Finite element modeling and control of a high-power SRM for hybrid electric vehicle

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\section*{ABSTRACT}

In this study, a new modified fuzzy-PI (MFPI) controller is designed to control a high-power Switched Reluctance Motor (SRM) modeled by means of the finite element method (FEM) for hybrid electric vehicle (HEV) applications. Finite element analysis has been carried out via the Maxwell 2D software package. The motor flux, inductance and torque characteristics obtained from the analyses have been presented. The obtained numerical analysis data was transferred to the Matlab/Simulink environment, and a non-linear dynamic SR motor model was created. The motor speed has been controlled by conventional fuzzy-PI (FPI) and new modified fuzzy-PI (MFPI) controller after designing the nonlinear model of the SRM.

The controller performances are compared in terms of maximum percentage overshoot (\(\%\text{OS}\)), rise time (\(t_i\)), steady-state error (\(e_{ss}\)), rate of torque ripple (\(T_{\text{ripple}}\)), and rate of ripple in speed (\(\text{odd}\)). The comparisons for the SRM's different operation situations show that MFPI generally yields the better performance in terms of the rise-time, the steady-state error, and the maximum percentage overshoot criteria. In addition, the high-power SR motor simulation computation time (fuzzy computation) for the MFPI controller appears to be shorter than the value for the conventional FPI controller.

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\section*{1. Introduction}

Switched reluctance motors (SRMs) are becoming a more attractive option among the other electrical machines due to their advantages, such as structural simplicity in variable speed drives, high reliability, and low cost \cite{10}. The SRM is used in many commercial applications for adjustable speed control due to its unique mechanical structure and simple power electronics driver requirements. Its unique simplicity and layout gives it a superior quality compared to other electrical machines \cite{7}. Many application areas for SRMs have emerged, along with developments in control techniques. These are general-purpose industrial drives, compressors, fans, pumps, special drive applications, such as centrifugal machines, electric vehicle applications, aircraft and spacecraft, and other related applications \cite{18}.

Today, many studies have been performed on the modeling and control of the SRM. Analysis of the studies in the field of control reveals that comparisons between the conventional PI controllers and the intelligent controllers have been performed. Song et al. \cite{20} performed the SRM speed control by a fuzzy-PID controller. Songyan & Xulong \cite{21} developed the current control strategy in order to reduce the power losses of a high-power SRM. Wu & Hao \cite{29} performed the SRM...