Sensorless Control of Switched Reluctance Motor Drive using ANFIS for Automotive Applications

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***Abstract*- This research paper presents the designing of the ANFIS controller to estimation of rotor position accurately and controls the speed of SRM for EV Applications. Even though there are many advantages for SRM, but due to high non linearity nature, it is complex to regulate the speed of the SRM. In order to control the speed of SRM is in superior way and to reduce the torque ripple a novel ANFIS Controller has been presented. The Speed performance of SRM has been presented in terms of the time-domain specifications and reduced the Torque ripples. The proposed control strategy has been provided the superior speed and torque performance under both no load and loaded conditions. The results are obtained using MATLAB/SIMULINK.**

***Index Terms*—ANFIS, Electric Vehicle, Speed, SRM, Torque Ripple.**

I. INTRODUCTION

Presently Electric Vehicles having the special kind of prominence in the global market due to some of the key advantages viz. pollution free, less maintenance, compact size. Therefore SRM has unique nature the application of EVs [7]. These all features are available in some other electric motors like BLDC, PMSM, DC Motor, etc. But the SRM has very highly attractive features like high efficiency, highly rugged construction, small in size, less cost and also having very high speed range. Even though there are many advantages are there compared to conventional motors but it is suffer from High torque ripple due to high non linearity of the motor[2], which leads to huge acoustic noise, Torque distortion and difficult to control the speed. It is using the flux linkage, Current and Rotor position (ψ-i-θ) characteristics and construct mapping between the input data-output data based on both human knowledge and predetermined input-output data. It is equivalent to fuzzy interface system and it estimates position of the rotor and the speed control of the motor [1].

Fuzzy logic control strategy [5] will provides the high torque ripple high rise time and settling time. The proposed control strategy does not require complex calculations and complex mathematical modeling, to develop the real-time control scheme [8].It has the capability to be tolerant to the noise signal and error. It improves the consistency and robustness of the system [9-10].In order to minimize the torque ripple and to control the speed of the SRM in better way the ANFIS method has been proposed in this research.

II. PROPOSED METHOD

In order to get the better speed control and to reduce the torque ripple, ANFIS control strategy has been proposed. In this control strategy, integrating (Combining) the fuzzy and neural network in a single model and taking help of the ability of using the expert knowledge and the strong learning ability of neural network, the ANFIS control shows high impending precision, quick reaching set speed and simple construction. It has broad applications in modeling, control and function approaching [6-7].

The typical structure of proposed method is described in Fig.1. Here the Circle and Square indicates fixed and adaptive nodes respectively. Here x, y are the inputs, z is output. In this research first order and T-S type of fuzzy rules are used.

***Rule* 1**	**If x is A_1 and y is B_1, then $Z_1=p_1x+q_1y+r_1$**
***Rule* 2**	**If x is A_2 and y is B_2, then $Z_2=p_2x+q_2y+r_2$**

Where,

A_i and B_i are the fuzzy sets in the antecedent.

p_i, q_i, r_i are the consequent parameters.

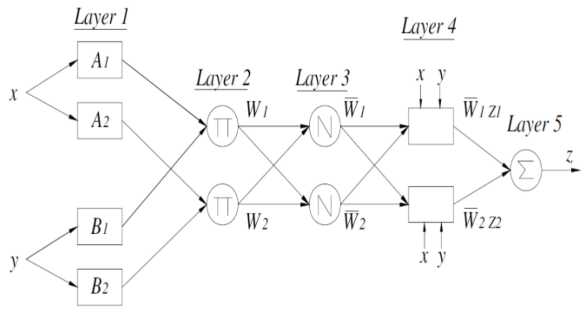

Fig.1.ANFIS Structure

Hybrid learning algorithm is adapted which merge the LSM and back propagation algorithm to train quickly. The functional block diagram of Sensorless control of SRM using ANFIS is shown in Fig.2

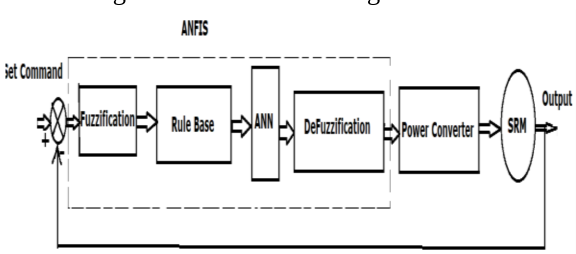

Fig.2. Functional block diagram ANFIS Control Strategy.

III. RESULTS AND DISCUSSION

The speed control and minimization of torque ripples of SRM using ANFIS controller and the responses of speed and torque characteristics are shown in fig (3-5).Table-1 shows the time responses of proposed controlled strategy of motor performance for different speed commands. When the speed command is varies from initial speed to 4000 RPM and which is raised to set command at 0.35 sec and settled at 0.35 sec, similar way for the speed command of 5000 RPM, the corresponding rise time 0.45 sec. The speed response also settles where rises to set speed. This kind of speed characteristics will helps to raise the vehicle speed with in very short interval of time. Its speed error is almost zero for all speed commands. The torque distortion is almost minimized for different speed commands. The speed response analysis in terms of time domain specifications has been listed in following table-1. The speed of SRM has been analyzed by considering the time domain specification as follows.

Table-1

Command Speed (RPM)	Ts (sec)	Tr (sec)	%Mp	Tp (sec)	%Error in speed
3000	0.25	0.25	0.01	0.25	0.01
4000	0.35	0.35	0.01	0.35	0.01
5000	0.45	0.45	0.01	0.45	0.01

The speed response and torque response of SRM for the speed command of 3000 RPM are as follows.

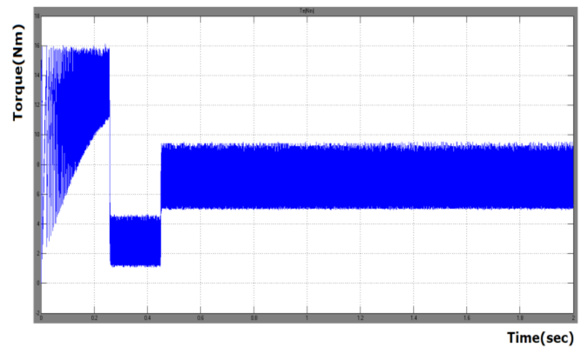

Fig.3.Torque response of SRM at command speed 3000 RPM.

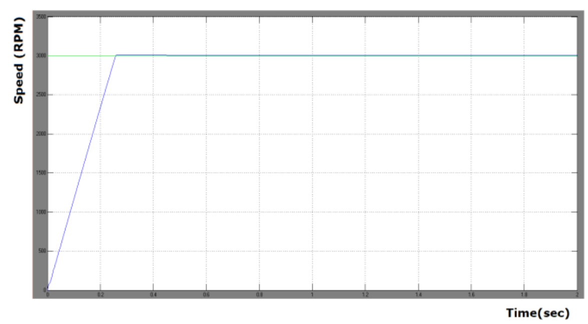

Fig.4. Speed response of SRM at command speed 3000 RPM.

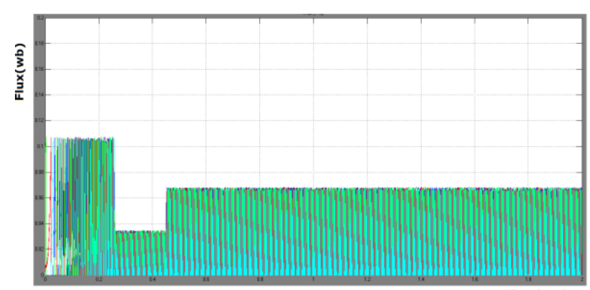

Fig.5.Flux response of SRM.

The speed response and torque response of SRM for the speed command of 4000 RPM are as follows.

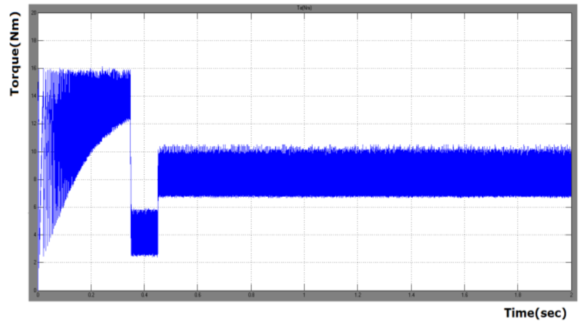

Fig.6. Torque response of SRM at command speed is 4000 RPM.

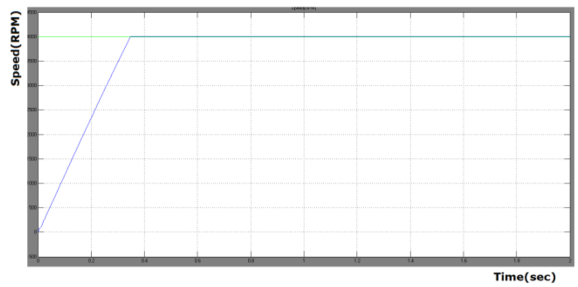

Fig.7.Speed response of SRM at command speed is 4000 RPM.

The speed response and torque response of SRM for the speed command of 5000 RPM are as follows.

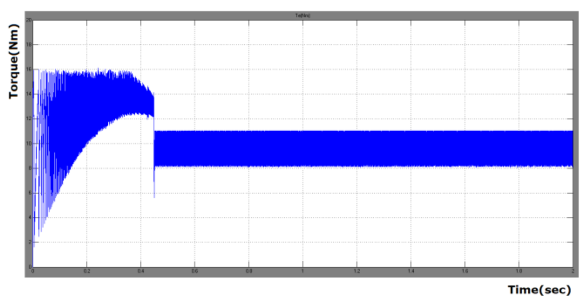

Fig.8. Torque response of SRM at command speed is 5000 RPM.

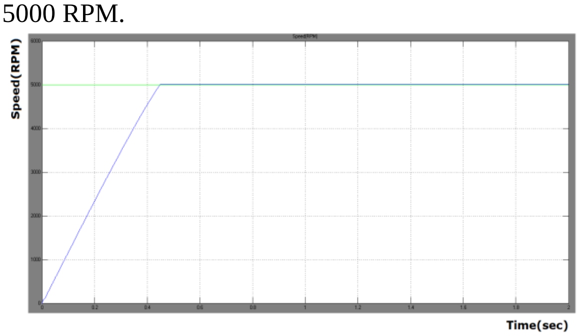

Fig.9.Speed response of SRM at command speed is 5000 RPM.

IV. CONCLUTION

The speed of responses has been analyzed by considering the time domain specifications like rise time, settling time and speed error. The proposed system makes the motor to reduce the rise time, settling time, percentage speed error and also improves the torque performance of SRM. This control strategy is suitable for low, medium and high speed. Chosen method shows the superior performance than the conventional strategies, which will be suitable for EV Applications.

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