ABSTRACT

Voltage fluctuations and low voltage profiles pose persistent challenges in industries, leading to equipment damage, costly downtime, and reduced productivity. Traditional voltage compensation devices, such as servo stabilizers, often fail to provide efficient and timely correction due to their slow reaction times and reliance on capacitors by a Dynamic Voltage Restorer (DVR). Additionally, the integration of solar photovoltaic (PV) systems with voltage compensators is often complex and costly, as separate units are typically used.

These issues emphasis the need for novel voltage compensation solutions that can effectively mitigate voltage fluctuations and maintain stable voltage at the Point of Common Coupling (PCC) in industries.

The thesis provides solution to the persistent voltage issues in industrial environment and proposes novel voltage compensation solutions to enhance grid stability. The research focuses on mitigating voltage fluctuations and maintaining unity power factor at the Point of Common Coupling (PCC) and integrating solar photovoltaic (PV) systems for improved grid stability and reliability.

The research investigates the integration of a solar PV inverter, Static Synchronous Compensator (STATCOM), and DVR into single equipment. These equipment's are typically used separately for maintaining Unity Power Factor (UPF) at the PCC, compensating for voltage fluctuations, and for exporting solar power to the grid. By integrating them, significant reductions in installation and maintenance costs can be achieved, along with improved system performance. Simulation studies are conducted to evaluate the integrated system's ability to maintain UPF, compensate for voltage sag and swell, and provide efficient solar power conversion.

In addition, a novel voltage compensation technique / system is proposed in this thesis. The proposed system does the voltage compensation for frequent voltage fluctuations and low voltage profile in the grid without the need of a DC bulk capacitor. MATLAB simulation is employed to evaluate the proposed system’s ability to compensate for voltage sag / swell and low voltage profile on the grid. The experimental study on the developed laboratory prototype validates its effectiveness and functionalities.

Furthermore, the thesis proposes an integrated device (with reduced number of power semiconductor switches) that combines the functionalities of a solar PV inverter and a voltage compensation device. Currently, these equipment’s are used as separate units, leading to increased costs, installation complexity, and potential inefficiencies. By integrating them into a single device, the research reduces the complexity, installation costs, and maintenance requirements. This integrated solution will offer simplified installation, reduced maintenance costs, and improved overall system performance for industries using rooftop solar installations. Power quality, reliability, and the stability of sensitive equipment are evaluated to demonstrate the benefits of the integrated approach.