以微控制器為基礎實現混合式步進馬達多軸多工隨機定位控制

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摘 要

在自動化控制中，步進馬達能以簡單的控制以及驅動來達成精確的定位。在解析度方面，則是取決於馬達的構造，一般兩相式混合型步進馬達為一步級1.8 ° 。而精度則是取決於馬達的加工精度而定，無負載時的停止精度誤差為±3分(±0.05 °)。在各種不同形式的步進馬達中，以混合式步進馬達的高效率與高轉矩的表現為最優異。 在本文中，我們將使用UDN2998雙全橋式馬達驅動用IC對兩相雙極型混合式步進馬達以兩相激磁方式與雙極性驅動法驅動馬達，在電流的控制方面則是採用定電流的驅動方式，使用LM393雙比較器IC與電流感測電阻進行電壓的比較，使電壓波形會隨著比較結果進行高低起伏的變化且電流會維持在一個定值，以達到脈寬調變(PWM)的效果。 在馬達的控制方面，使用MCS-51系列的組合語言進行馬達控制程式的編輯，以多軸多工的控制方式同時對數個馬達進行步數、轉速、正反轉的控制並搭配感測器以達成隨機定位。 關鍵字：混合型步進馬達、UDN2998雙全橋式馬達驅動用IC、兩相激磁、雙極性驅動法、定電流驅動、LM393雙比較器、脈寬調變(PWM)、MCS-51組合語言、多軸多工、隨機定位。

關鍵詞 : 混合型步進馬達、UDN2998雙全橋式馬達驅動用IC、兩相激磁、雙極性驅動法、定電流驅動、LM393雙比較器、MCS-51組合語言、脈寬調變、多軸多工、隨機定位

目錄

參考文獻

[1]Y. Kawase and K. Suwa, “ 3-D Dynamic Transient Analysis of stepping Motor for Wristwatch by Finite Element Method ” IEEE Transactions on Magnetics, Vol. 34, No. 5, September, 1998, pp. 3130-3133.

[2]W. D. Chen, K. L. Yung, and K. W. Cheng, “ A Learning Scheme for Low-Speed Precision Tracking Control of Hybrid Stepping Motors ” IEEE/ASME Transactions on Mechatronics, Vol. 11, No. 3, June 2006, pp.362-365.

[3]G. Amaratunga, K. W. Kwan, M. Tso, and D. Crawley, “ A Single-Chip CMOS IC for Closed-Loop Control of Step Motors ” IEEE Transactions on Industrial Electronics, Vol.36, No.4, November 1989, pp.539-544.

[4]W. D. Page, G. Singh, and B. C. Kuo, " Application of a Computer Control to a Study of Open-Loop Acceleration of Step Motors " Transactions on Industrial Electronics and Control, Instrumentation, Vol. IECI-22, No. 2, May 1975, pp.179-186.
[5]P. P. Acarnley, M. A., and P. Gibbons, " Closed-loop Control of Stepping Motors: Prediction and Realisation of Optimum Switching Angle " IEE Proc, Vol.129, Pt.B, No.4, July 1982, pp.211-216.
[6]F. Betin, D. Pinchon, and G. A. Capolino, " Fuzzy Logic Applied to Speed Control of a Stepping Motor Drive " IEEE Transactions on Industrial Electronics, Vol.47, No.3, June 2000, pp.610-622 [7] A. Bellini, C. Concari, G. Franceschini, and A. Toscani, " Mixed-Mode PWM for High-Performance Stepping Motors " IEEE Transactions on Industrial Electronics, Vol.54, No.6, December 2007, pp.3167-3177.
[8] T. S. Hwang, and J. K. Seok, " Observer-Based Ripple Force Compensation for Linear Hybrid Stepping Motor Drives " IEEE Transactions on Industrial Electronics, Vol.54, No.5, October 2007, pp.2417-2424.
[9] J. Tal, " Step Motor Control for Maximum Torque " IEEE Transactions on Automatic Control, April 1976, pp.224-227.
[10]S. E. de Lucena, and W. Kaiser, " Stepping-Motor-Driven Constant-Shear-Rate Rotating Viscometer " IEEE Transactions on Instrumentation and Measurement, Vol.57, No.7, July 2008, pp.1338-1343.
[11]A. P. Russell, and I. E. D. Pickup, " A Circuital Method for the Prediction of Pull-out Torque Characteristics of Hybrid Stepping Motors " IEE Proc., Vol.129, Ft. B, No.6, November 1982, pp.330-336.
[12]J. D. Wale, and C. Pollock, " A Low-Cost Sensorless Technique for Load Torque Estimation in a Hybrid Stepping Motor " IEEE Transactions on Industrial Electronics, Vol.46, No.4, August 1999, pp.833-841.
[13]J. K. Seok, and T. S. Hwang, " Cogging Force Reduction of Two-Phase Linear Hybrid Stepping Motor " IEEE Transactions on Magnetics, Vol.41, No.6, June 2005, pp.2202-2204.
[14]W. D. Chen, K. L. Yung and K. W. Cheng, " Profile Tracking Performance of a Low Ripple Hybrid Stepping Motor Servo Drive " IEE Proc. Pt.B Control Theory Appl., Vol.150, No.1, January 2003, pp.69-76.
[15]G. Singh, and B. C. Kuo, " Modeling and Simulation of Variable-Reluctance Step Motors with Application to a High-Performance Printer System " IEEE Transactions on Industry Applications, Vol.IA-11, No.4, July/August 1975, pp.373-383.
[16]K. B. Jang, S. Y. Lim, T. B. Lim, C. S. Jin, Y. H. Cho, Y. T. Kim, and J. Lee, " 2-D FE Analysis of Hybrid Stepping Motor Using Virtual Magnetic Barrier " IEEE Transactions on Magnetics, Vol.39, No.5, September 2003, pp.3268-3270.
[17]A. P. Russell, and I. E. D. Pickup, " Calculation of Pull-out Torque Characteristics of Hybrid Stepping Motors with Current-Regulating Drive Circuits " IEE Proc., Vol.133, Pt.B, No.6, November 1986, pp.341-346.
[18]S. M. Yang, and E. L. Kuo, " Damping a Hybrid Stepping Motor With Estimated Position and Velocity " IEEE Transactions on Power Electronics, Vol.18, No.3, May 2003, pp.880-887.
[19]D. W. J. Pulle, and A. Hughes, " Normalised High-speed Performance Analysis of Small Hybrid Stepping Motors " IEE Proc., Vol. 134, Pt. B, No. 6, November 1987, pp.333-338.
[20]T. Su, M. Ishida, and T. Hori, " Suppression Control Method for Torque Vibration of Three-Phase HB-Type Stepping Motor Utilizing Feedforward Control " IEEE Transactions on Industrial Electronics, Vol.49, No.4, August 2002, pp.896-904.
[21]K. C. Lim, J. P. Hong, and G. T. Kim, " Characteristic Analysis of 5-Phase Hybrid Stepping Motor Considering the Saturation Effect " IEEE Transactions on Magnetics, Vol.37, No.5, September 2001, pp.3518-3521.
[22]T. Miura, and T. Taniguchi, " Open-Loop Control of a Stepping Motor Using Oscillation-Suppressive Exciting Sequence Tuned by Genetic Algorithm " IEEE Transactions on Industrial Electronics, Vol.46, No.6, December 1999, pp.1192-1198.
[23]I. E. D. Pickup, and A. P. Russell, " Dynamic Instability in Permanent-magnet Synchronous/Stepping Motors " IEE Proc., Vol.134, Pt. B, No.2, March 1987, pp.91-100.
[24]J. C. Li, and G. C. Hsieh, " A Phase/Frequency-Locked Controller for Stepping Servo Control Systems " IEEE Transactions on Industrial Electronics, Vol.39, No. 2, April 1992, pp.112-119.
[25]J. TAL, " Control Modes of Step Motors " IEEE Transactions on Aerospace and Electronics Systems,Vol. 13, No. 1, January 1977, pp.56-61.
[26]D. I. Jones, and J. W. Finch, " Optimal Control of a Voltage-Driven Stepping Motor " IEE Proc., Vol. 130, Pt. D, No. 4, July 1983, pp.175-182.
[27]R. H. Brown, and M. Jaroudi, " Torque Prediction and Maximization Strategies for Bifilar-Wound Hybrid Step Motors " IEEE Transactions on Power Electronics, Vol.7, No.3, July 1992, pp535-541.
[28]D. Chen, and B. Paden, " Adaptive Linearization of Hybrid Step Motors: Stability Analysis " IEEE Transactions on Automatic Control, Vol.38, No.6, June 1993, pp.874-887.
[29]S. M. Yang, F. C. Lin, and M. T. Chen, " Micro-Stepping Control of a Two-Phase Linear Stepping Motor With Three-Phase VSI Inverter for High-Speed Applications " IEEE Transactions on Industry Applications, Vol.40, No.5, September/October 2004, pp.1257-1264.
[30]P. Krishnamurthy, and F. Khorrami, " Robust Adaptive Voltage-Fed Permanent Magnet Step Motor Control Without Current Measurements " IEEE Transactions on Control Systems Technology, Vol.11, No.3, May 2003, pp.415-425.
[31]B. C. Kuo, and G. Singh, " A DC-Type Hybrid Step Motor for Large Power Applications " IEEE Transactions on Industry Applications, Vol. IA.-11, No. 4, July/August 1975, pp.365-372.

[32]A. Masi, G. Conte, R. Losito, and M. Martino,“ DSP-Based Stepping Motor Drivers for the LHC Collimators ” IEEE Transactions on Nuclear Science, Vol. 55, No. 1, February 2008, pp.341-348.
[33]N. Matsui, M. Nakamura, and T. Kosaka,“ Instantaneous Torque Analysis of Hybrid Stepping Motor ” IEEE Transactions on Industry Applications, Vol. 32, No 5, September/October 1996, pp.1176-1182.
[34]T. Senjyu, and K. Uezato,“ Stability Analysis and Suppression Control of Rotor Oscillation for Stepping Motors by Lyapunov ’ s Direct Method ” IEEE Transactions on Power Electronics, Vol. 10, No. 3, May 1995, pp.333-339.
[35]J. Fetzer, S. Kurz, G. Lehner and W. M. Rucker,“ Transient BEM-FEM Coupled Analysis of 3-D Electromechanical Systems: A Watch Stepping Motor Driven by a Thin Wire Coil ” IEEE Transactions on Magnetics, Vol. 34, No. 5 , September 1998, pp3154-3157.
[36]T. R. Fredriksen,“ Applications of the Closed-Loop Stepping Motor ” IEEE Transactions on Automatic Control, Vol. AC-13, No. 5, October 1968, pp.464-474.
[37]T. Ishikawa, M. Matsuda, and M. Matsunami,“ Finite Element Analysis of Permanent Magnet Type Stepping Motors ” IEEE Transactions on Magnetics, Vol. 34, No. 5, September 1998, pp.3503-3506.
[38]V. V. Athani, and J. G. Mundhada,“ High-Performance Translator for a High-Torque PM Stepping Motor ” IEEE Transactions on Industrial Electronics and Control Instrumentation, Vol. 25, No. 4, November 1978, pp.343-346.
[39]王文金，“ 步進馬達簡介與應用 ”，電機月刊，第15卷，第6期，pp.176-184, 2005。
[40]林政彥，“ 步進馬達原理及應用 ”，機械月刊，第29卷，第1期，pp.51-61, 2003。
[41]郭益郎、楊勝明，“ 混合式步進馬達之主動式阻尼控制 ”，機械月刊，第36卷，第6期，pp.47-53, 2004。
[42]李文猶，“ 多軸控制器規劃與設計 ”，電機月刊，第15卷，第6期，pp.152-161, 2005。
[43]見城尚志、新村佳久(許溢适編譯)，“ 步進馬達原理與應用 ”，頁80-86，全華科技圖書股份有限公司，台北。
[44]海老原大樹、岩佐孝夫(陳熹棣編譯)，“ 步進馬達應用技術 ”，頁73-74，全華科技圖書股份有限公司，台北。
[45] 林錫寬，“ 步進馬達單晶片精密速度控制 ”， e科技雜誌，Vol.52, April 2005。