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Fuzzy Sliding Mode Control of a Switched Reluctance Motor

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Abstract

The simplicity, ruggedness, and low cost of a switched reluctance motor (SRM) makes it a viable candidate for various general-purpose adjustable-speed and servo-type applications. Sliding mode control (SMC) is one of the popular strategies to deal with uncertain control systems. The Fuzzy Sliding Mode Controller (FSMC) combines the intelligence of a fuzzy inference system with the sliding mode controller.PI controllers are generally used for the speed control of SRM main drawback of PI controller is high overshoot and large settling time. The main reason for this high overshoot and large settling time is due to the fixed nature of the controller parameters. In this paper, mathematical modelling of 6/4 SRM has been developed, speed performance of the motor using PI controller and FSMC has been analysed.Results of this study show that the overshoot is completely eliminated and the speed of response is improved when Fuzzy SMC is used for the speed control of SRM

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*Keywords:*Switched Reluctance Motor; PI Controller; Fuzzy Sliding Mode Controller

1. Introduction

The Switched Reluctance Motor (SRM) is an electric motor which runs by reluctance torque. For industrial applications requiring very high speed such as 50,000 rpm, the switched reluctance motor can be used. Switched Reluctance Motors have advantages such as high speed operation, high degree of independence between phases, short end-turn, and low inertia.

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Switched Reluctance Drive (SRD) is a step less speed regulation system, which is composed of SRM, converter and controller. In order to obtain high quality control in either torque or speed control applications, it is essential to have an accurate model of the motor that describes the torque characteristics. The SRM's drive performance is strongly dependent on its design and mostly on its control which allows for torque ripple reduction, or for improving the speed control [1]. Therefore, the motor's mathematical model and its accuracy are important [2][3][4]. SRM linear and nonlinear model with the voltage and hysteresis current control discussed in [5]. A simplified linear model for closed loop control of SRM with PI controller is presented in [6].A high efficiency control of SRM used as the integrated starter generator system for vehicles is mentioned in[7].In [8] Different torque control methods and a torque controller implementation for torque ripple reduction have been explained.

Sliding mode control (SMC) is one of the popular strategies to deal with uncertain control systems [9]. The main feature of SMC is the robustness against parameter variations and external disturbances. SMC has been success fully implemented to control drive systems like DC motor and BLDC motor [10] [11].

Over the past few years, fuzzy set theory [12] has been successfully applied to implementing fuzzy logic controllers (FLC) that express feedback control laws using heuristic knowledge, without knowing parameters of the control plants, for many practical industrial control systems [13]. Fuzzy Logic control is one of the popular strategies to deal with uncertain control systems. Nowadays, the quest for new controllers which provide functionality and guarantee precise performance has led the technology into the field of Fuzzy Logic [14] [15]. New control systems have been developed based mostly in this area of knowledge, control of Induction motors [16], antilock braking systems (ABS) [17], robot path planning [18], among others. Despite this, practical applications involving fuzzy controllers as a proved option to conventional controllers are hard to find.

Combining the intelligence with the sliding mode controller the performance of the sliding mode controller can be improved. This report is focused on the performance comparison of a Fuzzy sliding mode controller with PID controller for the speed control of a PM Synchronous Motor. In this report, mathematical modeling of 6/4 SRM has been developed, speed performance of the motor using PI controller and Fuzzy Sliding Mode Controller (FSMC) has been analysed. And torque ripple reduction methods are proposed without affecting the speed performance characteristics.

Nomenclature

V	Stator Voltage
i	Stator current
R	Stator Resistance
L	Stator inductance
Ψ	Flux linkage
θ	Angular displacement
ω	Angular velocity
T	Torque

2. Mathematical Modelling of SRM

A Switched Reluctance Motor is a singly excited, doubly salient machine in which the electromagnetic torques is developed due to variable reluctance principle. Both stator and rotor has salient poles but only stator carries winding. As in dc motor the SRM has wound field coils for stator windings. However the rotor has no attached coils or magnets. The projecting magnetic poles of salient pole rotor are made of soft magnetic material. When the excitation is given to the stator windings, a force is created by rotor's magnetic reluctance that bid to align the rotor pole with the adjacent stator pole. In order to preserve sequence rotation, the windings of stator pole switches in a sequential manner with the help of electronic control system so that the magnetic field of rotor pole was lead by the stator pole, pulling towards it. The rotor pole is said to be "fully unaligned position" when the rotor pole is equidistant from the two adjacent stator pole. This position is called as maximum magnetic reluctance for the rotor