frac{\alpha}{\Omega_1} \frac{\alpha\mu(k+1)^{\frac{\mu+1}{2}}}{k^{\frac{\mu-1}{2}} e^{k\mu}\, \Omega_2^{\frac{\mu+1}{2}}} \cdot \sum_{i_1=0}^{\infty} \left(\mu \frac{\sqrt{k(k+1)}}{\Omega_2}\right)^{2i_1+\mu-1} \frac{1}{i_1!\Gamma(i_1+\mu)}$$

$$\frac{1}{\alpha}(\Omega_1\Omega_2)^{\mu+i_1+1} \frac{z_1^{\alpha-1}}{\left(\mu(k+1)\Omega_1+\Omega_2 z_1^{\alpha}\right)^{\mu+i_1+1}} \Gamma(\mu+i_1+1). \tag{6}$$

Cumulative distribution function of z_1 is:

$$F_{z_1}(z_1) = \int_0^{z_1} dt\, p_{z_1}(t) = \frac{\alpha}{\Omega_1} \frac{\mu(k+1)^{\frac{\mu+1}{2}}}{k^{\frac{\mu-1}{2}} e^{k\mu}\, \Omega_2^{\frac{\mu+1}{2}}} \cdot$$

$$\cdot\sum_{i_1=0}^{\infty}\left(\mu\frac{\sqrt{k(k+1)}}{\Omega_2}\right)^{2i_1+\mu-1}\frac{1}{i_1!\Gamma(i_1+\mu)}\Gamma(\mu+i_1+1)$$

$$(\Omega_1\Omega_2)^{\mu+i_1+1}\frac{1}{\alpha\Omega_2}$$

$$\frac{1}{\mu+i_1}\left(\frac{1}{\left(\mu(k+1)\Omega_1\right)^{\mu+i_1}}-\frac{1}{\left(\mu(k+1)\Omega_1+\Omega_2 z_1^{\alpha}\right)^{\mu+i_1}}\right) \quad (7)$$

III. Performance of Macrodiversity System

Model of macrodiversity system considered in this paper is presented in Fig. 1.

Probability density function of x_{ij}, i=1,2; j=1,2 is:

$$p_{x_{ij}}(x_{ij})=\frac{\alpha x_{ij}}{\Omega_i}\cdot e^{-\frac{x_{ij}^2}{\Omega_i}}, \qquad x_{ij}\ge 0,\ i=1,2,\ j=1,2. \quad (8)$$

Random variables y_{ij} follows α-κ-μ distribution:

$$p_{y_{ij}}(y_{ij})=\frac{\alpha\mu(k+1)^{\frac{\mu+1}{2}}}{k^{\frac{\mu-1}{2}}e^{k\mu}s_i^{\frac{\mu+1}{2}}}$$

$$\cdot\sum_{i_1=0}^{\infty}\left(\mu\frac{\sqrt{k(k+1)}}{\Omega_2}\right)^{2i_1+\mu-1}\frac{1}{i_1!\Gamma(i_1+\mu)}$$

$$y_{ij}^{\alpha i_1+\alpha\mu-1}\cdot e^{-\frac{\mu(k+1)}{s_i}y_{ij}^{\alpha}},\ y_{ij}\ge 0. \quad (9)$$

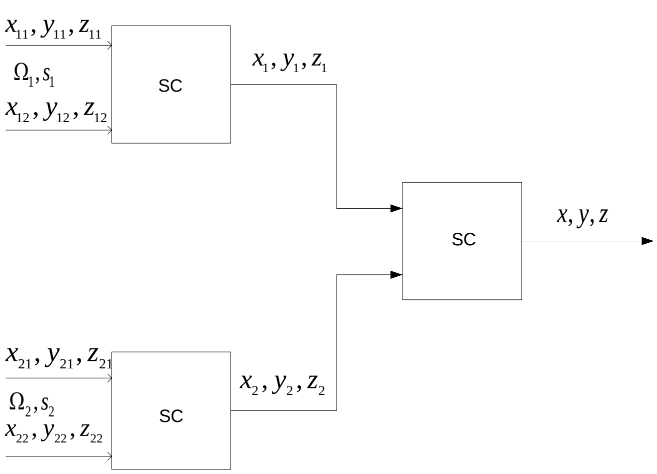

Fig.1. System model

Cumulative distribution function of z_1 is:

$$F_{z_1}(z_1)=F_{z_{11}}(z_1)\cdot F_{z_{12}}(z_1)=\frac{\alpha}{\Omega_1}\frac{\mu(k+1)^{\frac{\mu+1}{2}}}{k^{\frac{\mu-1}{2}}e^{k\mu}\Omega_2^{\frac{\mu+1}{2}}}\cdot$$

$$\cdot\sum_{i_1=0}^{\infty}\left(\mu\frac{\sqrt{k(k+1)}}{\Omega_2}\right)^{2i_1+\mu-1}\frac{1}{i_1!\Gamma(i_1+\mu)}\Gamma(\mu+i_1+1)$$

$$(\Omega_1 s_1)^{\mu+i_1+1}\frac{1}{\alpha s_1}\frac{1}{\mu+i_1}$$

$$\left(\frac{1}{\left(\mu(k+1)\Omega_1\right)^{\mu+i_1}}-\frac{1}{\left(\mu(k+1)\Omega_1+s_1 z_1^{\alpha}\right)^{\mu+i_1}}\right) \quad (10)$$

Joint probability density function (JPDF) of Ω_1 and Ω_2 is:

$$p_{\Omega_1\Omega_2}(\Omega_1\Omega_2)=\frac{2}{\Gamma(c)(1-\rho^2)\rho^{c-1}\Omega_0^{c+1}}\cdot$$

$$\cdot\sum_{i_3=0}^{\infty}\left(\frac{\rho}{\Omega_0(1-\rho^2)}\right)^{2i_3+c-1}\cdot\frac{1}{i_3!\Gamma(i_3+c)}\cdot$$

$$\Omega_1^{i_3+c-1}\Omega_2^{i_3+c-1}\cdot e^{-\frac{\Omega_1+\Omega_2}{\Omega_0(1-\rho^2)}},\ \Omega_1\ge 0, \Omega_2\ge 0 \quad (11)$$

where c is Gamma long term fading severity parameter, ρ is correlation coefficient, and Ω_0 is average value of Ω_1 and Ω_2.

Joint probability density function (JPDF) of s_1 and s_2 is:

$$p_{s_1 s_2}(s_1 s_2)=\frac{1}{\Gamma(c_1)\beta^{c_1}}\cdot s_1^{c_1-1}e^{-\frac{1}{\beta}s_1}.$$

$$\cdot\frac{1}{\Gamma(c_1)\beta^{c_1}}\cdot s_2^{c_1-1}e^{-\frac{1}{\beta}s_2},\ s_1\ge 0, s_2\ge 0 \quad (12)$$

where c_1 is Gamma long term fading severity parameter of interference, β is average value of s_1 and s_2.

Macrodiversity receiver selects microdiversity SC receiver with higher signal envelope average power at inputs.

Accordingly, cumulative distribution function of macrodiversity SC receiver output signal to interference ratio is:

$$F_z(z)=\int_0^{\infty}ds_1\,p_{s_1}(s_1)\int_0^{\infty}d\Omega_1\int_0^{\Omega_1}F_{z_1}(z/\Omega_1,s_1)p_{\Omega_1\Omega_2}(\Omega_1\Omega_2)d\Omega_2+$$

$$+\int_0^{\infty}ds_2\,p_{s_2}(s_2)\int_0^{\infty}d\Omega_2\int_0^{\Omega_2}d\Omega_1 F_{z_2}(z/\Omega_2,s_2)p_{\Omega_1\Omega_2}(\Omega_1\Omega_2)=$$

$$= 2\int_0^\infty ds_1\, p_{s_1}(s_1) \int_0^\infty d\Omega_1 \int_0^{\Omega_1} F_{z_1}(z/\Omega_1, s_1)\, p_{\Omega_1\Omega_2}(\Omega_1\Omega_2)\, d\Omega_2 =$$

$$= 2\frac{1}{\Gamma(c_1)\beta^{c_1}} \cdot \frac{1}{\Gamma(c)\left(1-\rho^2\right)\rho^{c-1}\Omega_0^{c+1}} \cdot$$

$$\cdot \sum_{i_3=0}^{\infty} \left(\frac{\rho}{\Omega_0\left(1-\rho^2\right)} \right)^{2i_3+c-1} \cdot \frac{1}{i_3!\,\Gamma(i_3+c)} \cdot$$

$$\left(\Omega_0\left(1-\rho^2\right)\right)^{i_3+c} \frac{1}{i_3+c} \frac{1}{\left(\Omega_0\left(1-\rho^2\right)\right)^{i_3+c}}$$

$$\cdot \sum_{j_1=0}^{\infty} \frac{1}{\Gamma(i_3+c+1)(j_1)} \frac{1}{\left(\Omega_0\left(1-\rho^2\right)\right)^{j_1}} \cdot$$

$$\alpha \frac{\mu(k+1)^{\frac{\mu+1}{2}}}{k^{\frac{\mu-1}{2}} e^{k\mu}} \cdot \sum_{i_1=0}^{\infty} \left(\mu\sqrt{k(k+1)} \right)^{2i_1+\mu-1} \frac{1}{i_1!\,\Gamma(i_1+c)}$$

$$\Gamma(\mu+i_1+1) \frac{1}{\alpha(\mu+i_1)}$$

$$\cdot \sum_{i_2=0}^{\infty} \left(\mu\sqrt{k(k+1)} \right)^{2i_2+\mu-1} \frac{1}{i_2!\,\Gamma(i_2+c)}$$

$$\Gamma(\mu+i_2+1) \frac{1}{\alpha(\mu+i_2)}$$

$$\int_0^\infty ds_1 s_1^{\alpha-1-\frac{\mu+1}{2}-i_1-\frac{\mu}{2}+\frac{1}{2}+\mu+i_1+1-1-\frac{\mu+1}{2}-i_2-\frac{\mu}{2}+\frac{1}{2}+\mu+i_2+1-1} e^{-\frac{1}{\beta}s_1}$$

$$\int_0^\infty d\Omega_1 \Omega_1^{2i_3+2c-1+j_1-1+\mu+i_1+1-1+\mu+i_2+1} e^{-\frac{\Omega_1}{\Omega_0\left(1-\rho^2\right)}}$$

$$\left(\frac{1}{\left(\mu(k+1)\Omega_1\right)^{\mu+i_1}} - \frac{1}{\left(\mu(k+1)\Omega_1 + s_1 z^\alpha\right)^{\mu+i_1}} \right)$$

$$\left(\frac{1}{\left(\mu(k+1)\Omega_1\right)^{\mu+i_2}} - \frac{1}{\left(\mu(k+1)\Omega_1 + s_1 z^\alpha\right)^{\mu+i_2}} \right) =$$

$$= J_1 - J_2 - J_3 + J_4. \tag{13}$$

Let's introduce some integrals to solve previous equation. The integral J_1 is:

$$J_1 = \int_0^\infty ds_1 s_1^{\alpha-1} e^{-\frac{1}{\beta}s_1}$$

$$\frac{1}{\left(\mu(k+1)\right)^{i_1+i_2+2\mu}} \int_0^\infty d\Omega_1 \Omega_1^{2i_3+2c-1+j_1} e^{-\frac{\Omega_1}{\Omega_0\left(1-\rho^2\right)}} =$$

$$= \beta^\alpha \Gamma(\alpha) \cdot \frac{1}{\left(\mu(k+1)\right)^{i_1+i_2+2\mu}}$$

$$\left(\Omega_0\left(1-\rho^2\right)\right)^{2i_3+2c+j_1} \Gamma(2i_3+2c+j_1) \tag{14}$$

The integral J_2 is:

$$J_2 = \frac{1}{\left(\mu(k+1)\right)^{i_1+\mu}} \int_0^\infty ds_1 s_1^{\alpha-1} e^{-\frac{1}{\beta}s_1} \cdot$$

$$\int_0^\infty d\Omega_1 \Omega_1^{2i_3+2c-1+j_1+\mu+i_2} e^{-\frac{\Omega_1}{\Omega_0\left(1-\rho^2\right)}}$$

$$\frac{1}{\left(\mu(k+1)\Omega_1 + s_1 z^\alpha\right)^{\mu+i_2}}. \tag{15}$$

Previous two-fold integral can be solved by using the formulae [13]:

$$\frac{1}{(a\Omega+bs)} \int_0^\infty ds\, s^{p_1-1} e^{-\alpha_1 p_1 s} \int_0^\infty d\Omega\, \Omega^{p_2-1} e^{-\alpha_2\Omega} =$$

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

$$ {}_2F_1\left(p_1+p_2-n, p_1, p_1+p_2; 1-\frac{\alpha_1 a}{\alpha_2 b} \right) \tag{16}$$

where ${}_2F_1(a,b,c;z)$ is Gauss hypergeometric function [14] [15].

For integral J_2, the parameters are:

$$p_1 = \alpha$$

$$p_2 = 2i_3 + 2c + j_1 + \mu + i_2$$

$$\alpha_1 = \frac{1}{\beta}$$

$$\alpha_2 = \frac{1}{\Omega_0\left(1-\rho^2\right)}$$

$$a = \mu(k+1)$$

$$b = z^2$$

$$n = i_2 + \mu$$

$$p_1 + p_2 = 2i_3 + 2c + j_1 + \mu + i_2 + \alpha$$

$$p_1 + p_2 - n = 2i_3 + 2c + j_1 + \alpha$$

$$p_1 - n = \alpha - i_2 - \mu$$

After substituting, the integral J_2 is [16]:

$$J_2 = \frac{1}{\left(\mu(k+1)\right)^{i_1+\mu}} \left(\mu(k+1)\right)^{\alpha - i_2 - \mu} \frac{1}{z^{2\alpha}}$$

$$\cdot \Gamma\left(2i_3 + 2c + j_1 + \mu + i_2\right)\left(\Omega_0\left(1-\rho^2\right)\right)^{2i_3+2c+j_1+\alpha}$$

$$\frac{\Gamma\left(2i_3 + 2c + j_1 + \alpha\right)\Gamma(\alpha)}{\Gamma\left(2i_3 + 2c + j_1 + \mu + i_2 + \alpha\right)}$$

$${}_2F_1\left(2i_3 + 2c + j_1 + \alpha, \alpha, 2i_3 + 2c + j_1 + \mu + i_2 + \alpha; 1 - \frac{\Omega_0\left(1-\rho^2\right)\mu(k+1)}{\beta z^2}\right) \tag{17}$$

The integral J_3 is:

$$J_3 = \frac{1}{\left(\mu(k+1)\right)^{i_2+\mu}} \int_0^\infty ds_1 s_1^{\alpha-1} e^{-\frac{1}{\beta}s_1} \cdot$$

$$\int_0^\infty d\Omega_1 \Omega_1^{2i_3+2c-1+j_1+\mu+i_1} e^{-\frac{\Omega_1}{\Omega_0\left(1-\rho^2\right)}}$$

$$\frac{1}{\left(\mu(k+1)\Omega_1 + s_1 z^{\alpha}\right)^{\mu+i_1}} . \tag{18}$$

For integral J_3, the parameters are:

$$p_1 = \alpha$$

$$p_2 = 2i_3 + 2c + j_1 + \mu + i_1$$

$$\alpha_1 = \frac{1}{\beta}$$

$$\alpha_2 = \frac{1}{\Omega_0\left(1-\rho^2\right)}$$

$$a = \mu(k+1)$$

$$b = z^2$$

$$n = \mu + i_1$$

$$p_1 + p_2 = 2i_3 + 2c + j_1 + \mu + i_1 + \alpha$$

$$p_1 + p_2 - n = 2i_3 + 2c + j_1 + \alpha$$

$$p_1 - n = \alpha - \mu - i_1$$

After substituting, the expression for integral J_3 becomes:

$$J_3 = \frac{1}{\left(\mu(k+1)\right)^{i_2+\mu}} \left(\mu(k+1)\right)^{\alpha - i_1 - \mu} \frac{1}{z^{2\alpha}}$$

$$\cdot \Gamma\left(2i_3 + 2c + j_1 + \mu + i_1\right)\left(\Omega_0\left(1-\rho^2\right)\right)^{2i_3+2c+j_1+\alpha}$$

$$\frac{\Gamma\left(2i_3 + 2c + j_1 + \alpha\right)\Gamma(\alpha)}{\Gamma\left(2i_3 + 2c + j_1 + \mu + i_1 + \alpha\right)}$$

$${}_2F_1\left(2i_3 + 2c + j_1 + \alpha, \alpha, 2i_3 + 2c + j_1 + \mu + i_1 + \alpha; 1 - \frac{\Omega_0\left(1-\rho^2\right)\mu(k+1)}{\beta z^2}\right) \tag{19}$$

The integral J_4 is:

$$J_4 = \int_0^\infty ds_1 s_1^{\alpha-1} e^{-\frac{1}{\beta}s_1}$$

$$\int_0^\infty d\Omega_1 \Omega_1^{2i_3+2c-1+j_1+i_1+i_2+2\mu} e^{-\frac{\Omega_1}{\Omega_0\left(1-\rho^2\right)}}$$

$$\frac{1}{\left(\mu(k+1)\Omega_1 + s_1 z^2\right)^{i_1+i_2+2\mu}} \tag{20}$$

The parameters for solving the integral J_4 by formulae (16) are:

$$p_1 = \alpha$$

$$p_2 = 2i_3 + 2c + j_1 + i_1 + i_2 + 2\mu$$

$$\alpha_1 = \frac{1}{\beta}$$

$$\alpha_2 = \frac{1}{\Omega_0\left(1-\rho^2\right)}$$

$$a = \mu(k+1)$$

$$b = z^2$$

$$n = i_1 + i_2 + 2\mu$$

$$p_1 + p_2 = 2i_3 + 2c + j_1 + i_1 + i_2 + 2\mu + \alpha$$

$$p_1 + p_2 - n = 2i_3 + 2c + j_1 + \alpha$$

$$p_1 - n = \alpha - i_1 - i_2 - 2\mu$$

After substituting, the expression for integral J_4 ensues:

$$J_4 = \left(\mu(k+1)\right)^{\alpha - i_1 - i_2 - 2\mu} \frac{1}{z^{2\alpha}}$$

$$\cdot \Gamma\left(2i_3 + 2c + j_1 + i_1 + i_2 + 2\mu\right)\left(\Omega_0\left(1-\rho^2\right)\right)^{2i_3+2c+j_1+\alpha}$$

$$\frac{\Gamma\left(2i_3 + 2c + j_1 + \alpha\right)\Gamma(\alpha)}{\Gamma\left(2i_3 + 2c + j_1 + i_1 + i_2 + 2\mu + \alpha\right)}$$

$$ {}_2F_1\left(2i_3+2c+j_1+\alpha,\alpha,2i_3+2c+j_1+i_1+i_2+2\mu+\alpha;1-\frac{\Omega_0\left(1-\rho^2\right)\mu\left(k+1\right)}{\beta z^2}\right) \tag{21} $$

After putting the formulas (14), (17), (19) and (21) in (13), we obtain cumulative distribution function of macrodiversity SC receiver output signal to interference ratio. Since the outage probability is defined as probability that receiver output signal envelope falls down the predefined threshold, mathematically, the outage probability is actually CDF of macrodiversity SC receiver output signal and deffined by [17, eq. (2.23)]:

$$ P_{out}\left(\gamma_{th}\right)=P\left(z<\gamma_{th}\right), $$

where γ_{th} is the threshold value.

IV. Numerical Results

Outage probability of macrodiversity system in the presence of Weibull desired signal, Gamma small scale fading and α-κ-μ co-channel interference versus macrodiversity SC receiver output signal to interference ratio is presented in Fig. 2 to 4. for several values of Gamma long term fading severity parameter, Gamma long term fading correlation coefficient, Weibull short term fading nonlinearity parameter, α-κ-μ short term fading nonlinearity parameter, α-κ-μ short term fading Rician factor and the α-κ-μ short term fading severity parameter.

When resulting signal to interference ratio increases, the outage probability increases also. The influence of signal to interference ratio at outage probability is higher for lower values of signal to interference ratio. Outage probability decreases when Rician factor increases.

The influence of Rician factor on the outage probability is higher for lower values of signal to interference ratio. Also, the influence of Rician factor on the outage probability is higher for lower values of Rician factor.

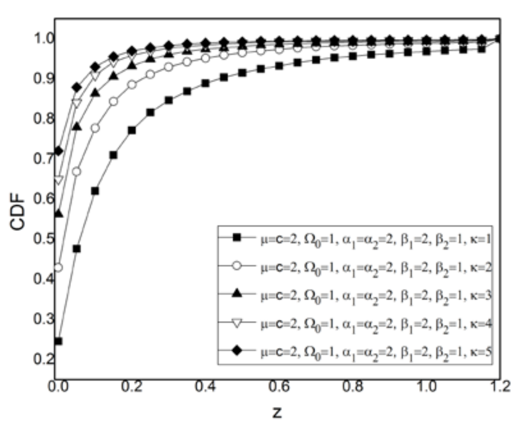

Fig. 2. Outage probability of macrodiversity system versus output signal to interference ratio

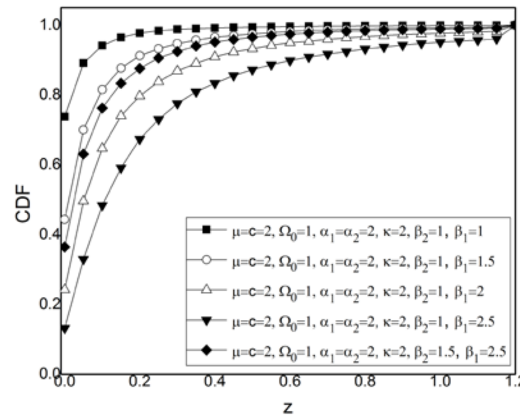

Fig. 3. CDF of macrodiversity system versus output signal to interference ratio *z*

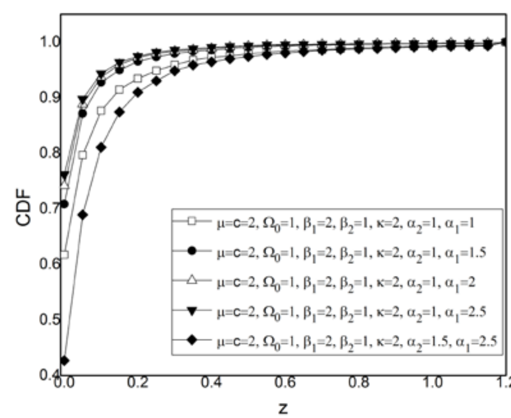

Fig. 4. CDF of macrodiversity system depending on output signal to interference ratio *z*

When signal to interference ratio goes to infinity, outage probability goes to one. Outage probability decreases when Gamma long term fading severity parameter decreases. The impact of Gamma long term fading severity parameter on the outage probability is higher for lower values of Rician factor and lower values of signal to interference ratio.

Correlation coefficient of Gamma long term fading goes from zero to one. When correlation coefficient goes to one, macrodiversity system operates as microdiversity. Outage probability decreases when correlation coefficient decreases. The influence of correlation coefficient on outage probability is higher for lower values of Rician factor and signal to interference ratio. Outage probability decreases when Weibull short term fading nonlinearity parameter increases. The influence of Weibull nonlinearity parameter on outage probability is higher for lower values of Rician factor and lower values of Weibull short term fading severity parameter.

V. Conclusion

In this paper, macrodiversity system with macrodiversity SC receiver and two microdiversity SC receivers in the presence of short term fading and long term fading is considered. Desired signal is affected by Weibull multipath fading and correlated Gamma long term fading, and interference signal is affected by α-κ-μ short term fading and also Gamma long term fading. Macrodiversity reception is used to mitigate short term fading effects, long term fading effects and co-channel interference effects on outage performance.

Macrodiversity receiver combines signals from antennas at base stations to select microdiversity with higher signal envelope average power resulting in long term fading reduction. Microdiversity combines signal envelopes from multiple antennas at base stations selecting the branch with the highest signal to interference ratio resulting in short term fading and co-channel interference effects reduction.

In this paper, probability density function and cumulative distribution function of Weibull and α-κ-μ random process ratio are efficiently calculated and used for cumulative distribution functions of signal to interference ratio at outputs of microdiversity SC receivers and macrodiversity SC receiver output signal to interference ratio evaluation.

By using derived formulas, outage probability of macrodiversity in the presence of Weibull short term fading, Gamma long term fading and Weibull co-channel interference can be determined. The influence of Weibull short term fading nonlinearity parameter, Gamma long term fading severity parameter, Gamma long term fading correlation coefficient, the α-κ-μ short term fading Rician factor, the α-κ-μ short term fading nonlinearity parameter and the α-κ-μ short term fading severity parameter on the outage probability is analyzed.

Outage probability decreases when Gamma long term fading severity parameter, Weibull short term fading severity parameter and α-κ-μ short term fading severity parameter increases. Also, outage probability increases when Rician factor increases.

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