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New Direct Torque Neuro-Fuzzy Control Based SVM-Three Level Inverter-Fed Induction Motor

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Abstract: In this paper, a novel direct torque neuro-fuzzy control (DTCNF) scheme combining with space voltage modulation (SVM) technique of a three levels inverter is presented. Using neuro-fuzzy technique, the reference space voltage vector can be obtained dynamically in terms of torque error, stator flux error and the angle of stator flux. Compared with conventional direct torque control (C_DTC), in this new technique, the ripples of both torque and flux are reduced remarkable, and switching frequency is maintained constant. Simulation results verify the validity of the proposed method.

Keywords: Direct torque control, induction motor, neuro-fuzzy, space vector modulation, stator flux, three level inverter.

1. INTRODUCTION

In recent years, the industrial applications of the field oriented control (FOC) induction motor drives have greatly increased, including steel and paper machines, machine tools, and so on [4]. In parallel, several researches has been devoted to find out different solutions for the control of the IM drives for reduction of the complexity of the algorithms involved in a field oriented control, and to develop robust control strategies.

Since its introduction in 1985, the direct torque control (DTC) [1] principle was widely used for IM drives with fast dynamics. The main advantages of DTC are absence of coordinate transformation and current regulator absence of separate voltage modulation block, DTC is able to produce very fast torque and flux control and, if the torque and flux are correctly estimated, is robust with respect to motor parameters and perturbations [1-6].

Common disadvantages of conventional DTC are he switching frequency varies according to the motor speed and the hysteresis bands of torque and flux; large torque ripple is generated at low speed [7].

Actually, because of their success, intelligent controllers such as neural networks and fuzzy logic have become one of the most favorable areas of research for controlling nonlinear systems [13]. In [9] a neural network-based space vector modulation for voltage-fed inverter was developed and implemented. In [5] fuzzy-logic controllers are proposed for vector-controlled drives. Among them, the methods based on the combination of artificial neural networks and fuzzy systems take a remarkable place, in [16,17] a NFC is used for a DTC drive. Later, in [14,18] the same system was implemented with excellent results; however additional calculations were needed to reach zero-steady-state error.

In this paper, a novel direct torque neuro-fuzzy control (DTCNF) scheme combining with space voltage modulation (SVM) technique of a three levels inverter is presented. This scheme uses a controller based on an adaptive NF inference system (ANFIS) to replace the switching table and the hysteresis comparators [14,18]. The ANFIS evaluate the reference voltage required to drive the flux and torque to the demanded values within a fixed time period, the reference space voltage vector can be obtained dynamically in terms of torque error, stator flux error and the angle of stator flux [13-18]. Compared with conventional direct torque control (DTC), in this new technique, the ripples of both torque and flux are reduced remarkable, and switching frequency is maintained constant. Simulation results verify the validity of the proposed method.

2. CONVENTIONALDIRECT TORQUE CONTROL

The block diagram of classical DTC proposed by I. Takahashi [1] is presented in Fig. 1. The commanded electromagnetic torque C_{eref} is delivered from outer PI speed controller. Then C_{eref} and commanded stator flux amplitudes φ_{sref} are compared with estimated values of C_e and φ_s respectively. The torque and flux errors are fed to two hysteresis comparators [1-4].

The digitized output variables ΔC_e and $\Delta\varphi_s$, and the stator flux position sector(N) selects the appropriate voltage vector from the switching table. Thus, the selection table generates pulses S_a, S_b, S_c to control the power switches in the inverter [19].

For the flux is defined two-level hysteresis controller for the torque three-level. The stator voltage calculator computes the voltage applied to the motor by:

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