ABSTRACT

The Switched Reluctance Motor (SRM) is also referred as a variable reluctance stepper motor. It has been widely used both in rotary and linear applications. However, the basic operation of SRM with magnetic saturation and double salient pole construction results in non-linear and non-sinusoidal relationships among phase current, flux linkage, output torque and rotor angles. The various advantages of SRM drive include greater efficiency, high operating speed, effective function of the motor along with the torque inertia ratio and four quadrant operation applicable for variable speed. The SRM comes under the drive category due to its extensive size, power, range of speed along with the cost effectiveness in its construction. The characteristic benefits of SRM are its modest building without winding on rotor side, its distinctive nature like high tolerance, strength, cheaper structure due to the absence of permanent magnet and it is likely to operate at high temperature or in extreme temperature deviations. The SRM torque production is due to the alignment of rotor poles and excited stator poles.

The operating principle mainly depends on the variation in the magnetic reluctance of magnetic field lines amongst the aligned and unaligned position of rotor. The rotor produces a force and is pulled to an aligned position due to the stator excitation. Because of the double salient pole construction and a nonlinear magnetic property of SRM, the acoustic noise and ripple on torque are more severe than other out-dated motors. It states that a magnetic salient rotor is free to move to a position of minimum reluctance to the flow of flux in the magnetic circuit. Enriched magnetic substances and advances in machine design made the SRM to come under variable speed drive market.
Nowadays, SRM has drawn exceptional attention from manufacturers and researchers. SRM is viewed rather amongst different electrical machines in the direction of the development of the motors which do not include scarce earth resources. Because of their simple construction without magnets and brushes, SRM offers low production and operation cost. In addition, they have high output power and system efficiency over a wide range of speed. Nonetheless, SRM has a hindrance of torque ripple considering the fact that the stator and rotor have salient poles. Consequently, the SRM has very high torque ripples throughout the phase commutation interval during the transfer of the torque production from the outgoing phase to the incoming phase. This higher torque ripple induces acoustic noise and fluctuations. The commutation problem occurs in the motor phases usually near the aligned position of motor poles, where the motor winding inductance is high and it gets slowly demagnetized. If the flux produced by the phase winding is increased, the conduction period of the phase extends into the decreasing inductance region, which results in the development of negative torque. This will severely affect the average torque production and the efficiency of the motor.

Therefore, various studies to minimize torque ripples have been done comprehensively. Due to the motor’s internal inductance, the delay in current rising and falling time weakens the performance of the motor. The major concern in the SRM drives is current and torque ripples.

In traditional SRM operation, the stator phase windings have excited one at a time, in sequence. Due to the finite phase winding inductance, instantaneous commutation of phase torque or current is not possible. There is a large variation in motor torque during phase commutation, leading to torque ripples. To acquire smooth operation with less torque pulsation, the torque ripple should be reduced in high performing servo applications. The minimization of the torque ripple is vital in high performance servo
applications, which runs smoothly with minimum torque pulsations. The admirable constructive features of an SRM can be developed in a servo system by emerging techniques of reducing the torque ripple. These types of drives have extensive applications in automotive industries, direct drive machine tools. Two principal methodologies are used to minimize the pulsations in torque: One technique is to develop the motor’s magnetic design and the other is to use refined electronic mechanism. The pulsation of torque is decreased by the machine designers by making a change in the structure of the rotor and stator poles, but at the expenditure of the motor’s performance. The electronic method depends on the selection of an optimum value of the functional parameters, which comprise the source voltage, turn on and turn off angles, level of current and the shaft load. It is necessary to be noted that the reduction of torque ripple gives rise to a decrease in average torque, because the proficiencies of the motor are not being entirely consumed at every position of rotor. In general, it can be identified that maximization of torque and minimization of ripple cannot be achieved simultaneously by electronic control.

Torque ripples can be minimized by controlling sharing of torque produced by neighbouring phases. Secondly, the torque production mechanism in SRM is highly nonlinear and hence it is difficult to achieve accurate torque control. This proposed work investigates various front end capacitive converter topologies for improving the performance of SRM. A comprehensive systematic model for these converter topologies is developed, facilitating the estimation of average torque and torque ripple. The simulation results of the front end capacitive converter of SRM with a DC voltage of 240 V, 60 kW are reported in this thesis to compare their effectiveness in terms of Torque Ripple Minimization (TRM) and average torque. Conventional converter cannot deliver adequate excitation voltage to build up a phase current. Comparatively, the proposed converter can produce a higher
voltage, which can build up fast excitation current. Moreover, the proposed converter also supports the high demagnetisation voltage, which produces a fast demagnetizing current. The fast demagnetisation voltage reduces the tail current, which improves the efficiency and output power by reducing negative torque. The simulation results confirmed the performance of the proposed converter giving better performance in comparison to soft switched boost asymmetric converter, series, parallel and series parallel converter. The effect of voltage variation and switching angle of switched reluctance motor fed proposed converter is also discussed.

The fundamental frequency of torque ripples in SRM is proportional to motor speed. The mechanical subsystem of the drive acts a low pass filter to the motor torque ripples. Hence, the effect on speed is reduced at high speed operations. Speed control of SRM using front end capacitive converter is also implemented and the experimental results are revealed that the proposed converter giving better performance than the traditional converter. This research work concludes that the proposed front end capacitive converter fed SRM is feasible and practically achievable.