

# 利用LCR與AFD方法對雙分支SC分集機制工作於特定衰落通道中之研究

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## 摘要

本論文提出平均準位跨越率(average level crossing rate, LCR)和平均衰落區間(average fade duration, AFD)的標準出現在雙分支選擇性分集成(selection combining, SC)接受性能上當烈雷(Rayleigh)相關與萊斯(Rice)相關之統計分布的評估結果。並且，平均準位跨越率和平均衰落區間在雙分支選擇性分集成的公式使其判斷更為清晰融合，在各種不同種類顯出其衰落差異，包括烈雷(Rayleigh)、萊斯(Rice)、Nakagami-m、韋布(Weibull)分布等。幾乎所有研究與出版的結果，本文將有完全的討論，關於平均準位跨越率和平均衰落區間在雙分支選擇性分集成的差異。另一方面，在雙分支分集成的平均準位跨越率和平均衰落區間之執行公式比較，廣義的導出和排列有關衰落統計模式之探討，也在相關與獨立方面考慮到多元分支之議題(一些公式說明雙分支選擇性分集成的假設多樣化)。

關鍵詞：選擇性分集成、平均準位跨越率、平均衰落區間、烈雷、萊斯、韋布、Nakagami-m分布

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## 參考文獻

- [1] M. A. Teneda, J. Takada, and K. Araki, " The Problem of the Fading Mobile Selection, " IEICE Trans. on Commun., Vol. E84-B, No. 3, pp. 355-358, 2001.
- [2] J. Proakis, Digital Communications, 3rd Ed., New York:Mcgraw-Hill, 2002.
- [3] T. S. Rappaport, Wireless Communication Principles & Practice, Prentice Hall PTR Upper Saddle River, New Jersey, 1996.
- [4] M. Patzold, Mobile Fading Channels, John Wiley & Sons, INC., 2002.
- [5] M. K. Simon, and M. -S. Alouini, Digital Communication over Fading Channels, 1st Ed., New York:John Wiley & Sons, INC., 2000.
- [6] Ning Kong, Thomas Eng, and Laurence B. Milstein, " A Selection Combining Scheme for Rake Receivers, " Fourth IEEE International Conference on Universal Personal Commun. Record, pp. 426-430, 1995.

- [7] M. -S. Alouini, and M. K. Simon, "Dual Diversity over Correlated Log-Normal Fading Channels," *IEEE Trans. on Commun.*, Vol. 50, pp. 1946-1959, 2002.
- [8] M. Z. Win, and J. H. Winters, "Analysis of Hybrid Selection/Maximal-ratio Combining in Rayleigh Fading," *IEEE Trans. on Commun.*, Vol. COM-47, pp. 1773-1776, Dec. 1999.
- [9] Q. T. Zhang, and H. G. Lu, "A General Analytical Approach to Multi-Branch Selection Combining over Various Spatially Correlated Fading Channels," *IEEE Trans. on Commun.*, Vol. 50, pp. 1066-1073, 2002.
- [10] F. Adachi, M. T. Feeney, and J. D. Parsons, "Level Crossing Rate and Average Proc., Vol. 135, No. 6, pp. 11-17, 1988.
- [11] X. Dong, and N. C. Beaulieu, "Average Level Crossing Rate and Average Fade Duration of Selection Diversity," *IEEE Commun. Lett.*, Vol. 5, pp.396-398, 2001.
- [12] D. G. Brennan, "Linear Diversity Combining Techniques," *Proc. IRE*, Vol. 47, pp.1075-1101, 1959.
- [13] B. Sklar, "Rayleigh Fading Channels in Mobile Digital Communication systems. I.Characterization," *IEEE Commun. Magazine*, Vol. 35, pp. 90-100, 1997.
- [14] W. C. Jakes, *Microwave Mobile Communication*, New York, NY:IEEE Press,1993.
- [15] C. D. Iskander, and P. T. Mathiopoulos, "Analytical Level Crossing Rate and Average Fade Durations for Diversity Techniques in Nakagami Fading Channels," *IEEE Trans. on Commun.*, Vol. 50, No. 8, pp. 1301-1309, 2002.
- [16] M. Patzold, and F. Laue, "Level-Crossing Rate and Average Duration of Fades of Deterministic Simulation Models for Rice Fading Channels," *IEEE Trans. On Veh. Tech.*, Vol. 48, No. 4, pp. 1121-1129, 1999.
- [17] L. Yang, and M. S. Alouini, "An Exact Analysis of the Impact of Fading Correlation on the Level Crossing Rate and Average Outage Duration of Selection Combining," *IEEE Trans. on Commun.*, Vol. 51, Issue 12, pp. 1997-2000, 2003.
- [18] Y. Chen, and C. Tellambura, "Performance Analysis of Three-branch Selection Combining over Arbitrarily Correlated Rayleigh-Fading Channels," *IEEE Trans. on Wireless Commun.*, Vol. 4, pp. 861-865, 2005.
- [19] T. T. Tjhung, and C. C. Chai, "Fade Statistics in Nakagami-Lognormal Channels," *IEEE Trans. on Commun.*, Vol. 47, No. 12, pp. 1769-1772, 1999.
- [20] M. Yacoub, J. Bautista and L. de R. Guedes, "On Higher Order Statistics of the Nakagami-m Distribution," *IEEE Trans. on Veh. Tech.*, Vol. 48, pp. 790-794, 1999.
- [21] N. C. Sagias, and G. K. Karagiannidis, "Performance of Dual Selection Diversity in Correlated Weibull Fading Channels," *IEEE Trans. on Commun.*, Vol.52, No.7, pp. 1062-1067, 2004.
- [22] J. I. -Z. Chen, "Evaluation for Average LCR and AFD of Dual MRC and SC Diversity over Correlated Nakagami-m Environments," *Journal of Marine Science and Technology*, (Accept), 2006.
- [23] J. I. -Z. Chen, "Average LCR and AFD for SC diversity over Correlated Weibull Fading Channels," *International Journal Wireless Personal Commun.*, Vol. 39, No. 2, pp. 151-163, Oct. 2006.
- [24] W.C. Jakes, "Microwave Mobile Communication." New York, NY IEEE Press,1993.
- [25] G.L. Stuber, "Principles of Mobile Communication." Boston, MA:Kluwer,1996.
- [26] F. Adachi, M. T. Feeney and J. D. Parsons, "Level Crossing Rate and Average Fade Duration for Time Diversity Reception in Rayleigh Fading Conditions," *IEEE Proc.*, Vol. 135, Pt. F, No. 6, Dec. 1988.
- [27] L. Yang and M. S. Alouini, "An Exact Analysis of the Impact of Fading Correlation on the Level Crossing Rate and Average Outage Duration of Selection Combining," *IEEE Trans. Veh. Technol.*, Vol. 1, pp. 241-245, Apr.2003.
- [28] X. Dong and N. C. Beaulieu, "Level Crossing Rate and Average Fade Duration of Selection Diversity," *IEEE Commun. Lett.*, Vol. 5, pp.396-398, Oct. 2001.
- [29] T. T. Tjhung and C. C. Chai, "Fade Statistics in Nakagami-Lognormal Channels," *IEEE Trans. Commun.*, Vol. 47, No. 12, pp. 1769-1772, Dec. 1999.
- [30] N. C. Sagias and G.. K. Karagiannidis, "Performance of Dual Selection Diversity in Correlated Weibull Fading Channels," *IEEE Tran. on Commun.*, Vol.52, No.7, pp. 1063-1067, July 2004.
- [31] Joy long-Zong Chen, "Evaluation for Average LCR and AFD of Dual MRC and SC Diversity over Correlated Nakagami Environments," *Wireless Personal Communications*, to be published, 2005.
- [32] Matthias Patzold, "Mobile Fading Channel." Wiley, pp.3-7, 2002.
- [33] B. Sklar, "Digital Communications:Fundamental and Applications." Prentice-Hall PTR, New Jersey, 1988.
- [34] K. Feher, "Wireless Digital Communications : Modulation and Spread Spectrum Applications." Prentice Hall PTR, New Jersey, 1995.
- [35] T. S. Rappaport, "Wireless Communications Principles and Practice." PrenticeHall PTR, New Jersey, 1996.
- [36] J. G. Proakis, "Digital Communications." 3rd ed., McGraw-Hill, New York,1995.
- [37] Yacoub, M. D., "Foundations of Mobile Radio Engineering", CRC Press Inc,1993.
- [38] Suzuki, H., "A Statistical Model for Urban Radio Propagation", *IEEE trans.Commun.*, Vol. 27, No. 4, pp. 657-670, Apr. 1979.
- [39] Nakagami, M., "The m-distribution – A Formula of Intensity Distribution of Rapid Fading in Statistical Methods in Radio Wave

Propagation, " W. G. Hoffman Ed., Oxford, England: Pergamon Press, 1960.

[40] I. S. Gradshteyn and I. M. Ryzhik, " Table of Integrals, Series, and Products, 5th ed. " New York: Academic, 1994.

[41] K. Bury, " Statistical Distribution in Engineering " , Cambridge, U.K: Cambridge Univ. Press, 1999.

[42] J. C. Lu and G. K. Bhattacharyya, " Some New Constructions of Bivariate Weibull Models, " Ann. Inst. Stat. Math, Vol. 42, No.3, pp. 543-559, 1990.

[43] S. Kotz, N. Balakrishnan and N. L. Johnson, " Continuous Multivariate Distributions. " Vol. 1: Model and Applications. New York: Wiley, 2000.

[44] A. Papoulis, " Probability, Random Variables, and Stochastic Processes, 3rd ed. " New York: McGraw-Hill, 1991.

[45] W. C. Y. Lee, " Statistical Analysis of the Level Crossing Rate and Duration of Fades of the Signal from an Energy Density Mobile Radio Antenna, " Bell System Technical Journal, Vol. 46, pp. 418, Feb. 1967.

[46] W. C. Y. Lee, " Mobile Communications Engineering-Theory and Applications, 2nd ED, " McGraw-Hill, 1998.

[47] A. Abdi, H. Allen Barger and M. Kaveh, " A Parametric Model for the Distribution of the Angle of Arrival and the Associated Correlation Function and Power Spectrum at the Mobile Station, " Submitted to IEEE Trans. Veh. Tech., Sep. 1999.

[48] W. C. Jakes, Jr., " Multipath Interference in Microwave Mobile Communications, " W. C. Jakes, Jr., Ed., New York: Wiley, pp. 17-78, 1974.

[49] M. Patzold, U. Killat and F. Laue, " An Extended Suzuki Model for Land Mobile Satellite Channels and Its Statistical Properties, " IEEE Trans, Veh. Tech., Vol. 47, pp. 617-630, 1998.

[50] N. Youssef, T. Munakata and M. Takeda, " Fade Statistics in Nakagami Fading Environments, " IEEE Int. Symp, Spread Spectrum Tech. Application, Mainz, Germany, pp. 1244-1247, 1996.

[51] Bodtmann W.F and Arnold H.W, " Fade Duration Statistics of a Rayleigh-Distributed Wave. " IEEE trans. on Commun, Vol. 30, pp. 54-549, 1982.

[52] Peterson. R. L., Ziemer, R. E., and Borth, D. E., " Introduction to Spread Spectrum Communications, " New York: McGraw-Hill, 1995.

[53] Brennan D. G., " Linear Diversity Combining Technique. " Proceeding of the IRE, Vol. 47, pp. 1075-1102, June 1959.

[54] Adachi, F., et al., " Effects of Correlated Fading on Level Crossing Rates and Average Fade Durations with Predetection Diversity Reception. " IEE Proc. 135 (1), pp. 11-17, Feb. 1988.

[55] Q. T. Zhang and H. G. Lu, " A General Analytical Approach to Multi-Branch Selection Combining over Various Spatially Correlated Fading Channels, " IEEE Trans. on Commun., Vol. COM-50, pp. 1066-1073, July 2002.

[56] A. A. Abu-Dayya, and N. B. Beaulieu, " Microdiversity on Rician Fading Channels ", IEEE Trans. on Commun., Vol. 42, pp. 2258-2267, 1994.

[57] S. W. Halpern, " The Effect of Having Unequal Branch Gains in Practical Predetection Diversity System for Mobile Radio " , Vol. VT-26, No. 1, pp. 94-105, 1977.

[58] Y. Chen, and C. Tellambura, " Performance of L-Branch Diversity Combiners in Equally Correlated Rician Fading Channels " , IEEE Global Telecommunications Conference, Vol. 5, pp. 3379-3383, Dec. 2004.