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Speed control of doubly fed induction motor

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Abstract

In this work the performance comparison study of the proportional integral and fuzzy logic speed controllers which used for the speed control of doubly fed induction machine is presented. For a long time, electromechanical systems used the squirrel-cage induction motors, as main actuators, however, doubly fed induction motors, present of estimable advantages at variable speed drive. From that, the performances of conventional speed controllers are sensitive to parameter variations of the motor. So, in this paper, the analyze of performances of speed fuzzy logic controller is presented. The simulation results showed that the fuzzy logic controller ensure the best dynamic performances in rotor resistance and load variations.

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Keywords: Doubly fed induction machine; variable speed; performances, fuzzy logic controller; simulation.

1. Introduction

The electric motors of industrial systems operate generally at variable speed. Since, the induction motors are often used because they are unquestionably an advantage over to the machine the DC machine [1, 2]. But, the coupling between the flux and torque of IM present a serious problem for its control. For this purpose, the vector control theory [3] has long since been applied successfully for three phase induction motors. However, the performances of the speed control are sensitizes at motor parameters variations [4, 5].

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Consequently, it is interesting to use the modern control techniques more towards for the high power in the energy renewable applications. Notably, fuzzy logic aims to study and representation of imprecise knowledge and approximate reasoning [6].

The description of imprecise or uncertain situations may contain the fuzzy expressions such as: big, medium, small, etc…These «linguistic" expressions are subject to membership functions [7-8]. Currently, fuzzy logic is used in many fields, such as, management, medicine and control systems. It is also used to match the degree of truth to a variable that can be linguistic. This scaling in the membership of an element has a situation that allows the modeling of man observation expressed in linguistic form [9, 10]. She allows you to translate a control strategy of a qualified set of easily interpretable linguistic rules and to treat linguistic variables whose values are sentences in natural language [11, 12].

In this works, doubly fed induction motor (DFIM) is used because he offers the opportunity to modulate power flow into and out the rotor winding in order to have, at the same time, a variable speed in the characterized super-synchronous or sub-synchronous modes in motor or in generator regimes [13-15]. The DFIM can be controlled from the stator or rotor by various possible combinations and the strategy of the flux orientation can to transform the non linear and coupled DFIM-mathematical model to a linear model leading to one attractive solution as well as under generating or motoring operations [15-17].

The paper is organized as follows. In section 2, modelling of doubly fed induction motor, the field oriented control and inverter are developed. The methodology approaches of the conventional and fuzzy logic controllers are presented, in section 3. The simulation results and their discussion are presented in section 4. Finally, conclusion is presented in last section.

2. Modeling system

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2.1. DFIM model

The structure of DFIM is very complex. Therefore, in order to develop a model, it is necessary to consider the following simplifying assumptions [16, 19]: the machine is symmetrical with constant air gap ; the magnetic circuit is not saturated and it is perfectly laminated, with the result that the iron losses and hysteresis are negligible and only the windings are driven by currents; the mmf created in one phase of stator and rotor are sinusoidal distributions along the gap. By this means, the DFIM state equations [20, 21] are described as follow:

$$\begin{cases} \dot{x} = Ax + Bu \\ y = Cx \end{cases} \tag{1}$$

With,

$x = \begin{bmatrix} i_{ds} & i_{qs} & i_{dr} & i_{qr} \end{bmatrix}^T$ is the state vector ;

$u = \begin{bmatrix} V_{ds} & V_{qs} & V_{dr} & V_{qr} \end{bmatrix}^T$ is input vector.