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Rotor Resistance Estimation using EKF for the Rotor Fault Diagnosis in Sliding Mode Control Induction Motor

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***Abstract*— The aim of this paper is the diagnosis of the rotor fault of squirrel cage induction motor controlled in sliding-mode (SMC). The faulty identification in this case is very difficult, due to the action of the control loop (SMC). Motor current signature analysis (MCSA) is the most widely used method for the faults identification in induction motors. This method generally suffers from load disturbance, speed variation. A broken rotor bar essentially leads to an increase in the rotor resistance of the induction motor. This paper present a method of broken rotor bars diagnosis based on the estimation of the rotor resistance using an Extended Kalman filter (EKF) and the spectrum analysis of stator current. The simulation results show that the presented algorithm is effective and accurate.**

***Index Terms*— Induction Motor, Sliding Mode Control, Fault Detection, Broken Rotor Bars, Diagnosis, Motor Current Signature Analysis, FFT, Rotor Resistance Estimation, Extended Kalman Filter.**

I. INTRODUCTION

Three-Phase squirrel-cage induction motors are widely used in industry, particularly in high-tech domains due to their high power-to-weight ratio, low price, and easy maintenance. However, their performance includes constraints such as electrical and mechanical faults [1]. The failure of the induction motor may be caused because of many reasons like manufacturing fault, designing fault of the engineer, overloading, environment and poor technical knowledge of the job about in handling the machine [2].

A sliding mode speed controller (SMC) based on a switching surface is demonstrated. With this switching surface, the stability is guaranteed for the speed control and insensitivity to uncertainties and disturbances is also obtained [3]. The SMC is studied in [4] and [5]. The passivity-based control approach is presented in [6] and [7]. Analysis of the control of an induction motor with broken rotor bars is presented in papers [8-10]. The problem of active closed-loop fault detection is important from two aspects. The first one is the important problem of fault detection based on control requirements.

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The second aspect is that a feedback may help to improve the fault detection. Concerning the traditional active robust detection in [11], it’s of interest to know whether or not we can guarantee the fault detection using a smaller auxiliary signal if a suitable feedback is implemented. The solution of this question depends on how we measure the auxiliary signal [12]. Other authors consider the detection is based from the apparent rotor resistance of an induction motor will increase when a rotor bar breaks. To detect broken rotor bars, the measurements of stator voltages and currents are processed by an EKF for the rotor resistance estimation. In particular, this resistance is estimated and compared with its nominal values to detect the broken rotor bars [13]. However, the rotor resistance change with temperature and excitation conditions and thus affects the control system performance largely. To achieve satisfied performance, estimate the rotor resistance rapidly and accurately is necessary [14]. Through the revision, the EKF has proved to be an excellent technique tool for the detection of broken rotor bars. EKF have been proposed in [13], [14]. In this paper, a method of rotor resistance estimation based on EKF is presented taken account the rotor fault in induction motor controlled by SMC.

II. MODEL WITH FAULT OF THE INDUCTION MOTOR

The mathematical model of the induction motor can be written as follows [15]:

$$[L]\frac{d[I]}{dt} = [V] - [R][I] \tag{1}$$

where:

$$[L] = \begin{bmatrix} L_{sc} & 0 & -\frac{N_r}{2}M_{sr} & 0 & 0 \\ 0 & L_{sc} & 0 & -\frac{N_r}{2}M_{sr} & 0 \\ -\frac{3}{2}M_{sr} & 0 & L_{rc} & 0 & 0 \\ 0 & -\frac{3}{2}M_{sr} & 0 & L_{rc} & 0 \\ 0 & 0 & 0 & 0 & L_e \end{bmatrix}$$

$$[R] = \begin{bmatrix} R_s & -\omega L_{sc} & 0 & \frac{N_r}{2}\omega M_{sr} & 0 \\ \omega L_{sc} & R_s & -\frac{N_r}{2}\omega M_{sr} & 0 & 0 \\ 0 & 0 & R_{rdd} & R_{rdq} & 0 \\ 0 & 0 & R_{rqd} & R_{rqq} & 0 \\ 0 & 0 & 0 & 0 & R_e \end{bmatrix}$$

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