Electric Power Systems Research 80 (2010) 1089–1095

Contents lists available at ScienceDirect

Electric Power Systems Research

journal homepage: www.elsevier.com/locate/epsr

Sliding mode observer for on-line broken rotor bar detection

Lane Maria Rabelo Baccarini[a,*], João Paulo Braga Tavares[a,*], Benjamim Rodrigues de Menezes[b], Walmir Matos Caminhas[b]

[a] Department of Electrical Engineering, Federal University of São João del Rei, Praça Frei Orlando, 170, Centro, 36307-352, Minas Gerais, Brazil
[b] Federal University of Minas Gerais, Av. Antônio Carlos 6627, Pampulha, 31270-010, Brazil

ARTICLE INFO

Article history:
Received 27 August 2009
Received in revised form 11 February 2010
Accepted 15 February 2010
Available online 21 March 2010

Keywords:
Sliding mode observer
Fault diagnosis
Nonintrusive approach

ABSTRACT

The major task for any monitoring system is to detect upcoming faults as early as possible. Rotor failures are responsible for a large percentage of total induction motor failures. Thus, a new nonintrusive and in-service approach has been proposed in this paper to detect one broken rotor bar in induction motor using only input quantities information. The method is not affected by the type of load and other asymmetries and it is capable of providing reliable fault diagnose without maintenance specialist intervention. The proposed sensorless technique is based on two real time state space discrete models that are used to estimate the flux of both the stator and the rotor and analyzes the differences obtained in torque when the two models are employed. One of the observers was designed for rotor resistance disturbance rejection. Firstly, simulation results have been conducted and sensitivity and robustness also have been checked for the proposed method. Secondly, an experimental setup has been constructed to implement the new technique in on-line model. The results obtained validate the proposed model and show the reliability of the new method.

1. Introduction

Induction motors are the workhorses of many industrial applications due to their ruggedness and versatility [1]. Since the possibility of electrical machine faults is unavoidable, the machine condition monitoring has received considerable attention in recent years [2–11]. Incipient faults within a machine generally affect the performance of the motor before major failures occur.

Rotor failures are responsible for a large percentage of total induction motor failures. Once a bar breaks, the neighboring bars also deteriorate progressively due to increased stresses [12]. To prevent such cumulative destructive process, the problem should be detected as early as possible, when the bars are beginning to crack. Then, the induction motor condition monitoring is a very important research topic with an abundance of related literature [13–23]. Because of the uninterrupted characteristic of industrial processes, some methods cannot be used for monitoring in-service motors.

The most well-known approaches for diagnosis of broken rotor bars are based on the monitoring the stator currents to detect side bands around this current fundamental components. Nevertheless, the task of distinguishing the fault conditions from the normal conditions based on frequency spectrum is very difficult. This is due to the fact that the stator current is a non-stationary signal of which the properties vary with the motor operation conditions [22]. Additionally, the method is affected by the load condition.

Monitoring the motor condition is crucial to detect any fault in early stage to eliminate the hazards of severe motor faults. The ultimate goal in fault diagnosis is the development of a diagnostic technique, which is able to detect any fault in the motor with a minimum knowledge about its parameters and constructional data. An efficient diagnostic technique should be noninvasive and requires only the acquisition of signals that are readily available in the motor control panel.

Baccarini et al. [21] designed a method for on-line motor monitoring with the purpose of detecting a broken rotor bar. The method avoids doing any frequency analysis; instead the machine state is observed by two different models. One of the observers (OMD) is designed for rejecting rotor resistance disturbances [24]. The other estimates the rotor flux by using the discrete model (DISC). The technique utilizes input signals from standard current and voltage sensors and encoder. The need for the rotor position measurement is highly disadvantageous and undesirable. Thus, this paper deals with an extended approach of OMD observer model. Rotor speed is extracted from the motor input currents instead of being measured directly. Consequently, it has been an endeavor ever since to eliminate the position sensor.

Measured results have been obtained for a conventional scheme with a position sensor and also with the proposed sensorless technique. The computational simulations results verify for both sensitivity and robustness of the method. An experimental setup

* Corresponding authors. Tel.: +55 32 3379 2552; fax: +55 32 3379 4850.
E-mail address: rabelo@ufsj.edu.br (L.M.R. Baccarini).

0378-7796/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.epsr.2010.02.001