An Improved Back-EMF Detection Method Of Sensorless Control On Brushless DC Motor

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ABSTRACT

In this paper, the back-EMF detection method of sensorless control on permanent magnet brushless DC motor (PMBLDC) was studied. The control unit adopts Microchip 33FJ32MC204 chip that is special purpose design. The chip combines analog and digital control and PWM module all in one chip. It is suitable for brushless DC motor sensorless control and design of power module drive. For the sensorless control, detecting the zero-crossing points of the back-EMF was based on motor terminal voltage and neutral voltage to compare. A digital filter was confirmed the zero-crossing points signal of the back-EMF and achieve the commutation of sensorless control on PMBLDCM. According to starting program, the motor is running in open-loop operation. When the motor speed increases to a certainly large enough value to detect the zero-crossing signal of the BEMF, then the controller got into the sensorless control using PWM signal to achieve the motor speed control. The sensorless control is not required external any position sensors so that the motor drive circuit reduce cost and size by using the digital filter. The PMBLDCM also have a wide range of speed control applications.

Keywords : Permanent magnet brushless DC motor、Back-EMF、sensorless control、Pulse width modulation

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REFERENCES

[1]梁賢達、黃惠容，＂電工機械II＂，台科大圖書，2009。

[2]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。

[3]黃冠霖，＂無刷直流馬達驅動器之設計與製作＂，碩士論文，私立逢甲大學，電機工程學系，2009。

[4]陳融生，＂無量測器直流無刷馬達控制系統設計與製作＂，碩士論文，國立台灣科技大學，電機工程學系，2003 [5]詹晉榮，＂直流無刷馬達驅動系統實務設計＂，碩士論文，私立大葉大學，電機工程學系，2003。

[6]孫清華，「最新直流無刷馬達」，全華科技圖書，2001。

[7]Ward Brown,＂Brushless DC motor control made easy,＂ Microchip Technology, 2002.

[8]吳大偉、王漢?、謝宗煌、吳清章，＂電機機械＂，文京圖書有限公司，1995.

[9]J. X. Shen, and K. J. Tseng,“ Analyses and compensation of rotor position detection error in sensorless PM brushless DC motor drives, ” IEEE Trans on Energy Conversion, vol. 18, no. 1, 2003.
[10]C. Elliott and S. Bowling,“ Using the dsPIC30F for Sensorless BLDC Control, ” Microchip Technology, 2004.
[11]K. Uzuka and Uzuhashi et al.,“ Microcomputer control for sensorless brushless motor, ” IEEE Trans on Industry Application,vol. IA-21, no. 4, 1985.
[12]P. Damodharan, Krishna Vasudevan,“ Indirect Back-EMF Zero Crossing Detection for Sensorless BLDC Motor Operation, ” IEEE Conference, 2005.
[13]C. H. Chen and M. Y. Cheng,“ A new sensorless commutation drive for brushless DC motors and alternators, ” IEEE ISIE, 2006.
[14]C. H. Chen and M. Y. Cheng,“ A new cost effective sensorless commutation without phase shift circuit and neutral voltage, ” IEEE vol. 22, no. 2, 2007.
[15]P. Damodharan and Krishna Vasudevan,“ Sensorless brushless DC motor drive based on the zero-crossing detection of back electromotive Force (EMF) from the line voltage difference, ” IEEE Trans on Energy Conversion, vol. 25, no. 3, 2010.
[16]Jianwen Shao, Dennis Nolan, Maxime Teissier, and David Swanson ,“ A novel microcontroller-based sensorless brushless DC (BLDC) motor drive for automotive fuel pumps, ” IEEE Trans on Industry Application, vol. 39, no. 6, 2003.
[17]R. C. Becerra, T. M. Jahns, and M. Ehsani,“ Four-Quadrant sensorless Brushless ECM drive, ” IEEE Conference,1991.
[18]Jianwen Shao, Dennis Nolan, and Thomas Hopkins“ A novel direct back EMF detection for sensorless brushless DC (BLDC) motor drives, ” IEEE Conference, 2002.
[19]Jianwen Shao,“ An improved microcontroller-based sensorless direct back EMF detection for sensorless brushless DC (BLDC) motor drives for automotive applications, ” IEEE Trans on Industry Application, vol. 42, no. 5, 2006.
[20]林政達，”以反電動勢零交越點為基礎之直流無刷馬達無感測控制器之設計與實現”，碩士論文，國立台灣科技大學，電機工程學系，2006。
[21]陳柏勳，”具相位超前之無刷馬達無感測控制系統”，碩士論文，國立成功大學，系統及船舶機電工程學系，2007。
[22]J. C. Moreita,“ Indirect sensing for rotor flux position of permanent AC motor operating in a wide speed rang, ” IEEE Industry Applications Society Annual Meeting, 1996.
[23]J. X. Shen, Z. Q. Zhu,“ Sensorless control of ultrahigh-speed PM brushless motor using PLL and third harmonic back EMF, ” IEEE Trans on Industry Applications, vol.40, no. 6, 2004.
[24]S. Ogasawara and H. Akagi,“ An approach to position sensorless drive for brushless dc motor, ” IEEE Transactions on Industry Applications, vol. 27, no. 5, 1991.
[25]C. M. Uang, Z. S. Ho, P. C. Wang, S.H. Liu,“ Sensorless position optimal control strategy of brushless DC motor, ” IEEE PEDS, 2011.
[26]M. B. B. Sharifian, T. Herizchi and K. G. Firouzjah,“ Field oriented control of permanent magnet synchronous motor using predictive space vector modulation, ” IEEE Symposium on Industrial Electronics and Applications, vol. 2, pp.574-579, 2009.
[27]X. Wang, R. Na and N. Liu,“ Simulation of PMSM field-oriented control based on SVPWM, ” IEEE Vehicle Power and Propulsion Conference, pp. 1465-1469, 2009.
[28]J. Zambade and D. Ded,“ Sensorless field oriented control of PMSM ”, Microchip Technology, 2010 [29]洪琮閔，”永磁無刷直流馬達無感測磁場導向控制”，碩士論文，私立大葉大學，電機工程學系，2010。
[30]T.Y. Kim and J. Lyou,“ Commutation instant detector for sensorless drive of BLDC motor, ” Electronics Lettets 10th, vol. 47, no. 23, 2011.
[31]D. K. Kim, K. W. Lee, and B.I. Kwon, ” Commutation torque ripple reduction in a position sensorless brushless DC motor drive, ” IEEE Transactions on Power Electronics, vol. 21 no. 6,2006.
[32]J. X. Shen,“ Sensorless control of ultrahigh-speed PM brushless motor using PLL and third harmonic back EMF, ” IEEE Trans on Industry Electronics, vol. 53, no. 2, 2006.
[33]G. H. Jang and M. G. Kim,“ Optimal commutation of a BLDC motor by utilizing the symmetric terminal voltage, ” IEEE Trans on Magnetics, vol. 42, no. 10, 2006.
[34]Yuanyuan Wu, Zhiquan Deng, Xiaolin Wang, Xing Ling, and Xin Cao,“ Position sensorless control based on coordinate transformation for brushless DC motor drives, ” IEEE Trans on Power Electronics, vol. 25, no. 9, 2010.
[35]Li Qiang, Lin Mingyao, Hu Minqiang ,Gu Weigang,“ Reserch on filters for back EMF zero-crossing detecting in sensorless BLDC motor drives, ” IEEE Conference, 2005.
[36]Daniel Torres,“ Sensorless BLDC motor control using a Majority Function ” Microchip Technology, 2008.
[37]T. Daniel,“ Sensorless BLDC control with back-EMF filtering using a majority function, ” Microchip Technology, 2008.
[38]Reston Condit Microchip Technology,“ Sensorless BLDC Control with back-EMF filtering, ” Microchip Technology, 2007.
[39]Justin Milks,“ Intelligent Fan Control, ” Microchip Technology, 2008.
[40]W. J. Lee,“ A new starting method of BLDC motors without position sensor, ” IEEE Transactions on Industry Applications, vol.42, no. 9 , 2006.
[41]S. D. Souza,“ Sensored BLDC motor control using dsPIC30F2010, ” Microchip Technology, 2004.

[42]Microchip,“ dsPIC33FJ32MC202/204 and PIC33FJ16MC304 data sheet,” Microchip Technology, 2009.
[43]曾百由，”數位訊號控制器原理與應用”，宏友圖書，2007。
[44]Microchip Regional Training Center,“ BLDC Control Techniques with 16 bit dsPIC processors,” Microchip Technology, 2008.
[45]Microchip,“ dsPICDEMTM MCLV development board user's guide,” Microchip Technology, 2008.