ABSTRACT

Development in the fields of power electronics and computers is changing the face of drives technology. Advent of high power variable frequency inverter circuits has made it possible to drive AC motors from a variable voltage variable frequency source. The complexity in their mathematical model and the consequent need for sophisticated control algorithms are being handled by the computational power of low cost microprocessors or digital signal processors. Under this backdrop this thesis reviews the state-of-the-art in various stages of modelling, parameter estimation, control system design and implementation of a variable speed synchronous motor drive and suggests certain novel solutions for several critical problems.

The dynamic model of a synchronous motor is nonlinear, even when expressed in the d-q axes reference frame. The parameters of the motors are usually determined from standstill data, so that the speed terms remain as zero and the nonlinearity due to these is absent. In this work a new algorithm is proposed, based on a simplified version of the nonlinear model, which utilizes the operating data of a rotating synchronous motor and can estimate both the electrical as well as mechanical parameters. The technique is validated using both simulated and experimental data.

The control system is designed around the concept of two-loop control. The outer speed control loop generates a torque reference using a PI controller. A given torque may be realized by different combinations of the armature and field currents. This flexibility is exploited to make additional specifications in the form of the torque angle and internal angle of the motor. These angles can be suitably chosen to achieve various control strategies such as field oriented control and unity power factor control. With these specifications, unique values of current references are generated. In case of permanent magnet and variable reluctance motors, since the field current is not controllable, either the torque angle or the internal angle can be independently specified.

The inner loop current controller is designed to be faster than the speed loop and utilizes the pole-placement technique via state feedback to achieve the desired dynamic response. Steady state following of the reference currents is obtained by incorporating an additional integral of output error term. The system is globally and exactly linearized by a nonlinear state feedback in order to be able to carry out the above design. The unmeasurable damper winding currents are estimated by a nonlinear reduced order observer.

The control system including the observer has been extensively simulated under various conditions and finally a PC-based practical implementation has been made. The speed and the position signals are measured using a digital shaft encoder and the current signals are measured via Hall-effect sensors. These signals are fed to the PC through a data acquisition card, which also outputs the voltage references required by a voltage source inverter feeding the motor. Comparison of experimental results with the corresponding simulated ones, clearly validates the control scheme proposed in the thesis.

Keywords: *Nonlinear modelling and parameter estimation; State feedback control; Feedback linearization; Nonlinear reduced order observer; Synchronous motor drive; Real-time control.*