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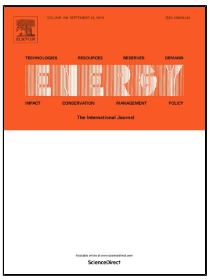

Energy Management Using Battery Intervention Power Supply Integrated with Single Phase Solar Roof Top Installations

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Abstract— In India, battery storage and time based tariff are yet to be introduced in solar micro grid tied inverters. Here, the authors propose an improved multi-stage converter topology intended for single phase solar roof top applications with battery storage. It works in six modes depending on solar-load-battery-grid profiles. The whole strategy is implemented in a battery intervention power supply that uses energy storage integrated with the solar generator that helps in smoothing of power, load shifting, load dispatch and load angle control. Notably, load dispatch decision is arrived based on several independent parameters that take different values at a time. A Boolean equation is derived relating the different parameters so as to arrive at a single decision. This is achieved by a variable entity k-map. A voltage control is also implemented that is done by load angle control of the inverter current. A novel MPPT scheme is also detailed that reduces oscillations in PV voltage during steady state and dynamic behavior of environmental conditions. Simulation studies are conducted to analyse the performance of the system using improved power management using k-map, modified MPPT algorithm and steady state and dynamic conditions of atmosphere under varying load-solar-grid profiles. The performance is validated by testing a prototype laboratory model that shows that the system works with acceptable limits of reactive compensation in the range of 95-99% with good grid stability through battery support.

Keywords—energy storage; solar; multi stage inverter

1. Introduction

Solar Photovoltaics based power generation is one of the most promising alternatives for electricity generation in the state of Kerala. This form of distributed generation installed at the roof tops of the beneficiaries in low tension lines are coming up as a good option of renewable energy usage. Depending upon their usage, they can support local priority loads and pump energy into grid. However, ramping of solar irradiance leads to poor power factor, high/low feeder voltage at point of common coupling (PCC), increased current harmonics, and reverse power flow [1]. We have to therefore attend these problems while maintaining conformance to operational limits. Due to ramping of solar power, the grid cannot reduce the dependence on the base power generation. Grid voltage fluctuations (sag and swell) affect the distributed generation (DG). Therefore, energy storage is integrated with solar that mitigates voltage fluctuations, reduces transient harmonics, improves quality of power, stabilizes grid by drawing less power from grid. However, the capacity of BIPS is limited by rules and regulation of the state government and Kerala State Electricity Board Limited (KSEBL) that has limited the end-user to prevent abusive benefit from excess power generation and get feed-in-tariff from the distribution power licensees.

A brief literature survey is done to understand work done in both national and international levels.

Various topologies of single-phase inverters are detailed for small DG in [2]. Multi stage inverters are recommended as they are capable of handling wide variations in input voltage. [3] explained the need for LLCL power filter for single phase inverters and compared the performance with traditional LCL filter. Power quality of the grid connected inverter is enhanced in [4] using damped resonant harmonic compensators. A review on different single phase inverters for single phase photovoltaic applications is detailed in [5]. Recent developments and trends are highlighted. A predictive current control strategy is tested on 10 kW prototype grid connected