Performance Analysis of Fuzzy Based Indirect Field Oriented Control of Induction Motor Drives for Hybrid Electric Vehicles

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Abstract

The main component of any hybrid electric vehicle (HEV) power train is the electric propulsion system that consists of a traction motor and its electrical drive. Efficient performance of a hybrid propulsion system depends on an appropriate motor selection, which is still an ongoing topic of research in automotive industry. Induction motors (IMs) are widely accepted for HEVs since they exhibit the torque-speed characteristics desired in traction applications and require a simple speed control much similar to DC motors; yet offer higher power and efficiency, more reliability and lower operating cost and maintenance.

Motor control for traction purposes in any hybrid or plug-in hybrid vehicle should offer low torque oscillations, wide speed ranges under constant operating power with more reliability and robustness. Field oriented control of IM is a control technique that decouples the stator current into torque producing and flux producing components, enabling an independent torque control for a precise speed control. Direct field control requires either a sensor to directly measure the rotor flux or calculate it using the terminal voltage. One method to eliminate the requirement of this additional sensor input and make the system more cost efficient is to indirectly estimate the rotor flux and field angle, i.e., indirect field oriented control (IFOC). However, this considerably increases the computation time, consequently affecting the timely motor response. Since the response of the torque-control loop in the system plays a critical role, an algorithm must be developed to reduce its response time. In this paper, IFOC is implemented using both a conventional PI as well as a fuzzy control system to compare their performance. As shown in Fig. 1, in either control schemes, the controller accepts motor speed input and estimates the rotor flux and torque producing component of the stator current to determine the slip speed. The torque and flux producing current components together with the rotor angle and slip angle constitute the magnitude and phase angle of the required current signal sent to the PWM inverter. It will be demonstrated in the full paper that fuzzy based control has a more efficient speed tracking performance in terms of faster response with smaller overshoot and a higher capability to maintain speed and desired torque under load disturbance. Moreover, the slip speed estimation in conventional PI control is dependent on rotor resistance that varies with temperature. It will be shown that fuzzy based control reduces this parameter sensitivity, improving the motor performance making it a more robust control algorithm for IM drives in HEVs.

Subject Area: Mathematical Modeling of Power Trains.

Keywords: Fuzzy logic, Hybrid Electric Vehicle, Indirect field oriented control, Induction motor drive, Performance analysis.

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Figure 1. Indirect field oriented control of induction motor for Plug-In HEV application.