ANALYSIS OF MOTOR DRIVE THROUGH SLIDING MODE CONTROLLER: A REVIEW

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The industrial standard for high performance motion control applications require, four quadrant operation including field weakening, minimum torque ripple, rapid speed recovery under impact load torque and fast dynamic torque and speed responses. DC motors with thyristorconverter and simple controller structure have been the traditional choice for most industrial and high performance applications. But they are associated with certain problems related to commutation requirement and maintenance. Low torque to weight ratio and reduced unitcapacity add some more negative points to DC machine drives. On the other hand AC motors,especially induction motors are suitable for industrial drives, because of their simple and robust structure, high torque to weight ratio, higher reliability and ability to operate in hazardous environments. However there control is a challenging task because the rotor quantities are not accessible which are responsible for torque production. DC machines are decoupled in terms offlux and torque. Hence control is easy. If it is possible in case of induction motor to control theamplitude and space angle (between rotating stator and rotor fields), in other words to supply power from a controlled source so that the flux producing and torque producing components of stator current can be controlled independently, the motor dynamics can be compared to that ofDC motor with fast transient response. Presently introduction of micro-controllers and high switching frequency semiconductor devices, and MATLABtechnology has led to cost effectivesophisticated control strategies.

I. INTRODUCTION

Although construction of induction motor is simple, its speed control is considered to be far more complex than that of DC motors. The reason is nonlinear and highly interacting multivariable state space model of the motor. The rapid and revolutionary progress in microelectronics and variable frequency static inverters with application of modern control theory has made it possible to build sophisticated controllers for AC motor drives. The design and development of such drive system require proper mathematical modeling of the motor to optimize the controller structure, the inputs needed and the gain parameters. In this chapter the modeling of induction motor is presented.

1.2 Induction Motor Modeling:

A proper model for the three phase induction motor is essential to simulate and study the complete drive system. The model of induction motor in arbitrary reference frame is derived in[16-17].

Following are the assumptions made for the model:

1. Each stator winding is distributed so as to produce a sinusoidal mmf along the airgap, i.e.
Space harmonics are negligible.
2. The slotting in stator and rotor produces negligible variation in respective inductances.
3. Mutual inductances are equal.
4. The harmonics in voltages and currents are neglected.
5. Saturation of the magnetic circuit is neglected.
6. Hysteresis and eddy current losses and skin effects are neglected.

1.2 Estimation of Speed

It is desirable to avoid the use of speed sensors from the standpoints of cost, size of the drive, noise immunity and reliability. So the development of shaft sensor less adjustable speed drive has become an important research topic. Many speed estimation algorithms and sensor less control schemes have been developed during the past few years. The speed information required in the proposed control technique is estimated by the algorithm described in this section. The speed of the motor is estimated by estimating the synchronous speed and subtracting the command slip speed. The synchronous speed is estimated using the stator flux components, because of its higher accuracy compared to estimation based on rotor flux components. The rotor speed of an induction motor is expressed in terms of synchronous and slip (angular) frequencies is as follows:

$$\omega_r = \frac{\omega_e - \omega_{sl}}{P}$$

The estimation of rotor speed is accomplished by an estimation of either synchronous, or slip frequency, with the other being known. In the proposed speed estimation scheme, the synchronous frequency is estimated and slip frequency is assumed as command.

II. DESIGN OF A SLIDING MODE CONTROLLER

In control theory sliding mode control, is a form of variable structure control (VSC). It is a nonlinear control method that alters the dynamics of a nonlinear system by application of a high-frequency switching control. The multiple control structures are designed so that trajectories always move toward a switching condition, and hence the ultimate trajectory will not exist entirely within one control structure. Instead, the ultimate trajectory will slide along the boundaries of the control structures. The motion of the system as it slides along these boundaries is called a sliding mode. Intuitively, for a dynamic system sliding mode control uses practically infinite gain to force the trajectories to slide along the restricted sliding mode subspace. The main strength of sliding mode control is its robustness. Because the control can be as simple as a switching between two states (e.g., "on"/"off" or "forward"/"reverse"), it need not be precise and will not be sensitive to parameter variations that enter into the control channel. Additionally, because the control law is not a continuous function, the sliding mode can be reached in finite time (i.e., better than asymptotic behavior). Sliding mode control is an appropriate robust control method for the systems, where modeling inaccuracies, parameter variations and disturbances are present. It is computationally simple compared to adaptive controllers with parameter estimation.

Induction motor with sliding mode control performs well in the servo applications, where the actuator has to follow complex trajectories. Sometimes sliding mode control has a demerit of chattering of the control variable and some of the system states.

The strengths of SMC include:
Low sensitivity to plant parameter uncertainty
Greatly reduced-order modeling of plant dynamics
Finite-time convergence (due to discontinuous control law)
The weaknesses of SMC include:
Chattering due to implementation imperfections

2.2 Sliding Mode Controller:
With sliding mode controller, the system is controlled in such a way that the error in the system states always moves towards a sliding surface. The sliding surface is defined with the tracking error (e) of the state and its rate of change (e˙) as variables. The distance of the error trajectory from the sliding surface and its rate of convergence are used to decide the control input (u) to the system. The sign of the control input must change at the intersection of the tracking error trajectory with the sliding surface. In this way the error trajectory is always forced to move towards the sliding surface. The basic equations below of vector controlled induction motor are simplified by assuming, the rotor flux ψdr to be constant. From the steady state value of the rotor flux can be obtained as

$$\psi_{dr}^{*} = \frac{a_5}{a_4} i_{ds}^{*} \qquad (3.1)$$

$$\widehat{\omega}_r = \frac{\widehat{\omega}_e - \omega_{sl}^{*}}{P}$$

III. EXPECTED OUTCOME

It is to supply electricity from a controlled source, so that the current product of the stucker can be controlled independently and the segment of the block can be independently controlled, motor speed science compared to DC motor with a rapid transit symbol can be done. Micro controller and current switching of high-frequency frequency semiconductor devices, and implement it to MATLAB technology. So the estimated rotor speed of the sensor less drive is obtained.

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