Abstract of Ph.D. Thesis
"Design and Development of Solar PV Array fed Synchronous Reluctance Motor Drive for Water Pumping System with Grid Synchronizations"
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Abstract

This research work deals with the analysis, design, development and control of synchronous reluctance motor (SyRM) drive for solar PV based water pumping systems. Compared to conventional three-phase induction motor, which exhibits a three-phase stator winding and either a wound rotor or a squirrel cage on the rotor, a synchronous reluctance motor has flux-barriers and flux-carriers, the presence of which produces torque, exhibit no rotor winding losses, thereby making them relatively more energy-efficient. In this work, a SyRM is designed using analytical and finite element analysis-based solution for improved performance and control for solar PV based water pumping systems. Designed SyRM is fabricated and simulated results are verified on the fabricated prototype. A reduced sensor-based simple, efficient and cost-effective SyRM drive is investigated. The estimation of rotor speed and position, is made stator flux linkage-based field oriented control. The system possesses a maximum power point tracking (MPPT) of the PV array by introducing a DC-DC converter between the PV array and VSI, feeding the motor. The work is extended towards an elimination of DC-DC converter and a single-stage PV array SyRM drive is also investigated for water pumping. Standalone solar PV based systems have serious constraints of power intermittency, which results in unreliability of overall system. Moreover, the installed water pump is underutilized in bad atmosphere conditions and is completely shut down at night. This problem is resolved through the introduction of auxiliary power source in the form of battery storage. In addition to it, an attempt is made for integrating unidirectional and bidirectional converters to the utility grid. The auxiliary power source, i.e., the battery integrated into the system, helps fulfill the power requirement to the load (pump, domestic loads) when the PV power is insufficient to obtain rated water discharge. Moreover, both the unidirectional and bidirectional power flow controls are implemented for a grid-interfaced PV array based SyRM driven water pumping system. In addition, the single-stage, grid-connected configurations are also developed and tested successfully. The bidirectional power flow control based topologies offer additional advantage of feeding power to the grid from the installed PV array, in conditions when water pumping is not required, which acts as a secondary source of earning, by the seller. This practice leads to the full utilization of installed resources. The power quality standards, such as power factor and total harmonic distortion (THD) of grid currents as per IEEE-519 standards are met by these configurations. All these configurations are simulated in MATLAB/Simulink platform and the laboratory prototypes of them are developed to validate the topology, control algorithm and the developed simulated model. The applicability of commercial potential of these systems are justified by their in-depth analysis based on efficiency, cost, simplicity and performance.