ABSTRACT

Multi-phase ac motor drives are strong candidature for variable speed application, due to numerous advantages that they offer when compared to their three-phase counterparts. Variable speed induction motor drives without mechanical speed sensors at the motor shaft have the attractions of low cost and high reliability. To replace the sensor, information of the rotor speed is extracted from measured stator currents and voltages at motor terminals. In most drive systems (speed and torque controlled), closed loop control is used in which shaft encoder is used for measurement of speed/position of the motor. However, in a compact drive system it is very difficult and expensive to use speed sensors for speed measurement (e.g. submarine applications). The cost of system can be reduced by eliminating the speed sensor and connection cables, and so the consistency and ruggedness of the overall drive system increases. Vector-controlled drives require estimating the magnitude and spatial orientation of the fundamental magnetic flux waves in the stator or in the rotor. Open-loop estimators and closed-loop observers are used for this purpose. They differ with respect to accuracy, robustness, and sensitivity against model parameter variations. The second part of this thesis analyses operation of an Open-loop, Model Reference Adaptive System (MRAS), Artificial Intelligence(AI), Luenberger Observer and Kalman Filter Observer based sensorless control of vector controlled five-phase induction machine and series-connected two five-phase machines with current control in the stationary reference frame. The sensorless operation of a three-phase induction machine is well established and the same principle is extended in this thesis for a five-phase induction machine and series-connected two five-phase machines. Performance, obtainable with hysteresis current control, is illustrated for a number of operating conditions on the basis of simulation results. Full decoupling of rotor flux control and torque control is realised in both type of configuration of the drive systems. The independent control of each five-phase motor in a five-phase two-motor drive system using a Volt per Hertz control and vector control scheme is also realized. Dynamics, achievable with a five-phase and series-connected two five-phase vector controlled induction machines, are presented to be essentially identical to those obtainable with a three-phase induction machine.

Finally, an experimental rig is described, which utilises a five-phase inverter, five-phase motor and DSP TMS320F2812. An analysis of the motor’s performance within the five-phase drive is presented and it is compared with performance of a three-phase motor drive. The experimental results fully verify the existence of full decoupling of rotor flux control and torque control of five-phase drive using sensorless schemes.