



Sensorless Position Control of Stepper Motor Using Extended Kalman Filter

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ABSTRACT: This paper describes simple position control of sensorless hybrid stepper motor (HSM). A mathematical model for hybrid stepper motor is derived using mechanical and electrical equations, which is used to estimate the position of the motor using Extended Kalman Filter (EKF). In position control, estimated value is compared with the reference position and when both coincide, the motor is held at a particular position for specified time and brought back to original position. The simulation results are presented.

Keywords: Hybrid stepper motor (HSM), Extended Kalman Filter (EKF), position control, sensorless.

INTRODUCTION

Stepper motors find several applications in varying fields such as robotics, computer peripherals, business machines, machine tools etc. Off late, the use of stepper motors has seen a surge mainly attributed to their precision, robustness, reliability, smaller size and lower cost. Stepper motors were originally designed to be used in open loop control. Their inherent stepping ability allows for accurate positioning without feedback. However, they show a poor performance with respect to very precise motion control and high dynamic requirements. Closed loop control of stepper motors has been increasingly employed to achieve faster response times and higher resolution capabilities. Initially, mechanical sensors were used to introduce closed loop control of stepper motor; but it led to the increase in size and cost of the system. Therefore, sensorless control of stepper motors emerged as an alternative and attractive solution since it saves the expensive and bulky mechanical sensor.

Several sensorless methods have been proposed for motors that can be applied to the stepper motor. C. Obermeier [1] implemented sensorless field oriented speed control using an EKF for a permanent magnet stepper motor. Ferrah, Bani-Younes, Bouzguenda, and Tami [2] described the use of full order EKF for sensorless speed and position estimation of two phase stepper motor. Bendjedja, Ait-Amirat, Walther, and Berthon [3] estimated rotor position, speed, and torque using steady-state EKF and state feedback control for position control.

Usually, sensorless control is defined as a control scheme where no mechanical parameters like speed and torque are measured. Traditional vector control systems use the method of flux and slip estimations based on measurements of the phase currents and DC link voltage of the inverter, but this has a large error in speed estimation particularly in the low-speed range. There are two forms for the implementation of an estimator as open loop and closed loop. The difference between these two is a correction term, involving the estimation error, used to adjust the response of the estimator. A closed loop estimator is referred to as an observer. An observer can be classified according to the type of representation used for the plant to be observed. If the plant is deterministic, then the observer is a deterministic observer; otherwise it is a stochastic observer. The Luenberger observer is of the deterministic type and the Kalman Filter is stochastic type.

The Kalman filter [4] is applicable to linear stochastic systems, and for nonlinear systems, EKF can be used, which can provide estimates of the states of a system or estimates of both the states and system parameters. EKF [5] is a recursive

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