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Finite Element Analysis of Switched Reluctance Motor with Exterior Rotor

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***Abstract*— This paper presents the two phase switched reluctance machine for higher efficiency operations The main drawbacks of switched reluctance machine is acoustic noises. The major source of an acoustic noise is flux reversal in the machine.in this paper a new winding topology has been proposed in order to eliminate the flux reversal in the stator back iron .The Finite Element Analysis (FEA) will be done in both electrical and mechanical aspects, in this project simulation work will be carried out using MagNet electromagnetic simulation package.**

***Index Terms*— Finite Element Analysis (FEA), Exterior rotor, Switched Reluctance Motor, Flux Reversal.**

I. INTRODUCTION

In switched reluctance motor torque will be produced by means of interaction of stator field with rotor saliency. This machine has various advantages especially in the field of automotive applications such as simplicity in construction, high speed applications, high power density, phase windings are electrically separated, low moment of inertia[4].But this motor has the disadvantage of acoustic noise. This paper deals with analysis of a switched reluctance motor having an exterior rotor. The construction of exterior rotor motor is varies from conventional motor by having an outer rotor and inner stator configuration. Even though conventional motor used for EV applications requires gear coupling arrangements. But this setup is not necessary for switched reluctance exterior rotor.

II. CONVENTIONAL EXTERIOR ROTOR SWITCHED RELUCTANCE MOTOR

In this conventional Direct Drive two phase SRM, the stator consists of four poles and the rotor consists of two poles and the flux path for Phase A and Phase B excitation area shown in the fig 2 and 3 respectively. The flux direction for Phase A and Phase B differ from each other. Difference in their flux path direction of two phases denotes the occurrence of flux reversal in back iron of the stator.

Fig. 1: Conventional 4/2 Exterior rotor two phase SRM

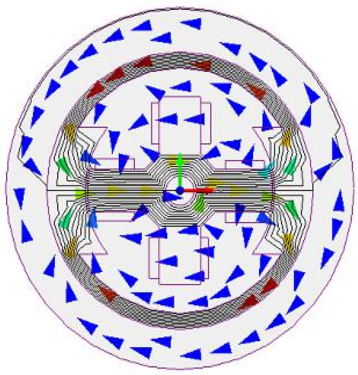

Fig.2 Excitation of Phase A

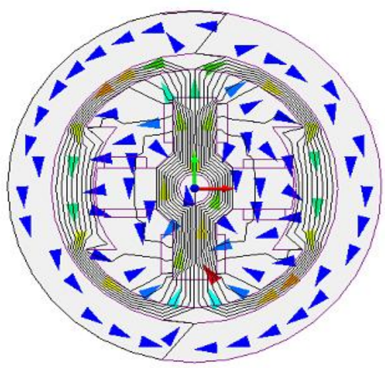

FIG. 3: EXCITATION OF PHASE B

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III. PROPOSED EXTERIOR ROTORSWITCHED RELUCTANCE MOTOR

In this proposed model, new winding topology is implemented in order to obtain the flux reversal free stator. The fig.4 shows the proposed 6/3 Direct Drive SRM. The stator consists of two main poles and four auxiliary poles and the rotor consists of three poles. The fig 5 and 6 shows the flux direction for excitation of phase a and phase b respectively. The flux direction is similar to all excitations [1].

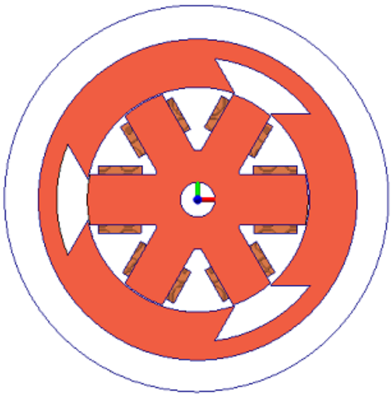

Fig.4 Proposed 6/3Exterior rotor SRM

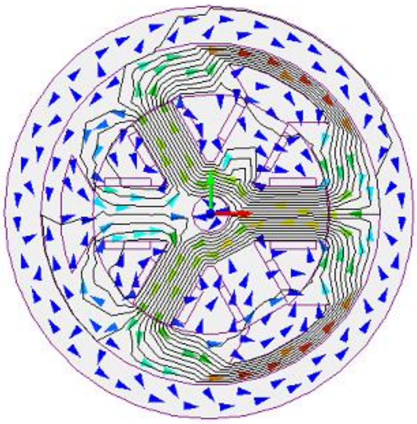

Fig. 5 Excitation of Phase A

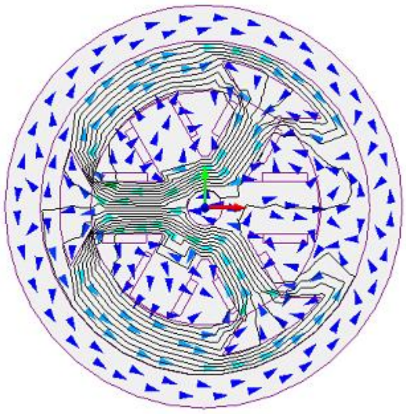

Fig. 6 Excitation of Phase B

IV. NEW WINDING TOPOLOGY

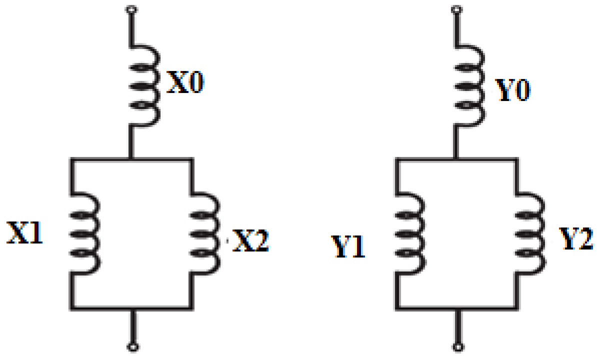

Fig. 7 New winding Topology

In this new winding topology X_0, Y_0 are the main windings similarly X_1, X2 and Y_1, Y2 are the auxiliary windings. Considering the aspect of flux reversal, the auxiliary windings are connected in parallel which is connected in series to the main field winding as shown in the figure [7].

V. DESIGN SPECIFICATIONS

Table 1 shows the machine dimensions of the proposed two phase 6/3exterior rotor SRM topology.

Table 1: Machine Dimensions

Power	250 Watts
Peak Voltage	36 Volt
Peak Current	8 Amps
No. of Phases	2
No. of stator poles	6
No. of Rotor poles	3
Stack length	50mm
Speed	1000rpm
Material	(M-19) Steel

VI. FINITE ELEMENT ANALYSIS

Using the software package FEA analysis of an Direct Drive switched reluctance motor is carried out for static and transient analysis to predict the performance characteristics in 2D model.

A. *STATIC*

In static FEA analysis various parameters like torque, flux linkages, ohmic losses, iron losses, current and energy are obtained with respect to instantaneous rotor position. In fig 8 and 9 shows the static flux density and flux distribution of Phase A and Phase B. The flux density for Phase A and Phase B is 2.18825Wb and 2.58549Wb. Fig 10 shows the static torque. Fig 11 and 12 shows the flux linkage for Phase A and Phase B. Fig 13 shows the static magnetic energy, fig 14 shows the static co-energy.

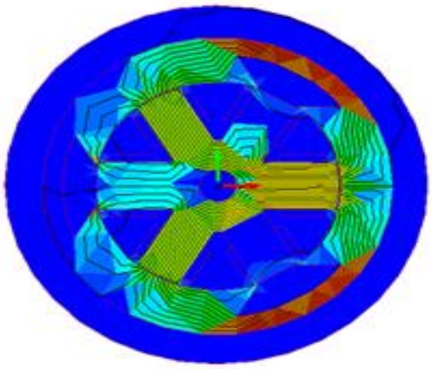

Fig. 8 Static Flux Density and Flux Distribution for Phase A Excitation

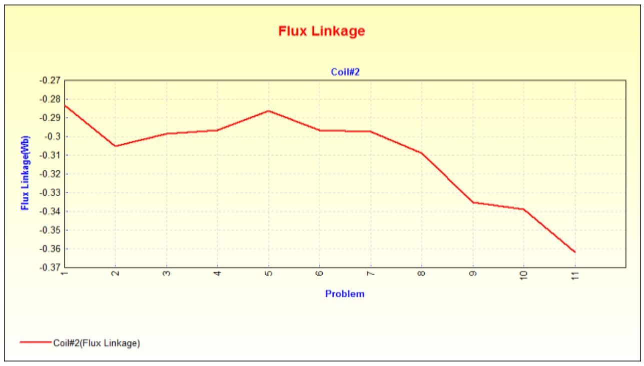

Fig.12 Fluxlinkage Phase B

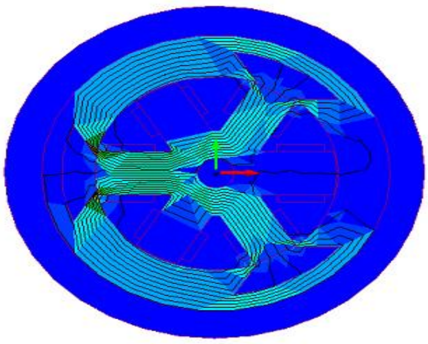

Fig. 9 Static Flux Density and Flux Distribution for Phase B Excitation

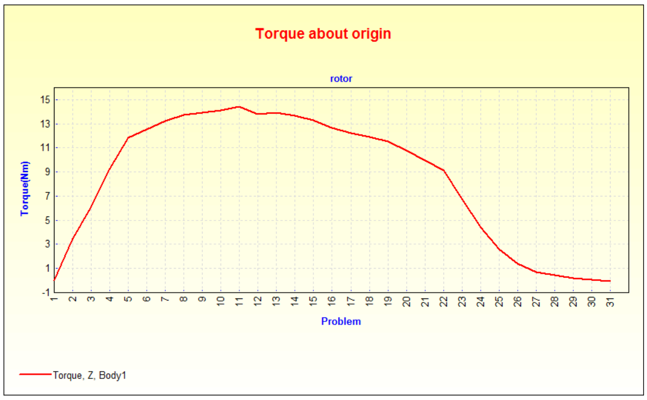

Fig. 13 Static Torque with respect to various rotor position

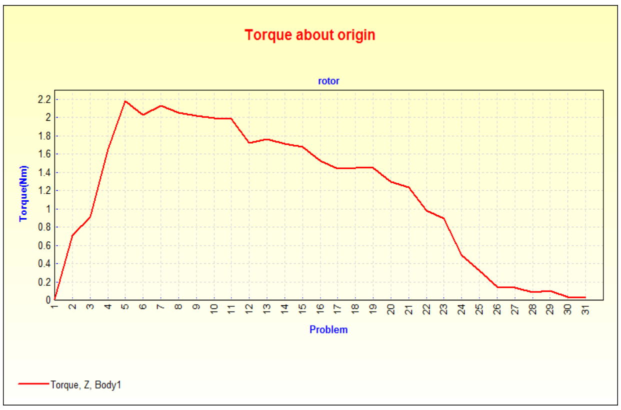

Fig. 10 Static Torque with respect to various rotor position

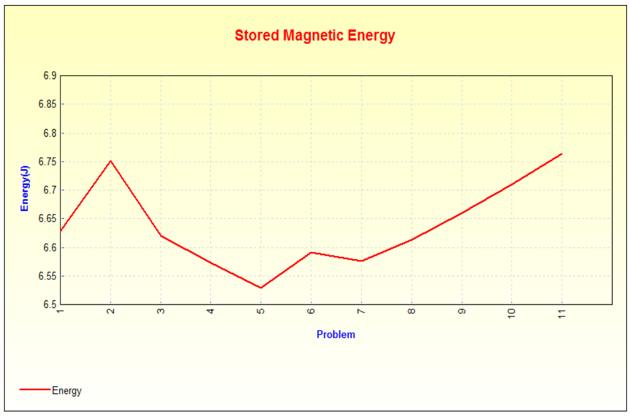

Fig. 13 Static Magnetic Energy

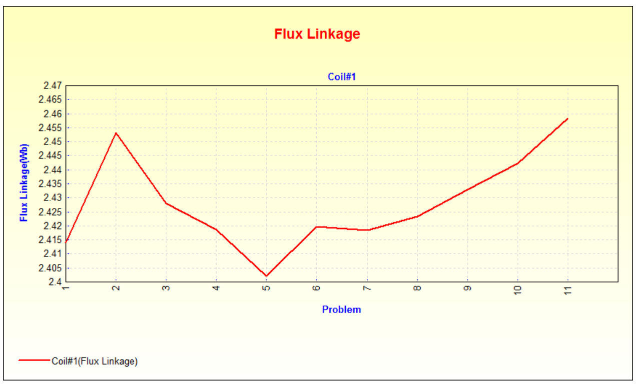

Fig.11 Fluxlinkage for Phase A

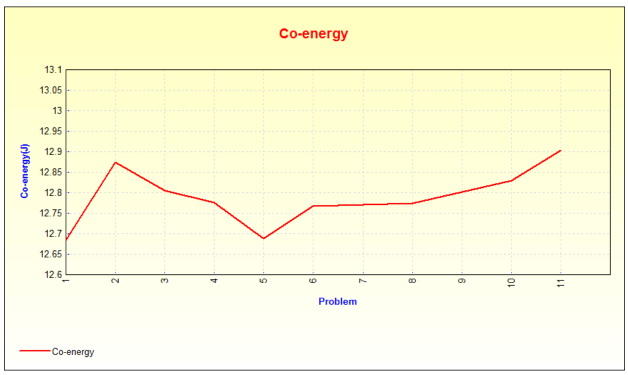

Fig.14 Static Co-Energy

B. *TRANSIENT ANALYSIS*

In order to predict the performance characteristics like torque, flux linkages, current, iron losses, ohmic losses, energy with respect to time transient analysis is preferred. The driver circuit is shown below in the fig 15. The circuit consists of two switches S1 and S2 which is connected to the winding as shown below. The fig 16 and 17 shows the Transient torque and transient magnetic energy respectively. Then the fig 18 and 19 shows the transient co-energy and Flux linkage for Phase A[5].

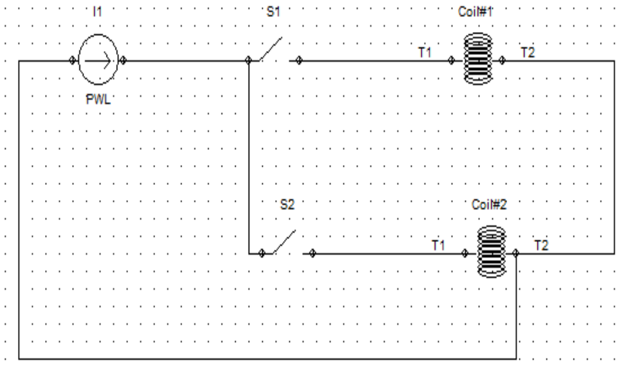

Fig. 15 Driver Circuit

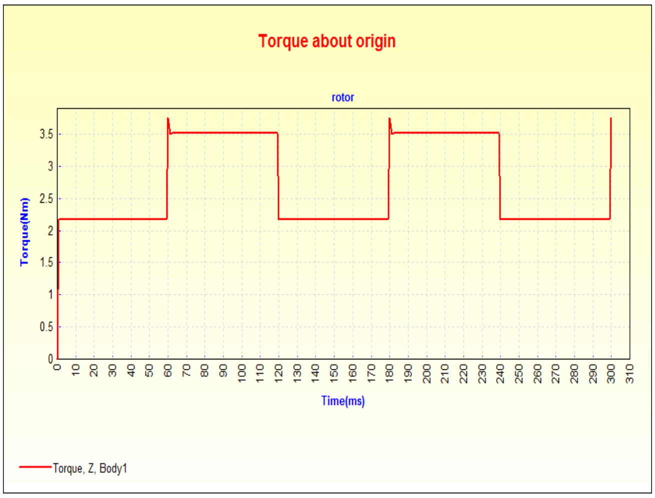

Fig. 16 Transient Torque

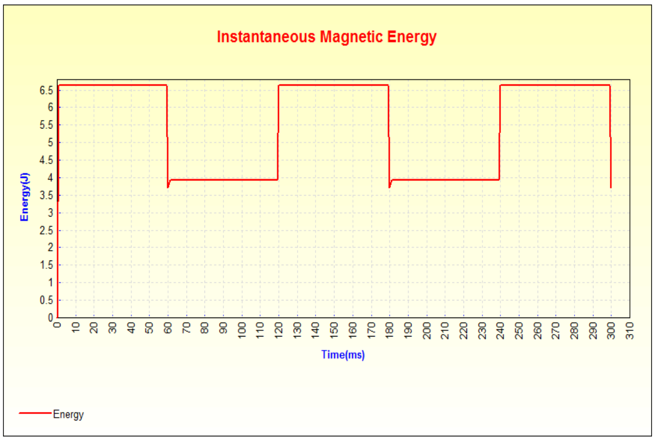

Fig. 17 Transient Magnetic Energy

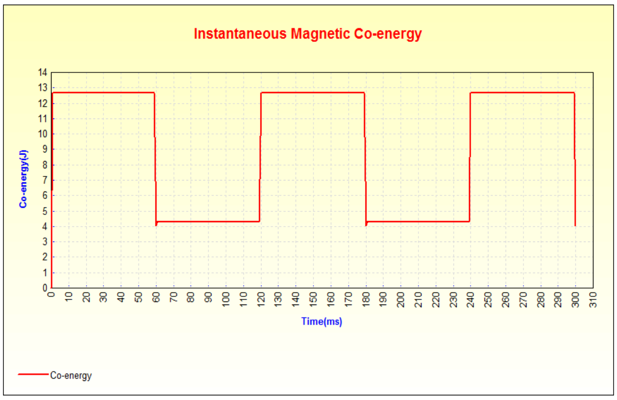

Fig. 18 Transient Co-Energy

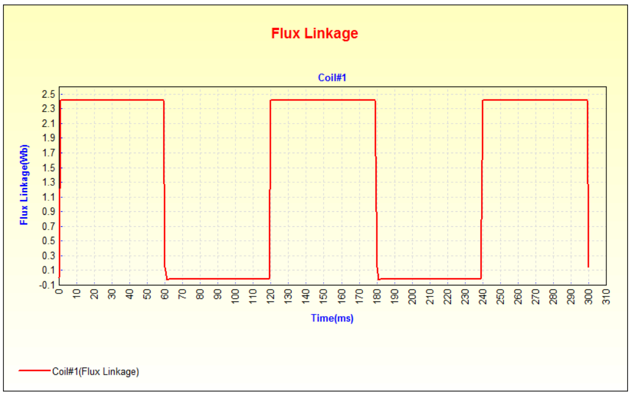

Fig. 19 Transient Flux Linkage

VII. CONCLUSION

This paper delivers the concept of flux reversal in the stator core during the excitation of all phases by new winding topology. The future scope of this work is to do transient with motion, torque ripple reduction, vibration, thermal and computational fluid dynamics (CFD) analysis for 6/3 switched reluctance motor with exterior rotor.

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