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Analysis of Photovoltaic Generators in Microgrid for Reactive Power Control

Sheikh Suhaib Gul[1*], Shahi Jahan Sultan[1#], Raof Ahmad Khan[2$]

[1] Deptt. of Electrical and Electronics Engineering, Government College of Engineering and Technology, Safapora Ganderbal, Kashmir, India-193504

[3] Deptt. of Mechanical Engineering, Government College of Engineering and Technology, Safapora Ganderbal, Kashmir, India-193504

[*]ersuhaib@gmail.com [#]shahijahansultan@gmail.com [$]roofkhanmech@rediffmail.com

***Abstract*—** Micro grids with segments for example, distributed energy assets and mechanized control speak to the up and coming age of grid incorporated assets. The smaller scale assets that are fused in a microgrid are involved little units, under 100 kW, furnished with power electronics (PE) interface. Most basic assets are Solar Photovoltaic (PV), Fuel Cell (FC), or micro turbines associated at the dissemination voltage level. The microgrid idea permits little distributed energy resources (DERs) to act in a planned way to give a vital measure of active power power and auxiliary administration when required. when a PV Generated microgrid is associated with the grid, the operational control of voltage and frequency is done altogether by the grid; however, a microgrid still supplies the basic burdens (loads) at PCC, consequently, going about as a PQ bus. In islanded condition, a microgrid needs to work without anyone else, free of the lattice, to control the voltage and frequency of the microgrid and thus, acts like a PV (control voltage) bus. The picked control parameters in the proposed techniques can flawlessly control inverter P-Q in grid associated mode. The controls are created in abc reference outlines utilizing the RMS/average estimations of voltages and active and reactive power. Thus, it is simple and productive to execute, and keeps away from the change to and from other reference outlines which incredibly rearranges the control procedures.

Keywords: Microgrids; MPPT Technique; Photovoltaic Generators;

I. INTRODUCTION

Although there are a few contrasts among these plans, nearness is developing of small limit DGs possessed by clients in the framework, for example, PVGs, power devices, etc. They can supply power to public network and provide many benefits in the transmission network they are connected to, for example, reducing power losses and costs improving power quality and increasing power supply reliability and security. As PV prices continue to drop, opportunities for their wider deployment are increasing, e.g. for urban houses. A number of pilots have been built during the past decades to study the benefits of using solar power. However, DC-AC changes, which are broadly utilized in PVGs, can infuse harmonic currents into the system above acknowledged points of confinement.. In this paper, HD is portrayed by IHDv and THDv separately. Serious HD levels can cause overheating of transformers and adversely influence delicate electronic devices.. HD studies when many PVGs are connected into system is very important.

Numerous studies have focused on HD when PVGs interconnect into system. In, the current and voltage data of 100kW PVGs in Ft. Davis, Texas area is recorded. The HD levels at PCC of PVGs are shown and compared with IEEE harmonic recommended practice. The harmonic properties of a 20kW PV system in Greece is analyzed. In this paper, a simulation model for PV system is established. In, the power and harmonic current produced by the PVGs are studied. The focus of this paper is on studying HD for existing PVGs on fixed locations. The locations and operation status of PVGs are normally not precisely known by a utility, because the owners decide when to connect or disconnect their PVGs to system. Utilities are interested whether the HD in the system is in an acceptable range rather than what the locations of PVGs are.

In this paper, a brief overview of general issues in designing microgrids with PVGs is analyzed. For power quality study, PVGs are connected into system at different penetration levels and their locations are assigned randomly. HD in the system is analyzed when harmonic outputs of loads and PVGs satisfy IEEE Std.519 limit. The influence of penetration and location of PVGs on HD limits is analyzed, including their impact on the critical locations HD-wise. The effect of allocating more PVGs near substation deploying a meshed on alleviating HD is investigated and compared.

I.I MODELING OF MICROGRID, LOAD AND DISTRIBUTED GENERATION

Microgrid structure under the regulation administering distribution framework activity, an islanding situation is allowed just for burdens with dedicated generation units. To consider the islanding operation of microgrids, in this paper the distribution framework is partitioned into a few

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zones so that in each zone, there is no DG, or there is any, balance of generation and consumption in that zone is possible regardless of main grid and by using only the power generated by DGs that exist in that zone. In other words, the distribution system is divided in two categories: the first category includes those zones that have no DG and their loads are fully supplied through the main grid, and the second category includes those zones that have one or more DGs and are capable of operating in the islanded mode. Considering of time varying load Capacitor placement is determined based on electrical energy demand curve, which means, on load versus time plot. In practice, load in distribution networks can vary with time over a wide range and depends on the point on the feeder where measurements are taken. In order to define the operation control program of switched capacitor banks, load duration curve (LDC) is approximated with piecewise curve. By increasing the numbers of segments in LDC results are more accurate but time consuming and vice versa. In this work it approximated by a three ladder function corresponding to the schedules of peak, medium and light load levelsDepending on the contract and control status of a DG unit, it may be operated in one of the following modes:

1. Real power production with the specific power.
2. Real power production with the capability of terminal voltage control

The generation nodes in the first mode can be well represented as PQ nodes. The generation nodes in the second mode must be modeled as a PV node.

The following text describes some of the key benefits of the microgrids.

Capacity, Reliability and Power Quality Improvements

Microgrid could be a lower-cost augmentation and alternative to a utility system construction or upgrade. For example, if a feeder needs an upgrade due to a load increase at the feeder end, it may be more cost effective to install a microgrid than to upgrade the feeder. A similar example is if remote loads are fed by a radial supply and there are potential supply interruptions (e.g. areas prone to fires). It may be more cost-effective to install microgrids close to the load than build a redundant supply path for a limited load size. Furthermore, recent storms in the US (e.g. Sandy) have spurred interest in microgrid installation that could make system less vulnerable to prolonged outages. In addition, physical and cyber security threats have emphasized a need to use micro grids to improve the resilience of the distribution system to provide power to as many customers as possible when the grid is under any type of attack or stress. Although microgrid installation may adversely impact power quality (e.g. increasing harmonic distortion), proper design and control of microgrids could alleviate those problems with proper managing of power quality needs of remote customers. It allows for multi-level of power quality based on customer needs. For example, various levels of power quality and reliability (availability) could be offered to various load classes:

- Premium power (DC)
- Emergency loads (A-class)
- Critical Loads (B1-class)
- Dispatchable - controllable load (B2/B3 class)
- Non-critical load (C-class)

In summary, microgrids enable improved outage management and power quality for critical, premium and remote customers.

II PROPOSED SYSTEM

The PV panel is interfaced with step up converter using MPPT technique. This is in turn connected via inverter to Microgrid to feed linear and non linear loads. The power injected depends on the magnitude of the PV panel output. This can be partial to the grid power or equal to grid power, accordingly the power is controlled. The IHD & THD is measured to ensure PV system is properly designed to ensure IEEE recommendations. This paper proposes several control algorithms through which the capability of PV generators for active and reactive power (P-Q) control in grid connected microgrids could be harnessed. The major contribution and novelty of the proposed control methods lie in the coordination among individual proposed control methods: MPPT control at the PV side, battery control, and P-Q control algorithm at the inverter side. The chosen control parameters in the proposed methodologies are, dependent on the PV, battery, and external power grid conditions, can be adaptively achieved with the changing system conditions

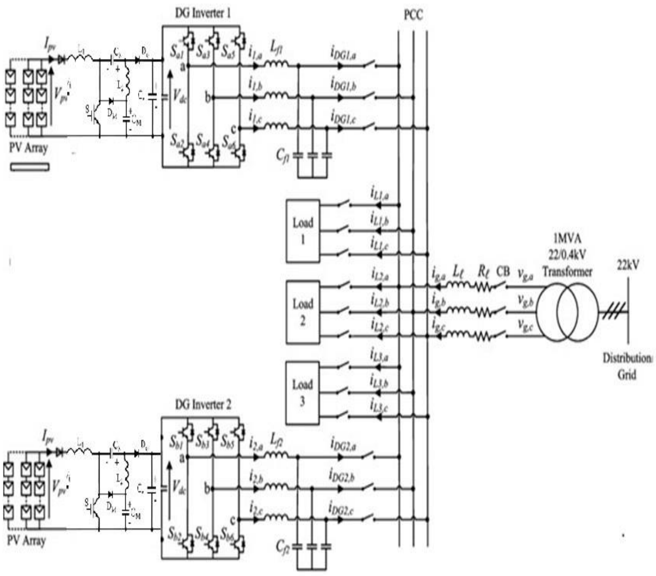

Fig.1 Circuit diagram of the proposed system

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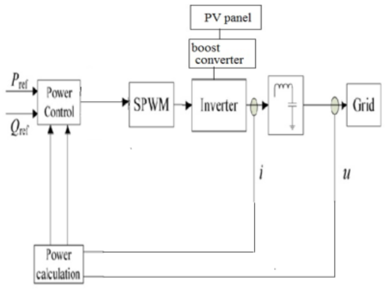

Fig.2 Block diagram of the proposed system

A microgrid may operate under two typical modes; the seamless transfer control of the microgrid is very important. The mode conversion controller is installed in microgrid and the control logic of master power is optimized for microgrid mode conversion. In the proposed scheme, master power is very important. The master-power is under the PQ control when microgrid is under grid-connected. The microgrid mode controller is used to solve the planned conversion. A microgrid is a low-voltage distribution grid comprising various controllable loads, storage devices, and distributed generators as a controlled entity that can either be isolated from or operate inter connectedly with the main grid. Distributed generation (DG) and the microgrid (MG) system have received increasing research attention.

The microgrid may operate under two typical modes: it can connect with the main grid, known as grid-connected mode (GM), and it can operate without main grid, called islanding mode (IM). Mode conversion is one of the core issues of the microgrid control. The researches have focused on the grid-connected mode inverter control, but few researches have been done on the mode conversion. The microgrid control may be implemented under the master-slave control mode, droop control mode and so forth. However, many microgrids have been built or under construction adopting master-slave mode, mainly because this type of microgrids can keep the voltage and frequency of the microgrid near nominal point. On the other hand, the active power of the solar and wind energy usually is not controllable continuously, and PV systems and wind turbines often work at the maximum power point (MPP). So, control of solar and wind energy is in PQ control mode whether it is under islanding mode or grid-connected mode. Control logic is relatively simple.

The reactive and active power of energy storage can be adjusted, and the energy storage system becomes the "master" power of microgrid when the microgrid is under islanding mode, and it is the frequency and voltage support of microgrid. Frequency and voltage of the "master-slave" architecture microgrid can remain near the nominal point, control structures is clear, the control logic of the "slave" power is simple, and the "slave" power has the plug and play features. Because of these advantages, this microgrid architecture has been used in a wide range of applications. In dual-mode inverter for this type of microgrid was researched, and the system is under PQ control when grid-connected mode is adopted. The mode conversion of microgrid with "master-slave" architecture is discussed in this paper. The microgrid mode conversion includes the following four types:

(1) planned conversion from grid-connected mode to islanding mode,

(2) Unplanned conversion from grid-connected mode to islanding mode,

(3) planned conversion from islanding mode to grid-connected mode,

(4) Unplanned conversion from islanding mode to grid-connected mode.

The fourth conversion can be avoided, but others cannot. In this study, for the microgrid mode conversion, microgrid sets a centralized mode controller and optimizes the master-power's control logic. The unplanned mode conversion is solved by the logic optimization of the master power, and the planned mode conversion is solved by the mode controller and the logic optimization of the master power. A detailed program of the mode controller and an optimization scheme of the master power converter control system are presented. The energy storage system as an example of master power is described. The master power operates under PQ mode when microgrid works under grid-connected mode. The microgrid operating mode is detected through the microgrid information such as current, voltage, and digital input. The master power will change the operating mode, when the microgrid changes its operating mode. In the mode conversion process, a series of programs will be used to ensure microgrid stability.

In a large number of the latest microgrid demonstration projects, a microgrid includes the photovoltaic power generation system, wind power systems, and energy storage system in which the "wind-solar-storage" mode is adopted. There are the photovoltaic power generation system, wind power systems, and energy storage system. Therefore, this study focuses on this type of microgrids. Without loss of generality, all of the PV systems are equivalent to one photovoltaic power generation system; all the wind systems in parallel are equivalent to one wind power system; all of the energy storage systems in parallel are equivalent to one storage system; load is distributed in microgrid.

In photovoltaic systems and direct drive wind power generation system of the microgrid, which are under PQ control mode, the maximum power tracking is always used and reactive power output is always 0. Storage system is under the PQ control when microgrid is under grid-connected mode. To achieve the smooth transition between islanding mode and grid-connected mode, the control of the microgrid mode conversion includes two parts: one is the conversion control system between PQ control and V/F control for the storage system and the other is the mode controller for the mode conversion of microgrid.

III PQ CONTROL OF THE STORAGE SYSTEM

When the storage system is under PQ control mode, the double loop control is used, which includes power outer-loop control and current inner-loop control

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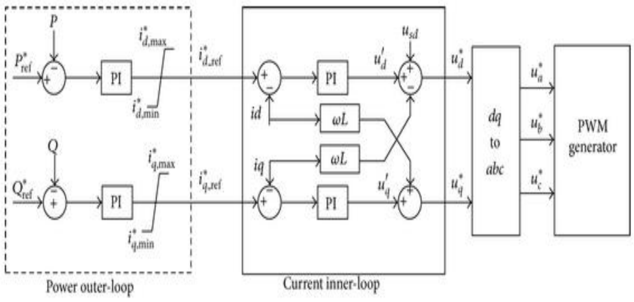


Fig.3 Schematic diagram of the PQ controller.

In power outer loop, the energy management system of the microgrid provides the active power reference value and reactive power reference value, which depend on the state of the storage system and the load balance of microgrid. The difference between the reference value and the actual value of active power is the input of the outer-loop PI regulator, for which the output is the reference values of the -axis current in the inner loop. In current inner loop, the difference between reference value and actual value of the -axis current is the input of the PI regulator, for which the output is the reference value of the -axis voltage of the inverter. The difference between reference value and actual value of the -axis current is the input of the PI regulator, for which the output is the reference value of the axis voltage of the inverter.

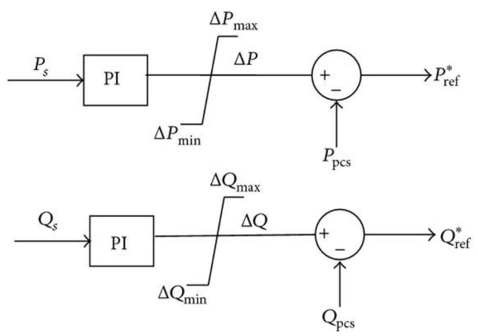


Fig.4 Schematic diagram of the power adjustment

To ensure the continuity of the PWM reference voltage, it is necessary to ensure continuous amplitude and phase. When the microgrid switches from grid-connected mode to islanding mode, storage system switch control includes the following.

(a)The amplitude and phase angle of PWM reference voltage is recorded when system is under grid-connected mode.

(b)When the microgrid switches from grid connected mode to islanding mode. When microgrid switches from islanding mode to grid-connected mode, the synchronization function is fulfilled by the mode controller of microgrid. The storage system only needs to change the response time of the PQ control mode (increasing and reducing).

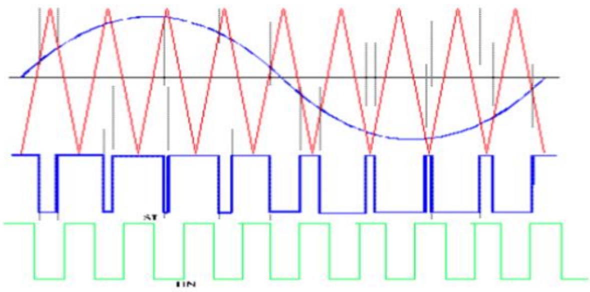


Fig 5: SPWM Signal

IV HARDWARE IMPLEMENTATION

For the hardware implementation we use different components. They are listed below as

- PIC Microcontroller dsPIC30F2010
- Voltage Regulators
- 7812 voltage regulator
- 7805 voltage regulator
- IC IR TLP250 for the amplification of the pulses given by dsPIC30F2010.

IV.I POWER SUPPLY CIRCUIT

Step-down transformer (230/15) V is used to give input supply to the power circuit.

- The 15V AC input is rectified into 15V pulsating DC with the help of full bridge rectifier circuit.
- The ripples in the pulsating DC are removed and pure DC is obtained by using a capacitor filter.

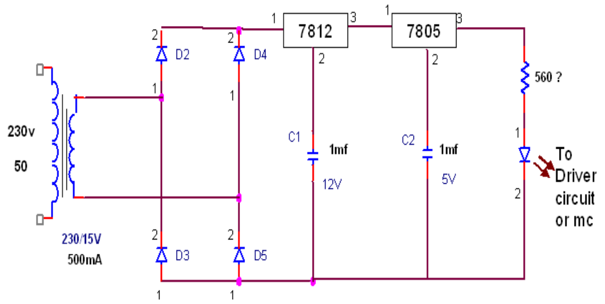


Fig.6 Power circuit

- positive terminal of the capacitor is connected to the input pin of the7812 regulator for voltage regulation.
- An output voltage of 12V obtained from the output pin of 7812 is fed as the supply to the The pulse amplifier.
- An output voltage of 5V obtained from the output pin of 7805 is fed as the supply to the micro controller.

From the same output pin of the 7805, a LED is connected in series with the resistor to indicate that the power is ON.

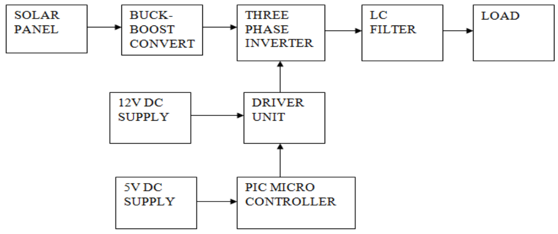


Fig.7 Hardware Block Diagram

V MAXIMUM POWER POINT TRACKING ALGORITHM

MPPT calculations are most required in PV applications on the grounds that the MPP of a sunlight based board causes bother since it changes with the temperature, so the utilization of these calculations are important for the reason to get the maximum power from perspective solar array.. Decades back many methods existed to fmd MPP across any network have been further developed and published. These techniques shows difference in many aspects such as lack of sensor requirements, complexity, cost factor and random rate of effectiveness, convergence in speed, perfect tracking when irradiation and/or climatic changes, hardware requirement for the implementation. The MPPT Algorithm operates on the output power (P) which is corresponding to the voltage (V) is equal to zero at the maximum power point.

VI RESULTS

The Simulation is done by using the MATLAB software. The input-waveform, inverter-output, converter-output results (required Waveforms) are shown in below figures . In this proposed method MOSFET switches are used for simulation.

VI.I SIMULINK MODEL

The System has a solar input. The input of the solar is low thus we use a DC-DC converter which is used to step up the DC voltage from Solar. This DC voltage is further converted to AC voltage through a three phase Inverter. We have two sections like this which is been further connected to the grid and distributed to load. Filter circuits have been used to reduce the harmonic distortion developed in the system.

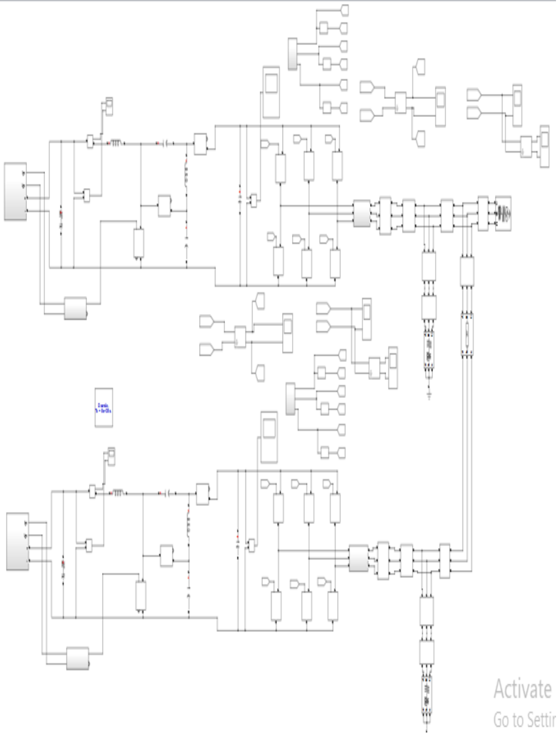
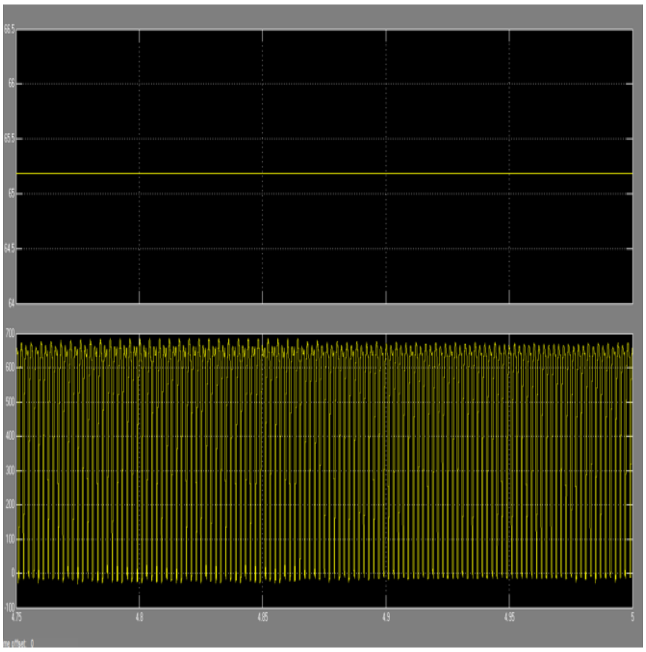


Fig.8 Simulation Diagram of Proposed Method

VI.II INPUT WAVEFORM



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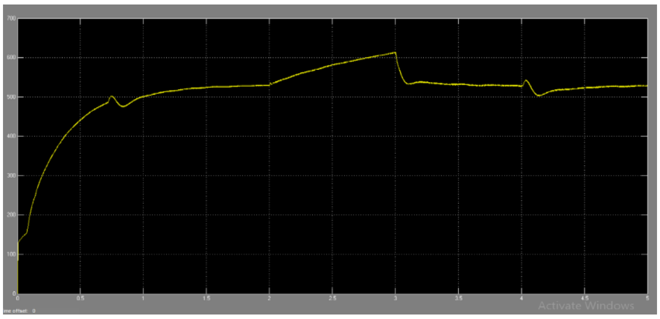
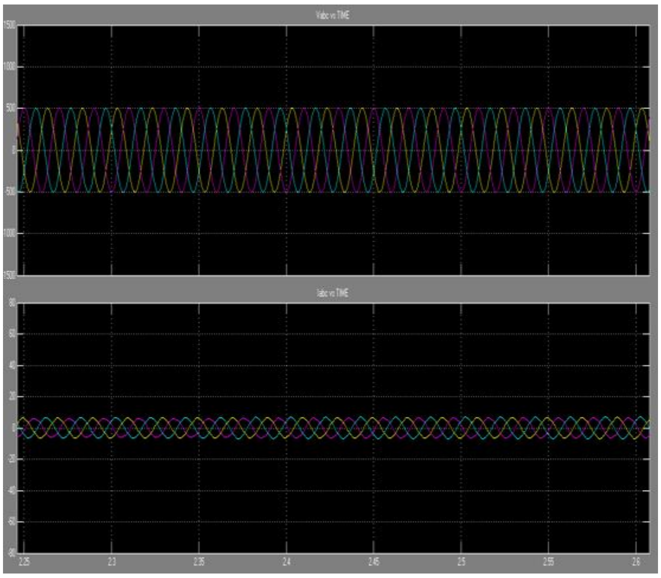
VI.III CONVERTER OUTPUT



VI.IV INVERTER OUTPUT



VII CONCLUSION

This project proposes and presents coordinated strategy of P-Q control for microgrids with PV generator and battery storage. In the control strategies, the PV generator is operated at MPP, and the battery storage acts as a buffer in order to inject and absorb deficit or surplus power by using the charge/discharge cycle of the battery. The project contributes in demonstrating the control strategies with effective coordination between inverter V-f (or P-Q) control, MPPT control, and energy storage control. The P and Q compensation with multiple PV generators with varying distance is analyzed in grid. The PQ control is done by simulation and analyzed.

FUTURE WORK

Hybrid energy system usually consists of two or more renewable/non renewable energy sources. Reactive power control in system with hybrid sources like wind and PV can be analyzed. The existence of the PQ problems due to the installation of wind turbines with the grid can be studied. And also using multi level inverters in the power system can be analyzed in future.

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