Design and Implementation of a DC Brushless Motor Drive

黃文伸、陳盛基

E-mail: 387149@mail.dyu.edu.tw

ABSTRACT

In this study, we present a design method of a permanent magnet brushless DC motor drive. The architecture includes a bridge rectifier circuit from AC to DC, an inverter for motor operation, and PWM signal modulation for speed control. The control kernel uses a microcontroller combining analog and digital control technology to adjust the PWM module. This study integrates brushless DC motor control and drive module design. The driver has been successfully used in 750W PMBLDCM for industry applications. The motor are tested based on a dynamometer testing system, waveforms under applying nominal load are measured at rated speed 4200rpm. The experimental results show that the motor drive system has good performance.

Keywords : Permanent magnet brushless DC motor、Inverter、Motor driver

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REFERENCES

[1] 王秀和，「永磁電機」，中國電力出版社，2007。

[2] 孫清華，「最新直流無刷馬達」，全華科技圖書，2001。

[3] D. C. Hanselman,“ Brushless Permanent Magnet Motor Design, ” Second Edition, 2003.

[4] Ward Brown,“ Brushless DC Motor Control Made Easy, ” Microchip Technology, 2002.

[5] 何禮高，「DSPIC30F電機與電源系列數字信號控制器原理與應用」，北京航空航天大學，2007。

[6] 劉和平、鄭群英、江渝、劉力、劉淑春，「DSPIC通用數字信號控制器原理與應用」，北京航空航天大學，2007。

[7] 曾百由，「數位訊號控制器原理與應用」，宏友出版社，2007。

[8] Daniel Torres,“ Sensorless BLDC Control with Back-EMF Filtering Using a Majority Function, ” Microchip Technology, 2008.

[9] Charlie Elliott,“ Using the DSPIC30F for Sensorless BLDC Control, ” Microchip Technology, 2004.

[10] N. Bianchi, S. Bolognani, J.H. Jang, S.K. Sul,“ Comparison of PM Motor Structures and Sensorless Control Techniques for Zero-Speed Rotor Position Detection, ” IEEE Trans. On Power Electron, vol. 22, no. 6, pp. 2466-2475, 2007.

[11] H. C. Chen, Y. C. Chang, C. K. Huang,“ Practical Sensorless Control for Inverter-Fed BDCM Compressors, ” IET Electron. Power Appl, vol. 1, pp. 127-132, 2007.

[12] B. Fahimi, A. Emadi, B. Jr.Sepe,“ Position Sensorless Control, ” IEEE Ind. Appl. Magazine, vol. 10, no. 1, pp. 40-47, Jan-Feb 2004.

[13] H. B. Wang, H. P. Liu,“ A Novel Sensorless Control Method for Brushless DC Motor, ” IET Electron. Power Appl, vol. 3, no. 3 , pp. 240-246, May 2009.
[14] A. Ward,“ The Electric Car: Development and Future of Battery, Hybrid and Fuel-Cell Cars, ” IEEE Review, vol. 48, no. 3, pp. 14, 2002.
[15] M. Ehsani, Y. Gao, And K. L. Butler,“ Application of Electrically Peaking Hybrid (Elph) Propulsion System to a Full-Size Passenger Car with Simulated Design Verification, ” IEEE Transactions on Vehicular Technology, vol. 48, no. 6, pp. 1779-1787, 1999.
[16] M. H. Rashid, Power Electronics: Circuits, Devices, and Applications, Prentice-Hall, 1993.
[17] D. C. Hanselman, Brushless Permanent-Magnet Motor Design, Mcgraw- Hill, 1994.
[18] J. M. Fiore, Op Amps and Linear Integrated Circuits, Delmar, 2001.
[19] 簡凌峰，永磁式同步馬達電流及轉速與弱磁控制之設計與DSP 單晶片實現，交通大學電機與控制工程學系碩士論文，1999。
[20] C. S. John,“ PWM Hybrid Inverter Drive Circuit Topologies that Employ a Dual Voltage and Current DC-Link, ” IEEE Transactions on Industry Applications, vol. 30, no. 3, pp. 707-716, 1994.
[21] D. N. Essah, R. M. O'connell, and R. S. Wallace,“ Design and Test of a Variable Topology Converter for Electric Motor Drive Applications, ” Industry Applications Conference on Thirty-First IAS Annual Meeting of IEEE, vol. 1, pp. 54-59, 1996.
[22] S. K. Biswas, B. Basak, and K. S. Rajashekara,“ Gate Drive Methods for IGBTS in Bridge Configurations, ” Industry Applications Conference on 79 Society Annual Meeting of IEEE, vol. 2, pp. 1310-1316, 1996.
[23]W. C. Wu, C. Y. Fan, Y. J. Wang, Y. A. Wang, and X. Q. Cui,“ SEM Investigation on IGBT Latch-Up Failure, ” 6th International Solid-State and Integrated-Circuit Technology Conference, vol. 2, pp. 1040-1042, 2001.
[24] H. R. Chang, and B. J. Baliga,“ 500-V N-Channel Insulated-Gate Bipolar Transistor with a Trench Gate Structure, ” IEEE Transactions on Electron Devices, vol. 36, no. 9, Part 2, pp. 1824-1829, 1989.
[25] M. J. Duta, and E. Cretu,“ Investigations of Avalanche Dynamics In IGBTS, Bipolar GTOS and MCTS, ” 17th International Telecommunications Energy Conference, vol. 2, pp. 340-345, 1995.
[26] T. P. Chow, B. J. Baliga, and D. N. Pattanayak,“ Counterdoping of MOS Channel (Cdc)-A New Technique Of Improving Suppression of Latching in Insulated Gate Bipolar Transistors, ” IEEE Electron Device Letters, vol. 9, no. 1, pp. 29-31, 1988.
[27] M. Mori, Y. Nakano, and T. Tanaka,“ An Insulated Gate Bipolar Transistor with a Self-Aligned DMOS Structure, ” Technical Digest on Electron Devices Meeting of IEEE, pp. 813-816, 1988.
[28] S. T. Chen, T. A. Lipo, and D. Fitzgerald,“ Modeling of Motor Bearing Currents in PWM Inverter Drives, ” IEEE Transactions on Industry Applications, vol. 32, no. 6, pp. 1365-1370, 1996.
[29] F. Klotz, J. Petzoldt, and H. Volker,“ Experimental and Simulative Investigations of Conducted EMI Performance of IGBTS for 5-10 Kva Converters, ” 27th Annual IEEE Power Electronics Specialists Conference, vol. 2, pp. 1986-1991, 1996.
[30] 陳伯宏 編譯, 電磁干擾與防止對策, 文笙書局, 1996.
[31] S. Chen,“ Generation and Suppression of Conducted Emi from Inverter-Fed Motor Drives, ” Industry Applications Conference on 34th IAS Annual Meeting of IEEE, vol. 3, pp. 1583-1589, 1999.
[32] S. Ogasawara, H. Ayano, and H. Akagi,“ Measurement and Reduction of EMI Radiated by A PWM Inverter-Fed AC Motor Drive System, ” IEEE Transactions on Industry Applications, vol. 33, no. 4, pp. 1019-1026, 1996.
[33] S. Takizawa, S. Igarashi, and K. Kuroki,“ A New Di/Dt Control Gate Drive Circuit for IGBTS to Reduce EMI Noise and Switching Losses, ” 29th Annual IEEE Power Electronics Specialists Conference, vol. 2, pp. 1443-1449, 1998.
[34] Chapman, Stephen J, Electric Machinery Fundamentals, 4/E, Mc Graw-Hill, 2005.
[35] 孫立志，「PWM與數字化電動機控制技術應用」，中國電力出版社，2008。
[36] 曾智堂，「永磁直流無刷馬達無感測控制技術之研究」，碩士論文，私立大葉大學，電機工程學系，2010。
[37] 陳伯龍，「改良式反電動勢偵測法之直流無刷馬達無感測控制」，碩士論文，私立大葉大學，電機工程學系，2012。
[38] Pragasen Pillay, Ramu Krishnan,“ Modeling, Simulation, and Analysis of Permanent-Magnet Motor Drives, Part Ii: The Brushless DC Motor Drive, ” IEEE Transactions on Industry Applications, vol. 25, no. 2, March/April 1989.
[39] N. Mohan, T. M. Undeland, and W. P. Robbins, Power Electronic, Converters, Applications and Design, 3th, Wiley, New York, USA, 2002.
[40] Christopher T. Kilian, Modern Control Technology, Components and Systems, 3th, Delmar Pub, 2005.
[41] 楊昌憲，「具智慧型保護機制之高功率馬達驅動器設計」，碩士論文，國立交通大學，電機與控制工程學系，2002。
[42] IR2101“ Control Integrated Circuit Designers Manual, ” Data Sheet no. pd-6.043c, International Rectifier.
[43] IRFP460n“ Control Integrated Circuit Designers Manual, Data Sheet no. pd-94098, International Rectifier.
[44] dsPIC30f4011/4012 Data Sheet – Microchip.