International Journal of Innovative Computing, Information and Control
Volume **5**, Number **2**, February **2009**

ICIC International ©2009 ISSN 1349-4198
pp. **479–488**

ADAPTIVE CONTROL OF PMSM SYSTEMS WITH CHAOTIC NATURE USING LYAPUNOV STABILITY BASED FEEDBACK LINEARIZATION

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Received November 2007; revised April 2008

Abstract. *Chaos in motor systems is undesirable in real-time implementation because it results in motor speed oscillations changes in steady-state torque. This paper presents an adaptive control approach for time-varying permanent-magnet synchronous motor (PMSM) systems with chaotic behavior. We consider bounded perturbations in the system parameters. First, we transform the nonlinear PMSM model to derive a nominal linear control strategy. Then, we design an auxiliary control to compensate for real-time control errors due to parameter changes using Lyapunov stability theory. We numerically simulate our PMSM controller and demonstrate its efficiency and reliability when compared to traditional controllers.*
Keywords: Adaptive control, PMSM, Chaos, Feedback linearization, Lyapunov stability

1. **Introduction.** Chaotic behavior of nonlinear motor systems can occur for certain ranges of their parameter values. Chaos yields unacceptable variations in output torque and oscillations in the motor speed. Consequently, we need control strategies to prevent chaos for satisfactory control performance in real-time implementations.

Several strategies to reduce or eliminate chaos in motor systems have been proposed in the literature [1-5]. The most popular method for mitigating chaotic behavior in motor systems is due to Ott-Grebogi-Yorke (OGY) [2]. The method is robust in theory but a critical drawback is that it rarely yields a feasible parameter set in practical implementation. In [1], the authors described bifurcation and chaos in PMSMs and its control. They used entrainment and migration control with the external torque as the manipulated variable to derive an exogenous input. Generally, using the torque as a manipulated variable is problematic because it imposes limitations in determining the initial conditions and the target. Ren *et al.* studied time-delay feedback control (TDFC) of chaos in PMSM [5] in which the direct axis and the quadrature axis stator voltages are used as manipulated variables without an exogenous force. In practice, it is difficult to estimate time delay for TDFC with a given target. More recently, nonlinear feedback control was utilized to overcome the disadvantages of TDFC [6]. The authors used the stator voltages as control inputs with an approximate linearized system model. In [7] the authors utilized an extended Kalman filter estimation for state variables and stator's resistance of induction motors, and employed virtual noise signals for compensating chaotic modeling error.