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Hysteresis Current Control of Switched Reluctance Motor Drive Using Linear Model

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ABSTRACT: The inductance of phase winding of a Switched Reluctance Motor (SRM) is a function of rotor position (θ) and current (i). An accurate dynamic model is required to predict the performance of the drive In the linear analysis, the inductance of the winding is assumed to be a function of rotor position only, as magnetic saturation is neglected. This paper deals with the Linear model of the SRM . The Linear model of the SRM drive is simulated with Hysteresis Current Control in MATLAB/SIMULINK..

KEYWORDS: Switched Reluctance Motor, Linear Model, Hysteresis Current Control.

I.INTRODUCTION

T**he** applications of SRM drive applications have increased in recent years because of advantages such as simple construction and low manufacturing cost. The main drawback of the motor is that it because of non-linear magnetic characteristics high torque ripple is high, which causes noise and vibrations [1,2].A dynamic simulation of the drive system enables verification of the analytical designs and the ability of the motor drive system to match the load torque over its entire speed range both in its steady state and during transients. With such verification, time and cost of the product development are minimized by avoiding a trial-and-error approach to prototype construction that may lead to repetitive testing and redesign until specifications are met. Simulation of the drive system requires accurate models for SRM drive systems. Investigating the operational behavior of the SRM requires mathematical model. Many different models and possible ways of modeling SRMs have been developed and published in the literature [3].

The phase inductance or flux-linkage is a non-linear function of rotor position and stator current. In linear analysis, neglecting the magnetic saturation the phase inductance depends only on the rotor position. Linear modeling of SRM has been presented by F.Soares et al. [4]. In this paper, the effect of varying turn-off angle on the torque ripple with two control strategies namely Hysteresis Current Control and Voltage Control is investigated. It has been concluded that, the torque ripple magnitude not only depends on the turn-off angle, but also on the motor speed and the load torque. The simulation results are compared with the experimental results, and found to be in close agreement with it. Linear model is simple, but inaccurate as it ignores the non-linear characteristics of the motor.

This paper analyses the performance of Hysteresis Current Control of SRM using linear model.

II. HYSTERESIS CURRENT CONTROL

At lower speeds, the motor back-EMF is small compared to the supply voltage and the current flowing through the stator winding can be regulated by current chopping. So current control method is applied to low and medium speeds [5, 6, 7]. The block diagram of Hysteresis Current Control is shown in Fig. 1. The actual speed is compared with the reference speed and error is given to a PI controller, which outputs reference current. The commutation controller takes the position sensor signal and decides which phase is to be switched On. The inputs to the Hysteresis Current Control block are reference current, actual current, θ_{on} and θ_{off} .When the current exceeds a specified set-point value $i_{H,}$ controller turns Off two switches in a phase leg of the converter to regulate the current. Switches are turned On again when the current falls below a second level $i_L = i_H - \Delta i$, where Δi is the hysteresis band [2].

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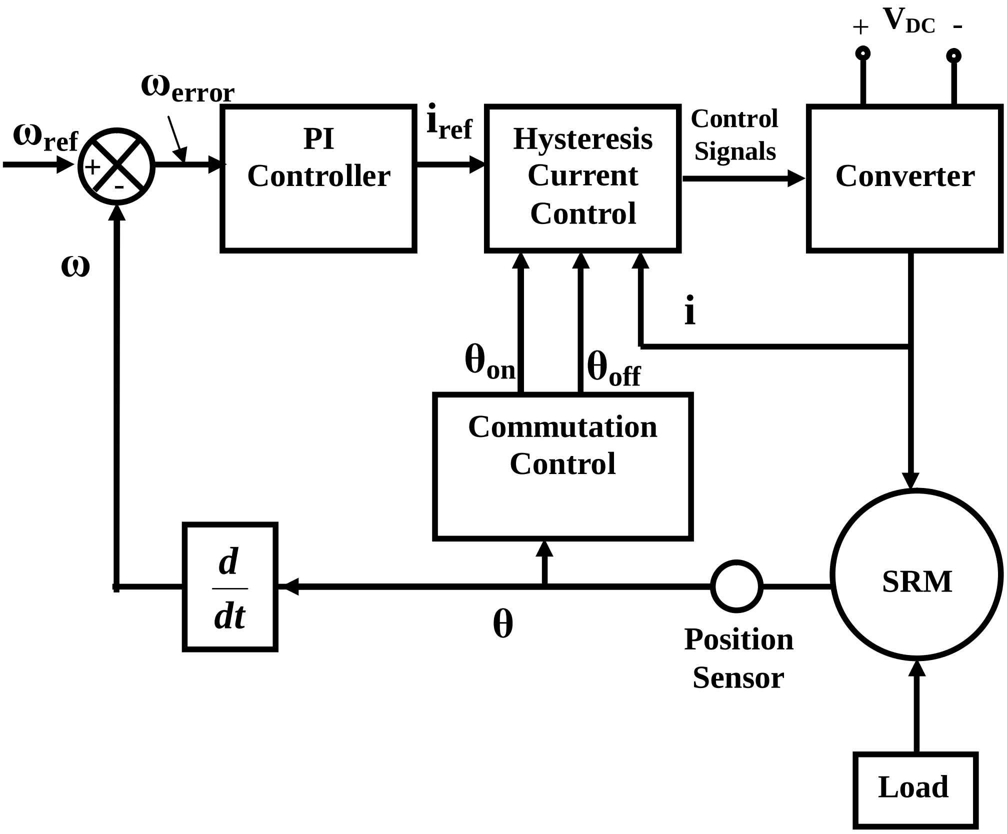

Fig.1 Block diagram of Hysteresis Current Control

III. SIMULATION AND ANALYSIS OF HYSTERESIS CURRENT CONTROL OF SRM DRIVE

The complete Linear model of the 4-phase 8/6 SRM with Hysteresis Current Controller is shown in Fig. 2 (a). The model consists of electrical system, mechanical system, position sensing, converter, PI controller and Hysteresis Current Controller blocks. Fig. 2 (b) shows the single phase model of the drive. The performance of the Hysteresis Current Control based SRM drive is analyzed for a Fan type load torque of 8 Nm and at a reference speed of 800 rpm. The *unaligned position* is 0^0 and the *aligned position* is 30^0. The simulation is performed by maintaining $\theta_{on} = 0^0$ and $\theta_{off} = 24^0$. The reference current is maintained at 16 A and the hysteresis band is set at 1 A. The actual speed is compared with the reference speed and the speed error is given to a PI controller. Fig.3 (a) shows the inductance, voltage, flux-linkage and current in one phase of the SRM in the steady state. Instantaneous phase currents of the four phases in the steady state are shown in Fig. 3 (b). It is observed that the current in each phase is maintained at 16 A with a set hysteresis band of 1 A. Fig. 3 (c) shows the flux-linkages of the four phases in the steady state. The instantaneous torques in all the four phases in the steady state is shown in the Fig. 3 (d). It is observed that there are small negative torques in each phase, but the total torque developed by the SRM is positive. Fig. 3 (e) shows the total torque developed by the motor over the entire simulation time. The total torque in the steady state is shown in Fig. 3 (f) and it is observed that the torque ripple is high. The calculated torque ripple is 362 %. The load torque is shown in Fig. 3 (g). The speed response is shown in Fig. 3 (h). The speed has ripples in the steady state, since the torque ripple is large.

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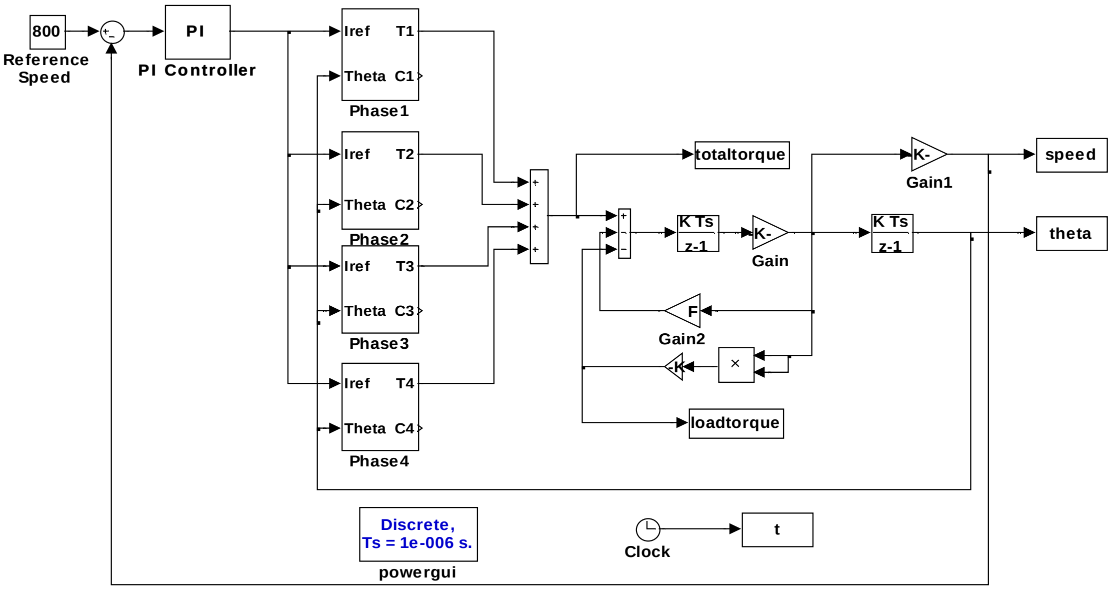
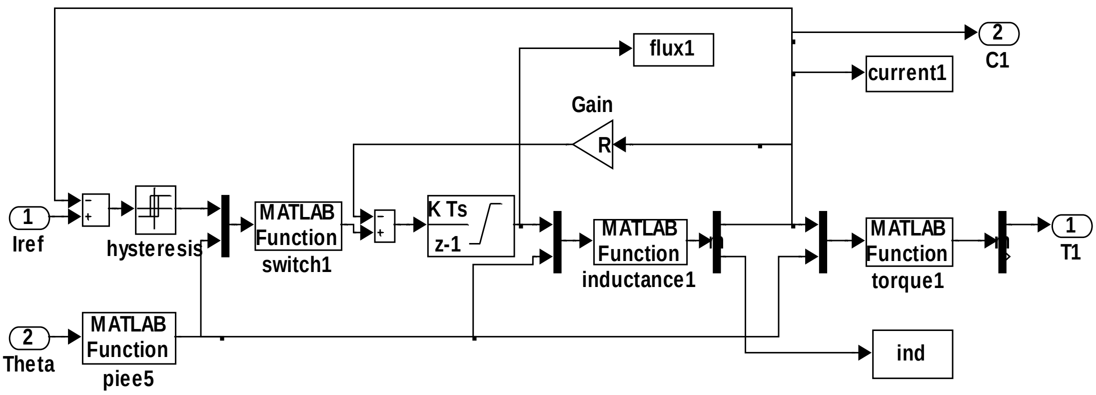
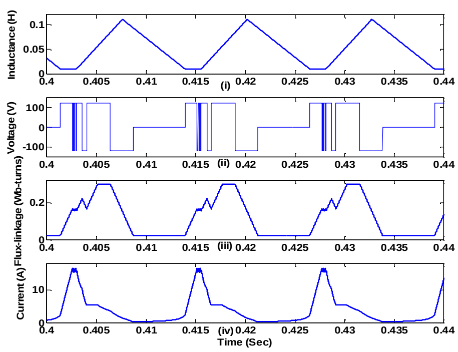


(a)

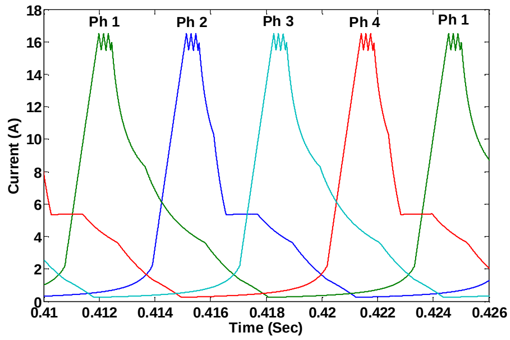


(b)

Fig. 2 (a) Simulation diagram of SRM with Hysteresis Current Control (b) Model of single phase



(a)



(b)

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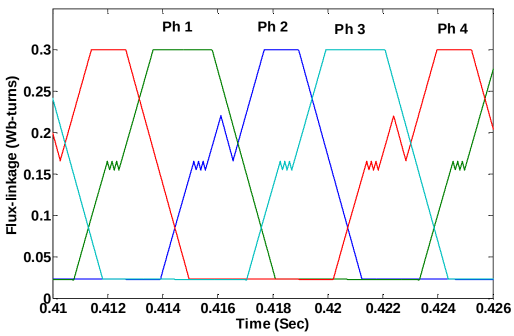

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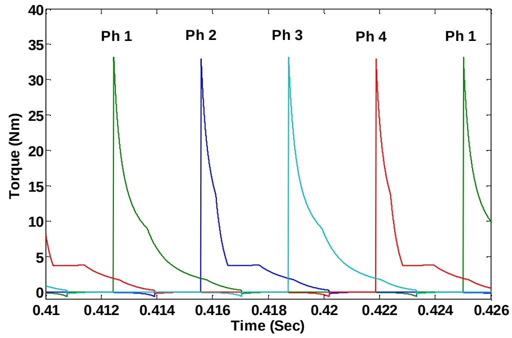

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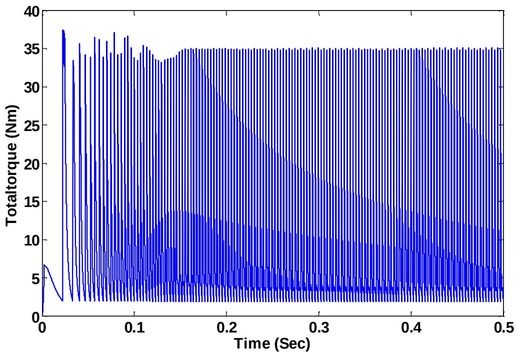

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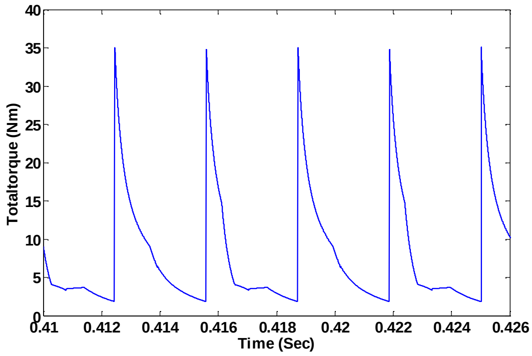
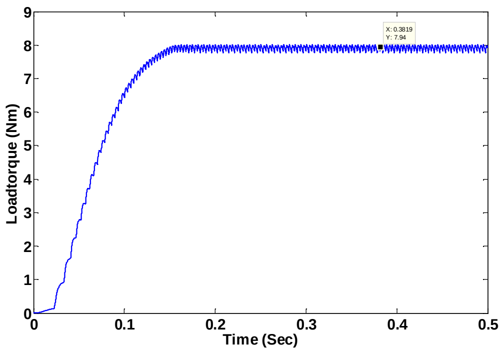
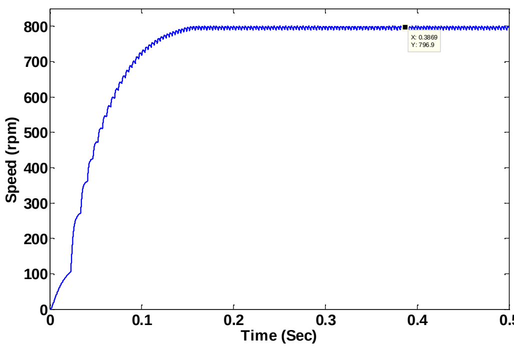


(f)



(g)



(h)

Fig.3 Hysteresis Current Control with Fan type load (Linear Model) (a) (i) Phase inductance (ii) Phase voltage (iii) Phase flux-linkage (iv) Phase current (b) Phase currents (c) Phase flux-linkages (d) Phase torques (e) Total torque (f) Total torque in the steady state (g) Load torque (h) Speed

IV.CONCLUSION

The Linear modeling of 4 phase 8/6 SRM is presented in this paper. The principle of operation of Hysteresis Current Control is discussed elaborately. The Linear model of SRM drive is simulated in MATLAB / SIMULINK with Hysteresis Current Control for Fan type load . It has been observed that in Hysteresis Current Control, the current is maintained at 16 A within a hysteresis band of 1 A. It can also be concluded that the SRM can be suitable for Fan type load. The torque ripple with Linear model is very high, as it does not consider the non-linear characteristic

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