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CONTROL OF AC INDUCTION MOTOR USING MICROPROCESSOR

Tran Thi Thanh Huyen

Faculty of Mechanical, Electrical and Electronic Technology,Thai Nguyen University of Technology, Vietnam

Abstract

Three-phase AC motors are widely used in the industry. For commercial equipment, operators must not interfere with the control structure due to the closed nature of the system. Therefore, the author proposes a solution to build a standardized hardware system that can interfere with the microprocessor's control structure. The advantage of this solution is that it is inexpensive and allows us to install different algorithms.

Keyword: IM, V/f Control, PWM

1.INTRODUCTION

The vector control method for the stator current that uses coordinate transformations is analyzed into two components: torque control and magnetic flux control [1,2, 4-8]. Three-phase motor control can be divided into scalar control and vector control [1-8]. The scalar control is simple to implement, but the dynamic quality of the system is not achieved as the vector control [3,9,10]. Therefore, the quality of control will be improved. However, the control structure of this method is complex and requires the computing power of the microcontroller to be strong enough. There have been some popular control methods implemented in industry: V/f control [3,9,10,11-16], FOC control [17-30], direct or non-direct control magnetic flux (DFOC, IFOC) [31-39], and flux attenuation control [40-45]. The two most common methods used in practical industry are the V/f control method and the FOC control method

2. CONTROL STRUCTURE

References ought to be included in the finish of the paper, and its equivalent citation will be included the order of their appearance in the content.

The V/f control law for motor torque is as follows:

$$M_e = \frac{L_m}{JL_r}\left(\psi_{r\alpha} i_{s\beta} - \psi_{r\beta} i_{s\alpha}\right) \qquad (1)$$

For the control method based on the rotor flux, derived from the three-phase asynchronous motor model on the dq coordinate system [1], we have:

$$\begin{cases} \dfrac{di_{sd}}{dt} = -\dfrac{1}{T_{sd}} i_{sd} + \omega_s \dfrac{L_{sq}}{L_{sd}} i_{sq} + \dfrac{1}{L_{sd}} u_{sd} \\ \dfrac{di_{sq}}{dt} = -\omega_s \dfrac{L_{sd}}{L_{sq}} i_{sd} - \dfrac{1}{T_{sq}} i_{sq} + \dfrac{1}{L_{sq}} u_{sq} - \omega_s \dfrac{\psi_p}{L_{sq}} \end{cases} \qquad (2)$$

According to [1], the FOC control law for flux and motor torque is as follows:

$$M_e = \frac{3}{2} z_p \frac{L_m^2}{L_r} \psi'_{rd} i_{sq} \qquad (3)$$

The V/f control structure that has been proposed is guaranteed by an amplifier stage with angular velocity input signal ω. The control structure deployed on the microcontroller is described as shown in Fig. 1. The speed controller adjusts the motor's sliding speed to stabilize the speed.

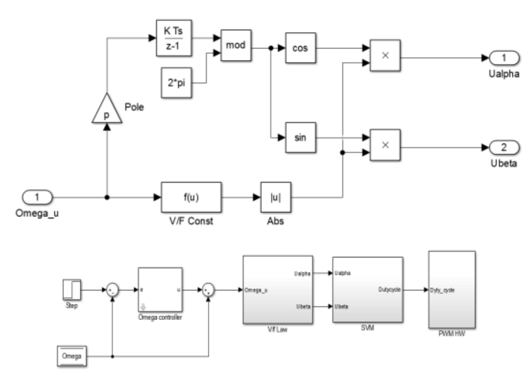

Figure 1 V/f control law

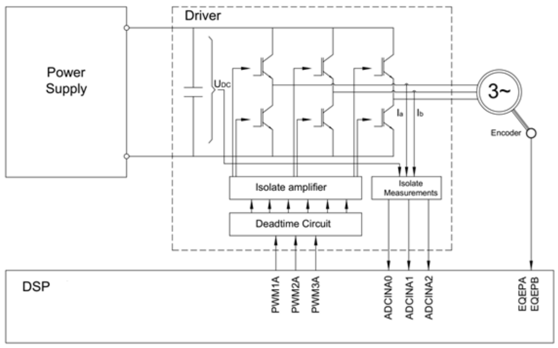

Figure 2 Hardware system using microprocessor

The structure of the hardware system is described in Fig. 2. The output of the controller is the control signal sent to the engine. The method uses an integrator, the rotation angle value of the voltage vector is calculated. The product of the torque constant with the angular velocity is the voltage applied to the motor.

3. CONCLUSIONS

With the open structure of the microprocessor, the intervention of control structure and algorithm setting becomes more convenient. In future works, the author will implement different algorithms to test control quality on the hardware system using the built-in real-time microcontrollers platform. This ensures the implementation of applications in practice and the implementation of different algorithms.

4. ACKNOWLEDGEMENT

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REFERENCES

[1] Quang NP, Dittrich JA (2008) Vector Control of Three-Phase AC Machines – System Development in the Practice. Springer Berlin Heidelberg.

[2] Trzynadlowski, A. M. (2000). Control of induction motors. Elsevier.

[3] Pabitra Kumar Behera, Manoj Kumar Behera, Amit Kumar Sahoo (2014), Speed Control of Induction Motor using Scalar Control Technique, International Journal of Computer Applications (0975 – 8887), International Conference on Emergent Trends in Computing and Communication (ETCC-2014)

[4] El-Faouri, Fares & Mohamed, Omar & Abu-Elhaija, Wejdan. (2017). D-Q model and control of a three-phase induction motor considering mutual flux saturation effect. 1-6. 10.1109/JIEEEC.2017.8051400.

[5] Abu-Rub, H., Iqbal, A., & Guzinski, J. (2021). High Performance Control of AC Drives with Matlab/Simulink. John Wiley & Sons.

[6] Neapolitan, R. E., & Nam, K. H. (2018). AC motor control and electrical vehicle applications. CRC press.

[7] Hannan, M. A., Ali, J. A., Mohamed, A., & Hussain, A. (2018). Optimization techniques to enhance the performance of induction motor drives: A review. Renewable and Sustainable Energy Reviews, 81, 1611-1626.

[8] Boldea, I. (2017). Electric generators and motors: An overview. CES Transactions on Electrical Machines and Systems, 1(1), 3-14.

[9] Bechar, M., Hazzab, A., & Habbab, M. (2017, October). Real-Time scalar control of induction motor using RT-Lab software. In 2017 5th International Conference on Electrical Engineering-Boumerdes (ICEE-B) (pp. 1-5). IEEE.

[10] Lee, K., Ahmed, S., & Lukic, S. M. (2017). Universal restart strategy for scalar (V/f) controlled induction machines. IEEE Transactions on Industry Applications, 53(6), 5489-5495.

[11] Texas Intruments, Scalar (V/f) Control of 3-Phase Induction Motors (2013), Application Report, SPRABQ8–July 2013.

[12] Bharti, R., Kumar, M., & Prasad, B. M. (2019, March). V/f control of three phase induction motor. In 2019 International Conference on Vision Towards Emerging Trends in Communication and Networking (ViTECoN) (pp. 1-4). IEEE.

[13] Chitra, A., Vanishree, J., Sreejith, S., Jose, S., & Pulickan, A. J. (2017). Performance comparison of multilevel inverter topologies for closed loop v/f controlled induction motor drive. Energy Procedia, 117, 958-965.

[14] Yussif, N., Abdel-Khalik, A. S., & Mohamed, A. M. (2019, October). An improved quadratic v/f-based control of photovoltaic battery-less induction motor driven water pumping system. In 2019 International Conference on Sustainable Energy Engineering and Application (ICSEEA) (pp. 1-6). IEEE.

[15] Liu, H., & Gao, D. (2018, May). A novel flux oriented V/f control method of induction motor based industrial adjustable speed drives. In 2018 13th IEEE Conference on Industrial Electronics and Applications (ICIEA) (pp. 1739-1744). IEEE.
[16] Tigade, C., & Sreejeth, M. (2018, October). Implementation of v/f adjustable speed drive for induction motor using dspace ds1104. In 2018 2nd IEEE International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES) (pp. 938-943). IEEE.
[17] Jo, G. J., & Choi, J. W. (2018). Gopinath model-based voltage model flux observer design for field-oriented control of induction motor. IEEE Transactions on Power Electronics, 34(5), 4581-4592.
[18] Wang, K., Li, Y., Ge, Q., & Shi, L. (2018). An improved indirect field-oriented control scheme for linear induction motor traction drives. IEEE Transactions on Industrial Electronics, 65(12), 9928-9937.
[19] Laoufi, C., Sadoune, Z., Abbou, A., & Akherraz, M. (2020). New model of electric traction drive based sliding mode controller in field-oriented control of induction motor fed by multilevel inverter. International Journal of Power Electronics and Drive Systems, 11(1), 242.
[20] Nishad, B. K., & Sharma, R. (2018, December). Induction motor control using modified indirect field oriented control. In 2018 8th IEEE India International Conference on Power Electronics (IICPE) (pp. 1-5). IEEE.
[21] Tousizadeh, M., Che, H. S., Selvaraj, J., Abd Rahim, N., & Ooi, B. T. (2018). Fault-tolerant field-oriented control of three-phase induction motor based on unified feedforward method. IEEE Transactions on Power Electronics, 34(8), 7172-7183.
[22] Zeb, K., Ali, Z., Saleem, K., Uddin, W., Javed, M. A., & Christofides, N. (2017). Indirect field-oriented control of induction motor drive based on adaptive fuzzy logic controller. Electrical Engineering, 99(3), 803-815.
[23] Zhang, J., Li, L., Zhang, L., & Dorrell, D. G. (2017, October). Hysteresis band current controller based field-oriented control for an induction motor driven by a direct matrix converter. In IECON 2017-43rd Annual Conference of the IEEE Industrial Electronics Society (pp. 4633-4638). IEEE.
[24] Listwan, J. (2018). Application of super-twisting sliding mode controllers in direct field-oriented control system of six-phase induction motor: experimental studies. Power Electronics and Drives, 3.
[25] Syamkumar, U., & Jayanand, B. (2020). Real-time implementation of sensorless indirect field-oriented control of three-phase induction motor using a Kalman smoothing-based observer. International Transactions on Electrical Energy Systems, 30(2), e12242.
[26] Iffouzar, K., Amrouche, B., Cherif, T. O., Benkhoris, M. F., Aouzellag, D., & Ghedamsi, K. (2017). Improved direct field oriented control of multiphase induction motor used in hybrid electric vehicle application. International Journal of Hydrogen Energy, 42(30), 19296-19308.
[27] Skowron, M., Wolkiewicz, M., & Tarchała, G. (2020). Stator winding fault diagnosis of induction motor operating under the field-oriented control with convolutional neural networks. Bulletin of the Polish Academy of Sciences. Technical Sciences, 68(5).
[28] Vachhani, U. V., & Patel, A. R. (2017). Analysis of Field Oriented Control Strategy for Induction Motor. Kalpa Publications in Engineering, 1, 214-219.
[29] Wang, F., Zhang, Z., Mei, X., Rodríguez, J., & Kennel, R. (2018). Advanced control strategies of induction machine: Field oriented control, direct torque control and model predictive control. Energies, 11(1), 120.
[30] Umoette, A. T., Okoro, O. I., & Davidson, I. E. (2021, September). Implementation of Indirect Field Oriented Control of a 2.2 kW Three-Phase Induction Motor Using MATLAB Simulink. In 2021 IEEE AFRICON (pp. 1-6). IEEE.
[31]. Listwan, J. (2018). Application of super-twisting sliding mode controllers in direct field-oriented control system of six-phase induction motor: experimental studies. Power Electronics and Drives, 3.
[32] Listwan, J., & Pieńkowski, K. (2020). Comparison of DFOC of Seven-Phase Induction Motor with PI and Fuzzy-Logic speed Controller under speed sensor fault. Przegląd Elektrotechniczny, 96.
[33] Saad, B., & Goléa, A. (2017). Direct field-oriented control using fuzzy logic type-2 for induction motor with broken rotor bars. Advances in Modelling & Analysis C, 72(4), 203-212.
[34] Iffouzar, K., Amrouche, B., Cherif, T. O., Benkhoris, M. F., Aouzellag, D., & Ghedamsi, K. (2017). Improved direct field oriented control of multiphase induction motor used in hybrid electric vehicle application. International Journal of Hydrogen Energy, 42(30), 19296-19308.
[35] BT, V. G. (2017). Comparison Between Direct and Indirect Field Oriented Control of Induction Motor. Int. J. Eng. Trends Technol, 43(6), 364-369.
[36] Tabasian, R., Ghanbari, M., Esmaeli, A., & Jannati, M. (2020). Direct field-oriented control strategy for fault-

tolerant control of induction machine drives based on EKF. IET Electric Power Applications.

[37] Listwan, J., & Pieńkowski, K. (2017, June). Control of five-phase induction motor with application of second-order sliding-mode Direct Field-Oriented method. In 2017 International Symposium on Electrical Machines (SME) (pp. 1-6). IEEE.

[38] Listwan, J. (2018). Application of super-twisting sliding mode controllers in direct field-oriented control system of six-phase induction motor: experimental studies. Power Electronics and Drives, 3.

[39] Ferdiansyah, I., Rusli, M. R., Praharsena, B., Toar, H., & Purwanto, E. (2018, July). Speed control of three phase induction motor using indirect field oriented control based on real-time control system. In 2018 10th International Conference on Information Technology and Electrical Engineering (ICITEE) (pp. 438-442). IEEE.

[40] Dong, Z., Yu, Y., Li, W., Wang, B., & Xu, D. (2017). Flux-weakening control for induction motor in voltage extension region: Torque analysis and dynamic performance improvement. IEEE Transactions on Industrial Electronics, 65(5), 3740-3751.

[41] Dong, Z., Yu, Y., Wang, B., Dong, Q., & Xu, D. (2018, May). Optimized Flux-Weakening Control of Induction Motor for Torque Enhancement in Voltage Extension Region. In 2018 International Power Electronics Conference (IPEC-Niigata 2018-ECCE Asia) (pp. 459-465). IEEE.

[42] Ekong, U. U., Inamori, M., & Morimoto, M. (2017, September). Flux weakening control for torque and efficiency optimization of a vector controlled four switch three phase inverter fed induction motor drive. In 2017 2nd International Conference on Power and Renewable Energy (ICPRE) (pp. 147-151). IEEE.

[43] Hu, Y., Li, Y., Ma, X., Li, X., & Huang, S. (2020). Flux-Weakening Control of Dual Three-Phase PMSM Based on Vector Space Decomposition Control. IEEE Transactions on Power Electronics, 36(7), 8428-8438.

[44] Zhongcui, M. I. A. O., Dongliang, L. I., Zhihao, W. A. N. G., Xianfei, Y. U., & Wenbin, Z. H. A. N. G. (2021). Field-weakening control system of induction motor based on model prediction. Journal of Measurement Science & Instrumentation, 12(3).

[45] Di Leonardo, L., Popescu, M., Fabri, G., & Tursini, M. (2019, October). Performance evaluation of an induction motor drive for traction application. In IECON 2019-45th Annual Conference of the IEEE Industrial Electronics Society (Vol. 1, pp. 4360-4365). IEEE.