National Institute of Technology Rourkela

Defence Seminar

Seminar Title	: Design and Development of Various Adaptive Filtering-Based Control Schemes for a Grid-Tied Multifunctional Photovoltaic System
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Venue	: Smart Seminar Room, EE-401
Date and Time	: 25 Nov 2024 (11.15 AM)

Abstract

: In view of the rising demand for electricity and fossil fuel pollution, environmentally acceptable alternatives to traditional electrical energy generation are essential. Using renewable energy sources (RES) to generate electrical energy reduces environmental impacts. Solar photovoltaic (PV)-based power generation is popular among RES due to its decentralized nature, reduced transmission losses, improved efficiency, minimal maintenance, increased safety, and lower solar panel costs due to technological advancements. This research work is on a single-stage configured grid-tied multifunctional PV system (GTPVS). On the other side, as the nature of various loads in the distribution grid (DG) degrades power quality (PQ), and due to the intermittent nature of PV power, the synchronization of PV power to the grid at enhanced PQ is a challenging task. Thus, to enhance PQ while handling the dynamic conditions associated with the environment and loads, this thesis focuses on the development of multifunctional control schemes based on various adaptive filters to operate the three-phase single-stage GTPVS. Firstly, this thesis considers ideal grid conditions where there are no distortions in the grid voltages and with nonlinear loads drawing harmonic currents, where there is a necessity to develop control schemes that filter only nonlinear load currents to estimate their fundamental components for enhancing grid PQ. Secondly, in general, as the interconnection of the PV system to the distribution grid faces challenges like non-ideal grid conditions such as voltage distortions, voltage swell, grid voltage sag, unbalanced voltages, and DC offset along with problems related to currents, the control schemes are developed to filter both distorted voltages and nonlinear load currents to estimate their fundamental components to enhance grid PQ. The selective harmonics and DC offset rejection capabilities are also considered further. The control schemes were developed by including various adaptive filtering algorithms that work with fixed step size and variable step size strategies for a GTPVS to improve PQ while extracting maximum PV power to synchronize the PV system to the grid. Further, the need for separate controllers to filter non-ideal voltages and distorted currents is eliminated by developing a control scheme that utilizes a single controller to achieve the desired functionalities of GTPVS. All the proposed control schemes mitigate harmonics, compensate load unbalances, achieve a unity power factor (UPF), and compensate load reactive power, thus inculcating multifunctional capabilities into GTPVS to deliver balanced sinusoidal currents with the UPF at the grid side and achieving effective power management between the PV system, grid, and loads to ensure THD of the grid current as specified by IEEE 519-2022 standard. Further, a comparative assessment between the proposed and the existing adaptive filtering algorithms is provided in terms of convergence, oscillations, mean square deviation (MSD), computational complexity, and grid current THD to confirm the superiority of the proposed control schemes. The GTPVS, along with all the proposed control schemes, are modeled in MATLAB/Simulink. The behavior of GTPVS is observed and analyzed under steady-state and dynamic conditions. Further, a laboratory-developed prototype of GTPVS is used to carry out the experimental validation of the proposed control schemes.