

A Modified Control Method for Grid Connected Multiple Rooftop Solar Power Plants

***Dr. Nataraja C, **Prajwal S M**

***Associate Professor, Dept of EEE**

Sri Siddhartha Academy of Higher Education, Tumkur

****Dept of EEE, SSIT, Tumkur, Karnataka**

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Abstract

The paper presents a control scheme to achieve enhanced operation of a grid connected photovoltaic system. A distributed control scheme along with communication signals is developed in order to improve the response of the system in dynamic conditions. The sources in system are controlled so as to provide real power as per the availability of the power with the source and the reactive power is injected as demanded by the local loads. This enhances the voltage and frequency regulation in the system. It also reduces the voltage fluctuations on distribution grid. In addition, the chattering of voltage under variable load is avoided. A complimentary modified control technique is developed to improve the power factor and the voltage regulation of the system. The simulation work is carried out using MATLAB/SIMULINK.

Key Words: *Grid connected solar PV; reactive power compensation; bus voltage regulation.*

I. Introduction

A grid-connected multiple solar rooftop power plants is a system in which several rooftop solar photovoltaic (PV) plants installed on different buildings or rooftops are electrically connected to a common utility grid. A grid-connected multiple rooftop solar systems consists of several independent or distributed PV plants whose AC outputs are coordinated and connected to the utility network. It allows solar energy from multiple rooftops to supply local loads and, when permitted, exchange surplus power with the grid. A grid-connected multiple solar rooftop power plant system is a solar photovoltaic (PV) generation system in which several rooftop solar plants, installed on different buildings or at different locations, are electrically connected to the utility grid. Each rooftop plant converts sunlight into electricity using PV modules and inverters. The generated power is primarily used by the connected building, while surplus electricity can be exported to the grid. When solar generation is insufficient, electricity is drawn from the grid. Unlike a single centralized solar power plant, a multiple-rooftop system distributes generation across several rooftops. This approach makes use of otherwise unused roof space and can reduce transmission and distribution losses because electricity is generated close to the point of consumption. In India, rooftop solar development accelerated through government programs and policies supporting grid-connected rooftop and small solar PV systems. The concept became particularly attractive for residential, commercial, institutional, and industrial consumers because rooftop generation can reduce electricity purchases from the grid while making use of existing building space. The next stage of development has been the deployment of multiple rooftop solar plants connected to a common electrical grid. This arrangement is useful for campuses, universities, hospitals, industrial facilities, residential communities,

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government buildings, and groups of geographically distributed buildings. Thus, the development of multiple grid-connected rooftop solar power plants represents a transition from conventional centralized electricity generation toward a more distributed, renewable and consumer-oriented power system. With advances in smart inverters, remote monitoring, energy management, and battery storage, such systems are becoming an important component of modern smart grids.

II. Literature Survey

Recent research in grid connected multiple rooftops solar power plants have effects of the smart grid system on the national grids. The infrastructure of the national grids of many countries is very old and includes classical technologies in terms of power production, transmission, and distributions. In addition, controllability and monitor ability of these systems are also not satisfactory Smart grid–reliability, security, self-healing standpoint, and state of the art, The industrial revolution in various fields has led to an increased demand for energy. Consequently, this has led to many challenges, not only for generation stations but also for distribution stations. This rise in energy demand pushed the system to be more complex which led to a substantial increase in the requirements for greater reliability, efficiency, security, and environmental and energy sustainability concerns. This great development in networks provoked many companies to switch to using smart methods, which is currently known as "smart grid" Because of the disadvantages of the traditional grid.

III. Problem Statement

This work proposes a modified control scheme for grid connected solar PV system. A modified control technique is developed to achieve reactive power compensation as per local and global loads. As a result, the power quality of grid is maintained, voltage regulation is achieved and power factor is improved. The proposed control scheme ensures minimal burden on interfacing converters. Priority based approach is developed for reactive and active power compensation for local load variation. The proposed control method ensures the maximum utilization of source power, guaranteeing minimum chattering of voltage resistance

IV. Proposed Methodology

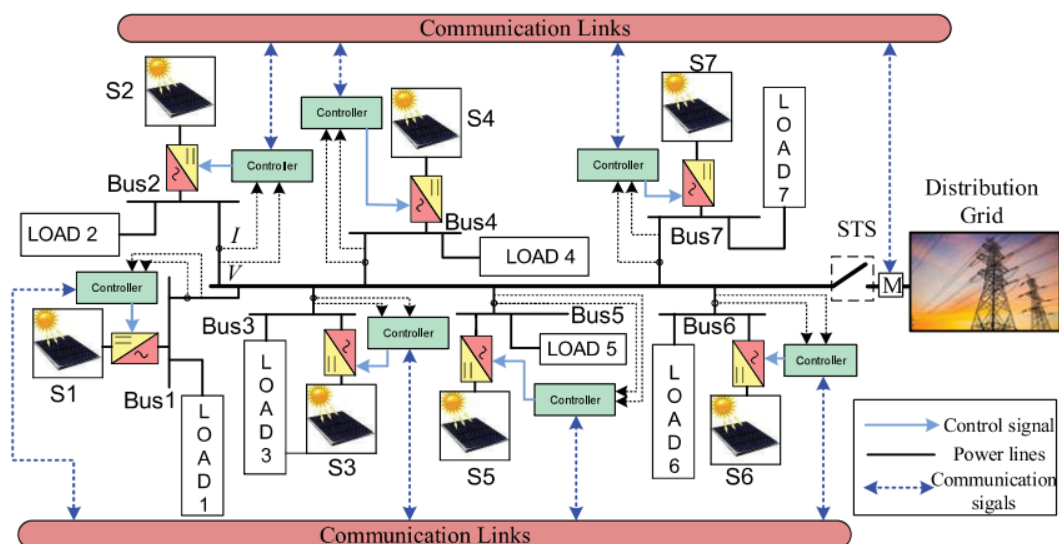


Fig 4.1 Schematic Diagram of Multiple Connected Rooftop System

The above figure illustrates the proposed schematic of a grid-connected solar power plant supplying local loads. The solar generation system is interconnected with the main utility grid through a Static Transfer Switch (STS). Under normal operating conditions, the solar power system remains connected to the main grid and is capable of exchanging power with the utility grid. In the event of a grid fault or abnormal operating condition, the solar generation system is electrically isolated from the main grid by opening the STS. Once the fault is cleared and the grid returns to a stable operating condition, the solar system is resynchronized and reconnected to the main grid by closing the STS. The proposed solar grid consists of seven rooftop photovoltaic (PV) generating stations, designated as PS1, PS2, PS3, PS4, PS5, PS6, and PS7. Each rooftop PV generating station is rated according to its designated power capacity and is connected to its corresponding local load, namely Load1, Load2, Load3, Load4, Load5, Load6, and Load7, respectively. In addition to supplying their respective local loads, the rooftop generating units are interconnected through a common main bus. Each rooftop PV generating station is interfaced with the main grid through a controlled power electronic converter, enabling regulated power exchange and coordinated operation with the utility grid.

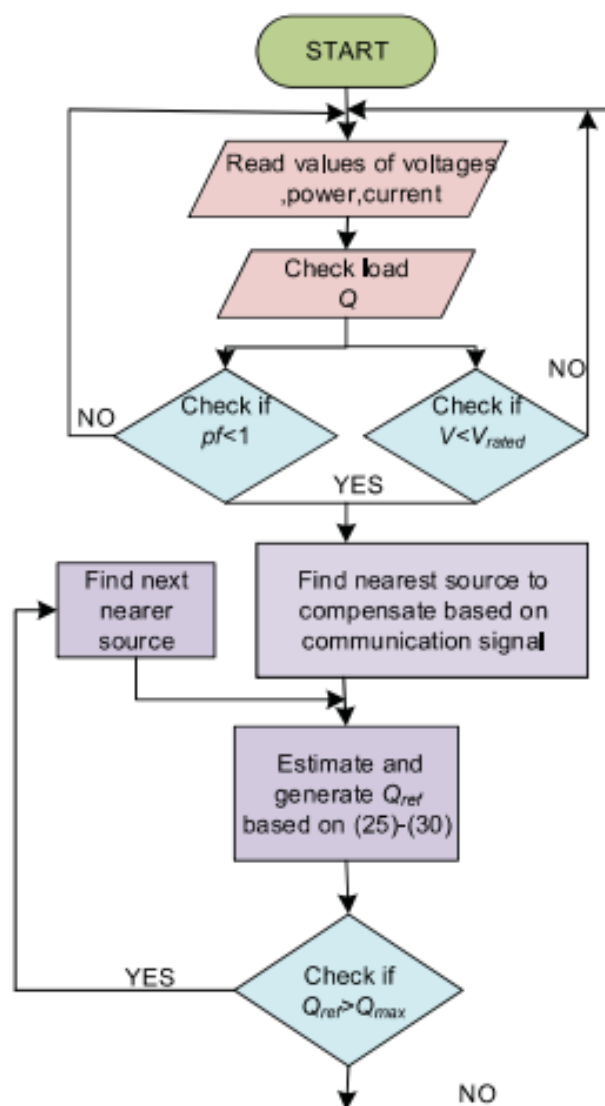


Fig 4.2 Flow Chat Describes the Algorithm

The above Fig 4.2 shows the flowchart describes show the algorithm to select the nearest source to compensate the reactive power. The proposed control algorithm gives brief information on how the reactive power is

compensated optimally. First the values of voltage, power and current are monitored continuously at different points. Also the reactive power at load is checked, if the power factor is less than one or voltage at load end is less than its rated value, it means the load is in demand of reactive power and hence, the nearest source is to be found to meet the reactive power demand using communication signals. If this calculated value turns out to be greater than the maximum reactive power supplying capacity of that source then, the communication signal again finds the next efficient source to compensate the remaining reactive power which the prior source was unable to supply this process is repeated continuously for the optimal reactive power compensation. In addition to this, the power factor of the system is also improved. The real power is injected based on estimated available power therefore the burden on the interfacing converter is minimum. The modified control scheme and proposed control algorithm is tested for various power scenarios in the proposed system.

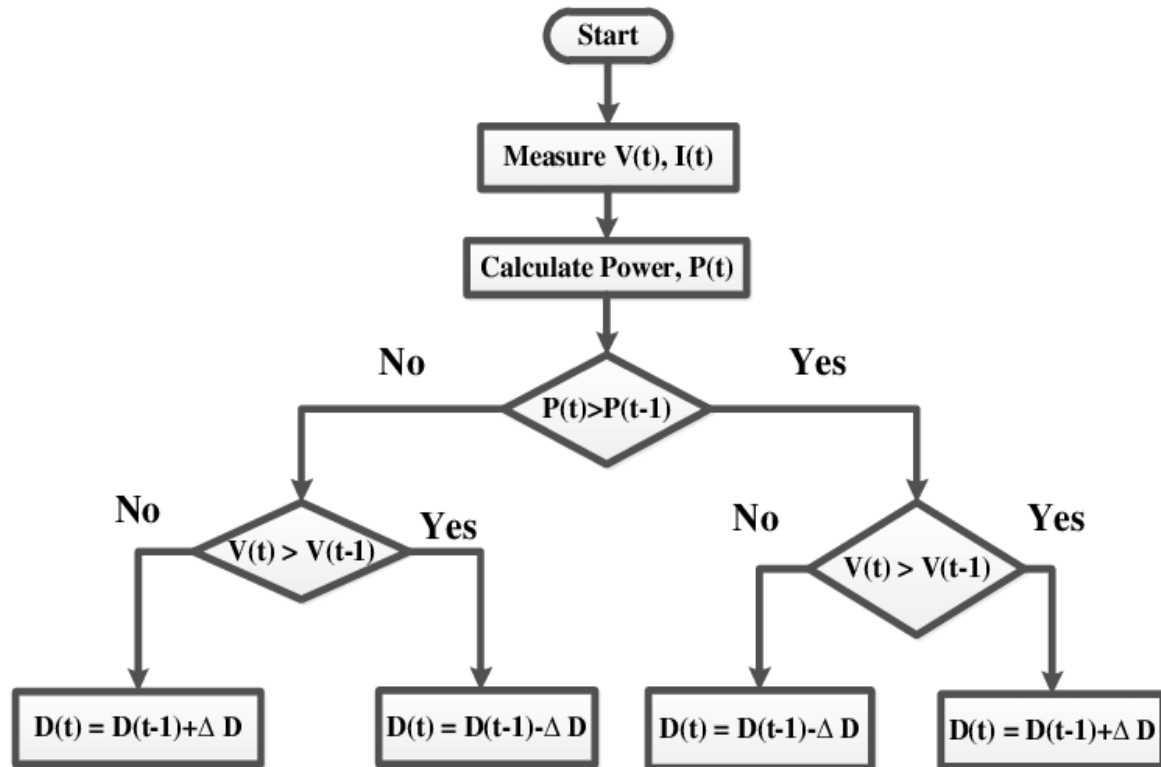


Fig 4.3 Flowchart describes for the MPPT algorithm

The above Fig 4.3 shows the flowchart represents the Perturb and Observe (P&O) Maximum Power Point Tracking (MPPT) algorithm, which is used in photovoltaic (PV) systems to extract the maximum available power from the solar panel. The algorithm continuously measures voltage and current, calculates power, compares the present and previous operating conditions, and adjusts the converter's duty cycle to keep the PV panel operating near its maximum power point.

V. Results and Discussions

The proposed control algorithm is tested and verified on grid connected multiple solar PV. The considered system is shown in Fig. 1. The parameters of system are given in Table. I. The proposed control scheme is developed in discrete time domain. The sampling time is considered as 50μsec. The communication signals are used to share the information and the controllers are distributed and takes decision on local measurement. The developed control scheme is tested for various power scenarios. Some of the power condition are discussed in this section.

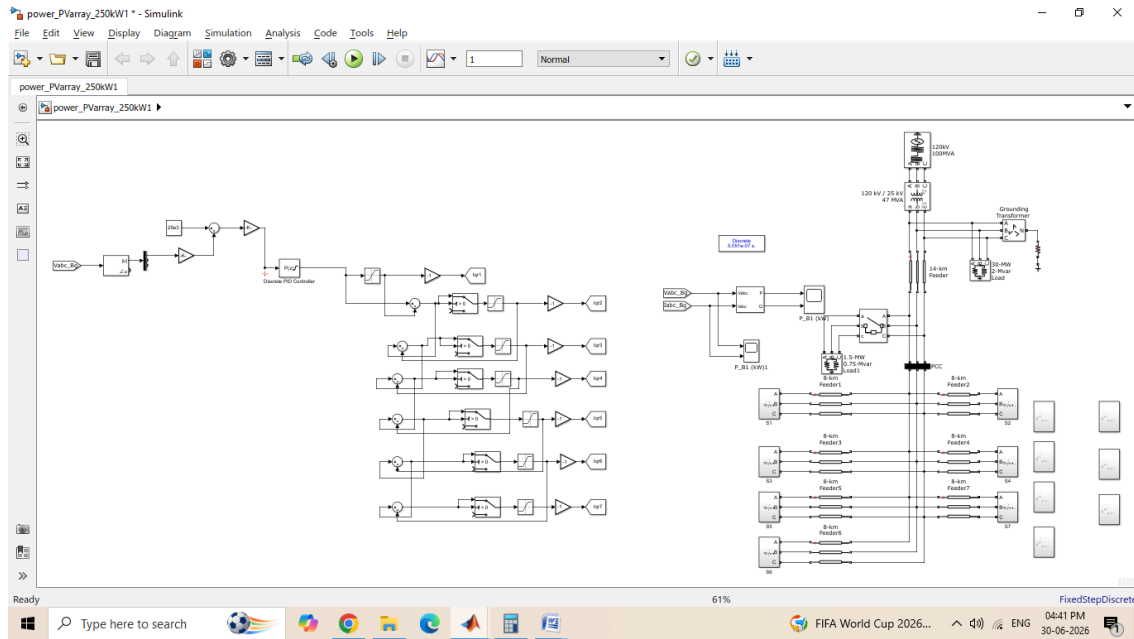


Fig 5.1 Simulation Circuit of Grid Connected PV Power Generation System

This Simulink model represents a **250 kW grid-connected photovoltaic (PV) power generation system** integrated with a **25 kV distribution network** through a three-phase voltage source inverter (VSI). On the left side of the model, the 3-phase grid voltage are compute and transformed into the synchronous reference frame, where a **discrete PI controller** regulates the inverter output current by comparing the measured voltage with a reference value (265.3 V). The controller generates the reference currents, which are processed by current control loops and compared with the measured inverter currents. The resulting current errors are fed into hysteresis/PWM comparators to generate the **seven reference quadrature axis currents (I_{q1} – I_{q7})** essential for the power electronic switches of the inverter. On the right side, after injects to the through inverter active power from the PV array into the **25 kV utility distribution feeder** through a step-up transformer and a PCC. The network consists of multiple **8 km feeders**, distributed loads (including 1.5 MW/1.5 MVar and 30 MW/2 MVar loads), a **120 kV utility grid** connected through a **120/25 kV, 47 MVA transformer**, and a grounding transformer to provide a neutral reference. Voltage and power measurement blocks monitor the real and reactive power exchanged between the PV system and the grid, allowing evaluation of voltage regulation, power flow, and grid stability under different operating conditions.

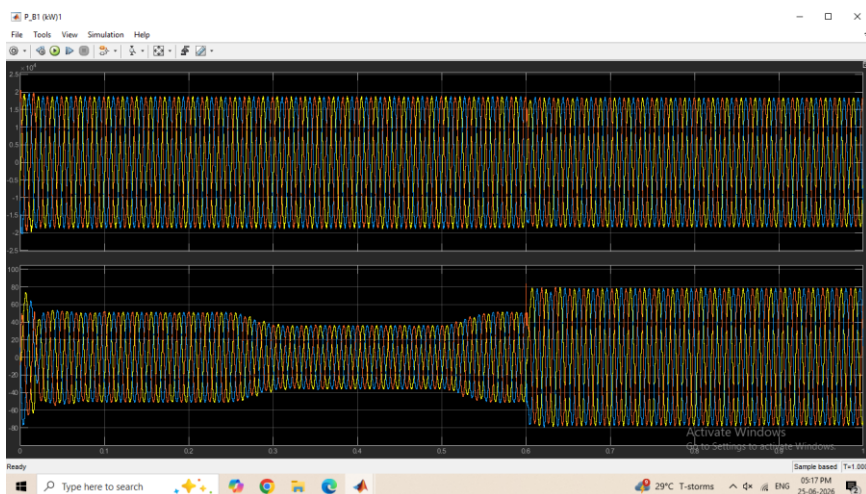


Fig 5.6 Simulation Circuit of Grid Connected PV Power Generation System

The figure illustrates the three-phase Point of Common Coupling (PCC) voltage and current waveforms of the 250 kW grid-connected photovoltaic (PV) system during variations in solar irradiance. The upper plot represents the three-phase PCC voltages (phases A, B, and C), while the lower plot shows the corresponding three-phase PCC currents injected by the inverter into the distribution network. The voltage waveforms remain balanced, sinusoidal, and nearly constant throughout the entire simulation, with a peak value of approximately ± 20 kV, indicating that the utility grid maintains a stable voltage despite changes in PV generation overall, these PCC waveforms confirm that the grid voltage remains essentially constant because it is regulated by the utility network, whereas the inverter current changes according to the solar irradiance and the available photovoltaic power. The balanced three-phase sinusoidal currents, together with the stable PCC voltage, demonstrate proper synchronization by the phase-locked loop (PLL), effective current regulation by the inverter controller, and successful integration of the PV system with the distribution grid while maintaining good power quality and low harmonic distortion.

VI Conclusion

The study of grid-connected multiple rooftop solar power plants demonstrates that distributed solar photovoltaic (PV) generation is an effective and sustainable approach for meeting increasing electricity demand while reducing dependence on conventional energy sources. By installing multiple rooftop PV systems at different locations and connecting them to the electrical grid, solar energy can be generated close to the point of consumption, thereby reducing transmission losses and improving overall energy utilization. The integration of multiple rooftop solar plants with the utility grid provides several technical and economic benefits. Coordinated operation and appropriate grid-interconnection standards are necessary to minimize issues such as voltage fluctuations, reverse power flow, harmonics, and protection coordination problems. With suitable monitoring and control strategies, these challenges can be effectively managed.

VII. References

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