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Indirect Field Oriented Control of Three-Phase Induction Motor Based on Current-Source Inverter

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Abstract

Medium-voltage drives are generally based on either voltage-source inverter(VSI) or current-source inverter (CSI). Three-phase CSI fed induction motor (IM) drives become a strong candidate in medium-voltage applications for the features of the simple topology, power reversal capability and a reliable short circuit protection. By decoupled control of the machine flux and torque, the conventional direct field oriented control(DFOC) CSI fed induction motor drives has gained the improved performance, however, this scheme faces practical challenges, like poor good dynamic response and machine parameter dependence. A high performance CSI fed indirect field oriented control (IFOC) method is described in this paper. A rotor flux observer and two proportional–integral controllers are used to get good dynamic response of the system. The rotor flux orientation is also obtained. The transient response analysis of the induction motor are also discussed in detail. The simulation results bases on MATLAB show that the control system has good dynamic performance and stability.

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Keywords: induction motor; current-source inverter; indirect field oriented control(IFOC); MATLAB

1. Introduction

In the variable speed drive systems, alternating current (AC) motor, especially three-phase induction motor (IM)induction motors are widely used in industrial application[1,2]. The induction motor drives employ mostly a voltage-source inverter (VSI) topology. However, its application is restricted by poor load current limitation

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capability, dynamic response retardation and four-quadrant operation limitation. Contrarily, the current-source inverter (CSI) is a strong candidate for induction motor drive systems due to the motor-friendly voltage waveforms, inherent short-circuit-proof protection and power reversal capability [3,4].These features make the CSI fed induction motor drives more attractive in medium to high power applications.

Constant voltage-to-frequency ratio (V/f) operation is the simplest control method for CSI fed induction motor drives. Open-loop V/f operation presents acceptable steady-state performance but has the poor dynamic response [5]–[7]. Therefore, closed-loop V/f operation shows better dynamic performance [8]–[9]. For faster response, field oriented control method relying on decoupling the machine flux and torque control variables presents the solution for CSI fed induction motor drive control. Nobuyuki Kasa, et. al. introduced a new filed oriented controlled CSI fed induction motor drive system in which the motor speed is expected from the *d* component of the stator voltage[10]. Morawiec et al. proposed a control system for the induction motor fed by CSI based on a multiscalar model in which speed observer system is applied to receive sensorless drive[11].

In this paper, an indirect field oriented control (IFOC) method is proposed. The induction motor mathematically modeled in the rotor flux reference frame is presented. A rotor flux observer is presented and the indirect oriented control system is built. The stator current frequency is obtained by adding the slip frequency to the mechanical speed. The presented method is capable of achieving superior transient and steady-state performance.

2. The modelling of IFOC method

The field oriented control technique relies on decoupling the machine torque and flux control variables, then the DC machine performance can be achieved. The schematic diagram of field oriented control method is shown as Fig.1.

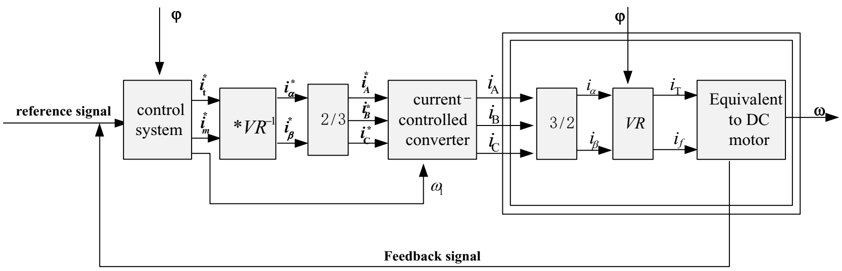
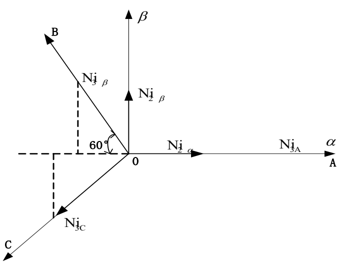


Fig.1. schematic diagram of field oriented control system

In order to get the DC machine performance, the Clarke transformation and the Park transformation are needed[1].Clarke transformation is the change from the three-phase ABC reference frame to the two-phase stationary αβ reference frame as shown in Fig.2. Park transformation is the change from the two-phase αβ reference frame to rotating dq reference frame as shown Fig.3.



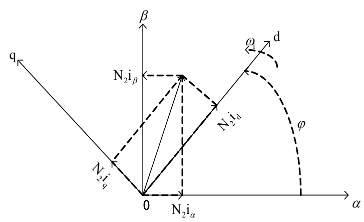


Fig.2. Stationary frame A-B-C to α-β axes transformation

Fig.3. α-β axes to synchronously rotating frame d-q axes transformation