Sensor less Field Oriented Control of Permanent Magnet Synchronous Motor Using Sliding Mode Observer

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Abstract: *The objective of this project is to develop a sensor less control solution for surface mounted permanent magnet synchronous motor. After a brief introduction, the dynamic model of the system is established, followed by the design of a Field Oriented Control scheme. Next, a Closed-loop flux observer, the study contains two main purposes; the first is a simple effective method to estimate the rotor position and angular speed of the permanent magnet synchronous motor. The second is to regulate the speed of the motor with varying the load using the PI controller and the sliding mode observer. The simulation of the system is established used PSIM package. The FOC algorithm maintains efficiency in a wide range of speeds and takes into consideration torque changes with transient phases by processing a dynamic model of the motor. Among the phase current sensors and use an observer for speed sensor less control.*

Key Word: Intrathecal, Bupivacaine, Buprenorphine, Nalbuphine, Postoperative

1. Introduction

Field oriented control is a preferred and widely used method to control Permanent Magnet Synchronous Motor. In this technique, PMSM can be controlled like a separately excited DC motor. This is achieved by dynamic decoupling of flux producing and torque producing current components through transformations which require precise information of rotor position. Conventionally, various position sensors such as used to calculating the rotor position to maintain 90 degree at stator for getting maximum torque However, these sensors add to system cost is high. In last few years, a number of estimation techniques have been developed to achieve speed and position sensor less PMSM drives to eliminate the need for a position sensor. . Here, we introduce sensor less control methods.

Several studies have been used to estimate both the position and speed using sliding mode observer. Many scientists use the SMO technique to estimate the speed and rotor position of the PMSM it is characterized by its robustness against uncertainties and also by its simplicity of implementation. In the authors propose a novel SMO of the PMSM drives where they replace the sign function by a continuous function whose name is sigmoid to decrease the chattering phenomenon. The authors in sensor less field oriented control with initial rotor position estimation a sensor lees field oriented control with initial rotor position estimation approach for PMSM drive.

In this paper, we discuss the key issues for implementation of SMO and techniques used for correction of rotor position estimation. Different approaches were observed in the literature to handle these implementation issues. We have implemented these solutions on the software setup. We have also proposed a different approach to handle the issue of phase angle compensation and provide results for the same.

2. Methodology for Sliding Mode Observer

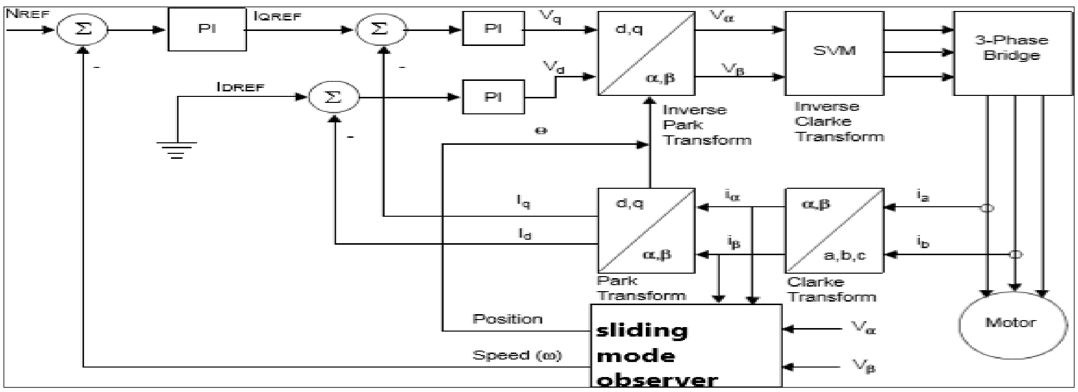

Figure 1. Block Representation of Sensor less Field Oriented Control of PMSM

The block representation of a rotor flux position estimator based on a sliding mode current observer is shown in Fig. 1.The inputs to the estimator are motor phase currents and voltages which are expressed in a α - β co-ordinate frame. A Mathematical model of PMSM in α - β co-ordinate frame .The mathematical model of PMSM in α - β coordinate frame is represented as

KVL,

$$Vs = is\,Rs + L\frac{d}{dt}is + e$$

3phase,

V a, V b, V c → Vα, $V\beta$.

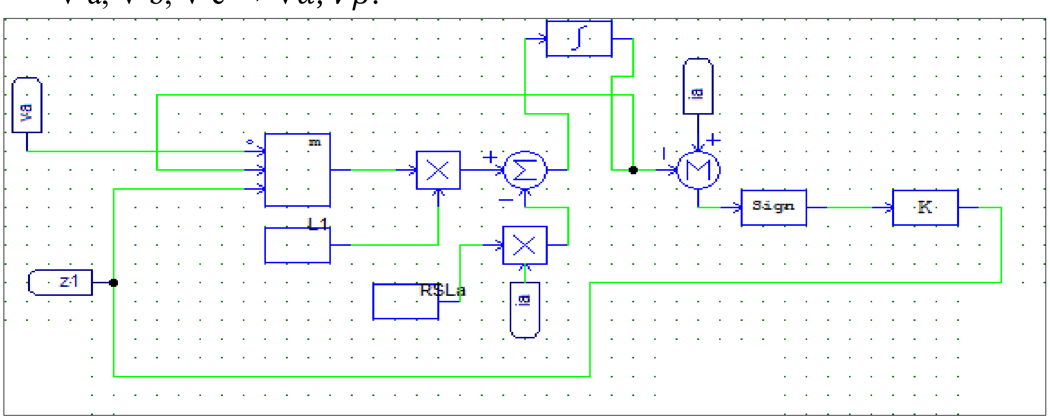

Figure 2.Block Representation of Vα Study Location

To find $V\alpha$

$$V\alpha = i\alpha\, Rs + L\,\frac{d}{dt}\,i\alpha + e\alpha$$

$$i\alpha\, Rs + L\,\frac{d}{dt}\,i\alpha = V\alpha + e\alpha$$

$$L\,[\frac{Rs}{L}\,I\alpha + \frac{d}{dt}\,I\alpha] = V\alpha + e\alpha$$

$$\frac{Rs}{L}\,I\alpha + \frac{d}{dt}\,I\alpha = \frac{1}{L}\,(V\alpha - e\alpha)$$

$$\frac{d}{dt} I\alpha = \frac{1}{L}(V\alpha - e\alpha) - \frac{R}{L}\,I\alpha$$

$$I\alpha = \int \{\frac{1}{L}\,(V\alpha - e\alpha) - \frac{Rs}{L}\,I\alpha\}$$

$$\hat{I}\alpha = \int \{\frac{1}{L}\,(V\alpha - e\alpha) - \frac{Rs}{L}\,i\alpha\}$$

The current observer control z is used to drive the current estimation error to zero. This is achieved by selecting a proper value for sliding mode gain k and correct formation of estimated back EMF. Equations 2 and 3 are expressed form as estimated alpha

To find $V\beta$;

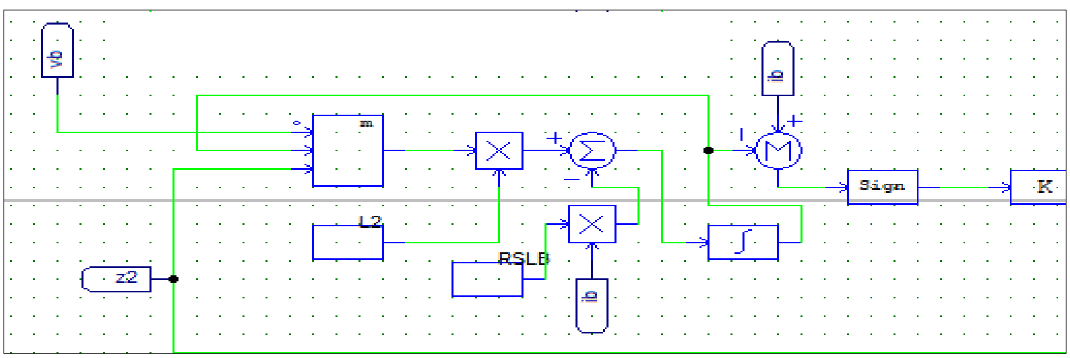

Figure 3. Block Representation of $V\beta$

$$V\beta = i\beta\, Rs + L\,\frac{d}{dt} i\beta + e\beta$$

$$i\beta\, Rs + L\,\frac{d}{dt}\,i\beta = V\beta + e\beta$$

$$L\,[\frac{Rs}{L}\,i\beta + \frac{d}{dt}\,i\beta] = V\beta + e\beta$$

$$\frac{Rs}{L}\,i\beta + \frac{d}{dt}\,i\beta = \frac{1}{L}\,(V\beta - e\beta)$$

$$\frac{d}{dt}\,i\beta = \frac{1}{L}\,(V\beta - e\beta) - \frac{Rs}{L}\,i\beta$$

$$i\beta = \int \{\frac{1}{L}\,(V\beta - e\beta) - \frac{Rs}{L}\,i\}$$

$$\hat{I}\beta = \int \{\frac{1}{L}\,(V\beta - e\beta) - \frac{Rs}{L}\,i\}$$

Equation for deriving Rotor Flux Angle Estimated rotor flux angle is obtained using

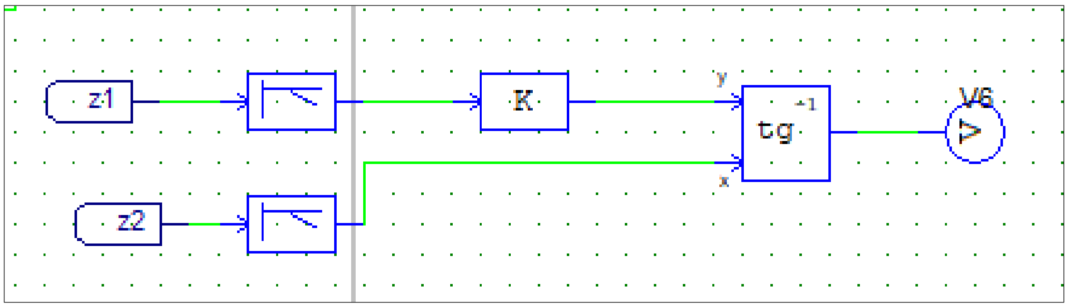

Figure 4. Estimated rotor position is calculated by Vα *and* $V\beta$. Tan ^-1[$e\alpha/e\beta$].

3. Simulation Result

To validate the effectiveness of our sliding mode observer, the Power simulation program allows the implementation of the system to calculate estimated currentα. Figure 3 displays the results of the proposed sensor less FOC utilizing the sigmoid function. Fig2gives the results of high speed sensor less FOC utilizing the sigmoid function, figure 3 (a) gives the estimated speed that follows the measured value at a cycle speed to 210 rad/s until 360 rad/s, figure 3 (b) indicates the error speed. We can see that both responses of the estimated/measured rotor position are practically identical shows the estimated back EMF. The step load is applied at time equal 1s as represented. We can notice that the rotor current in q-axis follows this load torque especially after the application of the latter but the id rotor current is retained at 0. We can see that the waveforms of the measured position/speed are identical and also we note also that the error of the speed and position are very low displays the results for low speed sensor less FOC. In figure 3 we remark that the waveforms of the actual and estimated speed are identical. Figure displays the response of estimated/measured position in the course the direction reversal

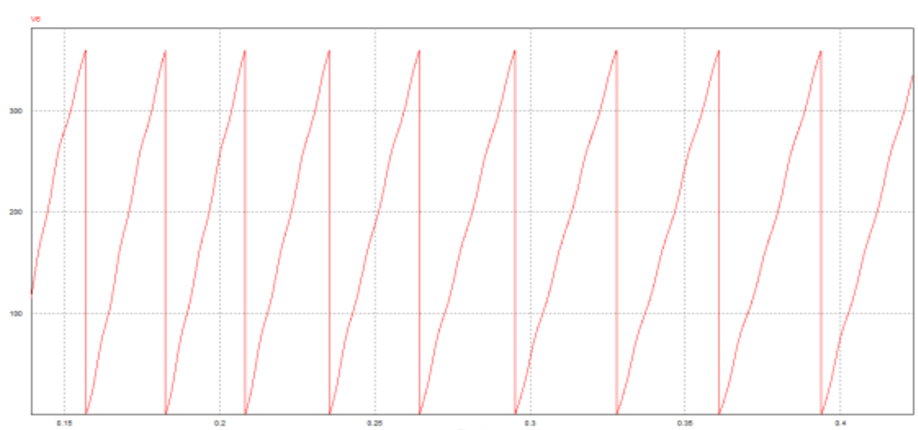

Figure 5. Scale: On X - axis: Time (s) On Y - axis: speed (rpm)

4. Observation

Motor runs smoothly using this technique. Sensor less operation is justified as encoder is not used in this method for position estimation or speed calculation.

5. Conclusion

We calculating the rotor position using SMO based sensor less PMSM operation. It is observed experimentally that due to basic principle of operation of the PMSM, the rotor position estimations play an important role in the successful implementation of sensor less operation. With this we have successfully implemented sensor less operation of PMSM. The approach proposed is compared with the existing approaches for practical implementation.

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