

Soft Computing Based Design of PID Controller for a Linear Brushless DC Motor

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Abstract: This study presents a Particle Swarm Optimization (PSO) Method for determining the optimal Proportional-Integral Derivative (PID) controller parameters for speed control of a linear brushless DC motor. The proposed approach has superior features including easy implementation, stable convergence characteristic and good computational efficiency. The brushless DC motor is modeled in Simulink and the PSO algorithm is implemented in MATLAB. Comparing with Genetic Algorithm (GA) and Linear Quadratic Regulator (LQR) Method, the proposed method was more efficient in improving the step response characteristics such as reducing the steady-states error, rise time, settling time and maximum overshoot in speed control of a linear brushless DC motor.

Key words: Brushless DC motor, particle swarm optimization, PID-controller, optimal control, Genetic Algorithm (GA).

INTRODUCTION

There are mainly two types of DC motors used in industry. The first one is the conventional dc motor where the flux is produced by the current through the field coil of the stationary pole structure. The second type is the Brushless DC motor (BLDC motor) where the permanent magnet provides the necessary air gap flux instead of the wire-wound field poles (Hambley, 1997). This kind of motor not only has the advantages of DC motor such as better velocity capability and no mechanical commutator but also has the advantage of AC motor such as simple structure, higher reliability and free maintenance. In addition, brushless DC motor has the following advantages: smaller volume, high force and simple system structure.

So, it is widely applied in areas which needs high performance drive (Kennedy and Eberhart, 1995). From the control point of view, DC motor exhibit excellent control characteristics because of the decoupled nature of the field and armature mmf's (Hambley, 1997). Recently, many modern control methodologies such as nonlinear control (Orng, 1997), optimal control (Jones, 1967), variable structure control (Bhimbra, 1993) and adaptive control have been widely proposed for linear brushless permanent magnet DC motor. However, these approaches are either complex in theoretical bases or difficult to implement. PID control with its three term functionality covering treatment to both transient and steady-states

response, offers the simplest and yet most efficient solution to many real world control problems. In spite of the simple structure and robustness of this method, optimally tuning gains of PID controllers have been quite difficult. Genetic algorithm is a stochastic optimization algorithm that is originally motivated by the mechanism of natural selection and evolutionary genetics. Though, the GA Methods have been employed successfully to solve complex optimization problems, recent search has identified some deficiencies in GA performance (Deb, 2002).

LINEAR BRUSHLESS DC MOTOR

Permanent magnet DC motors use mechanical commutators and brushes to achieve the commutation. However, BLDC motors adopt Hall Effect Sensors in place of mechanical commutators and brushes (Gen and Cheng, 2002).

The stators of BLDC motors are the coils and the rotors are the permanent magnets. The stators develop the magnetic fields to make the rotor rotating. Hall Effect Sensors detect the rotor position as the commutating signals. Therefore, BLDC motors use permanent magnets instead of coils in the armature and so do not need brushes. In this study, a three-phase and two-pole BLDC motor is studied. The speed of the BLDC motor is controlled by means of a three-phase and half-bridge Pulse-Width Modulation (PWM) inverter. The dynamic

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