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Comparative study of Speed Estimators Applied to Wind Turbine with Harmonic Distortion in both the Currents and the Voltages

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Abstract. This paper presents a comparative study of different speed estimators to implement a sensorless speed control loop in a wind generation system with a Three-phase boost rectifier operating in discontinuous conduction mode. For implementation of the speed estimators, the compared techniques start from the measurement of electrical quantities like currents and voltages, which are highly distorted because of the components at the switching frequency of the boost rectifier and also the low frequency harmonics at multiples of the generator fundamental frequency. It is shown the linear Kalman filter estimator is appropriate for this application because of its fast response time and low error obtained.

Key words

"Sensorless", "Wind Generator System", "PLL", "Extender Kalman Filter", "Linear Kalman Filter"

Introduction

For this application the power converter is a Three-Phase Boost Rectifier operated in Discontinuous Conduction Mode (DCM) with Peak Current Mode Control (PCC). The rectifier is connected to a power inverter, which injects the energy to the grid. The control system of the rectifier needs to know the generator speed, for closing the speed control loop.

In this work, the performance of several speed estimation techniques is studied: Speed estimation using a synchronous reference frame Phase Locked Loop, speed estimation using the Rectifier currents and voltages, Speed estimation using Extended Kalman Filter and speed estimation using the Linear Kalman Filter. The problem in developing estimators is that both the PMSG currents and the voltages contain harmonic of its fundamental frequency and components at the switching frequency.

Results

The estimator using PLL, the estimator using the EKF by measuring the voltages of the output generator, and the estimator using the LKF properly follow the actual speed. However, the estimator using the currents and voltages in the rectifier and the estimator using EKF by the electromotive force, one match at certain speeds but not at all speeds. The problem is attributed to the components of the switching frequency and of harmonics that contain the currents and the voltages of the output generator.

The estimator using PLL has a maximum ripple of ±16 rpm, the estimator using EKF measuring the voltages of the output generator has a maximum ripple of ± 4.5 rpm and the estimator using LKF has a maximum ripple of ± 10 rpm. Also shows the filtering error of each of the estimators. They are used to obtain the response time with step of 150 rpm in the generator speed. The estimator using PLL has a response time of 150 ms, the estimator using EKF measuring the voltages of the generator output has a response time of 250 ms and the estimator using the LKF has a response time of 80 ms.

Conclusion

From the results and the algorithms needed to implement each one of the estimators, it may be concluded that the appropriate for this application is the LKF, because it has better performance with regard to measurement noise. Besides, the LKF algorithm is less complex than the other that it has been studied. In the follow months, it will be built a wind turbine emulator to validate the PSIM simulations. Currently, Three-phase boost rectifier in DCM is operated with a control PCC.