CONTROLLING AND MONITORING OF ADVANCED SOLAR POWER SYSTEM BY USING SUPER-CAPACITOR AND SEPIC CONVERTOR

[1]Dr.P.Sudhakar, [2]Dr.D.Ramesh, [3]Dr.S.Rajesh kumar, [4]R.Aruna
[1,2,3] Professor, [4]UG Student, [1,2,3,4]Department of Electrical and Electronic Engineering, Visvesvaraya College of Engineering and Technology, Mangalpalle, Telangana, India

ABSTRACT
The need to convert to renewable energy sources and improve their functioning is urgent since traditional energy sources are running out. In this study, a design for a solar power system with a supercapacitor storage system and SEPIC converter is proposed. The super capacitor has a low energy density but the fastest charging time when compared to all other storage devices, as well as a longer lifespan in terms of charge cycles and a wide operational temperature range. The lithium battery offers a higher energy density, but for it to last longer, the charge profile must be precise. It is feasible to get a decent compromise in terms of energy density by combining the two storages. SEPIC convertors allow output from convertors to be higher or lower than its input and allow the output to be non-inverted state with respect to input. It also reduces the amount of harmonics present in the output. A Controller is added between the solar panel and the battery to improve the system performance. The solar power system is controlled and monitored using Arduino microcontroller.
KEYWORDS: Super capacitor, SEPIC converter, PV cells

INTRODUCTION

PV-based systems are being used more often in a variety of home and commercial applications as a result of the rising need for inexpensive energy and increased environmental awareness. Although though many different harvesting techniques are now possible, photovoltaic (PV) conversion of solar energy has the maximum power density, making it the best option for powering an embedded device that uses several milliwatts with a relatively tiny harvesting module the rising importance of energy conservation. As PV is a significant energy source, it is possible to link the dc loads directly to the dc bus. Stand-alone and grid-connected photovoltaic systems can be widely categorized. In isolated locations without access to electricity, the stand-alone system is frequently employed. The stand-alone configuration can providea well-regulated load voltage, but the reliability of power supply cannot be guaranteed. Storage batteries are widely used to improve the reliability of the stand- alone system. The integration of a PV system to the grid is rapidly increasing due to the improvement in the power electronics technology. In grid-connected PV systems (GCPVS), the generated PV power is fed to thegrid, or it supplies the linear and nonlinear loads connected at the ac side. In some hybrid systems battery is used to compensate the mismatch between thegeneration and demand.

Due to the size and complexity of most of the power systems, a good way to analyze them is through simulations for planning and operation. Basically simulation illustrates how the system performs based on the interaction between its different components. Most electric power systems nowadays are turning towards being electronic since this offers a high potential for life-cycle cost savings, great improvement in system's efficiency, high density, voltage regulation, reliability, smaller size and lighter weight with continuous growth of system complexity. Huge number of work has been carried out in computer applications to power systems are carried out. There are several simulation programs available nowadays, however, the selection is based on the application of the system. The system gets input from solar panel and it is processed through modified SEPIC converter and string current diverter and is givento output dc load.

A power management architecture that utilizes bothsuper capacitor cells and a lithium battery as energy storages for a photovoltaic (PV) is proposed. The super capacitor guarantees a longer lifetime in terms of chargecycles and has a large range of operating temperatures, but has the drawback of having low energy density and high cost. The lithium battery has higher energy density but requires an accurate charge profile to increase its lifetime, feature that cannot be easily obtained supplying the wireless node with a fluctuating source as the PV one. A Controller is added between the solar panel and the battery to improve the system performance. Sepic convertors allow output from convertors to be higher or lower than its input and allow the output to be non-inverted state with respect to input. The controller is usually a dc-dc converter and controls the input voltage or current another convertor is generally used as the output converter to step-up the voltage because of the low voltage of the super capacitor. Combining the two storages is possible to obtain good compromise in terms of energy density

RELATED WORKS

In [1] Chen.S.et.al presents this paper presents a new method based on the cost-benefit analysis for optimal sizing of an energy storage system in a micro grid (MG). The unit commitment problem with spinning reserve for MG is considered in this method. Time series and feed-forward neural network techniques are used for forecasting the wind speed and solar radiations respectively and the forecasting errors are also considered in this paper. Two mathematical models have been built for both the islanded and grid- connected modes of MGs. The main problem is formulated as a mixed linear integer problem (MLIP), which is solved in AMPL (A Modelling Language for Mathematical Programming). The effectiveness of the approach is validated by case studies where the optimal system energy storage ratings for the islanded and grid- connected MGs are determined. Quantitative results show that the optimal size of BESS exists and differs for both the grid-connected and islanded MGs in this paper.

In [2] Daniel.E et.al presents the increasing interest in integrating intermittent renewable energy sources into microgrids presents major challenges from the viewpoints of reliable operation and control. In this paper, the major issues and challenges in micro grid control are discussed, and a review of state-of-the-art control strategies and trends is presented; a general overview of the main control principles (e.g., droop control, model predictive control, multi-agent systems) is also included. The paper classifies micro grid control strategies into three levels: primary, secondary, and tertiary, where primary and secondary levels are associated with the operation of the micro grid itself, and tertiary level pertains to the coordinated operation of the micro grid and the host grid. Each control level isdiscussed in detail in view of the relevant existing technical literature.

In [3] Daniel.K et.al presents historically, centrally computed algorithms have been the primary means of power system optimization and control. With increasing penetrations of distributed energy resources requiring optimization and control of power systems with many controllable devices, distributed algorithms have been the subject of significant research interest. This paper surveys the literature of distributed algorithms with applications to optimization and control of power systems. In particular, this paper reviews distributed algorithms for offline solution of optimal power flow (OPF) problems as well as online algorithms for real-time solution of OPF, optimal frequency control, optimal voltage control, and optimal wide-area control problems.

In [4] Deilami.S et.al presents this paper proposes a novel load management solution for coordinating the charging of multiple plug-in electric vehicles (PEVs) in a smart grid system. Utilities are becoming concerned about the potential stresses, performance degradations and overloads that may occur in distribution systems with multiple domestic PEV charging activities. Uncontrolled and random PEV charging can cause increased power losses, overloads and voltage fluctuations, which are all detrimental to the reliability and security of newly developing smart grids. Therefore, a real-time smart load management (RT-SLM) control strategy is proposed and developed for the coordination of PEV charging based on real-time (e.g., every 5 min) minimization of total cost of generating the energy plus the associated grid energy losses.

In [5] Lakshmikant.M et.al presents this paper deals with a system in which DC motor is started by using parallel combination of Super capacitors and battery, for enhancing the battery-life. Super capacitors deliver energy during ride through periods, which typically are during starting or during overloads. While delivering the energy, their current demands heavily increase. For the cases of heavy drainage of energy, for a longer time, the reduction in terminal voltage of super capacitor reduces the power fed by the Super capacitors. Then another capacitor is added in parallel with previous capacitor, Super capacitors bank of element can lead to higher effective current while enhance the power fed to the load during this overload period.

PROBLEM DEFINITION

By increasing the penetration of grid-connected photovoltaic (PV) units in electrical energy systems, theconcern regarding the effect of these units on grid operation increases as well. A considerable proportion of PV units already installed in some countries are residential PVs that are usually connected to low voltage (LV) distribution systems. Since the maximum PV generation happens simultaneously with low residential load consumption, high PV generation may cause reverse power flow in the grid, which can potentially cause overvoltage, especially in weak grids.

PROPOSED SYSTEM

A new method to determine dynamic operating points for EESS control in LV grids is proposed. Using the proposed method, the effects of reactive power absorption by PV inverters are considered as well as the load consumption. The cost associated with grid reinforcement is high and as the controllable domestic loads are not necessarily used on a daily and continuousbasis, DSM cannot be considered as a reliable solution. Moreover, in some LV grids the R/X ratio is high; as a result, the reactive power absorption by PV inverters is not sufficient to prevent the overvoltage. In recent years, the concept of using electrical energy storage systems (EESS) for overvoltage prevention in high PV generation conditions has been addressed. Although battery technologies have developed in recent years, themain concern about the application of EESS is still the initial investment in the system, and a strategy to optimize the size of energy storage units in the distribution system is required. A sizing strategy for optimizing the size of energy storage units in a distribution system is proposed in and the EESS life time, the effect of energy storage utilization on operation cost of transformer with On-Load-Tap-Changer (OLTC), and the effects of EESS on reduction of peak power generation cost are considered

BLOCK DIAGRAM

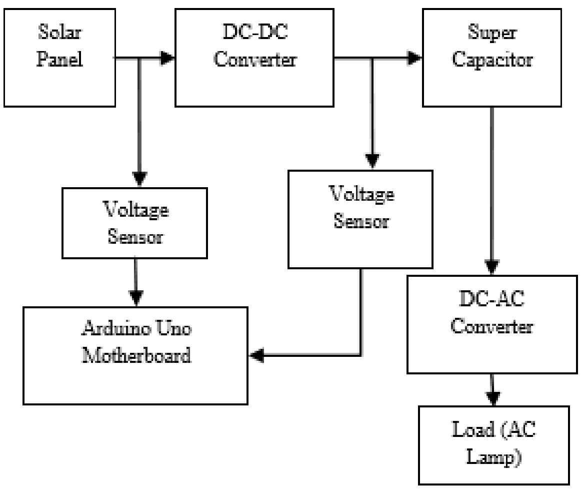


Fig 1 Block diagram

PROPOSED PROCESS EXPLANATION

Photovoltaic system

Photovoltaic (PV) cells, or solar cells, take benefit of the photoelectric outcome to produce electricity. PV cells are the construction blocks of every PV systems because they are the devices that exchange sunlight to electricity. When light falls on a PV cell, it may be reflecting, absorbed, or pass right through. But only the absorbed light generates electricity. The power of the absorbed light is relocate to electrons in the atoms of the PV cell semiconductor substance. When sufficient photons are engrossed by the negative layer of the photovoltaic cell, electrons are freed from the negative semiconductor material. Due to the developed process of the positive layer, these freed electrons obviously migrate to the positive layer create a voltage differential, comparable to a household battery.

These modules (from one to several thousand) are then wired up in serial and/or parallel with one another, into what's called a solar array, to generate the desired voltage and amperage output required by the given project. With their newfound energy, these electrons escape from their ordinary position in the atoms and happen to ingredient of the electrical flow, orcurrent, in an electrical circuit. An individual electrical possession of the PV cell provides the force, or voltage, needed to drive the current through an external load, such as a light bulb.

Fig 2 Solar panel

Battery technology

A cell is an electrochemical unit, while a battery is consists of two or more cells connected in series or parallel combination to accomplish particular operating ratings. A cathode is correspondingly the location where the reduction occurs, collecting the electrons from the anode through the external circuit. For a battery cell, the positive electrode becomes cathode during discharge and behaves as anode during charge, while the negative electrode becomes an anode during discharge and behaves as cathode during charge. In the common literature, however, the convention is to adopt the terminal name designations that are appropriate during discharge operation. The electrolyte is the medium that conducts the ions between the cathode and anode of a cell. The separator is a nonconductive layer that is permeable to ions, yet capable of preventing a galvanic short circuit between the cathode and anode terminals.

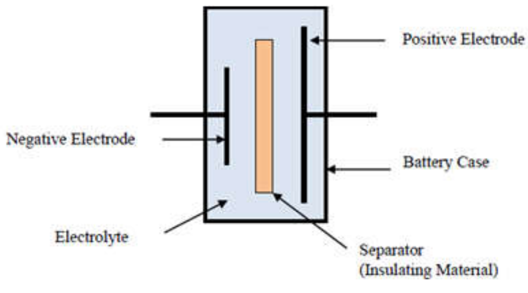


Fig 3 Battery unit

Power Supply Unit

The voltage, typically 220V rms, is joined to a transformer, which steps that air conditioner voltagedown to the level of the coveted dc yield. A diode rectifier at that point gives a full-wave amended voltage that is at first sifted by a basic capacitor channel to create a dc voltage. This subsequent dc voltage much ofthe time has some swells or air conditioning voltage variety. A controller circuit expels the swells and furthermore build-ups the comparative dc esteems regardless of whether the information dc voltage fluctuates, or the heap associated with the yield dc voltage changes. This voltage control is constantly gotten utilizing one of the prominent voltage controller IC units.

Transformer

The potential electrical gadget can venture down the capacity give voltage (0-230V) to (0-6V) level. At that point the optional of the potential electrical gadget are associated with the precision rectifier that is made with the help of op– amp. The pay of exploitation truth rectifier is offer pinnacle voltage yield as DC; rest of the circuits will offer exclusively RMS yield.

Bridge Rectifier

At the point when four diodes square measure related as uncovered in figure, the circuit is named as scaffold rectifier. The commitment to the circuit is sensible to the askew contrasting corners of the system, and along these lines the yield is taken from the remaining 2 corners.

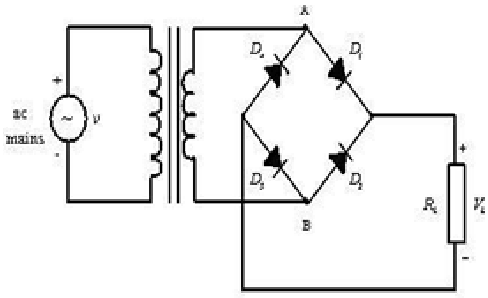


Fig 4 Bridge rectifier

Voltage Regulator

Voltage controllers cover a cluster of broadly utilized ICs. Controller IC units encase the electronic hardware for introduction supply, comparator electronic gear, administration gadget, and over-burden insurance beat one IC. IC units offer control of an immovable positive voltage, a rigid negative voltage, or flexibly set voltage. The controllers are decided for see with stack continuous from numerous milli amperes too many amperes, resultant to impact appraisals incitement milli watts to several watts.

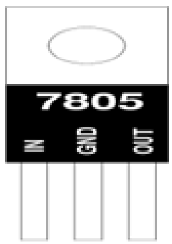


Fig 5 Voltage regulator

Arduino Microcontroller

Arduino is an open-source electronics platformbased on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), andthe Arduino Software (IDE), based on Processing.

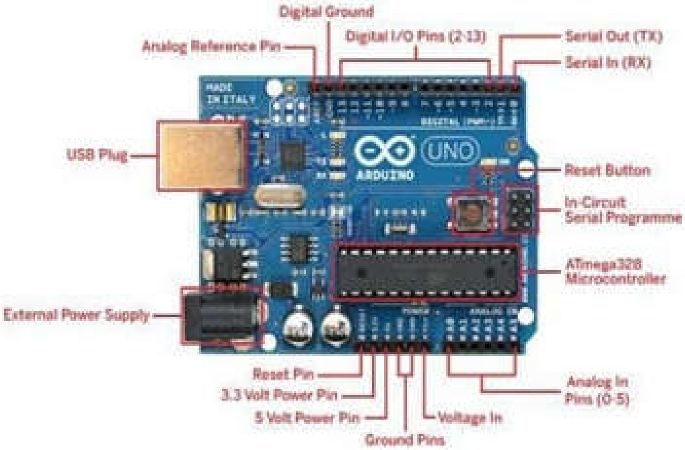


Fig 6 Arduino Microcontroller

Arduino's processor basically uses the Harvard architecture where the program code and program data have separate memory. It consists of two memories- Program memory and the data memory. The code is stored in the flash program memory, whereas the data is stored in the data memory. The Atmega328 has 32 KB of flash memory for storing code (of which 0.5 KB is used for the boot loader), 2 KB of SRAM and 1 KB of EEPROM and operates with a clock speed of 16MHz.

DC-DC converter

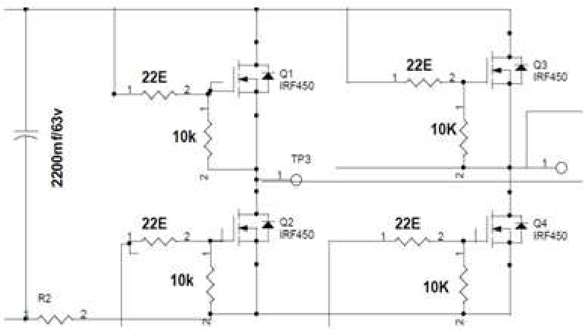


Fig 7 DC to DC Converter circuit

DC to DC converters are used in movable electronic devices such as cellular phones and laptop computers, which are supplied with power from batteries primarily. Electronic devices frequentlyinvolve several sub-circuits, every with its own voltage level requirement different from that supplied by the battery or an external supply. Additionally, the battery voltage declines as its stored energy is exhausted. Switched DC to DC converters offer a process to augment voltage from an incompletely lowered battery voltage thereby saving space instead of using numerous series to accomplish the identical thing. Most DC to DCconverter circuits also regulate the production voltage. To incorporate high-efficiency LED power sources, which are a variety of DC to DC converter that regulates the current through the LEDs, and humblecustody pumps which double or triple the output voltage. DC to DC converters urbanized to exploit the power harvest for photovoltaic systems and for wind turbines are called authority optimizers. Modifiers used for voltage exchange at mains frequencies of 50–60 Hz must be large and heavy for powers above a few watts. This makes them expensive, and they are subject to drive losses in their windings and due to eddy currents in their cores. DC-to-DC practice that employ transformers or inductors work at much superior frequencies, requiring only much smaller, lighter, and cheaper wound components.

Voltage Sensor

A voltage sensor is going to be able to determine and even monitor and measure the voltage supply. It is then able to take those measurements and turn them into a signal that one will then be able to read. The signal will often go into a specialized electronic device for recording, but sometimes, an observer will be present to manually read the sensor output. Voltage sensors are basically a device which can sense or identify and react to certain types of electrical or some optical signals

Fig 8 Voltage Sensor

Super Capacitor

Super capacitors are constructed somewhat like electrolyte capacitors. They have two electrodes that are made up of porous active carbon coating or carbon nanotubes. The coating is implemented on metal foils (generally aluminium) which serve as current collectors. The current collectors coated with electrodes are immersed in an electrolyte.

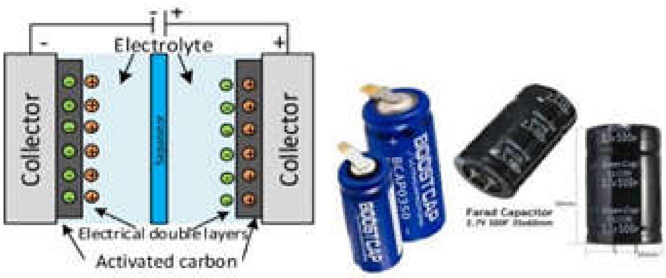


Fig 9 Super Capacitor

The capacitor is a fundamental electric component characterized by its ability to store energy in an electric field developed through the accumulation of electric charge. The capacitor's ability to accumulate electric charge and store electric energy is defined by its capacitance. Capacitors can in general be divided into three general categories: electro-static, electrolytic and electrochemical. The electrostatic capacitor is the conventional capacitor, consisting of two conducting plates with an isolating dielectric between the plates. An electrolytic capacitor employs a conductive electrolytic salt in direct contact with the electrodes, instead of a dielectric. This reduces the effective plate separation and thereby increases the capacitance of the capacitor.

DC-AC Converter

DC to AC converters produce an AC output waveform from a DC source. Applications include adjustable speed drives (ASD), uninterruptible power supplies (UPS), Flexible AC transmission systems (FACTS), voltage compensators, and photovoltaic inverters. Topologies for these converters can be separated into two distinct categories: voltage source inverters and current source inverters. As show in figure 2.5.Voltage source inverters (VSIs) are named so because the independently controlled output is a voltage waveform. Similarly, current source inverters (CSIs) are distinct in that the controlled AC output is a current waveform.

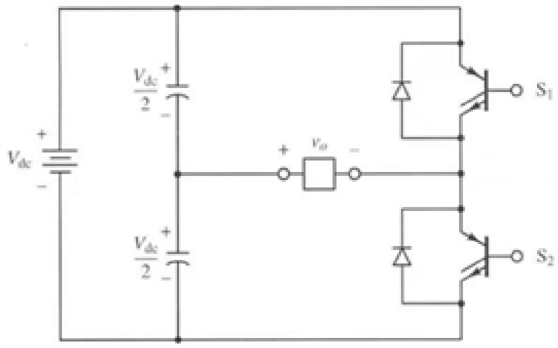


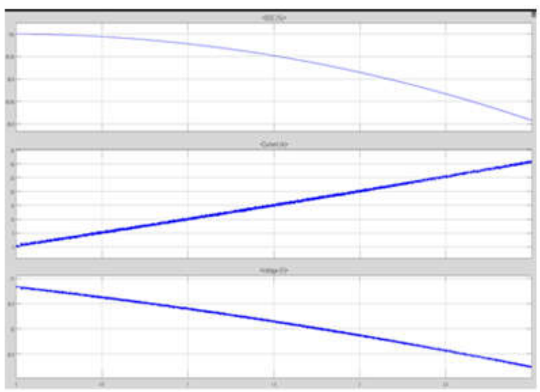
Fig 10 DC- AC Converter

LCD Display

A liquid crystal display is a flat panel display, electronic visual display, or video display that exercises the light modulates property of liquid crystals.Liquid crystals do not create illumination frankly. LCDsare reachable to display subjective images or permanentimages which preserve be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock. They use the similar basic knowledge, excluding that arbitrary images are made up of a large number of small pixels, while other displays have betterrudiments.

Fig 11 LCD display unit

OUTPUT RESULT



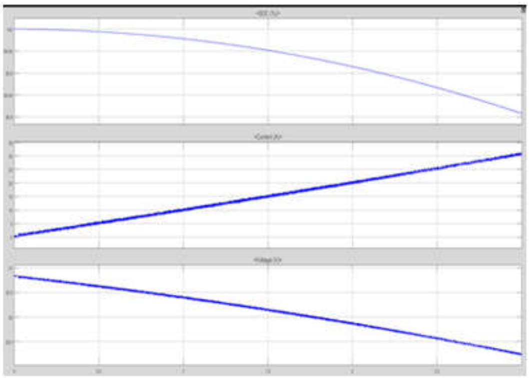


Fig 12 Super capacitor voltage and current

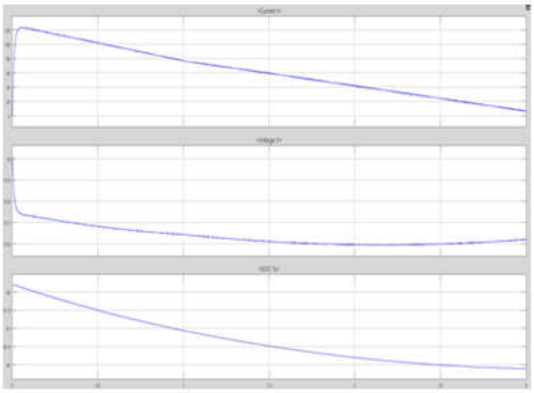


Fig 13 Battery voltage and current

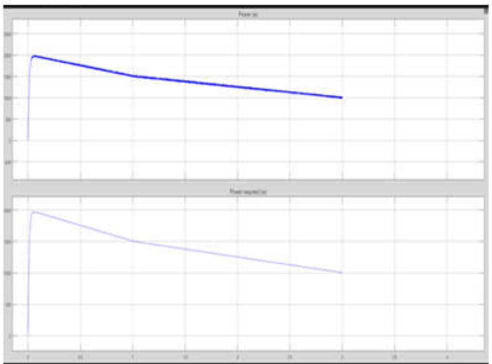


Fig 14 Super capacitor power

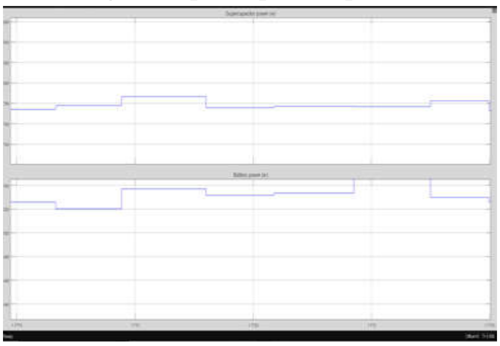


Fig 15 Comparison Super capacitor and battery

CONCLUSION

In this project, a new control approach wasproposed for energy storage management to prevent the overvoltage in load. To this aim, dynamic set points were determined for micro controller control considering the effects of reactive power absorption by PV inverters and the local load consumption. Simulations were performed on a realistic LV feeder to determine the energy storage capacity required to prevent overvoltage in the network considering two reactive power control methods, namely, reactive power as a function of voltage and power factor as a function of injected active power. The results indicated that busing the proposed method, the customers' voltage remained less than the predefined value in all locations of the grid and in all operation modes. In addition, compared to the fixed power threshold method, the energy storage that is required for overvoltage prevention was considerably decreased. Super capacitoruse the energy storage system is very high efficiency system. It is best energy storage system is better than other storage system. Simulations showed that by considering 5-kWh EESSs and applying the proposed method, the PV penetration in the grid could be increased to around 75%. In the same condition, byusing a fixed set point for energy storage control, thePV penetration had to be limited to around 50%. In addition, simulations indicated that in the selected LV grid, the PF method was more efficient in lower PV penetration and the Q (U) method showed better efficiency in higher PV penetration.

REFERENCE

1. Chen.S.et.al.,"Sizing of Energy Storage for Micro grids". 12 August 2017.IEEE.Trans. Smart Grid, vol. 5 no. 3, pp. 1270–1281, May 2014.
2. Daniel.E..,et.al."Trends in Micro grid Control",. 29 May 2018.IEEE Trans. Smart Grid, vol. 3, pp. 1039-1046, Jun. 2012.
3. Daniel.K.. :"A Survey of Distributed Optimization and Control Algorithms for Electric Power Systems,. 25May 2018. IEEE. Trans. Smart Grid vol.5, no. 5, pp. 2314–2325, Sep. 2014.
4. Deilami.S.et.al., Real-Time Coordination of Plug-In Electric Vehicle Charging in Smart Grids to Minimize Power Losses and Improve Voltage Profile. 18 June 2017 .IEEE. Trans. Smart Grid, vol. 3, no. 1 pp.271– 281, Mar.
5. Hamed Mohsenian-Rad., Autonomous Demand- Side Management Based on Game-Theoretic Energy Consumption Scheduling for the Future Smart Grid. 18 March 2017.IEEE.Trans.Smart Grid, vol %,pp.1514- 1522, May.2012.
6. Lakshmikant.M.et.al., Combination of parallel connected super capacitor & battery for enhancing battery life. 16 September 2017.IEEE. in innovative smart grid technologies Europe, Lyn by, 2013, pp.1-5.
7. Liang Che.et.al., Hierarchical Coordination of a Community Micro grid With AC and DC Micro grids. 06 April 2017.IEEE. trans. Smart grid, vol.5, pp.974- 981. Mar. 2014
8. Mrutyunjaya Mangaraj.ed.al. Power quality improvement by a 3-phase 4-leg Supercapacitors based DSTATCOM. 12 July 2016.IEEE.,"European photovoltaic Industry association (EPIA), 2017.
9. Nihal Kularatna.ed.al., A designer's view on non- traditional super capacitor techniques for sustainable energy applications. 17 May 2016.IEEE. trans. Power system, vol.28,pp. 4812-4820, 2013.
10. Preetha.S.et.al., Design of ultra-capacitor based DVR for power quality improvement. 04 November 2017.IEEE. trans. Power. Syst., vol 27,pp. 651- 662, may 2012.