

# 新世代寬頻智慧型天線系統應用於行動通訊

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## 摘要

本論文中，吾研究了移相陣列天線的理論與綜合研究方法，來設計多波束智慧型天線系統，它是由寬頻共平面觸角領結陣列天線、水平波束成型器及垂直波束成型器所組成，適合用在第四代寬頻智慧型天線系統於行動通訊基地台。此智慧型天線系統可產生多波束在方位角上，來減少同頻干擾。此智慧型天線系統為達到好的涵蓋區域與較佳的增益，而產生窄波束和傾斜波束在垂直面上。為了證明此智慧型天線系統的功能，吾共利用了三種量測系統來量測驗證，第一種為室內頻域量測系統、第二種為室外電子脈衝時域量測系統、第三種為專業智慧型天線系統測試平台。此智慧型天線系統獲得的量測天線場型與資料結果都與事先所計算、模擬的相吻合；吾實際驗證此智慧型天線系統，吾同時也精心建立與連結可控制的LabVIEW電腦軟體介面來調變運作行動通訊系統，並量測此智慧型天線系統的通訊品質。也就是運用了專業智慧型天線系統測試平台實測於GSM與WCDMA行動通訊中，且實測此智慧型天線系統使用中的EVM值。此智慧測u系統實際的被研發出來，用於GSM與WCDMA行動通訊基地台，且具有寬頻、線性垂直極化、傾斜波束、窄波束場型及八個波束方向掃描功能。

關鍵詞：智慧型天線系統；觸角領結陣列天線；多波束天線；多重路徑；巴特勒矩陣；均勻功率分配器；波束切換陣列天線；波束成型器

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## 參考文獻

- [1] D.C. Chang, S.H. Jou, J.W. Chen, C.C Wu, Y.S. Chen, " Smart Antenna System for GSM and WCDMA, " 2003 Asia-Pacific Microwave Conference (APMC '03) in Seoul, November.2003 [2] Dau-Chyrh Chang and Shin-Huei Jou, " The study of Butler Matrix BFN for Four Beams Antenna System. " 2003 IEEE AP-S International Symposium and USNC /CNC/ URSI National Radio Science Meeting [3] Shau-Gang Mao, Member, IEEE, Chih-Mying Chen, and Dau-Chyrh Chang, Senior Member, IEEE, " Modeling of Slow-Wave EBG Structure for Printed-Bowtie Antenna Array " 124 IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, VOL. 1, 2002 [4] Southworth, G. C., " Certain Factors Affecting the Gain of Directive Antenna Arrays, " Proc. IRE, Vol. 18, Sept. 1930, pp. 1502-1536.---Equ. (2.1.1.1)~ Equ. (2.1.1.2) [5] Hansen, R. C., " Linear Arrays, " in Handbook of Antenna Design, A. W. Rudge et al., Eds., IEEE/Peregrinus, 1983, Chapter 9.---Equ. (2.1.2.1)~ Equ. (2.1.2.6) [6] Mailloux, R. J., Phased Array Antenna Handbook, Artech House, 1994. ---Equ. (2.1.4.1)~ Equ. (2.2.1.5) [7] Diamond, B. L., " A Generalized Approach to the Analysis of Infinite Planar Array Antennas, " Proc. IEEE, Vol. 56, Nov. 1968, pp. 1837-1850. ---Equ.(2.4.1)~ Equ.(2.4.5) [8] Oliner, A. A. and Malech, R. G., " Mutual Coupling in Infinite Scanning Arrays, " in Microwave Scanning Antennas, Vol. , R.C. Hansen, Ed., Academic Press, 1966 [Peninsula Publishing,1985], Chapter 3. ---Equ. (2.4.6) [9] Catedra, M. F. et al. The CGT-FFT Method Application of Signal Processing Techniques to Electromagnetics, Artech House, 1995. ---Equ.(2.4.7)~ Equ.(2.4.12) [10] Luebbers, R. J. and Munk, B. A., " Cross Polarization Losses in Periodic Arrays of Loaded Slots, " Trans. IEEE, Vol. AP-23, Mar.1975, pp. 159-164. ---Equ. (2.4.13)~ Equ. (2.4.14) [11] Munk, B. A. and Burrell, G. A., " Plane-Wave Expansions for Arrays of Arbitrarily Oriented Piecewise Linear Elements and Its Application in Determining the Impedance of a Single Linear Antenna in a Lossy Half-Space, " Trans. IEEE, Vol. AP-27, May 1979, pp. 331-343. ---Equ. (2.4.15) [12] Larson, C. J. and Munk, B. A., " The Broad-Band Scattering Response of Periodic Arrays, " Trans. IEEE, Vol. AP-31, May 1983, pp. 261-267. ---Equ. (2.4.16) [13] Wheeler, H. A., " The Grating-Lobe Series for the Impedance Variation in a Planar Phased-Array Antenna, " Trans. IEEE, Vol.AP-14, Nov. 1966, pp. 707-714. ---Equ. (3.2.1)~ Equ. (3.2.2) [14] Frazita, R. F., " Surface-Wave Behavior of a Phased Array Analyzed by the Grating-Lobe Series, " Trans. IEEE, Vol. AP-15, Nov.1967, pp. 823-824. ---Equ. (3.2.3) [15] Rhodes, D. R., " On a Fundamental Principle in the Theory of Planar Antennas, " Proc. IEEE, Vol. 52, Sept. 1964, pp.013-1021.---Equ. (3.2.4) [16] Schelkunoff, S. A. and Friis, H. T., Antenna Theory and Practice, Wiley, 1952, pp. 368, 401. ---Equ. (3.3.1)~ Equ. (3.3.2) [17] Hansen, R. C. and Brunner, G., " Dipole Mutual Impedance for Design of Slot Arrays, " Microwave J., Vol. 22, Dec. 1979, pp. 54-56. ---Equ. (3.3.3)~ Equ. (3.3.5) [18] Hansen, R. C., " Formulation of Echelon Dipole Mutual Impedance for Computer, " Trans. IEEE, Vol. AP-20, Nov. 1972, pp. 780-781. ---Equ.(3.3.6)~ Equ.(3.3.7) [19] Hansen, P. W., " The Element-Gain Paradox for a Phased Array Antenna, " Trans. IEEE, Vol. AP-12, July 1964, pp. 423-433. ---Equ. (5.1.1.1)~ Equ. (5.1.1.11).
- [20] Oliner, A. A. and Malech, R. G., " Mutual Coupling in Infinite Scanning Arrays, " in Microwave Scanning Antennas, Vol. , R. C. Hansen, Ed., Academic Press, 1966 [Peninsula Publishing, 1985]. ---Equ. (5.1.1.12) [21] Diamond, B. L., " A Generalized Approach to the Analysis of Infinite Planar Array Antennas, " Proc. IEEE, Vol. 56, Nov. 1968, pp. 1837-1850. ---Equ. (5.1.2.1)~ Equ. (5.1.2.3) [22] Whittaker, E. T. and Watson, G. N., Modern Analysis, 4th ed., Cambridge University Press, 1952. ---Equ. (6.1.1)~ Equ. (6.1.6) [23] Hansen, R. C., " Comparison of Square Array Directivity Formulas, " Trans. IEEE, Vol. AP-20, Jan. 1972a, pp. 100-102. ---Equ. (6.1.7) [24] Hansen, R. C., Microwave Scanning Antennas, Vol. 1, Academic Press, 1964 [peninsula Publishing, 1985] ---Equ. (6.1.8)~ Equ. (6.1.9) [25] Sokolnikoff, I. S. and Sokolnikoff, E. S., Higher Mathematics for Engineers and Physicists, McGraw-Hill, 1941. ---Equ. (6.2.1) [26] Hansen, R. C., " Linear Arrays, " in Handbook of Antenna Design, A. W. Rudge et al., Eds., IEEE/Peregrinus, 1983. ---Equ. (6.2.2) [27] Day-Chyrh Chang, Ming-Hsiung Hu, Chih-Cheng Lai, " Development of Test Bed for Smart Antenna System, " Taiwan EMC conference, October.2003 ---Equ. (7.1.1)