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SIMULATION OF QUASI-Z SOURCE CASCADE MULTILEVEL INVERTER BASED PHOTOVOLTAIC SYSTEM

Jaydip Patel[1], Prof. Manish Patel[2]
[1]PG Scholar, Electrical Department, UVPCE, Ganpat University, Kherva, Gujarat, India
[2]Assistant Professor, Electrical Department,UVPCE, Ganpat University, Kherva, Gujarat, India

Abstract: This paper presents study of hybrid power system.A solar-wind hybrid system is a reliable alternative energy source because it uses solar energy combined with wind energy to create a stand-alone energy source that is both dependable and consistent. Solar power or wind power alone can fluctuate, when used together they provide a reliable source of energy. This paperproposes an energy stored qZS-CMI based PV power generation system. The system combines the qZS-CMI and energy storage by adding an energy stored battery in each module to balance the stochastic fluctuations of PV power. This paper also proposes a control scheme for the energy stored qZS-CMI based PV system. The proposed system can achieve the distributed maximum power point track for PV panels, balance the power between different modules, and provide the desired power to the grid. A detailed design method of controller parameters is disclosed. Simulation results verify the proposed system and the control scheme.

I. INTRODUCTION

Rapid depletion of fossil fuel resources on a worldwide basis has necessitated an urgent search for alternative energy sources to cater to the present days' demand. . Therefore, it is imperative to find alternative energy sources to cover the continuously increasing demand of energy while minimise the negative environmental impacts Recent research and development of alternative energy sources have shown excellent potential as a form of contribution to conventional power generation systems. There is a huge potential for utilizing renewable energy sources, for example solar energy, wind energy, or micro-hydropower to provide a quality power supply to remote areas. The abundant energy available in nature can be harnessed and converted to electricity in a sustainable way to supply the necessary power demand and thus to elevate the living standards of the people without access to the electricity grid.

The advantages of using renewable energy sources for generating power in remote islands are obvious such as the cost of transported fuel are often prohibitive fossil fuel and that there is increasing concern on the issues of climate change and global warming. The electric power generation system, which consists of renewable energy and fossil fuel generators together with an energy storage system and power conditioning system, is known as a hybrid power system. A hybrid power system has the ability to provide 24 hour grid quality electricity to the load. This system offers a better efficiency, flexibility of planning and environmental benefits compared to the diesel generator stand-alone system. The maintenance costs of the diesel generator can be decreased as a consequence of improving the efficiency of operation and reducing the operational time which also means less fuel usage. The system also gives the opportunity for expanding its capacity in order to cope with the increasing demand in the future. This can be done by increasing either the rated power of diesel generator, renewable generator or both of them.The disadvantage of standalone power systems using renewable energy is that the availability of renewable energy sources has daily and seasonal patterns which results in difficulties of regulating the output power to cope with the load demand. Also, a very high initial capital investment cost is required.

The energy stored qZS-CMI can have balanced and smooth power injected into the grid, where each module's energy storage will absorb redundant PV power and/or supply absent power to the grid. Therefore, the energy stored qZS-CMI requires different control methods compared to existing those of three-phase 2-level energy stored qZSI and qZS-CMI. This paper proposes an energy stored qZS-CMI applied in a PV power system. A control scheme is investigated and the controller parameters are designed by using the built small-signal model and bode plot method. With the proposed control scheme, the energy stored qZS-CMI based PV system can achieve the distributed MPPT for all PV panels; moreover, it can provide the desired power to the grid with the balanced module power.

Basic Block Diagram of MPPT system with DC-DC boost converter

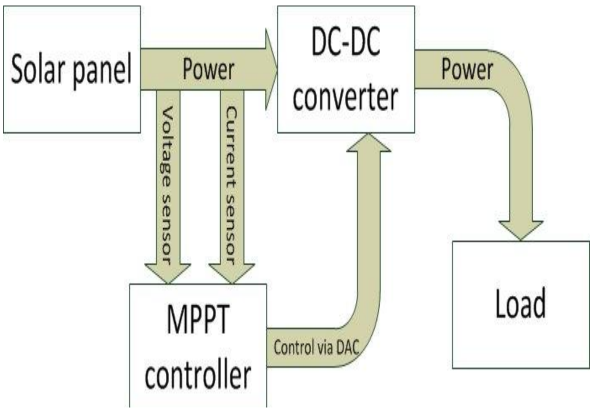


Fig.1. Basic Block Diagram

Maximum power point tracking (MPPT) is a technique that solar battery chargers and similar devices use to get the maximum possible power from one or more photovoltaic devices, typically solar panels, though optical power transmission systems can benefit from similar technology. Solar cells have a complex relationship between solar irradiation, temperature and total resistance that produces a non-linear output efficiency which can be analyzed based on the I-V curve. It is the purpose of the MPPT system to sample the output of the cells and apply the proper resistance (load) to obtain maximum power for any given environmental conditions.Above Fig.1 shows a typical feed-forward configuration of DC-DC Converter through MPPT controller which in total aids in tracking Maximum Power Point and makes it evitable for PV Array to operate at Maximum Power Point. The basic components used in MPPT system are

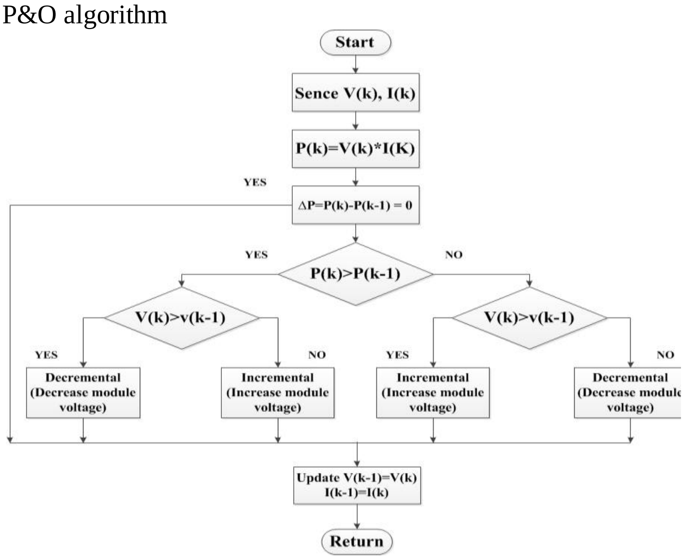
- Solar panel
- DC-DC converter
- MPPT controller

Solar PV Model

Fig.2. Solar panel

A photovoltaic system uses one or more solar panels to convert solar energy into electricity. It consists of multiple components including the photovoltaic modules, mechanical & electrical connections and mountings means of regulating and/or modifying the electrical output. Here above shown figure.2 is of solar panel

P&O algorithm



II. TOPOLOGY OF THE PROPOSED SYSTEM

A sample topology of the proposed system is shown in Fig.3, which consists of three modules with outputs connected in series. Each module includes a PV panel, a battery, and a qZS H-bridge inverter. The unipolar PWM method is used in each module to operate the H-bridge inverter. Considering the qZSI's operating principle, the shoot-through state is added in the conventional zero state in the modulation process. Therefore, each module in the system still outputs a 3-level voltage *vHn*. For the whole system's modulation, the PS-SPWM method in [1] is employed, and the carriers of three modules are shifted by 60º to each other. As a result, the energy stored qZS-CMI provides a 7-level output voltage *v*H to feed 50-Hz grid through L-filter.

III. MODELLING OF THE PROPOSED SYSTEM

In this paper, the two capacitors of each module have the same capacitance, and the two inductors of each module have the same inductance, i.e., C=C1=C2 and L=L1=L2. The reasons are as follows:

(1) Different capacitances will cause different current behaviours of the two inductors. There will be larger inductor current second harmonic (2ω) ripple (at least for the inductor L2) when compared to the case with the same capacitance. Large inductor current 2ω ripple will result in large loss and high current stress of inductors.

(2) Our design also aims to obtain constant inductor current without 2ω ripple. For this case, two capacitors will have the same 2ω current ripple. Two capacitors with equal capacitance will result in the same 2 ω voltage ripple, so the 2ω ripple of dc-link voltage is divided into two equal parts – half on the capacitor C1 and half on the capacitor C2. Otherwise, if the capacitor C2 has smaller

(3) A similar situation will occur if the two inductors have differing inductances. The modelling and controller design will also be complicated if C1≠C2 and L1≠L2

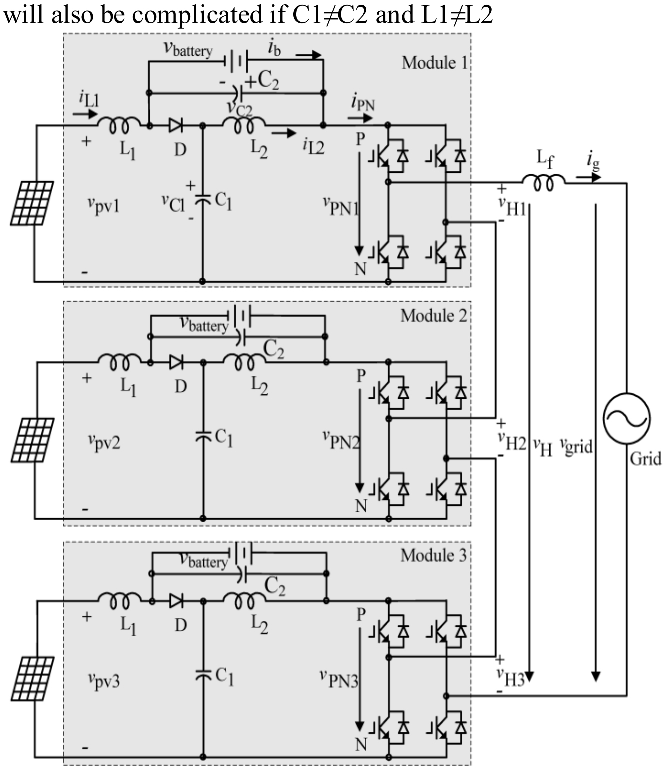


Figure 3: Topology of the proposed system. [1]

IV. SIMULATION AND RESULTS

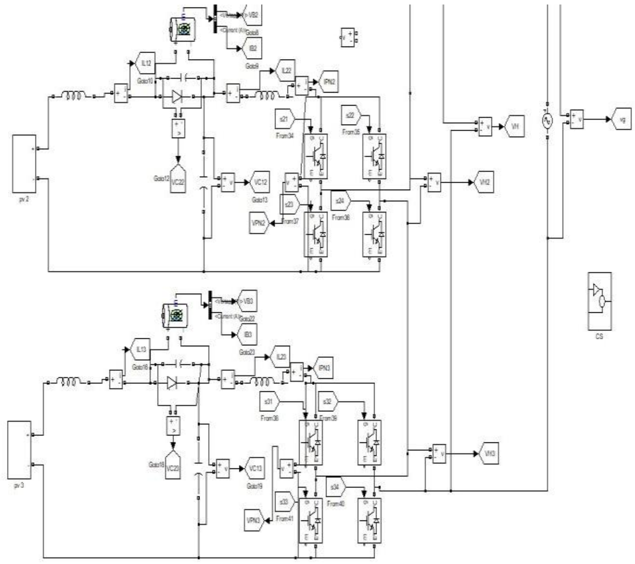


Fig 4- Simulation of Proposed system

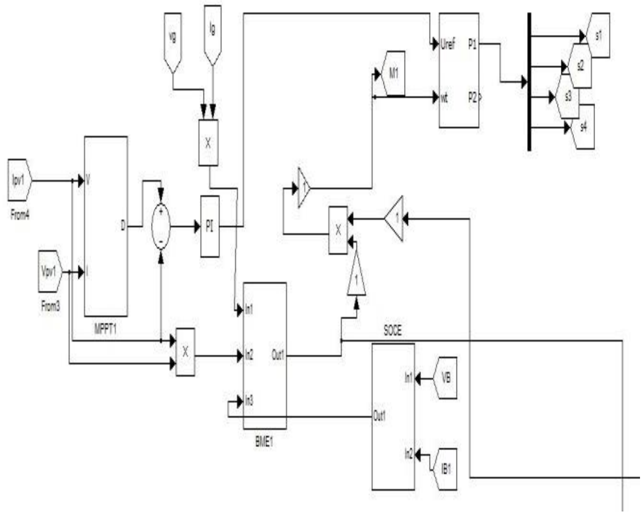


Fig 7- Controlling block Matlab subsystem

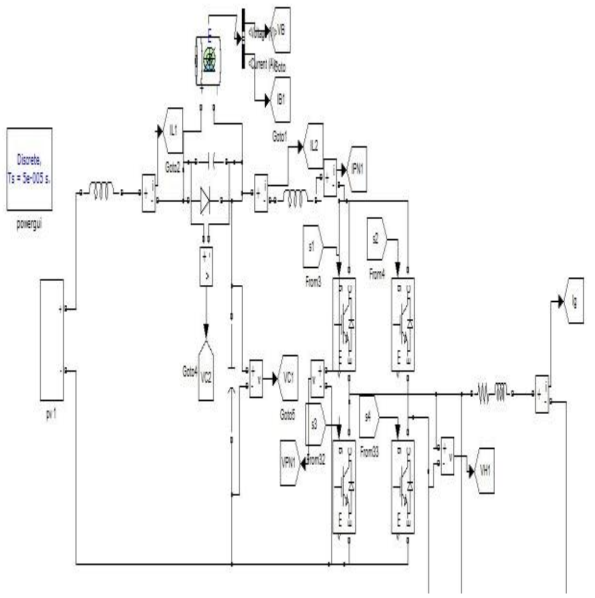


Fig 5- Main system Matlab Model

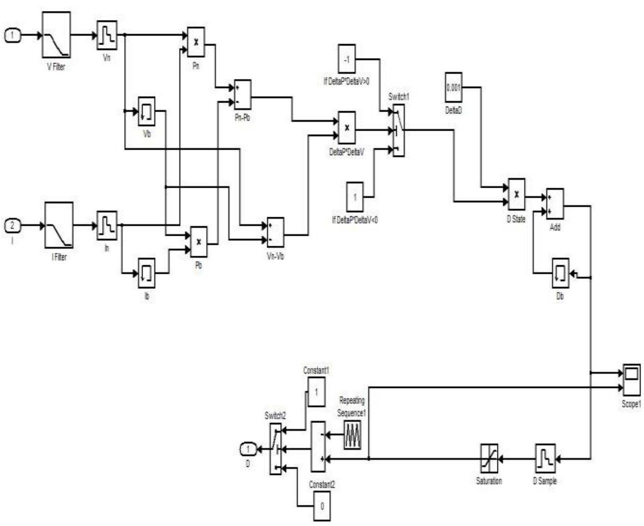


Fig 8- MPPT control system

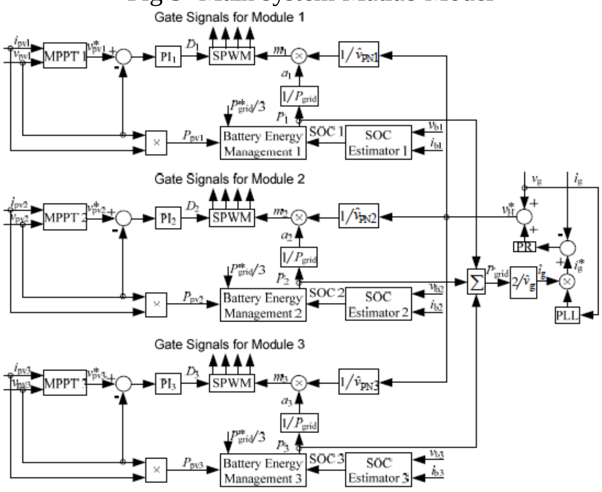


Fig. 6. Control scheme for the proposed system

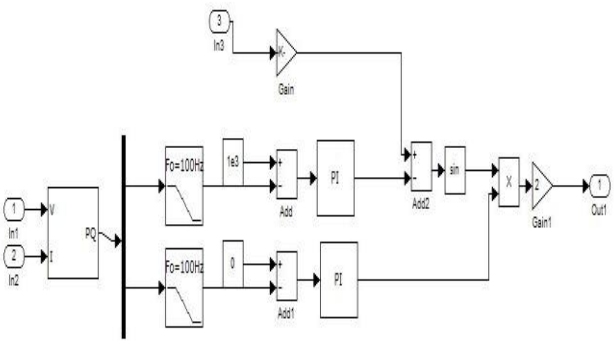


Fig 9- EMS (Energy Management System) control block

Simulation Results

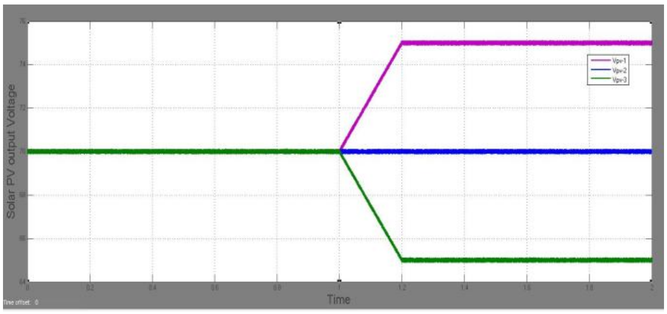


Fig 10- Solar PV Modules output Voltage

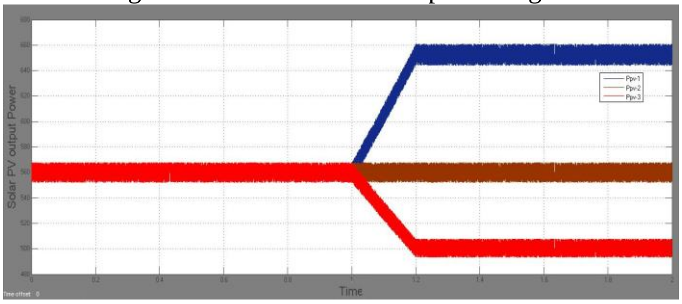


Fig 11- Solar PV modules output power

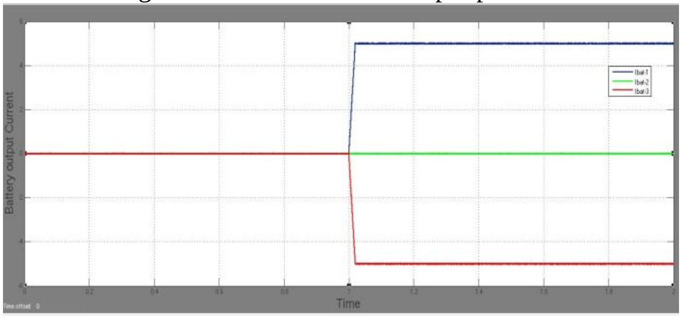


Fig 12- Battery output current

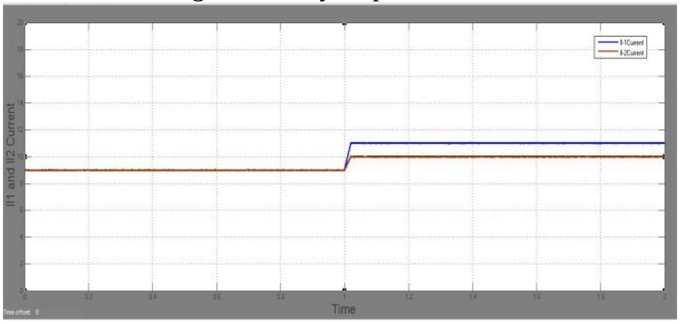


Fig 13-qZS network inductor currents of Module-1

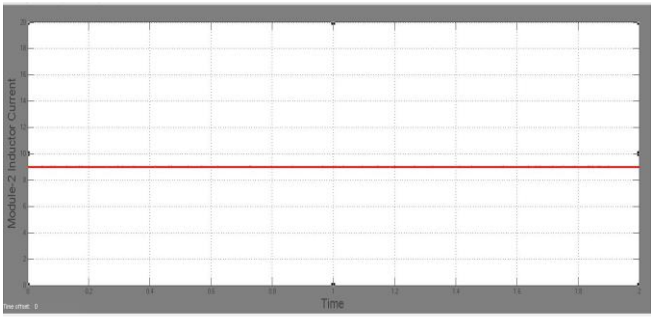


Fig 14-qZS network inductor currents of Module-2

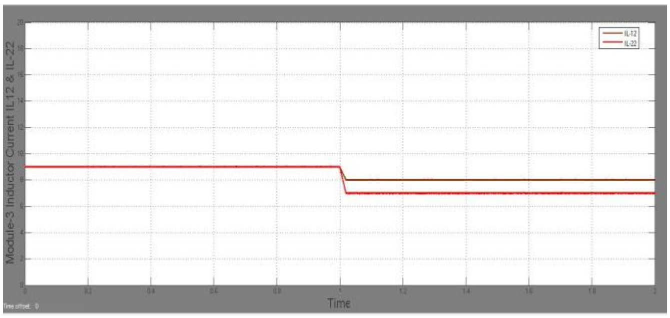


Fig 15- qZS network inductor currents of Module-3

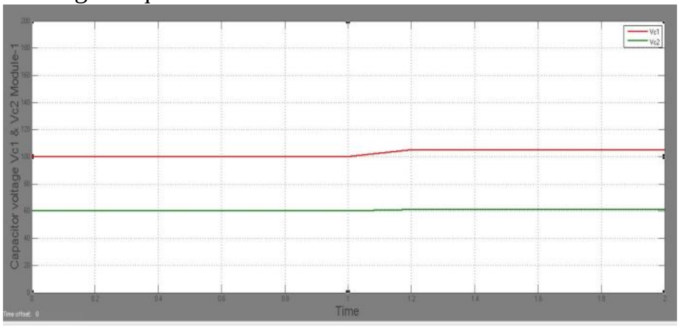


Fig 16-qZS network capacitor voltages of Module-1

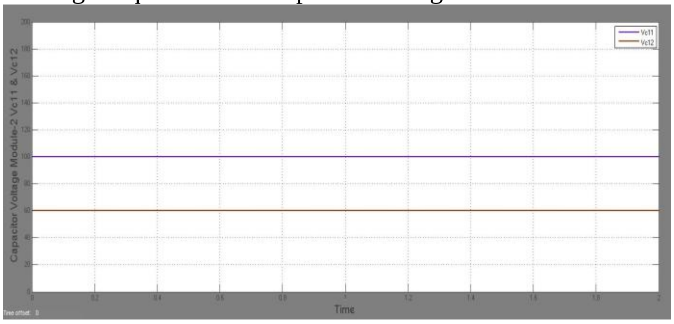


Fig 17-qZS network capacitor voltages of Module-2

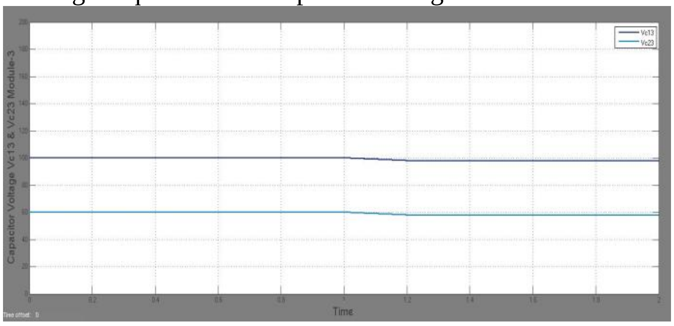


Fig 18-qZS network capacitor voltages of Module-3

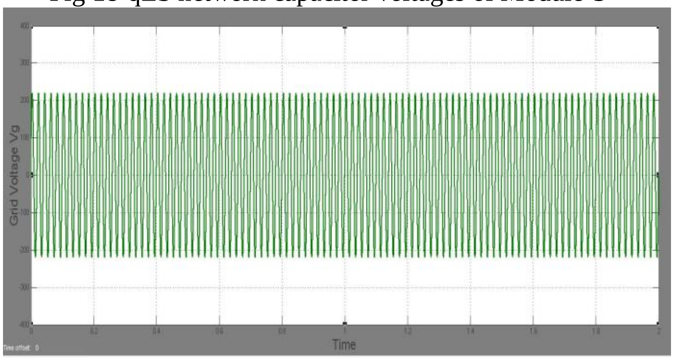


Fig 19-Grid Voltage

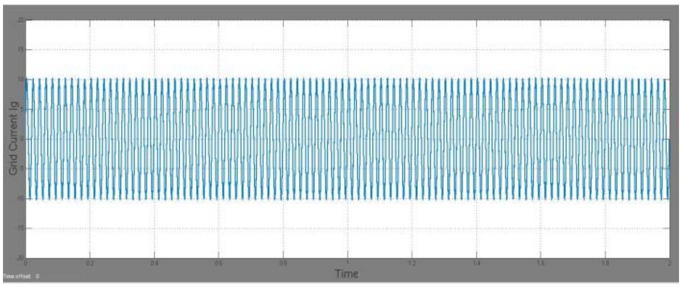


Fig 20-Grid Current

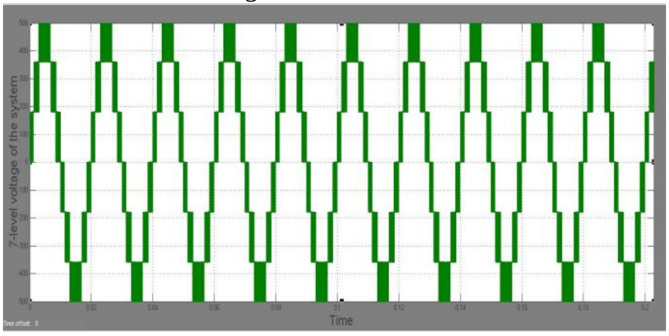


Fig 21-7-level voltage of the system

V. CONCLUSION

This paper presents a Solar PV energy system for standalone system. This paper proposed an energy stored quasi-Z source cascade multilevel inverter based PV power generation system. Its operating principle was presented in details and its control scheme was proposed. The controller parameters were well designed by employing the built small-signal model and bode plots. A 7-level energy stored qZS-CMI based PV system simulation was built. Multilevel inverter has several advantages compared to two level, as the harmonics and switching losses are reduced. The simulation results verified the proposed energy stored qZS-CMI based PV system and the proposed control method.

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