단상 하이브리드 SRM의 센서리스 제어기법

탕잉, Fengge Zhang, 이동희, 안진우
경성대학교

Sensorless Control Method of Single-Phase hybrid SRM

Ying Tang, Fengge Zhang, Dong Hee Lee,Jin Woo Ahn
Shenyang University of Technology, Kyunsung Unviersity

ABSTRACT

In this paper, a novel method of sensorless control scheme is proposed to apply on a single phase hybrid SRM used in high speed operation. The proposed method utilizes beneficially permanent magnet field whose performance is motor parameter independent to estimate the rotor position. The differential value of back EMF is used to detect its peak point when there is no current conducting in the winding. Through this approach, the adjustable turn on/off position can be achieved without prior knowledge of inductance profile which is always employed by many sensorless schemes. And this paper may offer an available method to do the sensorless control in hybrid SRM used for high speed running.

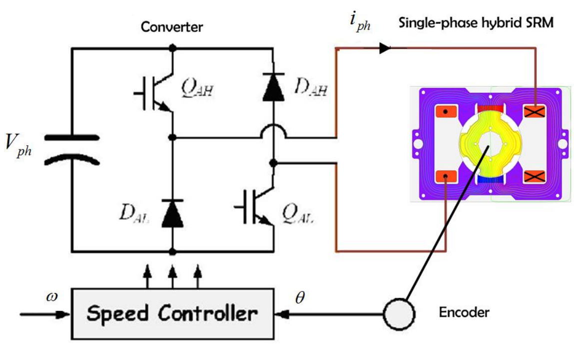
1. Introduction

For various industrial applications [1 2], the multi phase switched reluctance machine(SRM) has dominated the electrical drives for long decades. However, to be applied on high speed operation, the multi phase SRM suffers from high manufacture cost due to the switching power electronics and also the low efficiency caused by high switching loss. So, a single phase switched reluctance motors drive system suits naturally unipolar excitations and can be an effective way to replace the multi phase SRM drive system.

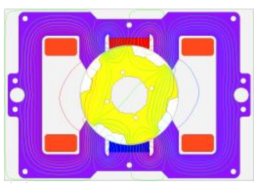
In order to assure the motor operated normally, accurate knowledge of rotor position is indispensable. With consideration of size reduction and easy to maintenance, the sensorless control techniques are attractive more than ever. Some sensorless control method has been proposed and applied on single phase hybrid SRM. In [3], the back EMF generated by permanent magnet flux linkage is utilized to achieve the rotor position detection. But this proposed idea has the limited application at high speed with heavy load because of the unavailable turn on angle. Thus, a novel method can be employed to estimate the rotor position with adjustable switch on/off angle should be come up with.In this paper, an optimized high speed single phase hybrid SRM is regarded as a target to achieve the sensorless control scheme.

2. The Working Principle of Hybrid SRM

Fig.1(a) shows the drive system of targeted single phase SRM.When there is no current flowing in the motor, the rotor will park at the position shown in Fig.1(a) (defined as the zero degree of rotor position), due to the asymmetrical structure of the rotor poles under the effect of two PM embedded in stator. Once the voltage is added to winding terminals, the generated current will flow in the coils and produce flux to circulate in the machine, thus, will produce a positive reluctance torque to pull the rotor to rotate forward, until the rotor poles are aligned with the stator reluctance poles shown in Fig.1(b), which is around 45 mechanical degrees. After about 45 mechanical degrees later, the current in winding coils should then be reduced to zero for the remaining period to allow the rotor align with stator poles again shown in Fig.1(a).By repeating this procedure, a steady state operation can be achieved.



(a) Singl phase hybrid SRM drive system



(b) Aligned Position

Fig. 1. Section view of the single phase hybrid SRM

3. Proposed Sensorless Control Scheme

The freewheeling period is a very valuable region that can be utilized to do sensorless control. During this period, only the permanent magnets act on rotor, and the phase current has to be maintained zero for roughly half of an electrical period due to the single phase nature of this machine. The back EMF generated by PM flux linkage is rotor position dependent and this value can be captured at the terminal of the winding. In [3], by detecting the crossing zero position of back EMF at terminal, the 0 degree,90 degrees,180 degrees, and 270 degrees (in mechanical) can be got to do the prediction of rotor speed which completes the sensorless control at the same time. However, generally, the current needs to be prebuilt to reach the ideal current level before inductance rising region and long freewheeling time should be shorten by advancing the switch off angle under high speed running condition, especially in heavy load situation, but the turn on angle in [3] must be later than 0 degree (in electrical), which means it cannot be regulated arbitrarily due to crossing zero detection of back EMF. To reach the goal of adjustable turn on angle, the differential value of back EMF is used instead of the back EMF value and this allows a simple estimation of the rotor position without involving any motor parameters. Fig.2 shows the proposed position estimation scheme diagram. In proposed sensorless method, the slope value of winding back EMF is employed as a medium to capture the maximum point of winding back EMF. It can be concluded that if the zero crossing point of the slope of back EMF is got, the 67.5degrees or 157.5 degrees or 245.5 degrees or 337.5 degrees (in mechanical) is arriving at that time. Thus, the rotor position estimation can be obtained by the following two equations.

$$\theta_{(k+1)} = \theta_{(k)} + \omega\Delta t$$

$$\omega = \frac{\Delta\theta}{\Delta t} \qquad (1.1)$$

The zero rotor position in figure below refers to the positon which rotor is aligned with PM, same as the experiment setup. Since the HSRM has four rotor poles, the estimation of the speed can be refreshed four times per revolution, synchronized to the rotor position.Fig.3 shows the flowchart of proposed scheme.

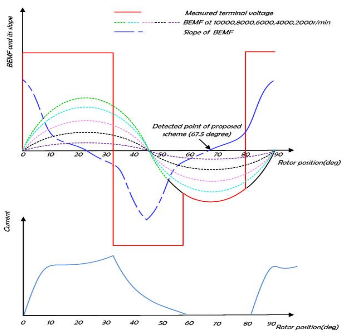


Fig.2 Proposed rotor position detection method

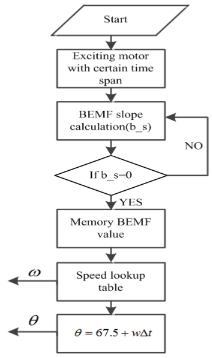


Fig.3 Flowchart of proposed scheme

4. Simulation of Proposed Scheme

Fig.4 shows open loop simulation block of proposed method, and Fig.5 shows the open loop simulation results in which the position estimation method are used.

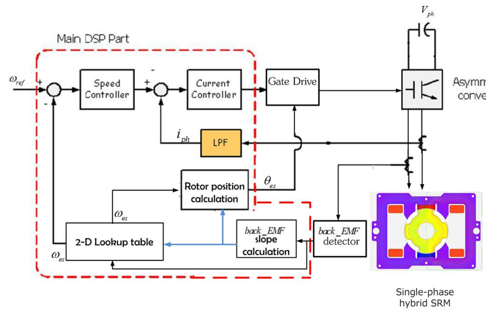


Fig.4 Block diagram of proposed scheme

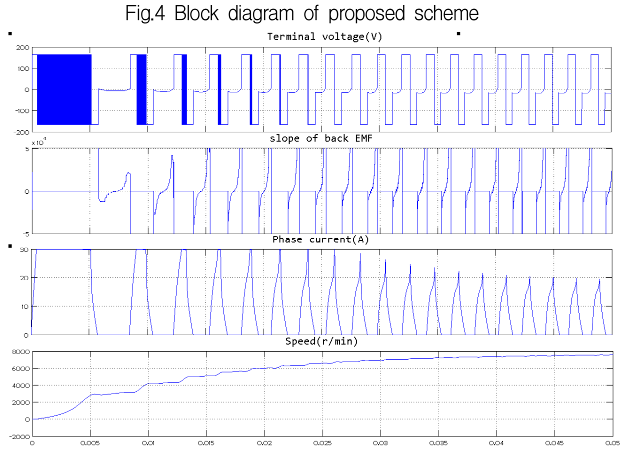


Fig.5 Simulation result of sensorless control scheme

Conclusion

In this paper, a sensorless controlled HSRM drive scheme is presented. The introduction of sensorless control to this drive is essential to maintain its small volume. By using the unique feature of this new HSRM, the sensorless control can be implemented simply and reliably. And the performance of this scheme need to verified in further study.

Reference

[1] J. M. Stephenson, 'Switched reluctance motors', US Patent, No. 5,548,173, Aug. 1996.

[2]Jakobsen,U.,'Sensorlesscontrol of low-cost single-phase hybrid switched reluctance motor drive', IEEE Trans. on Industry Application.Vol.PP.Issue:99, Dec.2014