Abstract of Ph.D. Thesis
"Development of Position Sensorless Switched Reluctance Motor Drives for Solar PV Array Fed Water Pumping"
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Abstract

The utilization of solar photovoltaic (PV) energy in water pumping is conservative particularly in isolated regions where the cost of transmission of power is either impractical or exorbitant. In this work, the research is inclined towards the development of sensorless control techniques for switched reluctance motor (SRM) drives for solar photovoltaic (SPV) fed water pumping systems. Even though permanent magnet (PM) motors are considered as the best for water pumping, the use of PMs makes the overall system expensive. Besides these, SRM comes in simple geometrical steel structure involving neither magnets nor rotor windings, with performance in comparable with the PM motors. Moreover, SRMs require zero maintenance as they do not employ brushes and are highly suitable for harsh environments. This finds the motivation to the researchers to aim for a low-cost high-performance drive using SRMs.

Even though the SRMs come with numerous advantages, major pull back of drive is necessity of its shaft position sensing equipment. The cost of these sensors accounts for major share of cost of drive. Moreover, mechanical sensors are highly sensitive to motor shaft vibrations and their use is unadvisable in case of operations in dust and dirt conditions especially for submersible pumps. Therefore, an elimination of these mechanical sensors improves both reliability and affordability. Moreover, there is no considerable research in the literature for sensorless controlled SRM driven solar pump. Therefore, this work focuses on development of mechanical sensor-free SRM drives to provide cost-effective and reliable solution.

Initially, this work aims at the development of sliding mode observer (SMO) based position sensorless control for SRM drive for PV-battery standalone submersible pumps. Unlike look-up table-based methods, SMO-based algorithm offers simple and robust architecture and does not require any pre-stored magnetic data. Besides implementing SMO for position estimation, a two-phase excitation-based algorithm is integrated to SRM control to guarantee the unidirectional operation during starting. However, this technique suffers from chattering and to eliminate which, later, an adaptive gain super twisting sliding mode observer (AGST-SMO) is implemented. Furthermore, this work presents a neural network approach for the development of position sensorless switched reluctance (SR) drive. In neural network, a real-time magnetic data is mapped through supervised training by using back propagation (BP) learning algorithm. Besides using a sensorless scheme, the drive uses an advance angle control for the speed control of SR drive which eliminates the switching losses induced by the hysteresis controller. Further, the works aims at developing a compact and economical drive by reducing the electrical sensor usage. The research proposes a current reconstruction strategy for a four phase 8/6 SRM driven by a split-DC (SDC) converter. This development drops the current sensors count by three, without sacrificing the drive performance. Moreover, the proposed method is validated for sensorless control by developing a starting scheme. Apart from the above advantages, the proposed method demands no extra hardware requirements and involves less computations.

The dependency on solar potential results in PV array an unreliable source for water pumping application. In bad climatic conditions, even though MPPT is employed, the system is underutilized since the pump is not operated at its full capacity and even leads to complete shutdown during nights. This problem is resolved by adding an auxiliary source in the form of a battery storage or through grid interaction. All these developed configurations are modeled and simulated in MATLAB/Simulink environment by using Simpower system toolbox to study the performance during various environmental conditions and the operability of the system is justified during starting, dynamic and steady state conditions. Simulated results are validated using a developed prototype in the laboratory.