ABSTRACT

Permanent magnet brushless dc (PMBLDC) motors are widely used in high performance servo systems due to their inherent advantages over conventional dc and ac drives. The research work presented in this dissertation covers the full modelling and analysis of a drive system with an 8-pole PMBLDC (Hall) motor fed from a three-phase inverter and driving a fluctuating mechanical load. The system also incorporates a speed controller for closed loop operation. The focus is on the determination of the open loop and closed loop steady state speed profile analytically and by simulation using SIMULINK toolbox and further development of different types of controllers for enhanced transient performance of the drive system.

As part of machine modelling, expressions for phase and d-q axis voltages are developed in terms of dc link voltage using Fourier series analysis and Park’s transformation. This leads to investigation of the basic electromechanical energy conversion process and derivation of the torque-balance equation. It is found that the equation is non-linear in speed and is solved analytically for open loop operation for various values of dc link voltage, with the load torque as a parameter. Further, the solution is extended for closed loop steady state operation using a proportional type of speed controller for different settings of reference speed and loading conditions. The above analytical results are cross-verified through simulation using SIMULINK toolbox.

The closed loop operation of the PMBLDC motor under load fluctuations assumes significance in view of servo drive applications, where stringent
specifications have to be satisfied. Accordingly, the mathematical model is extended to include the dynamics of a conventional PID controller. This transient problem is formulated as an optimisation exercise based on an integral-mean-squared-error criterion. The investigation of the variation of the performance index and settling time in the PID parameter space reveals the existence of a convex 3-D surface relating the above. This verifies the existence of a local minimum of the performance index, within a suitable range of parameter values from which the optimum set is obtained. The transient response corresponding to the above optimal parameters is obtained and is characterized by minimum overshoot/undershoot and settling time.

In an effort to further enhance the transient performance, alternate controller options are also considered. A controller based on adaptive Neuro-Fuzzy Inference System (ANFIS) is developed to minimize the overshoot and settling time following sudden changes in load. It is seen that the performance of the system with ANFIS controller exhibits fast settling and little overshoot, but some steady state error is present. A strategy to eliminate the steady state error prevailing with the ANFIS controller is worked out with implementation of a hybrid (ANFIS-PI) controller, as the PI controller has the potential to minimize the steady state error. The hybrid controller performance shows quick settling, little overshoot and negligible steady state error. The performances of all the three controllers are compared and it is found that the hybrid controller is having superior performance.