National Institute of Technology Rourkela

Defence Seminar

Seminar Title	: Design and Development of Standalone PV System with Non-Isolated Three Port Converter
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Abstract	: Traditional fossil fuel-based energy sources, such as coal, oil, and gas, contribute to pollution and global warming by emitting greenhouse gases. Due to rising energy demand and environmental concerns, renewable energy sources are becoming increasingly important. Photovoltaic (PV) systems are widely utilized among renewable energy sources since they are simple to maintain, have no moving parts, and are abundant in nature. The PV system can be broadly categorized as standalone (off-grid) or grid-connected (on-grid) systems. The primary focus of this thesis is the design and development of a non-isolated three-port converter (NI-TPC) for a standalone PV system. Due to their high power density, low cost, and compact structure, TPCs are frequently used for standalone PV systems, replacing the conventional multiple converter structure. A TPC can interface its input, bidirectional, and output ports with the PV panel, battery, and dc load. A NI-TPC has no galvanic isolation between its ports. This structure is gaining popularity due to its small size and lower cost. Several boost-based (boost operation from the PV side) NI-TPC circuits are presented in the literature. However, a buck-based operation from the PV side ensures low converter and panel wiring costs and maximum power extraction from the PV panel under low solar irradiance circumstances. Considering the advantages of a buck-based PV system, a buck-based NI-TPC circuit is designed, developed and presented in this thesis. The proposed buck-based NI-TPC circuit is derived from the parallel connection of the conventional buck and boost converter. The different operating modes of the circuit are explained in the thesis. The primary objectives of the proposed buck-based NI-TPC are as follows: (i) MPPT tracking from the PV panel, (ii) Battery charging-discharging control, and (iii) Output voltage regulation. Tracking the maximum power point (MPP) is essential for the efficiency of the PV system. Various MPPT methods have been presented in the literature to date. Due to their ease of implementation, perturb and observe (P&O) and incremental conductance (InC) are two of the most widely used MPPT techniques. A modified InC method is proposed to avoid the drift effect caused by increased irradiance. A hybrid MPPT technique is presented and validated to address the shortcomings of the conventional MPPT technique. The conventional and modified P&O and InC algorithms require voltage and current sensors for MPP tracking. To reduce the cost of the MPPT algorithm, a single input voltage sensor-based MPPT method is introduced in the literature and applied to two-port converters. In the case of the SIVS-based MPPT method, oscillations around the MPP are observed under steady-state conditions. To overcome this shortcoming, a SIVS-based MPPT method with zero steady-state oscillation is proposed and presented here to reduce costs and increase the performance of the PV system. The conventional and modified SIVS MPPT methods are verified using buck-based NI-TPC. The NI-TPC operates in various modes depending on the P_{pv}, P_o and battery conditions. The buck-based NI-TPC employs various switching configurations for its different operating modes. The small-signal analysis for different operating modes is presented here. As two control inputs and two control outputs are present in this converter, MIMO decoupling network is used to obtain the transfer functions and design their controllers. A control algorithm is proposed here to ensure seamless mode transfer depending on the operating conditions. A solar inverter is required to power the AC loads to develop a standalone PV system. An effective PWM method should be utilized to control the output voltage and frequency. Different SPWM methods are compared to ensure an efficient AC output from the inverter.