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Paper Authors
Dr. S. Ravindra, N. Naga lakshmi, L. Devanand, K. Lakshanyanjani,P. Victor Abraham Lincoln

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IMPROVING POWER QUALITY IN PV SYSTEM FIXED TO GRID

Dr. S. Ravindra[1], Professor, Department of EEE,
Vasireddy Venkatadri Institute of Technology, Nambur, Guntur Dt., Andhra Pradesh.

N. Naga lakshmi[2], **L. Devanand**[3], **K. Lakshanyanjani**[4],**P. Victor Abraham Lincoln**[5]
[2,3,4,5] UG Students, Department of EEE,
Vasireddy Venkatadri Institute of Technology, Nambur, Guntur Dt., Andhra Pradesh.
[1] **sanguravindra11@gmail.com,[2]lakshmi.naga052022@gmail.com,**
[3]devanandlakkiraju@gamil.com, [4]lakshikrovvidi@gmail.com,
[5]victordazzling21@gmail.com

Abstract

The project aims to enhance quality of electricity in a solar PV system connected to a weak grid, which is critical to a nation's economy due to the increasing demand for power caused by population growth. However, poor quality power generation can be a problem. An estimator of the positive series using integrators management is suggested as a solution to this problem in order to enhance power quality. Even in unusual circumstances like sag/swell, dc offset, and voltage distortion, this control can extricate positive order elements from distorted and grid voltages that are not regulated. The system can produce a quick transient reaction by computing grid reference currents and unit templates based on the positive sequence components and applying a photovoltaic grid feedforward term. The dc-link power is adjustable changed to lower voltage source converter losses when there is a weak grid. According to MATLAB models, the integrator-based positive sequence estimator control scheme works well in a variety of strange conditions, like intermittent sun irradiation, imbalance, voltage sag, swell, dc offset, and voltage distortions. In conclusion, this project offers a practical method for enhancing quality of electricity in a solar PV system connected to a shaky grid using an integrator-based positive sequence estimator control. Simulation findings demonstrate satisfactory system performance in a variety of scenarios.

Keywords: Photovoltaic(PV), VSC Controller, MPPT Controller, DC-DC Boost Converter

INTRODUCTION

In comparison to traditional forms of energy, renewable energy sources (RESs) are becoming more and more well-liked. Because it requires little maintenance and is widely available, solar photovoltaic (PV) generation is especially preferred. Poor grid circumstances, however, can result in subpar power quality (PQ) and apparatus breakdown when in a grid-connected state.An answer to this problem is a converter of voltage sources. Voltage and frequency are managed by the VSC of the AC power output to convert the PV array's DC output into AC electricity that can be delivered to the grid, as well as to enhance the PQ of the grid.

A control method is required to get the most electricity out of a PV array because of its nonlinear properties. One popular approach is maximum power point monitoring using the hill-climbing technique (MPPT), which aims to optimize the PV system's power output. A MPPT technique has been proposed to improve efficiency by eliminating oscillation and achieving a fast convergence rate. Even in the face of rapidly shifting environmental conditions, this method can monitor the maximum power point quickly and accurately. There are multiple grid interfaced topologies available for PV system, but the two-stage topology is often preferred over the single-stage topology due to its advantages. When there is a change in PV insolation, the PV array's voltage and the dc-link voltage are identical in a single-stage configuration. This may cause problems with dc-link voltage when PV array's insolation is very low. A two-stage topology, on the other hand, guarantees that dc-link voltage stays independent of the solar-panel insolation, leading to more stable performance under changing insolation levels.

To improve power quality (PQ) in the grid, A voltage source converter (VSC) is frequently employed as a shunt regulator. In order for the utility to operate at unity power factor (UPF), the VSC transfers electricity generated by the PV array to the distribution grid. For this, a phase-locked loop (PLL) built on synchronous reference frame is typically used. Another approach to PQ enhancement involves the use of a series compensator (dynamic voltage converter), which employs PQ-based control. However, this method requires various transformations that can increase the burden of computation on the machine. While Least squares methods have been proposed to address this, they do not always eliminate the system's DC shift. Generalized integrator-based programme is a promising solution for DC offset rejection. However, none of these algorithms can guarantee positive sequence component (PSC) extraction under distorted circumstances. Therefore, further improvements within the control system are needed to achieve effective PQ enhancement in the grid. For a two-stage PV array connected to the grid, the current research suggests a positive sequence estimator and control system built on integrators. In order to enhance power quality (PQ) during grid anomalies like distortion, dc offset, sag, and voltage rise this control mechanism isolates positive sequence elements (PSCs).

POWER QUALITY

Power quality is the ability to the capability of electrical power to deliver a consistent and clean voltage and current to electrical devices. This includes factors such as voltage levels, frequency, waveform distortion, interruptions, and voltage fluctuations. Issues with power quality can cause electrical equipment to malfunction or fail, as well as reduce efficiency and lifespan. Therefore, it is

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critical to guarantee dependable power quality the performance and longevity of electrical devices.

Poor power quality can result from a variety of factors, including lightning strikes, faulty equipment, electrical interference, and inadequate grounding. Some common power quality issues include voltage sags, spikes, transients, harmonic distortion, and electrical noise. To address these issues, electrical systems must be designed and maintained to meet relevant standards and regulations.

Power Quality Disturbances:

Power quality disturbances can be classified into different types based on their characteristics and impact on electrical systems and equipment. Some common classifications include:

1. Voltage variations, which encompass voltage sags, swells, and interruptions.
2. Frequency variations, which include changes in the nominal frequency of the power supply, such as frequency deviation and flicker.
3. Voltage imbalance, which refers to an uneven distribution of voltage across the three phases of a three-phase system.
4. Harmonics, which refer to waveform distortion of the power supply due to harmonic frequencies.
5. Transients, which include short-duration voltage spikes or impulses, such as those caused by lightning strikes or switching surges.
6. Intermittent interruptions, which are brief power losses typically lasting less than a few seconds.
7. Long-duration interruptions, which are extended power losses typically lasting more than a few seconds.
8. Voltage fluctuations, which involve rapid and repetitive changes in voltage amplitude, such as flicker.

BLOCK DIAGRAM

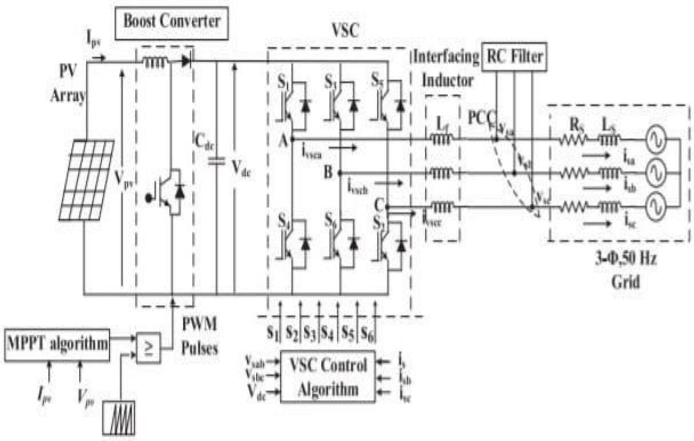

Figure 1: System Configuration

The fundamental design of a two-stage solar PV array that connects to a three-phase infrastructure is shown in Figure 1. a PV solar array, ac inductorsa voltage source converter (VSC), a three-phase grid, a dc-link capacitor, and a dc-dc boost converter, and a ripple filter are some of the essential parts of this system. The solar PV array's energy output is increased using the DC-DC boost converter. The PV array's VSC is in charge of using ac inductors to keep unity power factor (UPF) as it transmits power produced by the solar the PV array utility grid. Between the VSC as well as the DC-

DC surge converter, the dc-link capacitor acts as a transitional step to smooth out any voltage ripples.

Switching ripples generated by the VSC and the dc-dc boost converter are mitigated through the use of RC filters. Additionally, a dc-link voltage control device that is flexible is implemented to control the power of the dc-link.

In summary, this system is designed to transfer solar PV array power efficiently to the utility grid while maintaining stable the dc-link voltage.

Control Scheme:

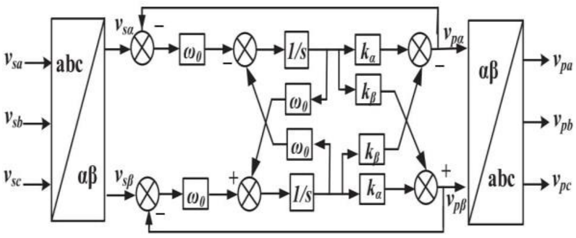

Figure 2: Block Diagram of Integrator Based positive sequence estimator

Figure 2 illustrates a block diagram of the integrator-based positive sequence estimator control scheme used in a double-stage solar PV system. The control scheme consists of two main controls: maximum power point tracking (MPPT) and voltage source converter (VSC) control.

By controlling the duty cycle of the DC-DC boost converter, the MPPT control is in charge of obtaining the most electricity possible from the solar PV source. This guarantees that the PV system works at the PV array's maximum power point (MPP). In order to control the power flow from the PV array to the grid and to improve power quality when abnormal grid conditions like voltage sag/swell, DC offset, grid voltage distortion, and unbalanced three-phase voltages at the point of common coupling occur, the VSC control algorithm produces gate pulses. (PCC).

The positive sequence estimator control using integrators scheme combines the MPPT and VSC controls to maintain stable grid conditions, improve power quality, and optimize the performance of the PV system.

MPPT CONTROLLER

In photovoltaic (PV) systems, MPPT (Maximum Power Point Tracking) controllers are frequently used to optimise the power production of a PV array by monitoring the array's maximum power point (MPP) under a variety of weather conditions. The Perturbation and Observation (P&O) approach, which is well-known for its simplicity, ease of application, and high reliability, is one of the most widely used MPPT techniques.

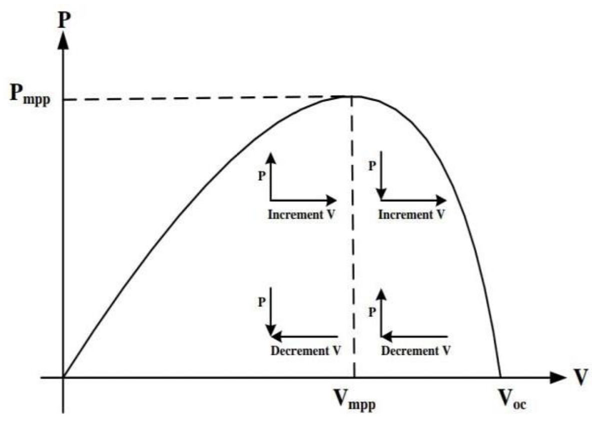

Figure 3: Principle of P&O

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The P&O MPPT technique works by continuously perturbing the voltage of the PV array and comparing the resulting power output with the previous power output to determine whether to increase or decrease the voltage further. This is done by checking the sign of the change in power output (dP) and the sign of the change in voltage (dV) to decide whether to increase or decrease the voltage. Specifically, if dP is greater than zero, then the technique checks whether dV is also greater than zero; if it is, the voltage is increased, otherwise, it is decreased. If dP is less than zero, the opposite occurs, with the technique checking whether dV is greater than zero and then either decreasing or increasing the voltage accordingly. The operation of P & O MPPT method is shown in figure 3 and its algorithm is shown in figure 4.

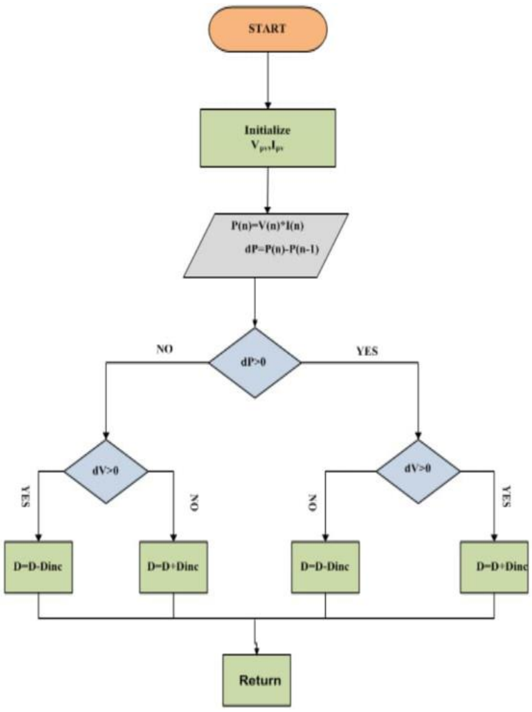

Figure 4: P&O Algorithm

DC-DC BOOST CONVERTER

The boost converter is a crucial part of a photovoltaic (PV) system that raises PV voltage to the required amount. The input to the boost converter is obtained directly from the PV array and is affected by factors such as temperature and irradiance.

The boost converter operates in continuous conduction mode and is controlled by pulses generated by the MPPT (Maximum Power Point Tracking) controller, which tracks the MPP of the PV array. To obtain a controlled voltage output, the capacitor value of the boost converter is chosen accordingly. On the other hand, the inductance of the boost converter is selected based on the maximum allowable ripple current at the minimum duty cycle. The boost converter is a critical component in ensuring that PV systems operate efficiently and effectively under various environmental conditions.

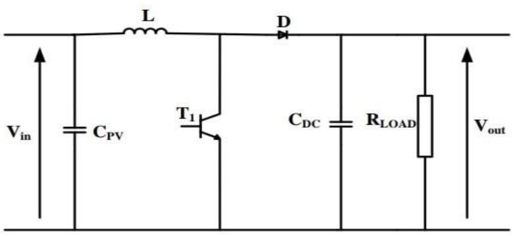

Figure 5: DC-DC BOOST CONVERTER

VSC CONTROLLER

The inverter controller is a critical component in the operation of a photovoltaic (PV) system. Its main function is to generate the gate pulses necessary for the inverter to convert DC

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power produced by the PV panels into AC power that can be fed into the grid.The controller is also in charge of using a phase-locked loop to synchronise the grid's voltage and frequency with the PV system output at the inverter terminals. (PLL).

The current control loop is the first of two control loops that make up the inverter processor. This loop is in charge of regulating the inverter current and resolving problems with power quality like increased power factor and reduced total harmonic distortion (THD. The inverter controller uses the d-q reference frame to simplify voltage and current management. By using the DC link voltage as a reference and setting the reactive current to zero, the active current can be controlled to maintain unity power factor and zero phase difference between the voltage and current. Overall, an essential component of a PV system, the inverter controller makes sure that the electricity produced by the PV panels is effectively converted and compatible with the grid.

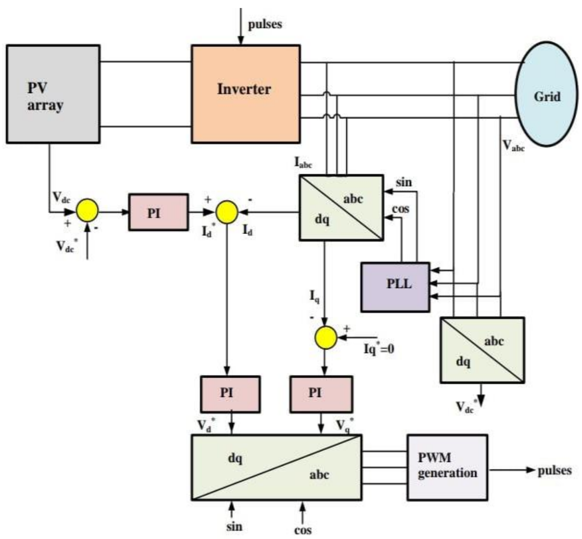

Figure 6: Block Diagram of inverter Controller

SIMULATION RESULTS

The proposed system is a photovoltaic (PV) system that is simulated using MATLAB/Simulink. The simulation results are shown at various operations.

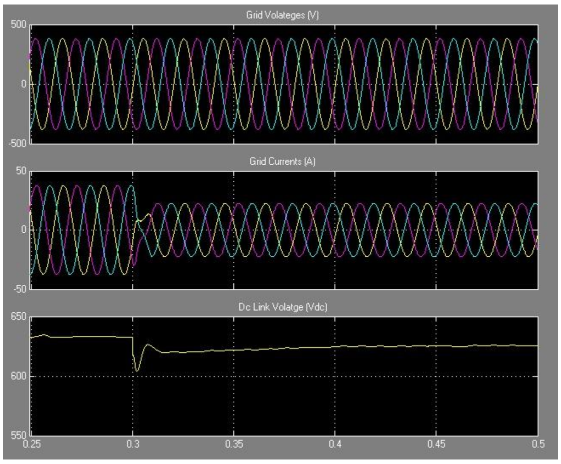

Figure 7: Operation at voltage Irradiation

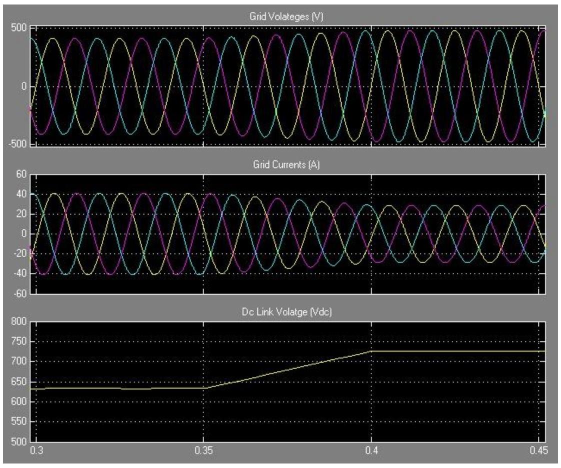

Figure 8: Operation at Voltage SELL

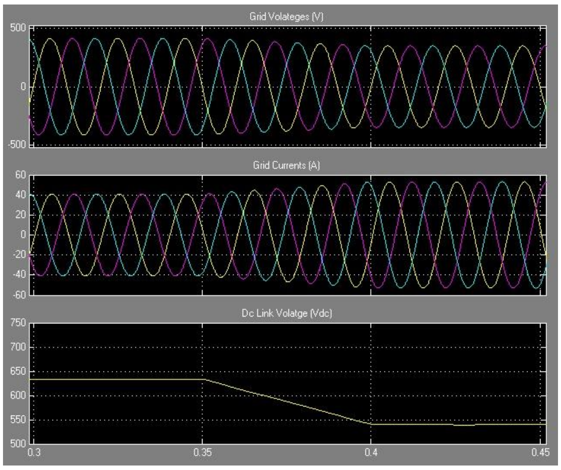

Figure 9: Operation at Voltage SAG

CONCLUSION

The efficacy and stability of a grid-connected, two-stage solar PV systems can be impacted by a variety of issues, including voltage sags, swells, and distortion. An estimator of the positive series using integrators control technique has been created to solve these problems. In order to lessen VSC losses during weak grid conditions, this technique estimates the positive sequence components (PSCs) of the distorted grid electricity during abnormal grid conditions and modifies the voltage of the DC-link appropriately. The integrator-based positive sequence estimator method can effectively deal with supply voltage power quality issues like harmonics, unbalance, flicker, and sags as well as load current power quality issues like harmonics, unbalance, reactive current, and neutral current. By addressing these problems, the method can guarantee that the system meets the necessary load demand, boost industrial output, and boost the nation's economy. In general, positive sequence predictor using integrators approach is a promising control method for enhancing the performance and stability of solar PV systems with a dual stage grid connection.

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