Abstract of PhD Thesis
"Control of Synchronous Reluctance Motor Drive for Solar PV Array Fed Water Pumping"
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This research work presents numerous topologies of a synchronous reluctance motor (SyRM) drive based solar PV array fed water pumping system. A SyRM is chosen because of its simple control, robustness and higher efficiency than other AC motors. The SyRM is characterized by the absence of rotor currents, which makes ideally the winding losses in the rotor zero. Therefore, the efficiency of the SyRM, is superior to than some other motors. It makes the drive control intelligible in comparison to an induction motor and permanent magnet motors. Thus, the use of SyRM for driving the pump and elimination of speed/position sensor, provide a unique solution for solar powered water pumping system.

In this work, an attempt has been made to develop solar photovoltaic array fed water pumping system with added features of grid interface. In standalone systems, single stage and two stage systems are implemented. Merits and demerits of both the systems are pointed out. For single stage, reference speed is altered until maximum power point is reached as power drawn is proportional to the cube of the speed. In this scheme, a boost converter is utilized for harvesting maximum available power from a PV array through an incremental conductance based maximum power point tracking algorithm. Here, it feeds power to a voltage source inverter (VSI) through a DC link capacitor. The DC link voltage is maintained to the reference value by adjusting the speed of the motor. In case of grid connected single phase unidirectional topology, power factor correction (PFC) boost converter is used in continuous conduction mode (CCM). The pump is run at rated speed in case of availability of the grid at unity power factor while taking maximum available power from the solar PV array.

As variable frequency drives draw nonlinear current, PFC boost converter reduces the total harmonics distortion (THD) of the current drawn to less than allowable limit of 5 %. In case of grid failure, pump continues to run at available maximum power from the solar PV array. Grid connected three phase bidirectional power flow configuration using front end converter (FEC) is also designed and tested in the laboratory. Apart from the features of the unidirectional topology, here excess power from the solar PV array is fed to the grid. This is important from the electricity bill reduction point of view. Moreover, single phase, bidirectional configuration is conceptualized and simulated.

The prime objective of proposed system, is to provide water supply for domestic and irrigation purposes, therefore, to avoid complexity and for increased reliability, the speed/position sensor is eliminated. A speed/position observer is utilized for the estimation of angular position of SyRM. A PV feed-forward term is used to estimate the reference speed, which aids in enhancing the transient behavior of proposed system. Moreover, the control is inherently resistant to the ageing related variation in pump's constant.

In this work, the magnetic saturation and cross coupling effects are taken into consideration while estimating the position. The magnetic saturation effects on the position estimation in SyRM, because the position is estimated with the help of direct and quadrature axes flux linkages. The direct and quadrature axes flux linkages directly depend on direct and quadrature axes inductances. If magnetic saturation or cross coupling effect is not taken into consideration, the center of the circle plotted between direct and quadrature axes flux linkages, is shifted from the origin because of magnetic saturation and cross coupling effect. Due to this effect, a delay is introduced between actual position and estimated position.

All the proposed topologies are modelled and simulated using MATLAB/Simulink platform in order to demonstrate their behavior during starting, steady state and dynamic conditions. The validity of simulation results are verified through test results obtained from experimental setup developed in the laboratory. The applicability and commercial potential of proposed systems are justified by their in-depth analysis based on efficiency, cost, simplicity and performance.