

of diversity branches is presented. Similar as in previous figures, conclusion that system performance improves as number of diversity branches and separation between base stations increase can be extracted. It is very interesting to observe that for lower values of y_0 performance of system with five branches coincides with performance of system with two branches but with larger spatial separation between base stations. In that case, it is more economic to ensure large separation between base stations than to increase number of antennas (diversity branches) and to hold small separation between base stations. Fig. 11 shows that the gap among the adjacent curves due to increase of N reduces. This implies that ABEP improvement due to increase of diversity branches number reduces with increment of that number.

Fig. 12 and Fig. 13 present ABEP of BFSK. The similar findings as from Fig. 10 and Fig. 11 can be extracted. Fig. 14 shows that system performance is better for BDPSK modulation.

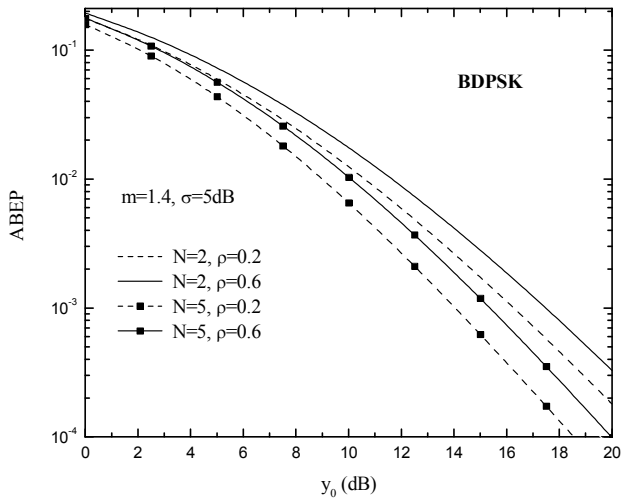


Fig. 10 ABEP of BDPSK versus y_0 for different values of correlation coefficient and diversity branches number

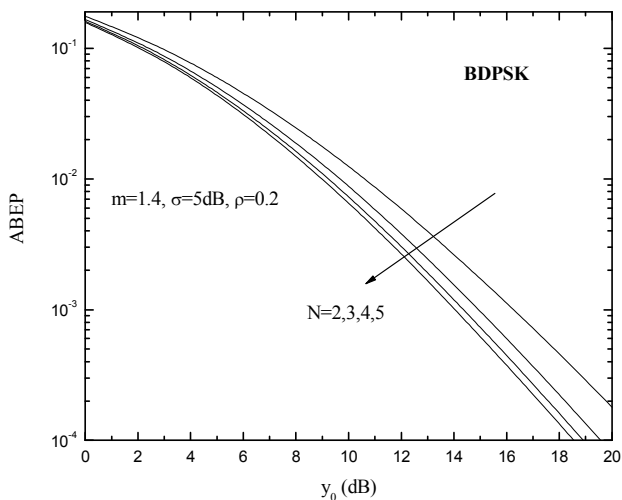


Fig. 11 ABEP of BDPSK versus y_0 for different number of diversity branches

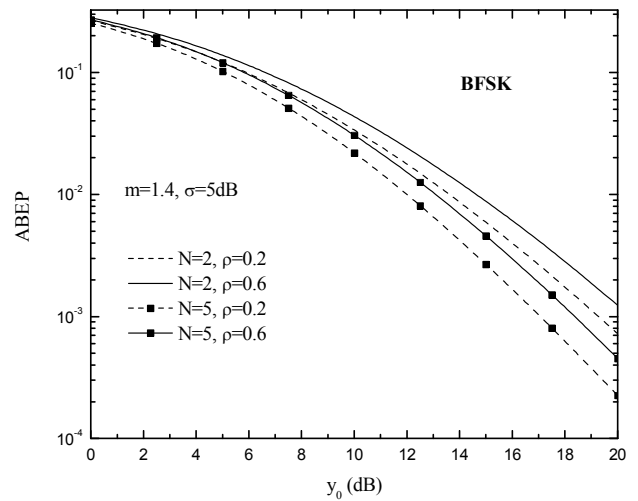


Fig. 12 ABEP of BFSK versus y_0 for different values of correlation coefficient and diversity branches number

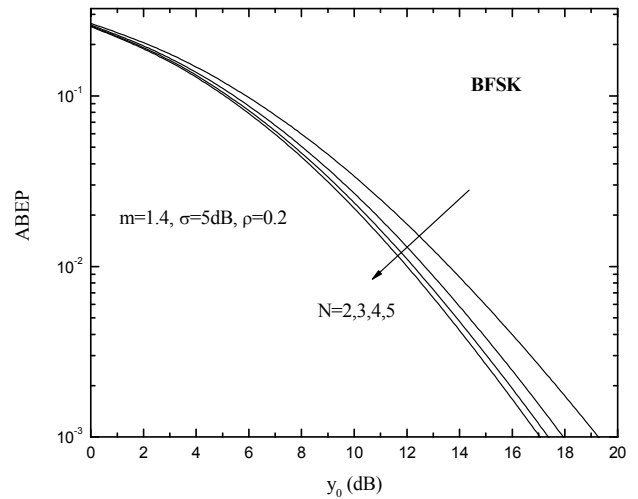


Fig. 13 ABEP of BFSK versus y_0 for different number of diversity branches

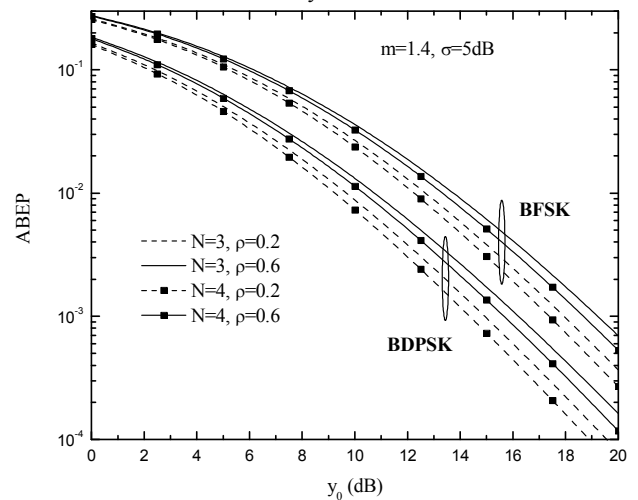


Fig. 14 ABEP of BDPSK and BFSK versus y_0 for different values of correlation coefficient and number of diversity branches

In Fig. 15 and Fig. 16, ABEP of BDPSK and BFSK, respectively, for systems without and with macrodiversity versus y_0 for several values of

correlation coefficient and number of diversity branches is presented. It is interesting to observe that in the case of higher shadowing, system with two branches at the micro level and with larger separation between base stations (smaller correlation coefficient) shows better performance than system with five branches at the micro level and smaller separation between base stations. Fig. 17 shows that system with BDPSK signalling shows better performance than system with BFSK signalling. For lower values of y_0 and lower values of shadowing severity, system with BDPSK signalling without macrodiversity shows better performance than system with BFSK signalling with macrodiversity.

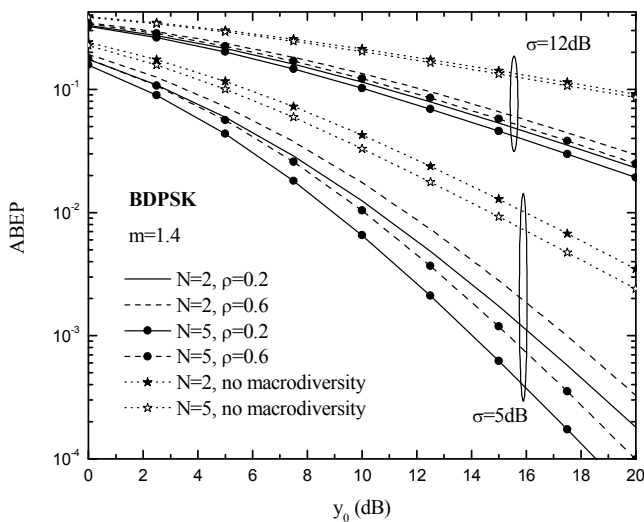


Fig. 15 ABEP of BDPSK versus y_0 for systems without and with macrodiversity for different values of correlation coefficient and number of diversity branches

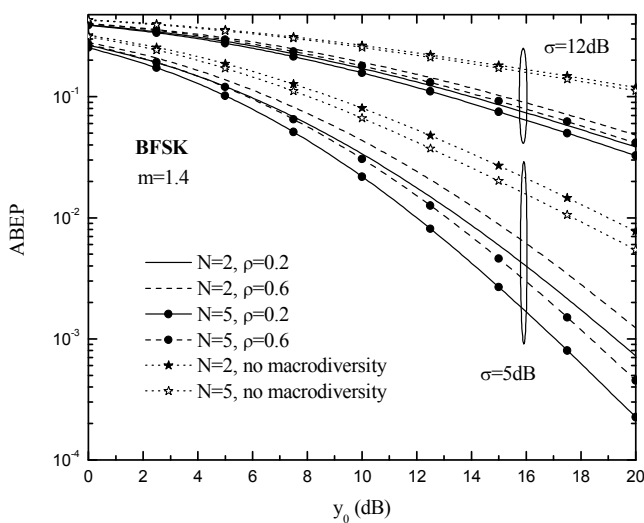


Fig. 16 ABEP of BFSK versus y_0 for systems without and with macrodiversity for different values of correlation coefficient and number of diversity branches

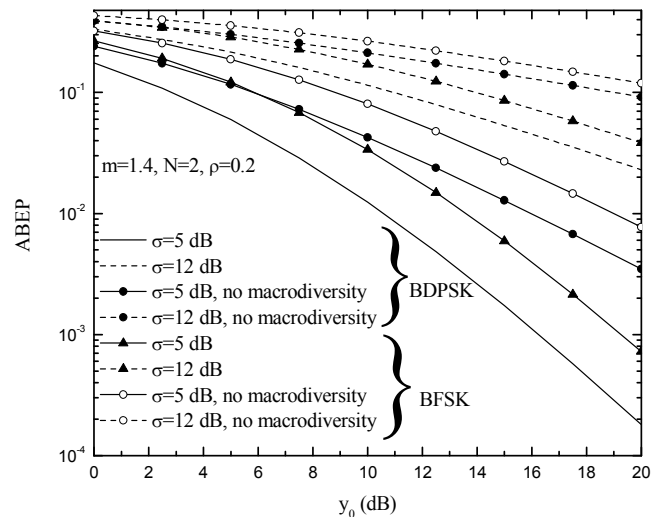


Fig. 17 ABEP of BDPSK and BFSK versus y_0 for systems without and with macrodiversity for different shadowing severity

4 Conclusion

In this paper, system with micro- and macrodiversity reception was considered. The received signal envelope has a Nakagami- m distribution and it also suffers gamma shadowing. Microdiversity scheme is based on MRC and macrodiversity scheme is based on SC. Expressions for the PDF, CDF and moments of the output signal are derived. These expressions are used to study important system performance criteria such as the outage probability, ABEP, average signal value and AoF. The presented infinite-series representations for the mentioned performance measures converge for any value of the parameters and accordingly, they enable great accuracy of the evaluated and graphically presented results. They show that the system performance improves with an increase of the Nakagami- m factor, number of diversity branches at the micro level and order of gamma distribution while an increase of the correlation coefficient leads to deterioration of the system performance. Improvement achieved through macrodiversity is also established. Expressions in the paper enable the designers of wireless communication systems to simulate different fading and shadowing conditions and readjust systems operating parameters in order to meet the QoS demands.

5. Appendix: The case of no macrodiversity

The PDF of the signal at the output of single base station (the case of no macrodiversity) in shadowed Nakagami- m fading channels is

$$p_x(x) = \int_0^{\infty} p_x(x|y)p_y(y)dy \quad (18)$$

where $p_y(y)$ is the gamma PDF of the average power given by [19]

$$p_y(y) = \frac{y^{c-1} \exp(-y/y_0)}{\Gamma(c)y_0^c}. \quad (19)$$

Substituting (3) and (19) in (18) and after some straightforward manipulations, integral can be solved with the use of [20, (3.471/9)], resulting in analytical expression for the PDF of x

$$p_x(x) = \frac{2M^{\frac{c+M}{2}} x^{\frac{c+M}{2}-1}}{\Gamma(M)\Gamma(c)y_0^{\frac{c+M}{2}}} K_{c-M} \left(2\sqrt{\frac{Mx}{y_0}} \right). \quad (20)$$

The CDF of x can be obtained using

$$F_x(x) = \int_0^{\infty} F_x(x|y)p_y(y)dy. \quad (21)$$

Substituting (8) and (19) in (21) and after some straightforward manipulations, integral can be solved with the use of [20, (3.471/9)], resulting in analytical expression for the CDF of x

$$F_x(x) = \frac{2}{\Gamma(M)\Gamma(c)} \sum_{k=0}^{\infty} \frac{(Mx)^{\frac{c+M+k}{2}}}{y_0^{\frac{c+M+k}{2}} \prod_{l=0}^k (M+l)} \quad (22)$$

$$\times K_{c-M-k} \left(2\sqrt{\frac{Mx}{y_0}} \right).$$

Substituting (20) in (11) and using [20, (6.561/16)], L th moment for the case of no macrodiversity can be written as

$$x_L = \frac{y_0^L \Gamma(c+L)\Gamma(M+L)}{\Gamma(M)\Gamma(c)M^L}. \quad (23)$$

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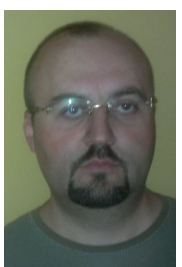
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