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Speed Control of a Doubly Fed Induction Motor Based on Fuzzy Gain-Adaptive IP

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ABSTRACT

This paper presents a comparison between a fuzzy-IP gain adaptive controller and a conventional IP controller used for speed control with a direct stator flux orientation control of a doubly fed induction motor. In particular, the introduction part of the paper presents a Direct Stator Flux Orientation Control (DSFOC), the first part of this paper presents a description of the mathematical model of DFIM, and an adaptive IP controller is proposed for the speed control of DFIM in the presence of the variations parametric, A fuzzy inference system is used to adjust in real-time the controller gains. The obtained results show the efficacy of the proposed method.

Keywords: *doubly fed induction motor, direct stator flux orientation control, fuzzy gain-adaptive IP controller, IP controller.*

1. INTRODUCTION

In recent years, the use of doubly fed induction machine (DFIM) is a best solution for applications where the torque is proportional to the square of the speed; DFIM is an asynchronous wound-rotor machine whose stator and rotor windings are connected to electrical sources [1-2] .

The advantages of DFIM in motor operation for high power applications such as traction, marine propulsion or as a generator in wind systems [3-5], the many benefits of this machine are: reduced manufacturing cost, relatively simple construction, higher speed and do not require ongoing maintenance. For operation at different speeds must be inserted in the machine a converter PWM (Pulse Width Modulation) between the machine and the network. For, whatever the speed of the machine, the voltage is rectified and an inverter connected to the network side is responsible for ensuring consistency between the network frequency and that delivered by the device. The DFIM is essentially nonlinear, due to the coupling between the flux and the electromagnetic torque [6] [7] .

With the field orientation control (FOC) method, induction machine drives are becoming a major candidate in high-performance motion control applications, where servo quality operation is required. Fast transient response is made possible by decoupled torque and flux control. The most widely used control method is perhaps the proportional integral control (PI). It is easy to design and implement, but it has difficulty in dealing with parameter variations, and load disturbances [8]. Recent literature has paid much attention to the potential of Gain Adaptive control in machine drive applications.

A number of methods have been proposed in the literature for nonlinear Adaptive applied to the DFIM. A Speed Sensorless Sliding-Mode Controller for DFIM Drives with Adaptive Backstepping Observer in [9] and Robust Speed Sensorless Control Based on Input-output Feedback Linearization Control Using a Sliding-mode Observer in [10]. Our purpose in this paper is to introduce a Fuzzy Gain-Adaptive IP control for DFIM drive system; Fuzzy logic, whose theoretical bases have been established since the early 1960, allows exploiting the linguistic information describing the dynamic behavior of the system. This information, provided by the human expert, can be expressed as a set of fuzzy rules type of If-Then.

The definition of rules and membership functions to said sets "fuzzy sets" enables designers to better understand the vague and difficult to model processes. One area of application of fuzzy logic that has evolved considerably and continues to attract the interest of many researchers is the modeling and control systems [11-13].

A number of methods have been proposed in the literature for PID gain scheduling [14] a stable gain-scheduling PID controller is developed based on grid point concept for nonlinear systems. Different gain scheduling methods were studied and compared [15], [16] a new PID scheme is proposed in which the controller gains were scheduled by a fuzzy inference scheme. Many method and research works in this domain in [17-20]. The interested readers can find a brief review of different fuzzy PID structures in [21].

The paper is organized as follows: In Section 2 mathematical model of the DFIM is presented. In section 3, we begin with the DFIM oriented model in view of the vector control; next the stator flux ϕ_s is estimated. The Fuzzy Gain-Adaptive IP and design Fuzzy Gain-Adaptive IP of motor speed in section 4, and the simulation results are given in section 5. Finally, we give some conclusion remarks on the control proposed of DFIM using fuzzy logic.

2. DESCRIPTION AND MODELING OF DFIM

The electrical model of the DFIM is expressed in a (d-q) synchronous rotating frame (figure 1).