Buletinul Ştiinţific al Universităţii "Politehnica" din Timişoara

Seria ELECTRONICĂ şi TELECOMUNICAŢII
TRANSACTIONS on ELECTRONICS and COMMUNICATIONS

Tom 53(67), Fascicola 2, 2008

Performance of Mobile Macro Diversity System with Ricean Fading and Shadow Effect

Goran Tomović[1], Suad Suljović[2], Danijela Aleksić[3], Zoran Popović[4]

Abstract – In this paper are given statistical characteristics of the signal at the output of macro diversity system which is made of two micro diversity systems in the presence of Ricean fading on the branches of micro diversity system and Log-normal shadow effect. Combiner of the macro diversity system is SC . For this macro diversity system the probability density function of the output signal and the joint probability density function of the output signal and their derivative are given.

Keywords: fading, shadow effect, diversity system, probability density function

I. INTRODUCTION

This paper gives statistical characteristics of the macro diversity system with consist of two micro diversity systems. Independent Ricean fading exist at the input of the micro diversity systems. Total signal power at the input of micro diversity systems is variable because of the shadow effect and has Log-normal the probability density function. Fading becomes correlated because of the port distances.

This correlation decreases the effect of the diversity technique on the performance of the mobile telecomunication systems. Every micro diversity system has two inputs. Output signals from micro diversity combiner goes to the input macro diversity combiner. Signal at the output macro diversity combiner equals the largest output signal from micro diversity combiner.

In this paper are defined the probability density function (PDF) of the output signal macro diversity combiner and the joint probability density function of the signal and their derivative at the output of macro diversity combiner. Before that the PDF of the output signals of micro diversity combiners are calculated. There are also defined joint PDF of the signal and their derivative at the output both micro diversity combiners.

The joint probability function of the signal amplitude with Ricean PDF and their derivative are known in literature and as such are given in this paper.

Using PDF of the output signal macro diversity combiner we can calculate probabilty of error of the coherent and uncoherent telecomunication systems, the outage probability and characteristic function. Also we may find level crossing rate of the signal at the macro diversity system output, the probability of system error and average fade duration of the output signal.

One of the ways that can be used to show spectral efficiency of the telecomunication systems is by microcells. In this system cells are 1 km apart. This system operate on low powers up to 1 W and antenas up to several meters. Micro cellular systems can be one or more dimensional. A few micro cellular systems can make one macro cellulcar system. It is shown that in micro cellular systems signal amplitude has Ricean probability density function. Ricean model fading may also be aplyed in satelite systems.

Fading effect on performance of mobile telecomunication systems can be reduced by diversity techniques, like space diversity. Macro diversity system are based on discovering the port with the largest input signal. Diversity system like that has the gain increase and also biger capacity of the telecomunication system .

In this paper is considered effect of the Ricean fading and shadow effect on a performance of mobile telecomunication system .

II. THE MODEL OF SYSTEM

System model that is concidered in this paper is shown on Fig.1. Macro diversity system consists of two micro diversity systems with SC combining. Each micro diversity system has two inputs r_{11} and r_{12} for the first micro diversity system and r_{21} and r_{22} for the

[1] The Faculty of Electronic Engineering, University of Nis, Serbia,
Aleksandra Medvedeva 14, 18000 Niš, Serbia, e-mail goran_t@ptt.rs
[2] The Faculty of Electronic Engineering, University of Nis, Serbia,
Aleksandra Medvedeva 14, 18000 Niš, Serbia, e-mail suadsara@gmail.com
[3] The Faculty of Electronic Engineering, University of Nis, Serbia,
Aleksandra Medvedeva 14, 18000 Niš, Serbia
[4] The Faculty of Electronic Engineering, University of Nis, Serbia,
Aleksandra Medvedeva 14, 18000 Niš, Serbia

second one. Output signals from micro diversity combiners are r_1 and r_2.

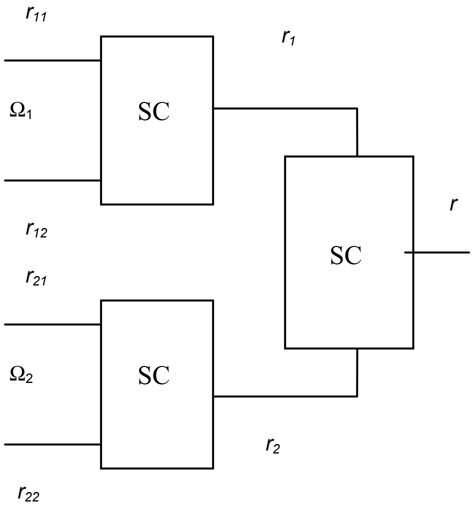

Fig.1. The model of system

There is an opinion that Ricean fading has variable intensity because of the shadow effect. The probability density function of power Ω_1 and Ω_2 is Log-normal. Concidered is the case when the port distances are such that input signal powers Ω_1 and Ω_2 are correlated. The probability density function of the signals r_{11} and r_{12} is Ricean and signals r_{11} and r_{12} are mutually independent. The probability density function derivative of the signal $\dot{r}_{11}$ is Gaussian and does not depend on r_{11}. The joint probability density function signals r_{11} and $\dot{r}_{11}$ is:

$$p_{r_{11}\dot{r}_{11}}(r_{11}\dot{r}_{11}) = \frac{r_{11}}{\Omega_1}\cdot e^{-\frac{r_{11}^2+A_1^2}{2\Omega_1}}\cdot I_0\left(\frac{r_{11}\cdot A_1}{\Omega_1}\right)\cdot$$

$$\cdot\frac{1}{\sqrt{2\pi}\cdot s_1}\cdot e^{-\frac{\dot{r}_{11}}{2s_1^2}}, \qquad (1)$$

where Ω_1 is the amplitude signal r_{11} and $s_{11}{}^2$ is the variance derivative of the signal $\dot{r}_{11}$.
On the similar way we get:

$$p_{r_{12}\dot{r}_{12}}(r_{12}\dot{r}_{12}) = \frac{r_{12}}{\Omega_1}\cdot e^{-\frac{r_{12}^2+A_1^2}{2\Omega_1}}\cdot I_0\left(\frac{r_{12}\cdot A_1}{\Omega_1}\right)\cdot$$

$$\cdot\frac{1}{\sqrt{2\pi}\cdot s_1}\cdot e^{-\frac{\dot{r}_{12}}{2s_1^2}} \qquad (2)$$

$$p_{r_{21}\dot{r}_{21}}(r_{21}\dot{r}_{21}) = \frac{r_{21}}{\Omega_2}\cdot e^{-\frac{r_{21}^2+A_2^2}{2\Omega_2}}\cdot I_0\left(\frac{r_{21}\cdot A_2}{\Omega_2}\right)\cdot$$

$$\cdot\frac{1}{\sqrt{2\pi}\cdot s_2}\cdot e^{-\frac{\dot{r}_{21}}{2s_2^2}} \qquad (3)$$

$$p_{r_{22}\dot{r}_{22}}(r_{22}\dot{r}_{22}) = \frac{r_{22}}{\Omega_2}\cdot e^{-\frac{r_{22}^2+A_2^2}{2\Omega_2}}\cdot I_0\left(\frac{r_{22}\cdot A_2}{\Omega_2}\right)\cdot$$

$$\cdot\frac{1}{\sqrt{2\pi}\cdot s_2}\cdot e^{-\frac{\dot{r}_{22}}{2s_2^2}} \qquad (4)$$

The cumulative function of the random variable r_{11} is:

$$F_{r_{11}}(r_{11}) = \int_0^{r_{11}} p_{r_{11}}(x)\cdot dx \qquad (5)$$

$$F_{r_{11}}(r_{11}) = \int_0^{r_{11}} \frac{x}{\Omega_1}\cdot e^{-\frac{x^2+A_1^2}{2\Omega_1}}\cdot I_0\left(\frac{x\cdot A_1}{\Omega_1}\right)\cdot dx$$

$$F_{r_{11}}(r_{11}) = \frac{1}{\Omega_1}\cdot e^{-\frac{A_1^2}{2\Omega_1}}\int_0^{r_{11}} x\cdot e^{-\frac{x^2}{2\Omega_1}}\cdot$$

$$\cdot\sum_{k=0}^{\infty}\left(\frac{A_1}{2\Omega_1}\right)^{2k}\cdot\frac{1}{(k!)^2}\cdot x^{2k}\cdot dx$$

$$F_{r_{11}}(r_{11}) = \frac{1}{\Omega_1}\cdot e^{-\frac{A_1^2}{2\Omega_1}}\cdot\sum_{k=0}^{\infty}\left(\frac{A_1}{2\Omega_1}\right)^{2k}\cdot\frac{1}{(k!)^2}\cdot$$

$$\cdot\int_0^{r_{11}} x^{2k+1}\cdot e^{-\frac{x^2}{2\Omega_1}}\cdot dx$$

$$F_{r_{11}}(r_{11}) = \frac{1}{\Omega_1}\cdot e^{-\frac{A_1^2}{2\Omega_1}}\cdot\sum_{k=0}^{\infty}\left(\frac{A_1}{2\Omega_1}\right)^{2k}\cdot\frac{1}{(k!)^2}\cdot$$

$$\cdot(2\Omega_1)^{k+1}\cdot\gamma\left(k+1,-\frac{r_{11}^2}{2\Omega_1}\right) \qquad (6)$$

The cumulative functions of the variables r_{12}, r_{21} i r_{22} are:

$$F_{r_{12}}(r_{12}) = \frac{1}{\Omega_1}\cdot e^{-\frac{A_1^2}{2\Omega_1}}\cdot\sum_{k=0}^{\infty}\left(\frac{A_1}{2\Omega_1}\right)^{2k}\cdot\frac{1}{(k!)^2}\cdot$$

$$\cdot(2\Omega_1)^{k+1}\cdot\gamma\left(k+1,-\frac{r_{12}^2}{2\Omega_1}\right) \qquad (7)$$

$$F_{r_{21}}(r_{21}) = \frac{1}{\Omega_2}\cdot e^{-\frac{A_2^2}{2\Omega_2}}\cdot\sum_{k=0}^{\infty}\left(\frac{A_2}{2\Omega_2}\right)^{2k}\cdot\frac{1}{(k!)^2}\cdot$$

$$\cdot(2\Omega_2)^{k+1}\cdot\gamma\left(k+1,-\frac{r_{21}^2}{2\Omega_2}\right) \qquad (8)$$

$$F_{r_{22}}(r_{22})=\frac{1}{\Omega_2}\cdot e^{-\frac{A_2^2}{2\Omega_2}}\cdot\sum_{k=0}^{\infty}\left(\frac{A_2}{2\Omega_2}\right)^{2k}\cdot\frac{1}{(k!)^2}\cdot$$

$$\cdot(2\Omega_2)^{k+1}\cdot\gamma\left(k+1,-\frac{r_{22}^2}{2\Omega_2}\right) \qquad (9)$$

III. CHARACTERISTICS OF THE SIGNAL AT THE MICRO DIVERSITY SYSTEM OUTPUT

Signals at the micro diversity system output are r_1 and r_2. The probability density functions for this signals are:

$$p_{r_1}(r_1)=p_{r_{11}}(r_1)\cdot F_{r_{12}}(r_1)+p_{r_{12}}(r_1)\cdot F_{r_{11}}(r_1)$$

$$p_{r_1}(r_1)=2\cdot\frac{r_1}{\Omega_1}\cdot e^{-\frac{r_1^2+A_1^2}{2\Omega_1}}\cdot I_0\left(\frac{r_1\cdot A_1}{\Omega_1}\right)\cdot\frac{1}{\Omega_1}\cdot$$

$$\cdot e^{-\frac{A_1^2}{2\Omega_1}}\cdot\sum_{k=0}^{\infty}\left(\frac{A_1}{2\Omega_1}\right)^{2k}\cdot\frac{1}{(k!)^2}\cdot(2\Omega_1)^{k+1}\cdot$$

$$\cdot\gamma\left(k+1,-\frac{r_1^2}{2\Omega_1}\right) \qquad (10)$$

$$p_{r_2}(r_2)=p_{r_{21}}(r_2)\cdot F_{r_{22}}(r_2)+p_{r_{22}}(r_2)\cdot F_{r_{21}}(r_2)$$

$$p_{r_2}(r_2)=2\cdot\frac{r_2}{\Omega_2}\cdot e^{-\frac{r_2^2+A_2^2}{2\Omega_2}}\cdot I_0\left(\frac{r_2\cdot A_2}{\Omega_2}\right)\cdot\frac{1}{\Omega_2}\cdot$$

$$\cdot e^{-\frac{A_2^2}{2\Omega_2}}\cdot\sum_{k=0}^{\infty}\left(\frac{A_2}{2\Omega_2}\right)^{2k}\cdot\frac{1}{(k!)^2}\cdot(2\Omega_2)^{k+1}\cdot$$

$$\cdot\gamma\left(k+1,-\frac{r_2^2}{2\Omega_2}\right) \qquad (11)$$

where $\gamma(n,x)$ is the incomplete Gama function:

$$\gamma(n,x)=\int_0^x t^{n-1}\cdot e^{-t}\cdot dt \qquad (12)$$

The cumulative distribution of signal r_1 is:

$$F_{r_1}(r_1)=\int_0^{r_1}\frac{2x}{\Omega_1}\cdot e^{-\frac{x^2+A_1^2}{2\Omega_1}}\cdot I_0\left(\frac{x\cdot A_1}{\Omega_1}\right)\cdot$$

$$\cdot\frac{1}{\Omega_1}\cdot e^{-\frac{A_1^2}{2\Omega_1}}\cdot\sum_{k=0}^{\infty}\left(\frac{A_1}{2\Omega_1}\right)^{2k}\cdot\frac{1}{k!}\cdot(2\Omega_1)^{k+1}\cdot$$

$$\cdot\gamma\left(k+1,-\frac{x^2}{2\Omega_1}\right)\cdot dx \qquad (13)$$

$$F_{r_1}(r_1)=\frac{2}{\Omega_1}\int_0^{r_1}x\cdot e^{-\frac{x^2+A_1^2}{2\Omega_1}}\cdot\sum_{i=0}^{\infty}\left(\frac{A_1}{2\Omega_1}\right)^{2i}\cdot\frac{1}{(i!)^2}\cdot$$

$$\cdot x^{2i}\cdot\frac{1}{\Omega_1}\cdot e^{-\frac{A_1^2}{2\Omega_1}}\cdot\sum_{k=0}^{\infty}\left(\frac{A_1}{2\Omega_1}\right)^{2k}\cdot\frac{1}{k!}\cdot(2\Omega_1)^{k+1}\cdot$$

$$\cdot\gamma\left(k+1,-\frac{x^2}{2\Omega_1}\right)\cdot dx$$

$$F_{r_1}(r_1)=\frac{2}{\Omega_1^2}\cdot e^{-\frac{A_1^2}{2\Omega_1}}\cdot\sum_{i=0}^{\infty}\left(\frac{A_1}{2\Omega_1}\right)^{2i}\cdot\frac{1}{(i!)^2}\cdot$$

$$\cdot\sum_{k=0}^{\infty}\left(\frac{A_1}{2\Omega_1}\right)^{2k}\cdot\frac{1}{k!}\cdot(2\Omega_1)^{k+1}\cdot$$

$$\int_0^{r_1}x^{1+2i}\cdot e^{-\frac{x^2}{2\Omega_1}}\cdot\gamma\left(k+1,-\frac{x^2}{2\Omega_1}\right)\cdot dx \qquad (14)$$

The cumulative distribution of signal r_2 is:

$$F_{r_2}(r_2)=\frac{2}{\Omega_2^2}\cdot e^{-\frac{A_2^2}{2\Omega_2}}\cdot\sum_{i=0}^{\infty}\left(\frac{A_2}{2\Omega_2}\right)^{2i}\cdot\frac{1}{(i!)^2}\cdot$$

$$\cdot\sum_{k=0}^{\infty}\left(\frac{A_2}{2\Omega_2}\right)^{2k}\cdot\frac{1}{k!}\cdot(2\Omega_2)^{k+1}\cdot$$

$$\cdot\int_0^{r_2}x^{1+2i}\cdot e^{-\frac{x^2}{2\Omega_2}}\cdot\gamma\left(k+1,-\frac{x^2}{2\Omega_2}\right)\cdot dx \qquad (15)$$

The joint probability density function of signal r_1 and $\dot{r}_1$ is:

$$p_{r_1\dot{r}_1}\left(r_1\dot{r}_1\right)=p_{r_{11}\dot{r}_{11}}\left(r_1\dot{r}_1\right)\cdot F_{r_{12}}(r_1)+p_{r_{12}\dot{r}_{12}}\left(r_1\dot{r}_1\right)\cdot F_{r_{11}}(r_1)$$

$$p_{r_1\dot{r}_1}\left(r_1\dot{r}_1\right)=\frac{2r_1}{\Omega_1}\cdot e^{-\frac{r_1^2+A_1^2}{2\Omega_1}}\cdot I_0\left(\frac{r_1A_1}{\Omega_1}\right)\cdot\frac{1}{\sqrt{2\pi}\cdot s_1}\cdot$$

$$\cdot e^{-\frac{\dot{r}_1^2}{2s_1^2}}\cdot\frac{1}{\Omega_1}\cdot e^{-\frac{A_1^2}{2\Omega_1}}\cdot\sum_{k=0}^{\infty}\left(\frac{A_1}{2\Omega_1}\right)^{2k}\cdot\frac{1}{k!}\cdot(2\Omega_1)^{k+1}$$

$$\cdot\gamma\left(k+1,-\frac{r_1^2}{2\Omega_1}\right) \qquad (16)$$

The joint probability density function of signals r_2 and $\dot{r}_2$ is:

$$p_{r_2\dot{r}_2}\left(r_2\dot{r}_2\right)=p_{r_{21}\dot{r}_{21}}\left(r_2\dot{r}_2\right)\cdot F_{r_{22}}\left(r_2\right)+p_{r_{22}\dot{r}_{22}}\left(r_2\dot{r}_2\right)\cdot F_{r_{21}}\left(r_2\right)$$

$$p_{r_1\dot{r}_1}\left(r_1\dot{r}_1\right)=\frac{2r_2}{\Omega_2}\cdot e^{-\frac{r_2^2+A_2^2}{2\Omega_2}}\cdot I_0\left(\frac{r_2A_2}{\Omega_2}\right)\cdot\frac{1}{\sqrt{2\pi}\cdot s_2}\cdot$$
$$\cdot e^{-\frac{\dot{r}_2^2}{2s_2^2}}\cdot\frac{1}{\Omega_2}\cdot e^{-\frac{A_2^2}{2\Omega_2}}\cdot\sum_{k=0}^{\infty}\left(\frac{A_2}{2\Omega_2}\right)^{2k}\cdot\frac{1}{k!}\cdot\left(2\Omega_2\right)^{k+1}$$
$$\cdot\gamma\left(k+1,-\frac{r_2^2}{2\Omega_2}\right) \quad (17)$$

IV. CHARACTERISTICS OF THE SIGNAL AT THE MACRO DIVERSITY SYSTEM OUTPUT

Input powers micro diversity systems define input signals macro diversity system. If $\Omega_1>\Omega_2$ combiner of macro diversity system transmit signal r_1 and if $\Omega_2>\Omega_1$ transmit signal r_2. Powers Ω_1 and Ω_2 are correlated random variables. The joint PDF this variables is:

$$p_{\Omega_1\Omega_2}\left(\Omega_1\Omega_2\right)=\frac{1}{2\pi\sigma^2\sqrt{1-\rho^2}\cdot\Omega_1\Omega_2}\cdot$$
$$\cdot e^{-\frac{(\ln\Omega_1-\mu_1)^2-2r(\ln\Omega_1-\mu_1)(\ln\Omega_2-\mu_2)+(\ln\Omega_2-\mu_2)^2}{2\sigma^2\left(1-\rho^2\right)}} \quad (18)$$

where ρ is the the correlation coefficient, and μ_1 and μ_2 are responsive middle values. Random variables Ω_1 and Ω_2 are in relationship with Gaussian random variables y_1 and y_2:

$$\Omega_1=e^{y_1}$$
$$\Omega_2=e^{y_2} \quad (19)$$

until the joint PDF Gaussian random variables y_1 i y_2 is:

$$p_{y_1y_2}\left(y_1y_2\right)=\frac{1}{\sqrt{2\pi}\cdot\sigma^2\cdot\sqrt{1-\rho^2}}\cdot$$
$$\cdot e^{-\frac{(y_1-\mu_1)^2-2\rho(y_1-\mu_1)(y_2-\mu_2)+(y_2-\mu_2)^2}{2\sigma^2\left(1-\rho^2\right)}} \quad (20)$$

The probability density function of the signal at the macro diversity system output can be written as:

$$p_r(r)=\int_0^{\infty}d\Omega_1\int_0^{\Omega_1}d\Omega_2\cdot p_{\Omega_1\Omega_2}\left(\Omega_1\Omega_2\right)\cdot p_{r_1}\left(r/\Omega_1\right)+$$
$$+\int_0^{\infty}d\Omega_1\int_{\Omega_1}^{\infty}d\Omega_2\cdot p_{\Omega_1\Omega_2}\left(\Omega_1\Omega_2\right)\cdot p_{r_2}\left(r/\Omega_2\right) \quad (21)$$

$$p_r(r)=\int_0^{\infty}d\Omega_1\int_0^{\Omega_1}d\Omega_2\cdot\frac{1}{\sqrt{2\pi}\cdot\sigma^2\cdot\sqrt{1-\rho^2}}\cdot$$
$$\cdot e^{-\frac{(\ln\Omega_1-\mu_1)^2-2\rho(\ln\Omega_1-\mu_1)(\ln\Omega_2-\mu_2)+(\ln\Omega_2-\mu_2)^2}{2\sigma^2\left(1-\rho^2\right)}}\cdot$$
$$\cdot\frac{2r}{\Omega_1^2}\cdot e^{-\frac{A_1^2}{\Omega_1}}\cdot e^{-\frac{r^2}{2\Omega_1}}\cdot I_0\left(\frac{rA_1}{\Omega_1}\right)\cdot\sum_{k=0}^{\infty}\left(\frac{A_1}{2\Omega_1}\right)^{2k}\cdot\frac{1}{(k!)^2}\cdot$$
$$\cdot\left(2\Omega_1\right)^{k+1}\cdot\gamma\left(k+1,-\frac{r^2}{2\Omega_1}\right)+$$
$$+\int_0^{\infty}d\Omega_1\int_{\Omega_1}^{\infty}d\Omega_2\cdot\frac{1}{\sqrt{2\pi}\cdot\sigma^2\cdot\sqrt{1-\rho^2}}\cdot$$
$$\cdot e^{-\frac{(\ln\Omega_1-\mu_1)^2-2\rho(\ln\Omega_1-\mu_1)(\ln\Omega_2-\mu_2)+(\ln\Omega_2-\mu_2)^2}{2\sigma^2\left(1-\rho^2\right)}}\cdot$$
$$\cdot\frac{2r}{\Omega_2^2}\cdot e^{-\frac{A_2^2}{\Omega_2}}\cdot e^{-\frac{r^2}{2\Omega_2}}\cdot I_0\left(\frac{rA_2}{\Omega_2}\right)\cdot\sum_{k=0}^{\infty}\left(\frac{A_2}{2\Omega_2}\right)^{2k}\cdot\frac{1}{(k!)^2}\cdot$$
$$\cdot\left(2\Omega_2\right)^{k+1}\cdot\gamma\left(k+1,-\frac{r^2}{2\Omega_2}\right) \quad (22)$$

The joint PDF of signals r i $\dot{r}$ is:

$$p_{r\dot{r}}\left(r\dot{r}\right)=\int_0^{\infty}d\Omega_1\int_0^{\Omega_1}d\Omega_2\cdot p_{\Omega_1\Omega_2}\left(\Omega_1\Omega_2\right)\cdot p_{r_1\dot{r}_1}\left(r\dot{r}/\Omega_1\right)+$$
$$+\int_0^{\infty}d\Omega_1\int_{\Omega_1}^{\infty}d\Omega_2\cdot p_{\Omega_1\Omega_2}\left(\Omega_1\Omega_2\right)\cdot p_{r_2\dot{r}_2}\left(r\dot{r}/\Omega_2\right) \quad (23)$$

The error probability for coherent system can be expressed in the form:

$$P_e=\int_0^{\infty}P_{e/r}\cdot p_r(r)\cdot dr=\int_0^{\infty}a\cdot erfc\left(br^2\right)\cdot dr \quad (24)$$

The error probability for some noncoherent systems is:

$$P_e=\int_0^{\infty}a\cdot e^{-br^2}\cdot p_r(r)\cdot dr \quad (25)$$

The outage probability can be obtained as:

$$P_o=\int_0^{r_T}p_r(r)\cdot dr \quad (26)$$

The level crossing rate on some level r is:

$$N = \int_0^\infty \dot{r} \cdot p_{r\dot{r}}\left(r\dot{r}\right) \cdot d\dot{r} \quad (27)$$

The average fade duration of the signal is quotient of the outage probability and the level crossing rate:

$$S = \frac{P_o}{N} = \frac{\int_0^{r_T} p_r(r) \cdot dr}{\int_0^\infty \dot{r} \cdot p_{r\dot{r}}\left(r\dot{r}\right) \cdot d\dot{r}} \quad (28)$$

The characteristic function of the signal at the makro diversity combiner output is:

$$M_r(s) = \int_0^\infty e^{rs} \cdot p_r(r) \cdot dr \quad (29)$$

The cumulative distribution this signal can be obtained as:

$$F_r(r) = \int_0^r p_r(x) \cdot dx \quad (30)$$

Moments of the output signal are:

$$m_n = \int_0^\infty r^n \cdot p_r(r) \cdot dr \quad (31)$$

Macro diversity system can work on that way if $r_1>r_2$ transmit signal r_1 and if $r_2>r_1$ transmit r_2 . Now PDF of the signal at the macro diversity system output is:

$$p_r(r) = \int_0^\infty d\Omega_1 \int_0^\infty d\Omega_2 \cdot p_{\Omega_1\Omega_2}(\Omega_1\Omega_2) \cdot p_{r_1}(r/\Omega_1) \cdot F_{r_2}(r/\Omega_2) +$$

$$+ \int_0^\infty d\Omega_1 \int_0^\infty d\Omega_2 \cdot p_{\Omega_1\Omega_2}(\Omega_1\Omega_2) \cdot p_{r_2}(r/\Omega_2) \cdot F_{r_1}(r/\Omega_1) \quad (32)$$

The joint PDF of signals r and $\dot{r}$ in that case is:

$$p_{r\dot{r}}\left(r\dot{r}\right) = \int_0^\infty d\Omega_1 \int_0^\infty d\Omega_2 \cdot p_{\Omega_1\Omega_2}(\Omega_1\Omega_2) \cdot p_{r_1\dot{r}_1}\left(r\dot{r}/\Omega_1\right) \cdot F_{r_2}(r/\Omega_2) +$$

$$+ \int_0^\infty d\Omega_1 \int_0^\infty d\Omega_2 \cdot p_{\Omega_1\Omega_2}(\Omega_1\Omega_2) \cdot p_{r_2\dot{r}_2}\left(r\dot{r}/\Omega_2\right) \cdot F_{r_1}(r/\Omega_1) \quad (33)$$

The characteristic function of signal r_1 is:

$$\overline{r_{11}^n} = \int_0^\infty r_{11}^n \cdot p_{r_{11}}(r_{11}) \cdot dr_{11} \quad (34)$$

$$\overline{r_{11}^n} = \int_0^\infty r_{11}^n \cdot \frac{r_{11}}{\Omega_1} \cdot e^{-\frac{r_{11}^2 + A_1^2}{2\Omega_1}} \cdot I_0\left(\frac{r_{11}A_1}{\Omega_1}\right) \cdot dr_{11}$$

$$\overline{r_{11}^n} = \frac{1}{\Omega_1} \cdot e^{-\frac{A_1^2}{2\Omega_1}} \int_0^\infty r_{11}^{n+1} \cdot e^{-\frac{r_{11}^2}{2\Omega_1}} \cdot$$

$$\cdot \sum_{k=0}^\infty \left(\frac{A_1}{2\Omega_1}\right)^{2k} \cdot \frac{1}{(k!)^2} \cdot (r_{11})^{2k} \cdot dr_{11}$$

$$\overline{r_{11}^n} = \frac{1}{\Omega_1} \cdot e^{-\frac{A_1^2}{2\Omega_1}} \cdot \sum_{k=0}^\infty \left(\frac{A_1}{2\Omega_1}\right)^{2k} \cdot \frac{1}{(k!)^2} \cdot$$

$$\cdot \int_0^\infty r_{11}^{n+1+2k} \cdot e^{-\frac{r_{11}^2}{2\Omega_1}} \cdot dr_{11}$$

$$\overline{r_{11}^n} = \frac{1}{\Omega_1} \cdot e^{-\frac{A_1^2}{2\Omega_1}} \cdot \sum_{k=0}^\infty \left(\frac{A_1}{2\Omega_1}\right)^{2k} \cdot \frac{1}{(k!)^2} \cdot$$

$$\cdot (2\Omega_1)^{1+k+n/2} \cdot \Gamma\left(1+k+n/2, -\frac{r_{11}}{2\Omega_1}\right) \quad (35)$$

V. CONCLUSION

In this paper macro diversity system for decreasing effect fading on the performance of the mobile telecommunication systems is considered. This macro diversity system consist of two micro diversity systems in the presence identical noncorrelated Ricean fading. Between of the micro diversity systems exist the shadow effect. For that macro diversity sytem the probability density function of the output signal and the joint probability function of the output signal and their derivative are calculated. These probability density function and the joint probability function can be used for calculation another statistical characteristics of the signal at the macro diversity system output.

REFERENCES

[1] F. Patenaude, J. Lodge, J. Chouinard, "Temporal correelation analysis of frequency selective fading channels", *Proc. 6 Annual Int. Conf. Wireless Communications*, Calgary, Canada, July 1994, pp.134-139

[2] J. Pierce, S. Stein, "Multiple diversity with nonindependent fading", *Proc.IRE, vol.48*, January 1960, pp.89-104.

[3] M. Simon, M. Alouni, "Digital Comunication over Fading Channels", *Jhon Wiley&Sons*, Inc. 2000.

[4] W. Lee, "Mobile Cellular Communications", *McGraw-Hill Book Co.*, New York, 1989.

[3] P. Bithas, P. Takis Mathiopoulos, "Dual diversity over Correlated Ricean Fading Channels", *Journal of Communications and Networks*, Vol. , No. 1, March 2007.