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POWER QUALITY IMPROVEMENT OF A WEAK GRID WITH PV SUPPORT USING NORMALIZED LAPLACIAN KERNEL ADAPTIVE KALMAN FILTER AND FUZZY BASED MPPT ALGORITHM

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ABSTRACT

This work proposes a novel Normalized Laplacian Kernel Adaptive Kalman Filter (NLKAKF) based control technique and Learning based Incremental Conductance (LIC) MPPT (Maximum Power Point Tracking) algorithm, for low voltage weak grid-integrated solar photovoltaic (PV) system. The inputs are linked at the PCC in this two-stage design three-phase grid-integrated solar PV system. (Point of Common Coupling). To minimize disturbances at the load and grid side, a sophisticated dc voltage control loop with fuzzy logic is developed, along with voltage and current control loops based on NLKAKF. Proposed LIC is an enhanced version of the Incremental Conductance (InC) method that effectively addresses the intrinsic drawbacks of the original InC technique, including steady state instability, sluggish dynamic reactions, and set step size issues. The main goal of the suggested NLKAKF management is to use produced solar PV power to supply the active power needs of the loads, with any surplus power being transmitted to the grid after the loads have been supplied. When produced PV power, however, falls short of the necessary demand power, NLKAKF management fills the gap by utilizing additional grid power. The grid's electricity grade is raised during this procedure. Reactive power adjustment, power factor correction, noise filtration, and other power quality problems are all mitigated by the controller action. Additionally, the Voltage Source Converter (VSC) functions as a DSTATCOM (Distribution Static Compensator) when the sun energy is negative, increasing the system's usage rate. The performance of the suggested techniques is experimentally tested on a developed prototype under conditions of variable solar insolation, unbalanced loading, and various grid disturbances, such as over-voltage, under-voltage, phase imbalance, harmonic distortion in the grid voltage, etc

INTRODUCTION

At the moment, a substantial quantity of renewable distributed generation is being fed into low-voltage weak distribution networks, which is having significant repercussions on the operation as well as the power management of the system [1]. The most significant benefit is a support for power generation that incurs no cost for the fuel used, causes no pollution, and has the lowest possible running costs. In comparison to other types of renewable resources, the solar PV (photovoltaic) based energy generating system is one of the most often used since it has a fixed structure and is relatively compact. As a result, the three-phase two-stage grid integrated solar PV topology is commonplace on the residential level, where it is implemented as a rooftop PV array, and on the commercial level, where it is implemented as a PV park [2].

Because the DC-DC converter keeps the DC link voltage constant, a two-stage system has the advantage of being able to work with any rating of the PV array. This is made possible by the fact that the DC link voltage is maintained. Because there are two distinct controllers being utilized, the overall control complexity is significantly reduced. One controller is used for the DC-DC converter, such as a boost converter, and the second controller is used for the DC-AC converter, such as a Voltage Source Converter (VSC). In addition, the fluctuation of PV voltage in partial shade conditions [3][4] is very quick in massive amounts [5, so the only alternative for running in constant DC link voltage condition is the two-stage system.

To achieve optimum performance, a DC-AC converter (VSC) must have, first and foremost, a control strategy that is reliable as well as effective. The primary purpose is to first supply enough power to meet the demand of the load, and then, once that objective has been met, to send any excess power to the main grid. On the other hand, if the power that is generated is not enough to meet the load requirements, then the load requirements are fulfilled by drawing additional required electricity from the grid. To improve the power quality of the supply power, to act as a DSTATCOM (Distribution Static Compensator) when solar irradiation is zero, to convert power from direct current to alternating current, to follow the grid code for synchronization to the grid, and to manage power. These are the responsibilities that fall under the purview of the control technique during this process. In addition, the grid's power quality is enhanced while this process is being carried out; as a result, the power factor is increased, reactive power is supported, harmonics are filtered, and other power quality problems are alleviated.

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Photovoltaic (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect. Photovoltaic power generation employs solar panels comprising a number of cells containing a photovoltaic material. Materials presently used for photovoltaic include mono crystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium selenide/sulfide. Due to the growing demand for renewable energy sources, the manufacturing of solar cells and photovoltaic arrays has advanced considerably in recent years.

As of 2010, solar photovoltaic generates electricity in more than 100 countries and, while yet comprising a tiny fraction of the 4800 GW total global power-generating capacity from all sources, is the fastest growing power-generation technology in the world.

Between 2004 and 2009, Grid-connected PV capacity increased at an annual average rate of 60 percent, to some 21 GW. Such installations may be ground-mounted (and sometimes integrated with farming and grazing) or built into the roof or

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walls of a building, known as Building Integrated Photovoltaics or BIPV for short. Off-grid PV accounts for an additional 3–4 GW. Driven by advances in technology and increases in manufacturing scale and sophistication, the cost of photovoltaic has declined steadily since the first solar cells were manufactured. Net metering and financial incentives, such as preferential feed-in tariffs for solar-generated electricity; have supported solar PV installations in many countries.

SYSTEM CONFIGURATION

A two-stage topology of three-phase grid-tied solar PV system is given in Fig.1, where solar PV power is supplied to the grid, through a DC-DC converter and a three-phase voltage source converter (VSC) in such a way that the operating point of PV array is at MPP (Maximum Power Point) and, the converter is synchronized to the grid.

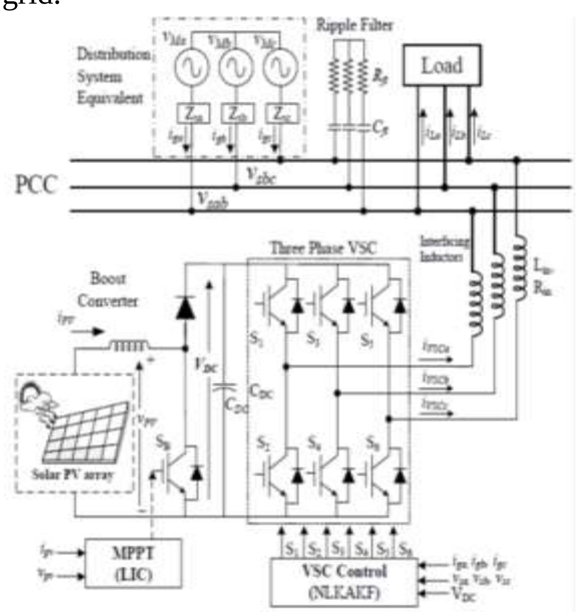

Fig 1 Proposed circuit topology

Here for control, LIC MPPT algorithm is used for the DCDC converter, and NLKAKF based control algorithm is used for the VSC. In this configuration, at the point of common coupling (PCC), ripple filter (Cfl, Rfl), grid through interfacing inductors (Lin, Rin), load and output terminals of VSC are connected. Here, the ripple filter is used for absorbing switching ripples, which are produced by VSC. The main objectives of control scheme, are during PV power generation, the power is fed to the grid in UPF (Unity Power Factor) mode of operation, and when PV power is unavailable then it operates in DSTATCOM mode.

SIMULATION RESULTS

The simulation results for different operating condition. The simulation results for change in insolation level and voltage variation are shown. The simulations are carried out in MATLAB simulink and sim power system tool box. The SPV array considered for simulation study. Other system parameters are given in Appendix.

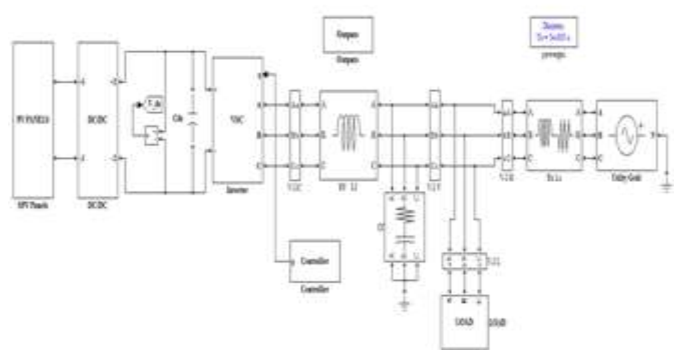

Fig 2 simulation circuit

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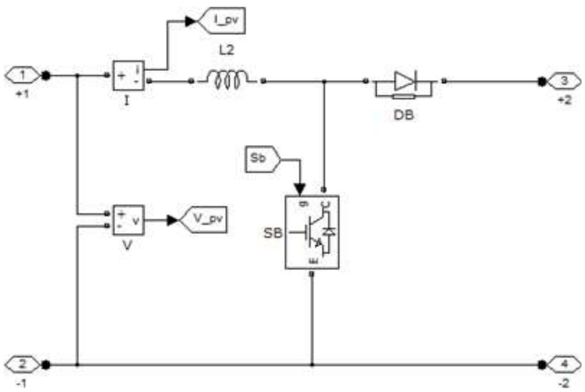

Fig 3 boost converter

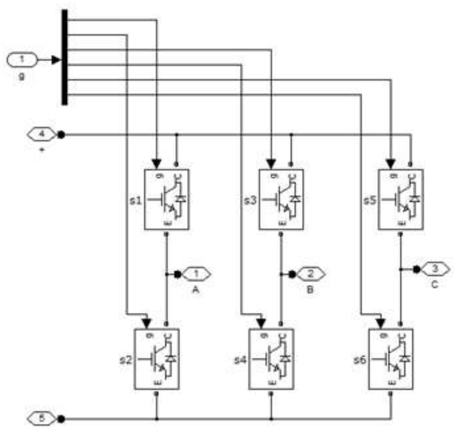

Fig 4 three phase inverter

Fig 5 grid voltages grid currents load currents

CONCLUSION

This work proposes a novel Normalized Laplacian Kernel Adaptive Kalman Filter (NLKAKF) based control technique and Learning based Incremental Conductance (LIC) MPPT (Maximum Power Point Tracking) algorithm, for low voltage weak grid-integrated solar photovoltaic (PV) system. Here, a two-stage topology of three-phase grid integrated solar PV system is implemented, where the loads are connected at the PCC (Point of Common Coupling). Proposed LIC is the improved form of Incremental Conductance (InC) algorithm, where inherent problems of traditional InC technique, like steady state oscillation, slow dynamic responses and fixed step size issues, are successfully mitigated. The prime objective of proposed NLKAKF control is to meet the active power requirement of the loads from generated solar PV power, and after feeding load, excess power is fed to the grid. However, when generated PV power is less than the required load power, then NLKAKF control meets the load by taking extra required power from the grid. During this process, power quality is improved at the grid. The controller action provides reactive power compensation, power factor correction, harmonics filtering and mitigation of other power quality issues. Moreover, when the solar irradiation is zero, than VSC (Voltage Source Converter) acts as DSTATCOM.

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