European Association for the Development of Renewable Energies, Environment and Power Quality

International Conference on Renewable Energies and Power Quality (ICREPQ'09)

Valencia (Spain), 15th to 17th April, 2009

Synchronization Techniques Comparison for Sensorless Control applied to PMSG

L. G. González[1], E. Figueres[2], G. Garcerá[2], O. Carranza[3]

[1]Departamento de Electrónica y Comunicaciones, Universidad de los Andes, Mérida, Venezuela.
Phone:+0058 02742402907, e-mail: lgerardo@ula.ve,

[2]Departamento de Ingeniería Electrónica – UPV, Camino de Vera S/N, 7F, Valencia, 46022, España.
Phone:+0034 963876001, e-mail: efiguere@eln.upv.es, ggarcera@eln.upv.es

[3]Escuela Superior de Cómputo - Instituto Politécnico Nacional, Av. Juan de Dios Bátiz S/N, D. F., 07738, México.
Phone:+005255576000, Ext: 52020 , e-mail: ocarranzac@ipn.mx

Abstract: This paper encompasses a comparative study of techniques for position and speed estimation applied to permanent magnet synchronous generators (PMSG), connected to the distribution grid by means of a back to back converter. In the context of low and medium power wind energy conversion systems, the robustness of the sensorless techniques are studied taking into account the tolerance of the PMSG parameters.

Keywords

Sensorless Control, Extended Kalman Filter, Sliding Mode Observer, PLL, Simplified Kalman Observer, Permanent Magnet Synchronous Generators.

1.- Introduction

The use of PMSGs has special interest in low power wind energy applications, due to their small size and high power density. PMSGs operate in a large speed range, so that it is mandatory to measure or estimate their speed and position. In small and medium power applications it is preferred the use of sensorless techniques in order to reduce the implementation cost, allowing vector control with a position and speed machine estimation. The general system performance strongly depends on the chosen estimation technique.

About the control strategies, it is necessary to emphasize that in systems with generator position and speed sensors the wind energy conversion efficiency ranges between 56% and 63%, whereas with sensorless techniques that efficiency is usually between 55% and 61%. In low power systems that conversion efficiency reduction is generally acceptable, taking into account the cost and complexity reduction achieved by sensorless control.

In this work the performance of several estimation techniques is studied, like the sliding mode observer (SMO), the synchronous reference frame three-phase phase locked loop (PLL), the linear observer with extended *Kalman* filter (EKF) and its simplified implementation, called the simplified *Kalman* observer (SKO). A comparative study has been carried out, allowing to select a technique which increases the overall system performance.

The system topology used in this article is based in a PMSG, controlled by a back to back converter, as shown in figure 1. This topology shows a better performance compared to the PMSG connected through a diode bridge rectifier and a boost converter to the DC-link for the small and medium power range [1]. The back to back converter transfers the energy generated by the PMSG to the grid. The chosen control strategy is the zero reactive current, which allows to achieve the maximum system performance; with this control technique the active and reactive currents are controlled by PI regulators. For the active current control loop, the reference will be obtained by the maximum power point tracker (MPPT) algorithm. It is worth to point out that the goal is getting more torque-current ratio, which depends on the estimated position signal.

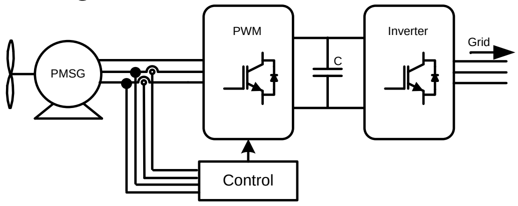
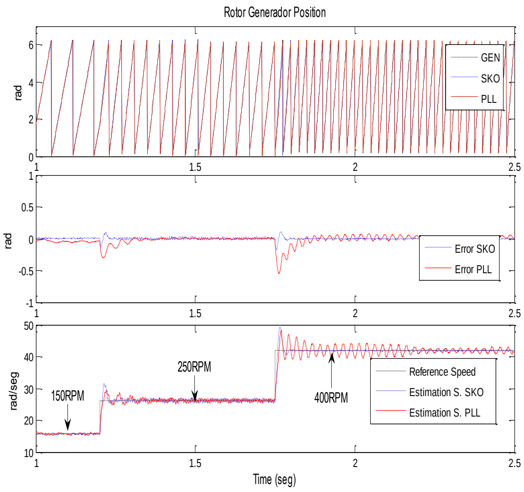


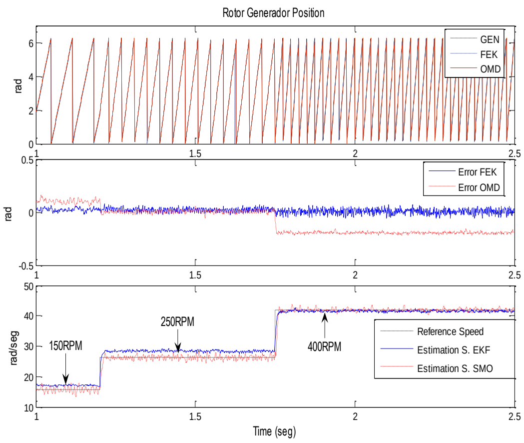
Fig. 1. Wind energy system under study.

7.- Results of the Comparative Study

The system parameters used in the PSIM™ simulation are described in Table 1. The studied position and speed estimation techniques have similar behaviors. The study has been carried out for the speed range from 150 to 400 RPM. Figures 2*a* and 2*b* show the position estimators performance at step changes of the speed reference. The best performance is achieved by the SKO and PLL techniques. When using EKF and SMO the response is faster but noisier (a higher ripple is observed). The SMO technique has errors in the estimated position signal for various speeds due to the used low-pass filter. The robustness of the position and speed estimators was studied by simulation, with identification errors in the resistance and inductance of the machine. Figures 3*a* and 3*b* show the sensitivity to a ±25% tolerance in R_s and L_s.

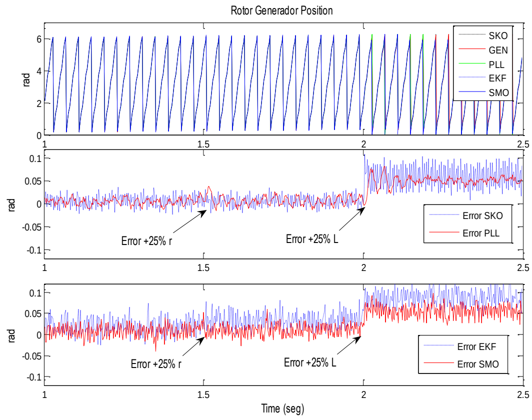


2a

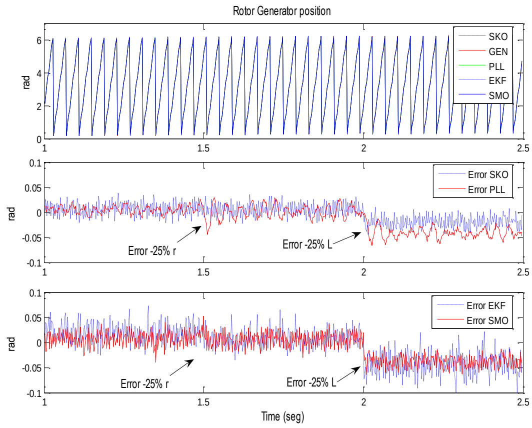


2b

Fig. 2a and 2b. Position and speed observer performance at step changes of the speed reference.



3a



3b

Fig. 3a and 3b, Position observer performance, with errors of ±25% in R_s and L_s, at 250 RPM.

Table 1	
Number of poles P	*12*
Armature resistance and Inductances	*5 Ω, 25mh*
Sampling time (T_s)	*10µseg.*
Amplitude of the flux linkages coefficient	*0.9022 volt/rad/s*
Speed of the generator maximal	*625RPM*
DC link Voltage	*800volt.*
Inertia coefficient systems	*0.083kg*m /seg^2*

8.- Conclusions

A comparative study of the performance achieved by several estimation techniques for sensorless control of PMSGs has been carried out in this paper. The OSK technique has the best performance among all of the estimation techniques under study, using a simple algorithm which uses a constant gain matrix. The performance of the PLL technique is affected by the tuning parameters, and the SMO technique has an error in the position and speed estimation at different speed operations. Finally the EKF technique has a noisy performance and its implementation is difficult due to mathematical complexities.