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

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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

The renewable energy sources (RES) are widely used to generate the electrical power. The solar photovoltaic (PV) is emerging as a clean energy source to mitigate the electrical power demand. The rooftop solar is a great step towards battling climate variation. They are incredibly efficient and can be installed easily and require very little maintenance. The rooftop solar PV sources possess potential to provide electrical power supply at distribution end. Therefore, it reduces the transmission losses and burden on existing transmission system. The PV source can be interfaced to grid with local loads. However, the power from PV source cannot be interfaced directly to grid due to its variable nature. The interfacing of solar PV source is carried out by controlled power electronics converters. In grid connected mode, the RES sources are operated in current controlled mode to inject power into the grid. In this case the source voltage is maintained constant. The current operated sources should follow the reference grid voltage to supply power. In current controlled mode, the Master slave and average power techniques are mostly used for load sharing between sources. In average power technique, the load power is shared among the sources by taking average of total load. It does not require communication links. The average power references are given to each controlled source. However, the load changes are directly reflected on grid. This enhances the power fluctuations on the main distribution grid. The reactive load demand is supplied by distribution grid. Therefore, the system bus voltage and frequency affected by these load reflections. In case of light load condition, it injects the power into the grid irrespective of grid requirement. This increases the voltage regulation in the system. In Master-slave method, one of the sources in the system operates as voltage controlled source acting as Master. The remaining sources in the system operate as current controlled source. In this case, the master source maintains the system voltage. The current controlled sources are operated by reference current. This control scheme requires a communication link. The total load disturbances are handled by master source. This requires that Master source should have large power rating to support large load disturbances. However, the reliability of Master source affects the overall reliability of system. As the disturbances are reflected on master source, the system voltage gets affected. In addition to it, the increasing reactive power demand is supplied by master source. In KVA tariff system, it increases the electricity bills in grid connected solar PV system with net metering due to increase in reactive load demand. It also reduces the power factor of overall system.

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

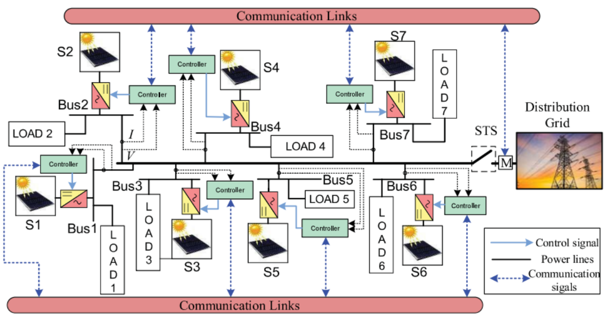


Fig 1.0 Schematic diagram of grid connected Multiple Rooftops solar power plants

The smart generation system shown above has been selected to be a case study for the proposed control method. The system contains a PV generation station connected with the grid, and the load used is R load.

The schematic in above Fig **1.0** represents the proposed grid connected solar power plant in an area with local loads. The solar source is interconnected to main grid through static transfer switch (STS). Under normal conditions solar source is connected to main grid and can exchange power with grid, however, under faulty conditions solar grid is isolated from main grid by opening the STS. When fault is cleared, the solar grid is reconnected to main grid by operating STS. In solar grid, seven rooftop solar generating stations are interconnected whose ratings are given as PS1, PS2, PS3, PS4, PS5, PS6 and PS7 each rooftop is connected to individual loads which are (Load1, Load2, Load3 Load4, Load5, Load6 and Load7) respectively as well as to the main bus. Each rooftop generating station is connected to main grid by controlled converters.

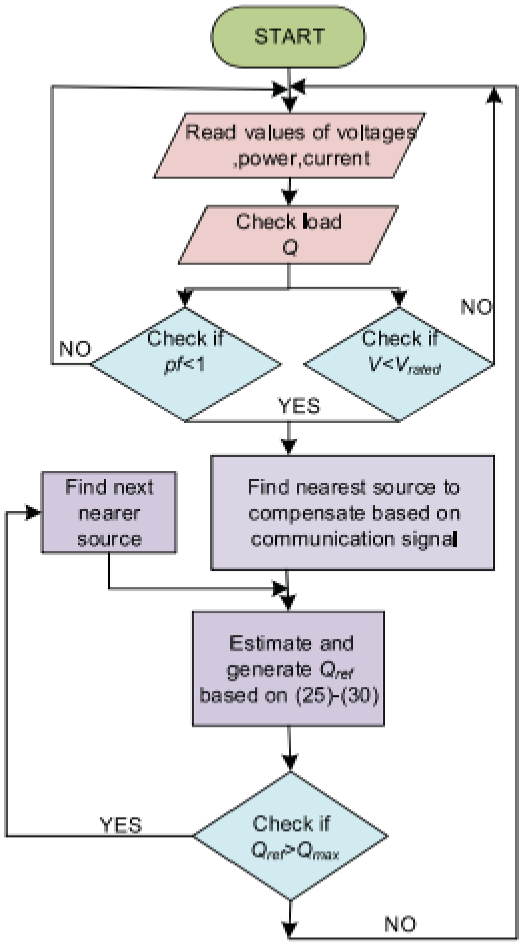


Fig 1.1 Flowchart describes the algorithm to select the nearest source

The above Fig **1.1** 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.

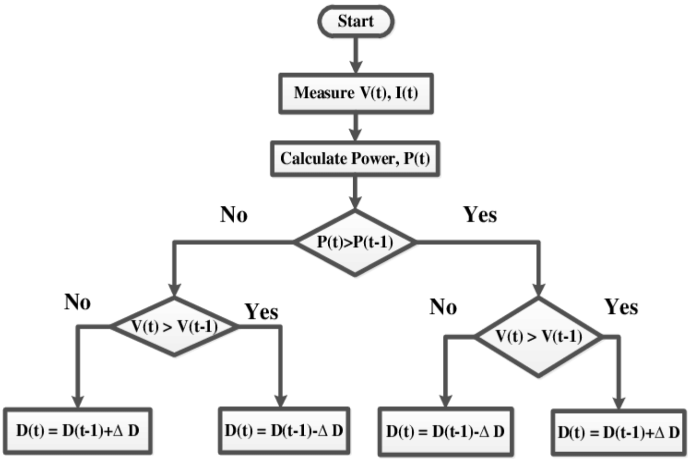
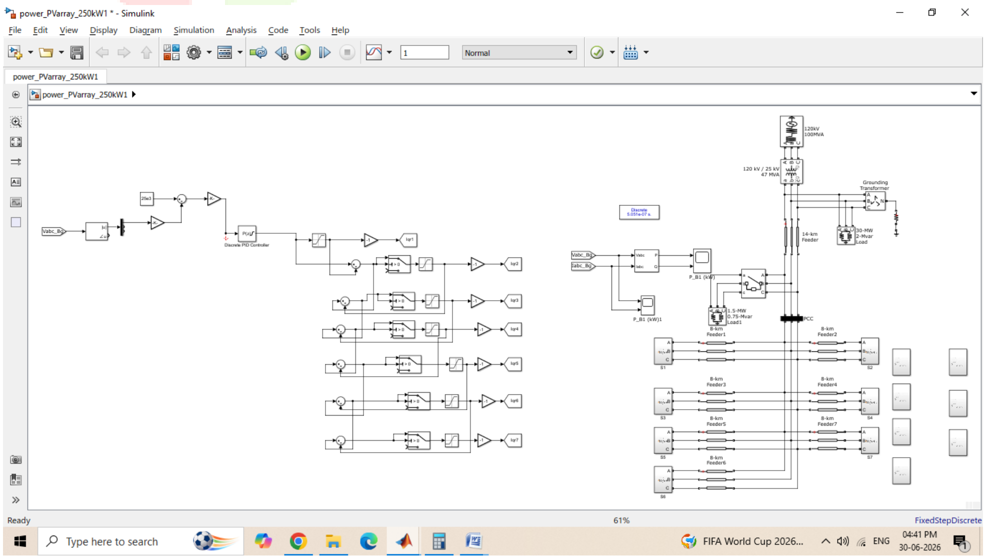


Fig 1.2 Flowchart describes for the MPPT algorithm

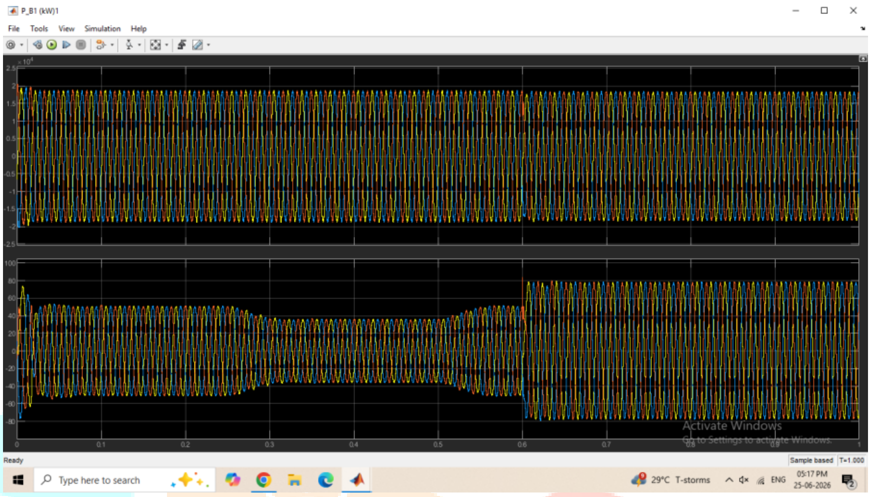
The above Fig **1.2** shows the flowchart describes for the MPPT the step by step working of a MPPT controller based on the describe algorithm. As shown below, the inputs taken are the dc link voltage and current and output is the required duty cycle. In the second step, the controller is computing the dc link power by multiplying mathematically the input dc link voltage and current. The next step explains (n-1) th value of dc link power which is obtained by using a delay function in Simulink. If the difference in nth and (n-1) th value of dc link power is greater than zero then the algorithm goes forward and computes the difference in dc link voltage. Accordingly the difference in dc link voltage generates new duty cycle by adjusting delta D which is added or subtracted as per the conditions applied

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.



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 three-phase grid voltages are measured 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 produce the seven reference quadrature axis currents (Iq1–Iq7) required for the power electronic switches of the inverter. On the right side, the inverter injects active power from the PV array into the 25 kV utility distribution feeder through a step-up transformer and a point of common coupling (PCC).



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

In this article a control scheme is developed to achieve enhanced operation of a grid connected multiple 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 voltage and frequency in the system is regulated at its nominal value by proposed control scheme. This is achieved by controlling real power as per the availability of the power with the source and the reactive power as demanded by the local loads. The fluctuation on the distribution grid because of dynamic local load is reduced by proposed control method. 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 developed control scheme is verified on various power scenarios and it is tested for a grid connected system with seven rooftop solar generating stations.

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