International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 03 | Mar 2020 www.irjet.net p-ISSN: 2395-0072

VECTOR CONTROL OF PERMENANT MAGNET SYNCHRONOUS MOTOR

Namiya Minas S[1], Praveen Raj R S[2]

[1]*PG Student, Power Control and Drives, Dept of EEE, MBCET, Trivandrum, Kerala, India*
[2]*Assistant professor, Dept of EEE, MBCET, Trivandrum, Kerala, India*

***

Abstract –*In this paper a vector control strategy is presented for PMSM (PERMANENT MAGNET SYNCHRONOUS MOTOR), where current controller with hysteresis controller is used. The vector control helps in speed control of the Permanent Magnet Synchronous Motor by providing quadrature axis current command from the speed controller. The closed loop speed control for the Permanent Magnet Synchronous Motor with voltage source inverter (VSI) and abc to dq blocks is designed. The presented model is built in matlab/simulink environment. Simulation results have illustrated that this control method can control the Permanent Magnet Synchronous Motor successfully and give better performance.*

Key Words: Vector control, PMSM, Hysteresis control, PID controller, VSI, Matlab Simulation.

1. INTRODUCTION

Permanent Magnet Synchronous motor have attracted interest for many applications like automotives, mechatronics, machine drives etc. PM motors are classified into two types: PMSM and BDCM (Brushless DC Motor). PMSM has several advantages over other motors such as high efficiency factor, minimal size and weight parameters, low rotor inertia, high reliability, and significant life expectancy. The efficient operation of PMSM demands careful choice of the control system. The concept of vector control, which allows controlling such parameters of space vectors of voltage and flux such as magnitude, angular frequency and instant position, is common for high performance of AC motor control techniques [1].

1.1 VECTOR CONTROL TECHNIQUES

This part describes some of the vector control techniques that are used for the PMSM.

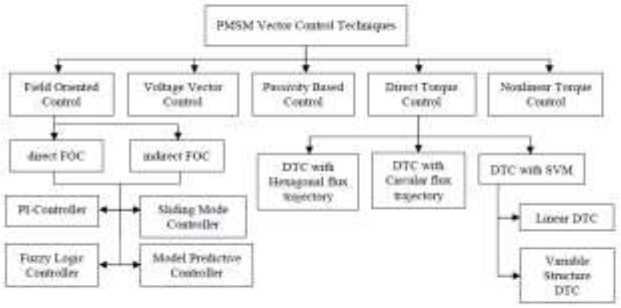

Figure 1: shows different vector control techniques for PMSM

1.2 VECTOR CONTROL TECHNIQUES DESCRIPTION

This portion takes a closer look at the some of the vector control techniques presented in the figure 1, which makes it possible to carry out careful analysis and give the reasonable determination of application areas for each technique.

A) FIELD ORIENTED CONTROL (FOC)

FOC is the widely used vector control technique. The FOC can be constructed with a position sensor (direct) or without one (indirect). In the first model the mathematical model of the system is simpler; the control is faster and more precise.

In FOC, currents of the stator phases of the motor are measured and transformed to a two-phase αβ system via Clarke Transformation. The value of the rotor angle from the position sensor (or one calculated indirectly in case of no sensor) is used for the following transformation of currents via Park Transformation from the static reference frame αβ to the rotated dq one connected with the rotor flux linkage. In accordance with the reference speed signals and the d-component of the stator current, taking into account the feedback signals, a separate control of the torque and the motor excitation flux is carried out [2]. This is the key principle of FOC.

B) DIRECT TORQUE CONTROL

DTC circuits have simpler structures than the FOC circuit, they do not require the use of an inverter with PWM, a speed sensor and reference frame transformers. All calculations are performed in the stator reference frame as information about the exact position of the rotor in such systems is not required (except the start-up case of the synchronous motor).

However, their steady-state operation is characterized by high ripples levels of the stator current, flux linkage and torque, especially at low speeds, that greatly limits their use for high-precision drives. Direct Torque Control with Space Vector Modulation (DTC with SVM) is designed to overcome the disadvantages of DTC. DTC with SVM uses the pulse width modulation approach to generate the voltage [3]. There are several variations of the circuits that significantly improve the efficiency of the control system, compared to DTC.

C) VOLTAGE VECTOR CONTROL

Voltage Vector Control does not require information about the position of the rotor, however, as in case of the FOC circuit, reference frame transformations are used. At the same time, only the flux-forming component of the stator current is regulated. Both approaches provide a quick enough response to control signals. VVC is less sensitive to motor parameter changes than the classic FOC, its circuit structure and computational algorithms are simpler [4].

D) PASSIVITY BASED CONTROL

In terms of complexity, the PBC system structure is not simpler than the one of the FOC. It uses position feedback, reference frame transformations, PWM. The PBC provides good dynamics in terms of speed; however, the torque peaks in transient processes are significant[5]. The level of ripples is also clearly higher than the one while using FOC. Thus, the accuracy of the presented approach (as well as those of the DTC, VVC techniques) cannot be compared to the FOC

2. PMSM DRIVE SYSTEM

A PMSM drive system includes different components such as PMSM, inverter and PID controller. In the PMSM, excitation flux is set up by magnets subsequently no magnetizing current is needed from the supply. This easily enables the flux orientation mechanism by forcing the d-axis component of the stator current vector to be zero. As a result, the electromagnetic torque will be proportional to the q-axis component of the stator current vector (i_q*); hence better dynamic control performance is obtained by controlling the electromagnetic torque; therefore the torque equation can be written by:

$$T_e = k_t \cdot i_q \quad (1)$$

$$k_t = \left(\frac{3}{2}\right)\left(\frac{P}{2}\right)\lambda_f \quad (2)$$

Where λ_f is the flux linkage of the rotor permanent magnet and p is the no of poles. This equation describes the constant torque control strategy for PMSM, this is performed by making the torque producing current i_q* equal to the supply current. In the vector control scheme, torque can be controlled by suitable regulation of the stator current; this implies that the accurate speed control depends on how well the current vector is regulated. In the case of a high performance vector drives, a current-control loop with high band width is necessary to ensure accurate current tracking; this is to reduce the transient period as small as possible, inorder to make the voltage source inverter to act as a current source amplifier within the current loop band width[6]. A system configuration of the vector controlled PMSM is shown in figure 2.

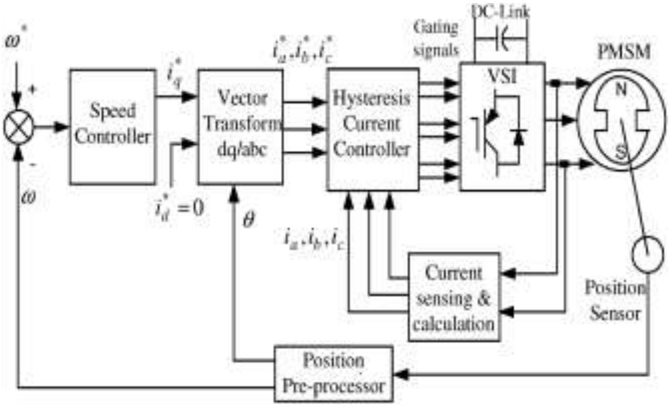

Figure 2: shows vector control of PMSM for constant flux operation

In this particular work we have used hysteresis band controlled voltage source inverter, this is to achieve regular switching frequency and low harmonic content in the stator current, a band hysteresis controller is used. This controller will generate the reference currents with the inverter within a range which is fixed by the width of the band gap. In this controller the desired current of a given phase (i_a*, i_b*, i_c*) is summed with negative of the measured current (i_a, i_b or i_c). The error is fed to a comparator having a hysteresis band. When the error crosses the lower limit of the hysteresis band, the upper switch of the inverter leg is turned on, but when the current attempts to become less than the upper reference band, the bottom switch is turned on. Figure 3 shows the hysteresis band with the actual current and the resulting gate signals.

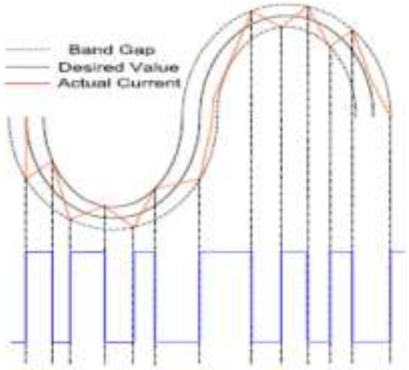

Figure 3: shows the gate signals for the voltage source inverter

Speed controller calculates the difference between the reference speed (w*) and the actual speed (w) producing an error, which is fed to the PI controller, PI controllers are widely used for motion control systems. An incremental encoder is used as position sensor. The dynamic dq modelling is used for the study of motor during transient and steady state. It is done by converting the dq0 variables to three phase currents by using the inverse park transformations.

3 SIMULATION AND RESULTS

Simulink has the advantage of being capable of complex dynamic system simulations, graphical environment with visual real time programming and broad selection of tool boxes. The simulation environment of simulink has a high flexibility and expandability which allows the possibility of development of a set of functions for detailed analysis of the drive system. Its graphical interface allows selection of their functional parameters interactively, and description of signal flow by connecting their data lines using mouse device system blocks are constructed of a lower level grouped into a single maskable block. Simulink simulates analogue systems and discrete digital systems. The PMSM drive simulation was built in several steps like dq0 variable transformation to abc phase, calculation torque and speed, control circuit, inverter and PMSM. The dq0 variables transformation to abc phase is built using reverse parks transformation. For simulation purpose the voltages are the inputs and the currents are output. The system built in simulink for PMSM drive system has been tested with hysteresis current control method at the constant torque region of operation. The motor parameters used for simulation are given in Table 1.

Table -1: motor parameters

PMSM PARAMETERS		
Torque	T	10 Nm
Dc link voltage	Vdc	400 V
No. of poles	P	6
Rated speed	N	3000 rpm
Flux linkage	Λf	0.175 Wb
Stator resistance	Rs	0.3 ohm
q and d axis inductances	Ld ,Lq	0.0085 H
Motor inertia	J	0.0755 kgm^2

Using all the drive system blocks; the complete system block has been developed as shown in figure 4.

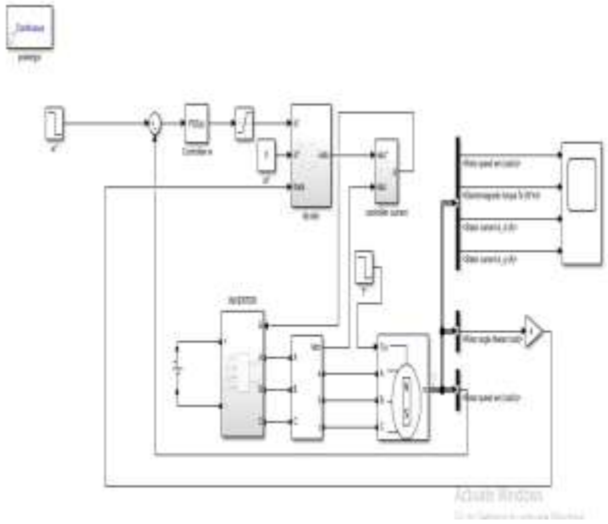

Figure 4: shows implementation of vector controlled PMSM

The following figure shows the hysteresis current controller design that gives gate signals to the voltage source inverter.

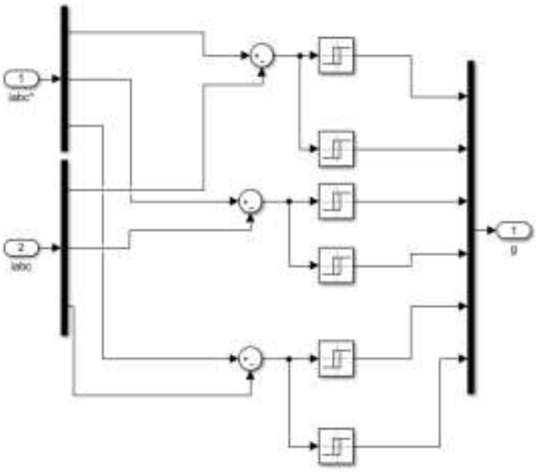

Figure 5: shows hysteresis current controller

The following figure 6 shows the simulated output of the vector controlled PMSM drive system.

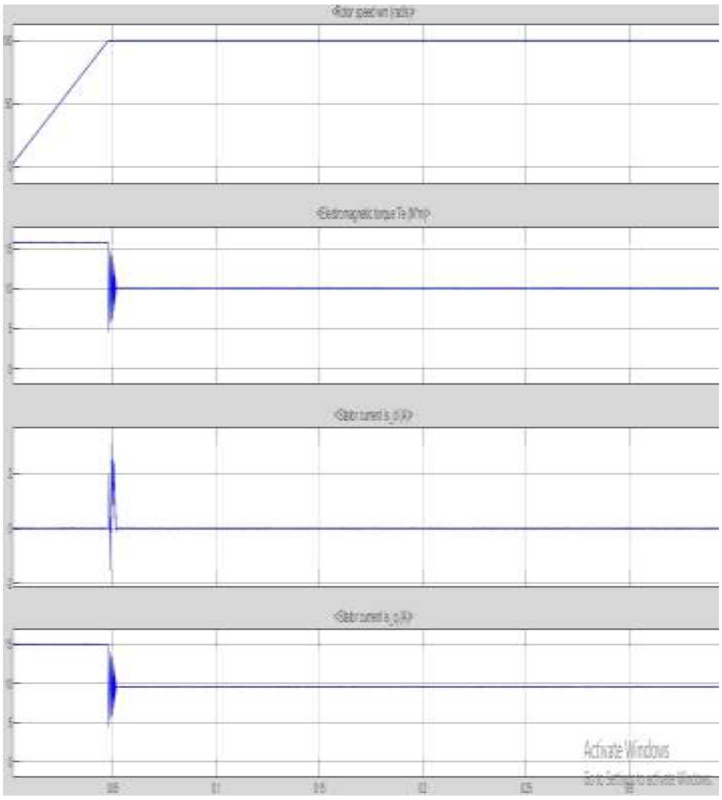

Figure 6: shows simulated results of vector controlled PMSM

The above figure shows variation of rotor speed with time, the steady state speed is same as that of the commanded reference speed. The starting torque is the rated torque of the motor, the steady state torque of the motor is about 10 Nm, stator d-axis current and stator q-axis current.

4. CONCLUSIONS

The proposed vector control for PMSM drive can handle the effects of step change in reference speed and parameter variations. The overall system performance is quite good in terms of dynamic and steady state response.

Simulation results show that the proposed control scheme guarantees stable and robust response of the PMSM drive. Subsequently it can be utilized in high performance motion control applications.

REFERENCES

[1] Dr.Karunamoothy B and Dhivya D "Design of PMSM and its Application", International Journal of Current Research vol.9,may 2017

[2] Mehimmedtsi Boujemma, chenni ruchid "Field oriented control of PMSM supplied by photovoltaic source", International journal of Electrical and Computer Engineering, vol.69, june 2019

[3] L.Wang .Y.Gao, "A Novel strategy of Direct Torque control for PMSM drive Reducing Ripple in Torque and Flux", Electric Machines and Drives Conference 2007, IEEE International,Vol.1, may 2007.

[4]Ambrish Pati Tripathi, Vikram Singh "Permanent Magnet Synchronous motor Voltage Vector Control by simulation", IJSEE.org.ISSN 2229-5518, May 2015

[5]M.Khanchoul, M.Hilairet, D.Normonel Cyrof "A Passivity Based Controller under Low Sampling for Speed Control of PMSM", Control Engineering Practise Volume 26, Pages 20-27, May 2014

[6] Abdul karim, Alsayid Basid "DSP based speed control of the surface mounted permanent magnet synchronous with hysteresis current controller", Recent Research in System Science.

AUTHORS

NAMIYA MINAS S received the Bachelor of Technology degree in Electrical and Electronics Engineering from Kerala University, India. Currently doing masters in Power Control Drives from Mar Baselious College of Engineering, Nalanchira, India.

PRAVEEN RAJ R S
Asst. professor, EE Department, Mar Baselious College of Engineering, Nalanchira, India.