ABSTRACT

Induction motors are preferred in most of the industries because of their simple structure, ruggedness, reliability and less maintenance. Variable frequency ac motor control can be divided into scalar and field oriented or vector control. Scalar control uses the magnitude and frequency control. Vector control uses orientation in addition. For control purpose, the speed of the induction motor is sensed by encoders or tacho-generators. In recent years, various speed and position sensorless control schemes have been developed for variable speed induction motor drives. The main reasons for the development of these sensorless drives are: reduction of hardware complexity; increased mechanical robustness and overall ruggedness; higher reliability; decreased maintenance requirements; increased noise immunity; elimination of sensor cables etc.

In applications like electric traction and steel processing industries, two (or three) induction motors are connected in parallel and controlled by a single inverter to save cost and also to reduce space and weight. The ratings and parameters of the parallel connected induction motors in traction drives are usually identical. If the motors have matched speed-torque characteristics and their speeds are equal, their torque sharing will be equal at all operating conditions. In practice, both mismatch in motor characteristics and unequal wheel diameter problems exist. In such cases, the speed and torque of both the motors differ and unbalance condition arises. If average currents flowing through the stator windings and rotor fluxes are considered, the speeds of both motors deviate much from the reference speed. To reduce the speed difference, average and differential parameters are used to determine the current references.

Adaptive rotor flux observer was used to estimate the speed and rotor fluxes. It needs some correction term in order to follow the speed changes and the estimation always lags the actual values. The selection of gain matrix constant is tedious in such an observer. To avoid such difficulties, natural observer is proposed in this work to estimate the stator currents, rotor fluxes, load torques and rotor speeds of both the motors connected in parallel. The structure of the natural observer is simple. Its convergence rate is faster than adaptive rotor flux observer and is robust to noise and parameter uncertainty. The gain matrix is absent in natural observer. Torque is estimated by load torque adaption and the average rotor flux is maintained constant by rotor flux feedback control. The rotor speed is estimated from the load torque, stator current and rotor flux.

Simulations are carried out in MATLAB-Simulink environment for various running conditions and the speed difference of the induction motors for unbalanced load is found to be less. Effects of stator and rotor resistances variations of the induction motors are investigated for various load conditions in this work. The speed difference of the motors is found to be less in natural observer than adaptive rotor flux observer for variations in motor parameters compared with identical motor parameters at balanced and unbalanced load conditions. The proposed scheme results in a much improved response for parameter variations such as shorter rise time and fewer oscillations at sudden loading. Simulations are also performed for different motor ratings connected in parallel.

Two identical 0.746 kW (1HP) three-phase squirrel cage induction motors are used for verifying the results experimentally. Hall Effect current and voltage sensors are used to measure the stator currents and voltages. The measured signals are processed in TMS320F2812 DSP processor to estimate the speed, load torque, rotor fluxes and stator currents. TMS320F2812 DSP processor works as a central processing unit and it performs all the arithmetic calculations. It generates PWM pulses to enable the IGBT switches. Three-phase IGBT based Intelligent Power Module (IPM) performs the inverter operation. The experimental results are obtained for different running conditions and they tally with the simulation results.

The stability analysis of the parallel connected two motor drive system is performed by transfer function approach. The transfer function of the induction motor is derived under the assumption of constant rotor flux linkages. The block diagram representation of the vector controlled parallel connected induction motor drive is constructed by applying the transfer functions of various subsystems. The speed response of the parallel connected two-motor drive system is simulated with transfer function model for various running conditions and stator and rotor resistances variations in MATLAB. It is similar to the response obtained by constructing the drive system with various simulink blocksets. Stability analysis is performed in LabVIEW for unbalanced load conditions with similar and dissimilar stator and rotor resistances and the system is found to be stable.