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Implementation of fuzzy modeling system for faults detection and diagnosis in three phase induction motor drive system

Shorouk Ossama Ibrahim [a,*], khaled Nagdy Faris [b], Esam Abo Elzahab [a]

[a] *Electrical Power and Machines Engineering, Faculty of Engineering, Cairo University, Egypt*
[b] *Electronics Research Institute, National Researcher Center Building, Giza, Egypt*

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Abstract

Induction motors have been intensively utilized in industrial applications, mainly due to their efficiency and reliability. It is necessary that these machines work all the time with its high performance and reliability. So it is necessary to monitor, detect and diagnose different faults that these motors are facing. In this paper an intelligent fault detection and diagnosis for different faults of induction motor drive system is introduced. The stator currents and the time are introduced as inputs to the proposed fuzzy detection and diagnosis system. The direct torque control technique (DTC) is adopted as a suitable control technique in the drive system especially, in traction applications, such as Electric Vehicles and Sub-Way Metro that used such a machine. An intelligent modeling technique is adopted as an identifier for different faults; the proposed model introduces the time as an important factor or variable that plays an important role either in fault detection or in decision making for suitable corrective action according to the type of the fault. Experimental results have been obtained to verify the efficiency of the proposed intelligent detector and identifier; a matching between the simulated and experimental results has been noticed.

Keywords: Fuzzy logic; Direct torque control (DTC); Matlab/Simulink; Motor condition (MC); Type of fault (TF)

1. Introduction

Induction motors are used worldwide as the "workhorse" in industrial applications. Although, these electromechanical devices are highly reliable, they are susceptible to many types of faults. Such faults can become destructive, harmful and cause production shutdowns, and personal injuries. So it is important that these faults are detected as early as possible in order to prevent the complete failure of the machine and also to prevent unexpected production costs (Thorsen and Dalva, 1999).

The effects of such faults in induction motors include unbalanced stator voltages and currents, torque oscillations, efficiency reduction, overheating, excessive vibration, and torque reduction (Sivakotaiah, 2009). An accurate fault

* Corresponding author.
E-mail addresses: sho_sunrise@yahoo.com (S.O. Ibrahim), khalederi@yahoo.com (k.N. Faris), Zahab0@yahoo.com (E.A. Elzahab).
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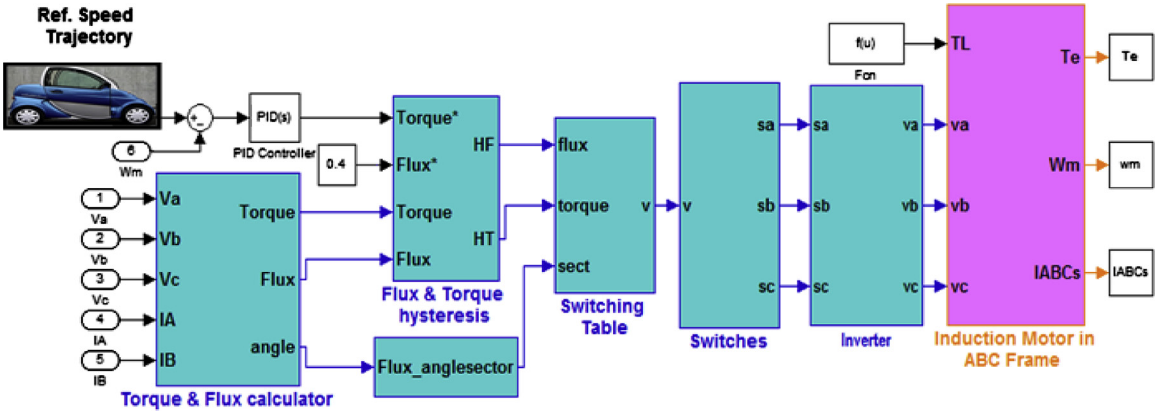

Fig. 1. Simulink block diagram of DTC for induction motor.

detection system exhibits high rates and low false alarm rates; if the detection capability of a fault detection system is poor, then it is likely to miss developing faults which may lead to critical machine failures and breakdown of entire systems. Whereas, if the fault detection system is too sensitive then it is likely to generate high rates of false alarms and may lead to a wrong decision being made. So the measured phase's stator currents and time are considered as inputs for fuzzy logic system to investigate the balance detection between fault detection system as either poor or too sensitive.

2. Induction motor drive system modeling

The idea of using direct torque control method is based on comparing the measured stator flux and torque with the theoretically desired bands. Advantages of DTC are simple structure, no coordinate transformation, no separate voltage modulation block, no current control loops, and very good flux and torque dynamic performance but the disadvantages are variable switching frequency, low speed operation and high torque ripples. The analysis of the induction motor in the proposed system by using Maltab/Simulink is shown in Fig. 1.

The parameters of the three phase induction motor model are obtained by running the m-file and all the values of the parameters can be accessed by the model from the workspace.

2.1. Sub models

Sub models and equations governing the subsystem of induction motor:

2.1.1. Torque and flux estimation

The direct, quadrature axis flux linkage and torque are calculated as follows (Ansari and Deshpande, 2010):

$$F_d = \int (V_d - R_s I_d)dt \tag{1}$$

$$F_q = \int (V_q - R_s I_q)dt \tag{2}$$

$$F = \sqrt{({F_d}^2 + {F_q}^2)} \angle tan^{-1} \left(\frac{F_q}{F_d} \right) \tag{3}$$

$$T_e = \frac{3}{2} p(F_{ds} i_{qs} - F_{qs} i_{ds}) \tag{4}$$

A classical DTC scheme has two hysteresis comparators, one for the stator flux linkage and the second for the torque. A typical scheme is shown in Fig. 2 (Abdul Wahab and Sanusi, 2008). The instantaneous error for the stator flux linkage h_f thus has two possible values (1 and 0); whereas the instantaneous torque error is h_{Te} thus has three