Chapter 18

Non-Linear Adaptive Control of Induction Motor Drive for Standalone Photovoltaic Water Pumping System

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ABSTRACT

The integration in the isolated areas and rural sectors is a better solution for producing the electrical energy needed for applications such as pumping systems. The rural water demand for crop irrigation and domestic water supplies is increasing. For this, one of the most conceived solutions is the photovoltaic water pumping technology which has the advantage of being sustainable and respectful of the environment to supply water to rural areas. This chapter describes a robust control of a standalone photovoltaic water pumping system using induction motor drive coupled with a centrifugal hydraulic pump. The induction motor is controlled by algorithm called an adaptive nonlinear control uses a combination of the adaptive observer for rotor flux and nonlinear control technique. The variables to be controlled are the rotor speed and the rotor flux norm required to implement the nonlinear control algorithm is estimated by adaptive flux observer. Simulations are carried out in order to show the effectiveness of the drive and the robustness to parameters variations.

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INTRODUCTION

For over fifty years, Direct Current (DC) motors have been widely used in variable speed drives applications principally due to their fast torque response, high precision of regulation and the possibility to use these motors in whichever mode of operation (Cruz & Rivas, 2000). However, DC motors with drawbacks of spark, corrosion and necessity of maintenance, have been replaced by AC induction motors (IMs) (Wai & Lin, 2005). Since its discovery, induction motor is considered as actuator privileged in the in all industries with a reported 90% utilization in electrical motor applications, since it has many advantages such as low cost, high efficiency, good self-starting, simplicity of design, absence of the collector brooms system and a small inertia (Hussein et al., 2017; Cruz & Rivas 2000; Archana et al., 2012). The inventions of power electronics and advances in computing have made a radical revolution in developing control strategies for induction motors. Many control strategies have been developed and used for IM drives namely Scalar Control Technique, Direct Torque Control (DTC) and Field-Oriented Control (FOC), (Muchande et al, 2013). FOC schemes, proposed by F. Blaschke in 1972 (Blaschke, 1972), can provide at least the same performance, for an inverter-driven induction motor, as it is available for a DC motor (Wade et al., 1997), by decoupling the stator flux and electromagnetic torque. However, this technique is very sensitive to the deviation of motor parameters, particularly the rotor time-constant (Wai & Lin, 2005) and it requires a mechanic sensor to correctly determine the orientation of the rotor flux vector (Cruz & Rivas, 2000). This mechanic sensor increases the cost of the drive equipment and makes the driving system much larger and unstable (Casadei et al., 2002).

Trying to reduce the complexity of the algorithms involved in a FOC, researchers presented new techniques used for estimation of the motor speed and fluxes without a need of speed and flux sensors that can reduce the cost and having the features of precision, rejection of disturbance and fast torque response (Zhu et al., 2013). One of the most popular control methods is the feedback linearization which is based on the transformation of the nonlinear model into a linear one which makes the linear feedback control easy to be applied in respect to trajectory reference (Zhu et al.; Enev, 2007). The feedback linearization based on differential geometry control theory is used to uncouple and linearize the model, put it under canonical form and then make control using linear control techniques (Enev, 2007; Raumer et al., 1993). The advantage of the Input-Output Linearization Control (IOLC) over the FOC is the fact that by applying the linearization transformation, system stability and a complete decoupling of the torque and flux in a stator fixed reference frame is achieved, which enables the optimization of motor performances without degrading the mechanical output regularization (Raumer et al., 1993).

To improve the Field Oriented Control, many control strategies have been proposed (Wade et al., 1997). Several feedback linearization based solutions were proposed. It is, by now, well known that the induction motor model with a linear magnetic circuit is not feedback linearizable by static feedback (Ismail, 2012). In (Enev, 2007) the authors have proposed a controller designed to track torque and rotor flux references, in (Marino et al., 1993) have developed an input-output decoupling controller which decouples the regulation of the rotor flux and the rotor speed. To solve the influence of large dependencies on the parameters variation and need accurate cancellation the dynamic when using exact linearization method to nonlinear system. The authors in (Meng et al., 2011; Rashed et al., 2006) introduced Nonlinear decoupling control of induction motor based on parameter adaptive identification to observe the load torque changes. In (Enev, 2007) the author proposed an input-output linearizing control for induction motor, along with a simple scheme enabling the calculation of the rotor resistance and the load torque using steady-state speed and stator current information. In (Moutchou,2014) a structure

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