ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 15, Issue, 04, pp.24349-24351, April, 2023
DOI: https://doi.org/10.24941/ijcr.45158.04.2023

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

COMPARISON OF VECTOR CONTROL SCHEME FOR PERMANENT MAGNET SYNCHRONOUS MOTOR DRIVES

*Monika Gairola and Dr. A.K. Swami

GBPUAT, Pantnagar, India

ARTICLE INFO

Article History:
Received 04th January, 2023
Received in revised form
10th February, 2023
Accepted 16th March, 2023
Published online 25th April, 2023

Key words:

PMSM, FOC, DTC, MATLAB/Simulink etc.

**Corresponding Author:*
Monika Gairola

ABSTRACT

The two most common vector control techniques for motor drives are field-oriented control (FOC) and direct torque control (DTC). Pulse-width modulation (PWM) and a linear controller are used by FOC to regulate the main load voltage component. DTC, on the other hand, is a nonlinear technique that produces a voltage vector directly without a modulator. A comparative analysis of both control techniques is presented in this work. The benefits and drawbacks of both vector scheme are covered here for permanent magnet synchronous (PMSM) drives. The discussion is supported with the result using MATLAB/Simulink to draw a fair comparison between the performance of two schemes.

Copyright©2023, Monika Gairola and Dr. A.K. Swami. *This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.*

Citation: ***Monika Gairola and Dr. Swami, A.K.*** **2023.** "Comparison of Vector Control Scheme for Permanent Magnet Synchronous Motor Drives.*". International Journal of Current Research*, 15, (04), 24349-24351.

INTRODUCTION

PMSM are commonly used in electric motors and aerospace applications. In terms of performance, the PMSM have an improved transient response time in the majority of applications. The uninterrupted running of the motor across the full speed range, the ability to manage torque even at zero speed, and quick acceleration and deceleration are characteristics of PMSM drives. But, the optimized control strategies are necessary and inevitable to enhance the effectiveness & efficiency of motor in the industrial applications. By the help of variable frequency drive, PMSMs are capable to run at different speeds. Classically, there are three different category of control theory of PMSM: scalar control, field- oriented control (FOC)**,** and direct torque control (DTC) which is shown in figure 1. For PMSM, FOC and DTC are regarded as the high performance control techniques. There are certain benefits and drawbacks of both the strategies. This study compares these two widely used approaches for tests of robustness to shifting loads and amount of speed regulation. **Need of the Study:** The need of study is reasonable and important to give a clear picture of both the control scheme for PMSM drives so that they are used according to the application.

MATERIALS AND METHODS

Matlab 2021b is used in order to model both the vector control scheme including all the switching signals. The switching states are used to achieve a fast torque and the flux response during simulation.

This control strategy control the stator currents which is represented in the form of vector**.** This control is based on projections that change a three-phase, time- and speed-dependent system into a two-coordinate, time-invariant system using only the d and q co-ordinates based on Clarke and Park transformation respectively**.** In Clarke transformation the measured value is transformed to 2-axis reference frame. Two phase currents of motor are first measured and then transformed to 2- phase. Measured speed (w) is compared with the reference speed and output is passed through a PI controller, which generates reference signal for the torque. The *q*-axis component is responsible for the torque production hence the reference signal of torque generated by the PI controller is compared with the stator current's q-axis component. While DTC is characterized by simplicity, good performance and robustness. Absence of PI regulators, current regulators coordinate transformations along with PWM signals generators makes it more effective. In this control strategy the control algorithm gives the output result by comparing the actual and desired values. The flux linkage is directly controlled using this strategy instead of controlling the currents that is used in FOC control technique.

RESULT AND DISCUSSION

Simulation of FOC and DTC for PMSM is done in MATLAB environment. The first parameter used for comparison is speed regulation. Here, the reference speed is taken as 100 rad/s, and at 0.5 s, a load of 5 Nm is applied.

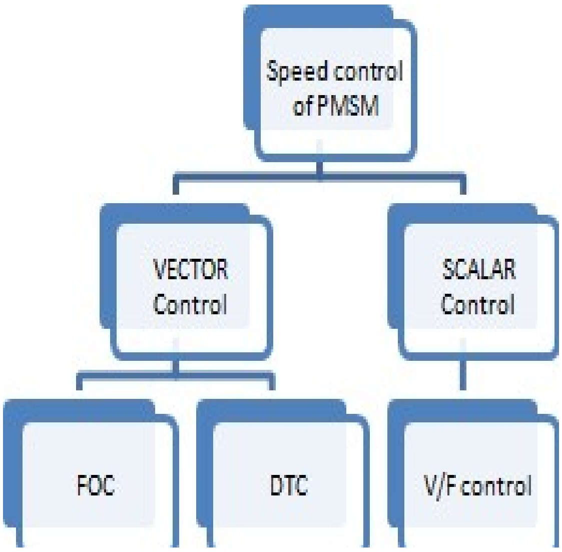

Figure 1. Speed Control Methods of PMSM

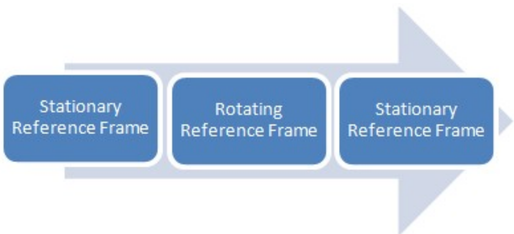

Figure 2. Flowchart for FOC

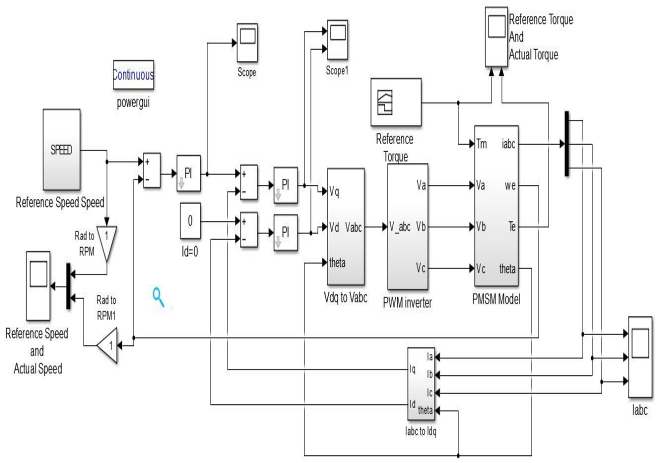

Figure 3. MATLAB model of FOC

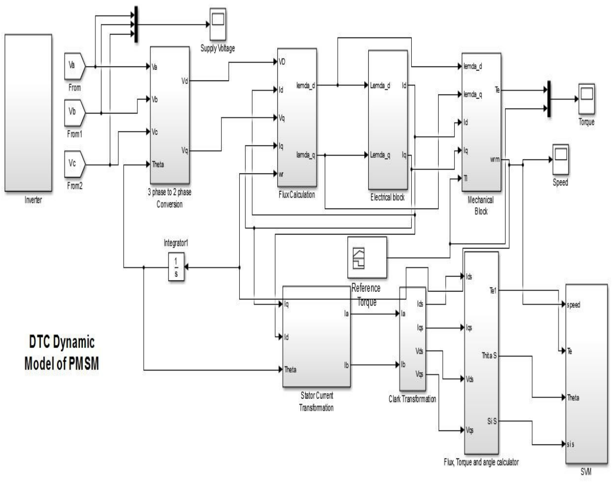

Figure 4. MATLAB model of DTC

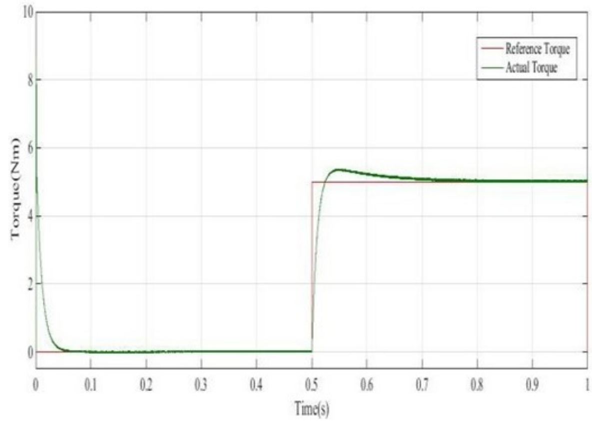

Figure 5. Torque waveform for FOC

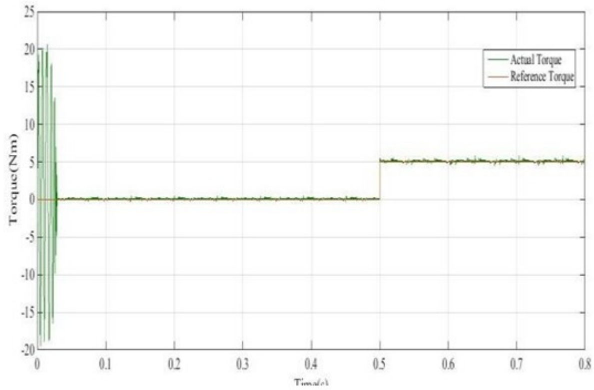

Figure 6. Regulation of Torque for DTC

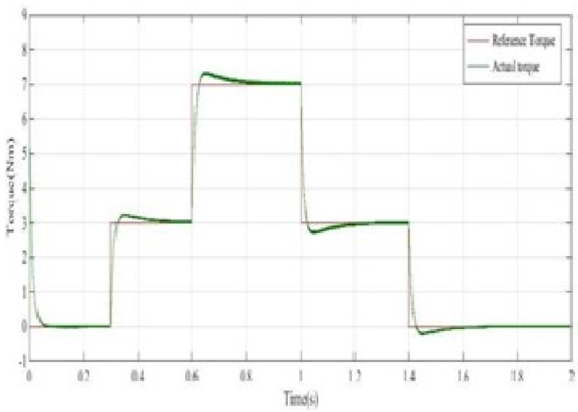

Figure 7. Torque Waveform for FOC

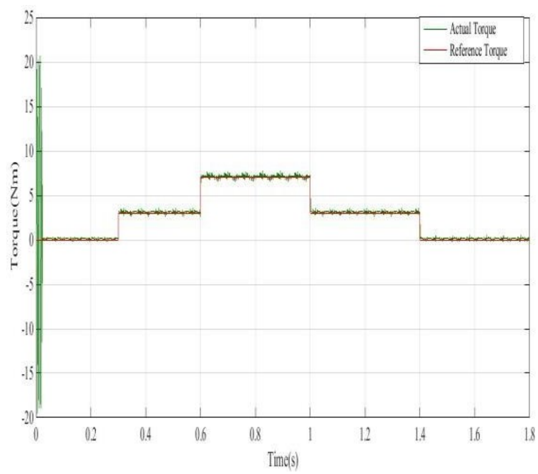

Figure 8.Torque waveform for DTC

Table 1. Comparison of FOC and DTC

S. No.	Comparison Basis	FOC	DTC
1	Transformation	Present	Void
2	Speed Sensor	Necessary	Less Necessary
3	Regulators	Three Stator Regulators	Torque and Flux Regulators
4	No. of PI Controller	1-3	1
5	Torque Ripples	Less	More

It is noted that DTC has large torque ripples initially, but when a sudden load is applied, DTC takes less dynamic time as compared to FOC to regain the reference speed. During sudden disturbances, FOC has more peak overshoot than DTC. It is found that DTC has a lower dynamic response time, less error, and less peak overshoot during sudden changes in load compared to FOC. But the operation of FOC is much smoother than that of DTC. The second parameter for comparison is test of Robustness for Load Changing. Here reference speed of 100rad/s is applied all the time and load is changed after particular time period to check the response of both the control strategies .At starting machine is started at no load, at 0.3s a load of 3Nm is applied, again at 0.6s load is changed to 7Nm, and again at 1.0s load is changed to 3Nm and at 1.4s all load is removed. It is noted that whenever there is change in load DTC responds very quickly and reaches the reference speed and torque with less dynamic response time compare to FOC. Error in DTC is less but in torque, DTC has more ripples.

CONCLUSION

In this paper, main characteristics of FOC and DTC at different load conditions are studied in MATLAB Simulink environment with an aim to highlight the pros and cons of each strategy. It is hard to state the superiority of DTC versus FOC because both strategies has certain pros and cons. Although, we can conclude that FOC is better adoptable with load variations and has less torque ripples while DTC is fast with less dynamic response time.

REFRENCES

Abassi, M., Khlaief, A., Saadaoui, O., Chaari, A., & Boussak, M. 2015. *Performance analysis of FOC and DTC for PMSM drives using SVPWM technique.* In 2015 16th International Conference on Sciences and Techniques of Automatic Control and Computer Engineering (STA) (pp. 228-233). IEEE.

Ming, C., Hanying, G., & Hongming, S. 2011. *Simulation study on a DTC system of PMSM.* In Proceedings of 2011 6th International Forum on Strategic Technology (Vol. 1), pp. 564-569. IEEE.

Baader, U., Depenbrock, M., & Gierse, G. 1992. *Direct self control (DSC) of inverter-fed induction machine: a basis for speed control without speed measurement.* IEEE transactions on industry applications, 28(3), 581-588.

Wang, Z., Chen, J., Cheng, M., & Chau, K. T. 2015. *Field-oriented control and direct torque control for paralleled VSIs fed PMSM drives with variable switching frequencies*. IEEE Transactions on Power Electronics, 31(3), 2417-2428.

Zhong, L., Rahman, M. F., Hu, W. Y., & Lim, K. W. 1997. *Analysis of direct torque control in permanent magnet synchronous motor drives*. IEEE transactions on power electronics, 12(3), 528-536.

Krause, P. C., Wasynczuk, O., Sudhoff, S. D., & Pekarek, S. D. 2013. *Analysis of electric machinery and drive systems* John Wiley & Sons. (Vol. 75).

Kivanc, O. C., & Ozturk, S. B. 2015. *MATLAB function based approach to FOC of PMSM drive.* In 2015 IEEE European Modelling Symposium (EMS) (pp. 96-102). IEEE.

Sahoo, B., Routray, S. K., & Rout, P. K. 2020. *A novel sensorless current shaping control approach for SVPWM inverter with voltage disturbance rejection in a dc grid–based wind power generation system.* Wind Energy, *23*(4), 986-1005.

Tanwir, N. S., & Hamzah, M. I. 2020. *Predicting purchase intention of hybrid electric vehicles: Evidence from an emerging economy*. World Electric Vehicle Journal, *11*(2), 35.

****