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# Optimization Control for Stability Improvement in Grid-Connected PV System

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**ABSTRACT:** Generally, PV power systems are not stable due to the variable power output of the PV panel, and this leads to many problems for the grid. Due to the fluctuation in PV power, the entire grid went into an unstable state. The proposed system has implemented the Particle Swarm Optimization (PSO) algorithm to mitigate the problems caused by the PV array. The power fluctuation in the PV array and the instability caused by the unbalanced load are immediately corrected and the system comes to a stable state due to the immediate action taken by the PSO. This maintains a constant output voltage across the inverter unit. PSO is a powerful algorithm that quickly brings the unbalanced system to a stable state. The voltage stability problem caused by the unstable PV generation can be reduced using the PSO algorithm. The proposed system is verified by the MATLAB Simulink model and tests the output. The stability of the system is enhanced.

**KEYWORDS:** Particle Swarm Optimization, PV power, stability.

## I. INTRODUCTION

A grid-connected photovoltaic (PV) system, also known as a grid-tied or on-grid solar system, is a renewable energy system that generates electricity using solar panels. The generated electricity is used to power homes and businesses, and any excess energy can be fed back into the electrical grid. In this way, grid-connected PV systems play an important role in reducing carbon emissions, promoting energy independence, and increasing access to clean energy[01-03].

A grid-connected PV system typically consists of solar panels, an inverter, a charge controller, a monitoring system, and an electrical distribution panel. When exposed to sunlight, solar panels produce direct current (DC) electricity. The inverter then converts this DC electricity into alternating current (AC) electricity, which is what is used in most homes and businesses. The charge controller regulates the flow of electricity between the solar panels, the inverter, and the electrical distribution panel. The monitoring system tracks the performance of the system, and the electrical distribution panel connects the system to the electrical grid[04-07].

One of the main advantages of a grid-connected PV system is that it allows you to use solar power even when the sun is not shining. When the sun is shining, the system generates electricity that is used to power your home or business. If the system generates more electricity than you need, the excess energy is fed back into the electrical grid. When the sun is not shining, you can draw electricity from the grid to meet your energy needs. This means that you do not need to store large amounts of energy, which would require batteries and other expensive components. Another advantage of a grid-connected PV system is that it can reduce your energy costs. By generating your own electricity, you can lower or even eliminate your dependence on the electrical grid, and reduce your monthly energy bill. Additionally, many utility companies offer net metering programs, which allow you to receive credits on your bill for the excess energy that you feed back into the electrical grid. Grid-connected PV systems are also an environmentally-friendly option. Solar power is a clean, renewable energy source that does not produce greenhouse gases or other harmful emissions. By using solar power, you can reduce your carbon footprint and help to protect the environment[08-13]. Finally, grid-connected PV systems are relatively easy to install and maintain. Unlike off-grid systems, grid-connected systems do not require batteries, and they do not need to be connected to a backup generator. This means that they are typically less expensive and less complex than off-grid systems.



## II. LITERATURE SURVEY

### Grid-Connected Photovoltaic System Nasreddine Attou, Sid-Ahmed Zidi, Mohamed Khatir, and Samir Hadjeri.

As energy needs increase and fossil resources decrease, the development of grid-connected photovoltaic energy is becoming an important part of the energy mix in the majority of countries. In this article, our attention has been concentrated on a strategy to control and interface photovoltaic power injection systems to the grid without batteries in order to make a significant and reliable contribution to sustainable energy supply and further improve the performance and stability of the power system. Different control mechanisms are considered in power flow management, maximum power point tracking (MPPT) for a three-phase photovoltaic inverter connected to the grid, PLL design standards (Phase Locked Loop), the current and voltage regulator VDC are also presented. The simulation results demonstrate the ability of the proposed control systems to control the energy flow, ensuring a good transfer of all maximum power to the grid

### A Review of Fault Detection and Diagnosis Approaches for Photovoltaic Systems Using Voltage and Current Analysis

Nurmalessa Muhammad; Nur Munawwarah Ridzuan Over the previous decade, there has occurred a substantial worldwide proliferation in the utilisation of photovoltaic systems (PVSs) for the aim of utilizing solar power. Nevertheless, it is significant to acknowledge that faults can manifest in various components of these systems, including modules, connection lines, converters, and inverters. When left unaddressed, these faults, whether in stand-alone or grid-connected PVSs, can significantly impact the system's overall performance, energy output, security and reliability. Consequently, implementing fault detection and diagnostic (FDD) technologies becomes paramount to ensure optimal operational efficiency, system dependability, and the safety of PV installations. The principal aim of this study is to comprehensively analyze the numerous classifications of failures that may arise in PVSs while offering a complete evaluation of FDD methods that depend on the analysis of current and voltage data. The present article aims to classify data analysis methodologies according to the distinct fault detection techniques, the specific type of failure being targeted, the parameters being measured and the methodology being employed.

### Analyzing the key technologies of large-scale application of PV grid-connected systems

Huan Wang; Yanchang Peng; Zilong Yang As the solar PV power is unstable and poor regulation energy, and PV power generation is impacted largely by the weather and geographical, large scale PV power plants (10MW and above) will bring adverse effects to not only grid security, stability and economic operation, but also the grid power quality. As the technology and market development, when the installed capacity of PV power plants compared with the local power grid capacity in a comparable order of magnitude, the effect to grid should not be overlooked. The grid-connected PV power will bring many problems to the existing electric power generation models, grid technologies and economic etc. So it's very important to analyze these problems and propose specific solutions. The article discusses the technology of grid-connected inverter that can participate in power dispatching; low-voltage tolerance of PV grid-connected inverter; PV Inverter group control technology; power management and dispatching automatization of PV power plant.

## III. PROPOSED SYSTEM

### 3.1 Block Diagram

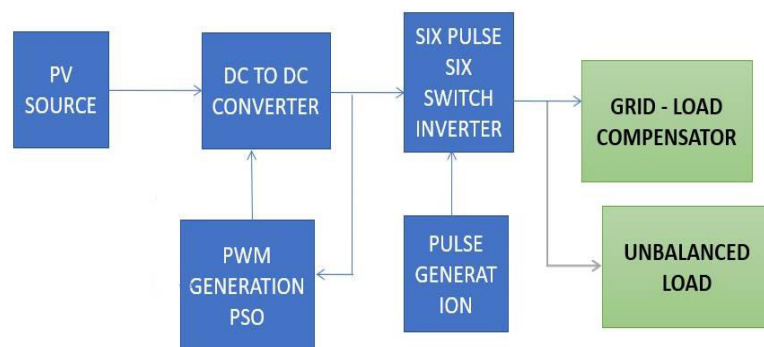


Fig 3.1 Block Diagram of Optimisation

Power produced from the solar PV is a fluctuating quantity therefore to make it as constant it needs to be provided with converter. To energise the AC loads again one more converter is provided to convert the DC to AC [14-17].

- In a three-phase system, an unbalanced load occurs when the electrical load (power consumption) is not evenly distributed across the three phases. The block diagram of the proposed system is shown in figure 3.1.
- **Ideal vs. Real-World:**
- In an ideal, balanced system, each phase carries the same amount of current and voltage. However, in real-world scenarios, loads may vary, leading to imbalances.

#### Causes:

- **Uneven Power Distribution:** Different equipment connected to each phase may have varying power requirements.
- **Single-Phase Loads:** Connecting single-phase loads to a three-phase system can create imbalances.
- **Faulty Equipment:** Problems like blown fuses, damaged components, or faulty power factor correction equipment can lead to imbalances.
- **Unequal Impedances:** Differences in cable lengths, wire sizes, or transformer resistances can also contribute to imbalances.
- **Harmonics:** Nonlinear loads can create current/voltage distortions.

#### Effects:

- **Overheating:** Phases carrying heavier loads may overheat, potentially damaging equipment.
- **Reduced Efficiency:** Imbalances can lead to decreased system efficiency and increased energy consumption.
- **Neutral Current:** The neutral conductor may carry excessive current, potentially leading to overheating and safety hazards.
- **Voltage Drop:** Uneven voltage levels across phases can cause voltage drops and damage equipment.
- **Torque Pulsations:** In motors, unbalanced currents can cause torque pulsations, increased vibration, and mechanical stress.

### 3.2 Simulation Diagram

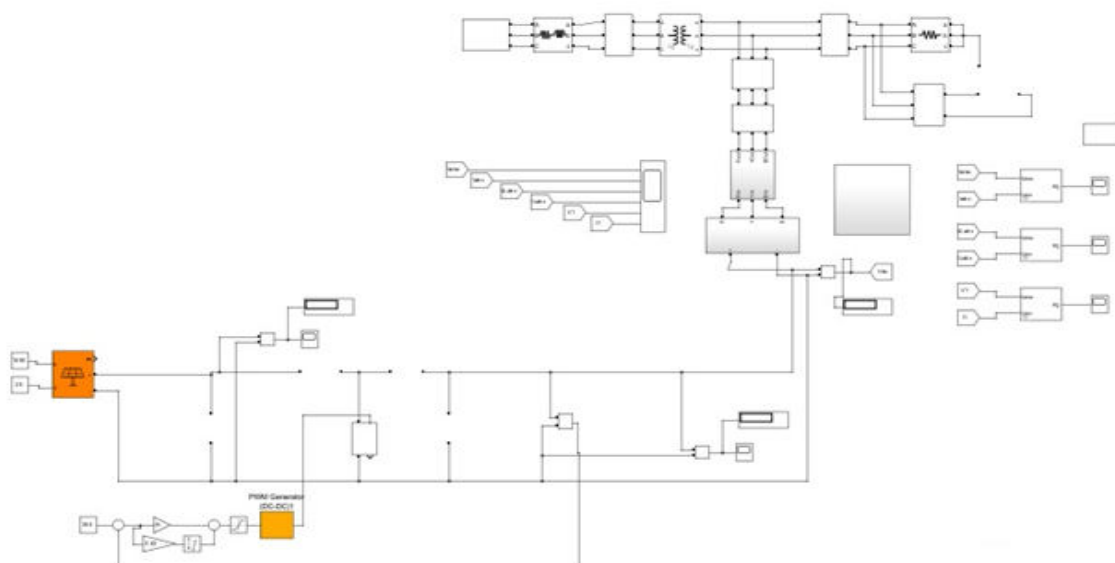


Fig 3.2; Simulation Diagram of proposed system

The solar PV array is connected with grid through a isolator. The Opening condition represents the fault or nil production in solar PV. Switch closing condition represents power production in the solar PV. For both the condition the output was taken from MATLAB simulink tool and output was verified. The simulation diagram of the proposed system is depicted in figure 3.2.

### 3.3 Simulation Outputs

#### Simulation Output when Switch is open



Fig 3.2; Output wave form of proposed system when Switch is opened

When the isolator provided between the PV supply and grid is kept open, the characteristics were studied using MATLAB simu-link. Even in the open condition there is no supply from the PV side will not affect grid voltage magnitude, it is kept as constant. Therefore the loads connected in the grid will not be affected. In the above figure 3.2; the 1 and 2 shows the grid voltage and current. The last two graphs are PV voltage and current. We can see the difference in the last two only. The grid voltage and current are kept in constant even in the PV power production is not available.

#### Simulation Output when switch is closed

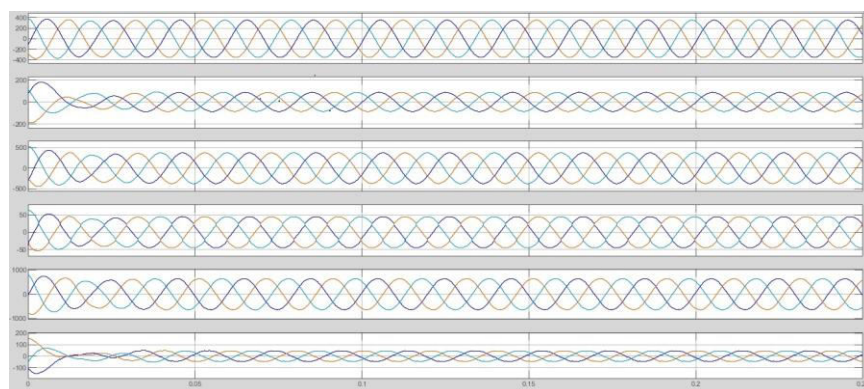


Fig 3.4 Output wave form of proposed system when Switch is Closed

When the isolator provided between the PV supply and grid is kept closed, the characteristics were studied using MATLAB simu-link. In the closed condition there is no supply from the PV side will not affect grid voltage magnitude, it is kept as constant. Therefore the loads connected in the grid will not be affected. In the above figure 3.3; the 1 and 2 shows the grid voltage and current. The last two graphs are PV voltage and current. The grid voltage and current are kept in constant.

#### IV. CONCLUSION

The proposed algorithm Particle Swarm Optimization (PSO), the powerful tool will mitigate the voltage stability issue in the PV-grid connected system. The oscillations in the power generation of the PV array also taken in to account for the stability analysis and it mitigates the voltage instability. The fault ( short duration ) in the grid also leads the instability, The proposed system will also mitigate this issue and bring the system to stable at the earliest. The stability of the grid with PV can be improved by the proposed system. The above said problems were analyzed using MATLAB simulink and mitigated the issues. The output for the various condition were analyzed using MATLAB simulation.

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