High-precision Position and Contour Tracking Control for Two-axis Linear Motor Drives

徐浚庭、陳昭雄

E-mail: 386816@mail.dyu.edu.tw

ABSTRACT

This thesis proposes an intelligent cross-coupled controller for the trajectory tracking of two-axis permanent magnet linear synchronous motor (PMLSM) driver systems. Based on the basic crossed-coupled configuration, a cross-coupled controller is firstly designed by using the fuzzy logic system. A mathematical formula is then derived to calculate contouring errors that is fed to the proposed intelligent cross-coupled controller. The contouring errors are immensely reduced to complete the high-precision tracking performance through synchronously compensating the contour-tracking errors in each axis of PMLSM drive systems. The experimental setup is comprised by a host computer, two servo control boards, two motor drivers and a two-axis PMLSM table. The proposed control algorithm is implemented using Microsoft Visual C++. Finally, experiments on a practical two-axis PMLSM table confirm the effectiveness of the proposed methods.

Keywords : permanent magnet linear synchronous motor、cross-coupled control、contouring error、fuzzy control

Table of Contents

REFERENCES

[1]C.L. Lin and H.T. Huang,“ Linear servo motor control using adaptive neural networks, ” Proc Instn Mech Engrs Part I: J Systems and Control Engineering, vol. 216, pp.407-427, 2002.

[2]E. Kim, and S.G. Lee,“ Output feedback tracking control of MIMO systems using a fuzzy disturbance observer and its application to the speed control of a PM synchronous motor, ” IEEE Trans. Fuzzy Systems, vol. 13, no. 6, pp. 725-741, 2005.

[3]F.J. Lin, C.H. Lin and P.K. Huang,“ Recurrent fuzzy neural network controller design using sliding-mode control for linear synchronous motor drive, ” IEE Proc. Control Theory Appl., vol. 151, no. 4, pp. 407-416, 2004.

[4]F.J. Lin, P.H. Shen, S.L. Yang, and P.H. Chou,“ Recurrent radial basis function network-based fuzzy neural network control for permanent-magnet linear synchronous motor servo drive, ” IEEE Trans. Magnetics, vol. 42(11), pp. 3694-3705, 2006.

[5]F.J. Lin, P.H. Chou, P.H. Shieh, and S.Y. Chen,“ Robust control of an LUSM-based X – Y – θ motion control stage using an adaptive interval type-2 fuzzy neural network, IEEE Trans. Fuzzy Systems, vol. 17, no. 1, pp. 24-38, 2009.

[6]G.W. Younkin, W.D. Mcglasson, and R.D. Lorenz,“ Considerations for low-inertia Ac drives in machine tool axis servo applications, ” IEEE

Trans. Industry Applications, vol. 27, no. 2, p.p. 262-267, 1991.
[7]H.Y. Chuang and C.H. Liu, A model-referenced adaptive control strategy for improving contour accuracy of multiaxis machine tools, ” IEEE Trans. Industry Applications, vol. 28, no.1, pp. 22 1-227, 1992.
[8]R.J. McNab and T.C. Tsao, “ Receding time horizon linear quadratic optimal control for multiaxis contour tracking motion control, ” ASME J. of Dynamic Systems, Measurement, and Control, vol. 122, pp. 375-381, 2000.
[9]T.C. Chiu and M. Tomizuka, “ Contouring control of machine tool feed drive systems: a task coordinate frame approach, ” IEEE Trans. Control System Technology, vol. 9, pp. 130-139, 2001.
[10]Y.T. Shih, C.S. Chen, A.C. Lee, “ A novel cross-coupling control design for Bi-axis motion, ” International Journal of Machine Tools & Manufacture, vol. 42,1539 – 1548, 2002.
[11]K.Y. Zhu and B.P. Chen, “ Cross-coupling design of generalized predictive control with reference models, “ Proc InstnMech Engrs Part I, vol 215, pp. 375-384, 2001.
[12]Z.Z. Liu, F.L. Luo, and M.A. Rahman, “ Robust and precision motion control system of linear-motor direct drive for high-speed X – Y table positioning mechanism, ” IEEE Trans. Industrial Electronics, vol. 52, no. 5, pp. 1357-1363, 2005.
[13]K. Huh, S. Han, and B. Lee, “ Non-linear adaptive control of a linear-motor-driven X – Y table via estimating friction and ripple forces, ” Proc. IMechE Part C: J. Mechanical Engineering Science, vol. 222, pp.911-918, 2008.
[14]K.L. Barton and A.G. Alleyne, “ A Cross-Coupled Iterative Learning Control Design for Precision Motion Control, ” IEEE Trans. Control Systems Techn., vol. 16, no. 6, pp. 1218-1231, 2008.
[15]蔡凱宸（民95）， “ 以DSP為控制架構之線性馬達驅動系統之研究 ”，大葉大學，機電自動化研究所，碩士論文。
[16]林法正，魏榮宗（民91）， “ 電機控制 ”，頁284-290，滄海書局。
[17]劉昌煥（民94）， “ 電動機控制：向量控制與直接轉矩控制原理 ”，東華書局。
[18]R.D Lorenz, and P.B. Schmidt, “ Synchronized motion control for process automation, ” Proceedings of the 1989 IEEE Industry Applications Annual Meeting, pp. 1693-1698,1989.
[19]Y. Koren, “ Cross-coupled biaxial computer for manufacturing systems, ” ASME Journal of Dynamic Systems, Measurement and Control. Vol. 102, no. 4, pp. 265-272, 1980.
[20]楊英魁（2002）， “ 模糊控制理論與技術 ”，全華。
[21]王進德、蕭大全（1994）， “ 類神經網路與模糊控制理論入門 ”，全華。
[22]王文俊（2005）， “ 認識Fuzzy-第三版 ”，全華。