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Photovoltaic Power injected to the Grid with Quasi Impedence Source Inverter

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Abstract - The Z-source inverter (ZSI) with battery operation can balance the stochastic fluctuations of photovoltaic (PV) power injected to the grid/load, but the existing topology has a power limitation due to the wide range of discontinuous conduction mode during battery discharge. This paper proposes a new topology of the energy stored ZSI to overcome this disadvantage. Two strategies are proposed with the related design principles to control the new energy stored ZSI when applied to the PV power system. They can control the inverter output power track the PV panel maximum power. The voltage boost, inversion, and energy storage are integrated in a single stage inverter. The obtained results verify the theoretical analysis and prove the effectiveness of the proposed control of the inverter's input and output powers and battery power regardless of the charging or discharging condition.

Keywords - quasi-Z Source Inverter (qZSI), Photovoltaic (PV), Sinusoidal Pulse Width Modulation (SPWM), Maximum Power Point Tracking (MPPT).

INTRODUCTION

This paper deals with the [13] photovoltaic energy stored quasi-Z-source Inverter to connect with grid. With the worsening of the world's energy shortage and environmental pollution problems, protecting the energy and the environment becomes the major problems for human beings. Thus the development and application of clean renewable energy, such as solar, wind, fuel cell, tides and geothermal heat etc., are getting more and more attention. Among them, solar power will be dominant because of its availability.[12] The worldwide installed photovoltaic (PV) power capacity shows nearly an exponential increase due to decreasing costs and the improvements in solar energy technology. Power converter topologies employed in the PV power generation systems are mainly characterized by two or single stage inverters. The single stage inverter is an attractive solution due to its compactness, low cost, and reliability. However, its conventional structure must be oversized to cope with the wide PV voltage variation derived from changes of irradiation and temperature.

BLOCK DIAGRAM

Fig 1.1 shows that the basic block diagram for PV power injected to the grid. The PV power is observed by MPPT [6], and it is calculated for the conversion by qZSI. By applying the SPWM to the qZSI to boost the voltage [6].The boosted voltage is again applying for transmission by step-up transformer and it is tied with grid for distribution

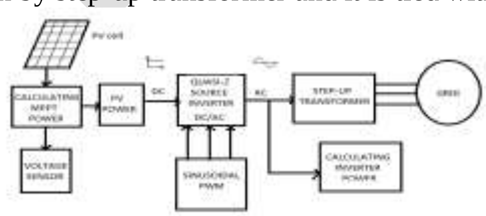

Fig 1.1 Block diagram of PV power injected to the grid

ENERGY CONVERSION EFFICIENCY

$$\eta = \frac{P_m}{E * A} \qquad (1.1)$$

The equation (1.1) expressed as, Energy conversion efficiency η is the percentage of power converted (from absorbed light to electrical energy. When a solar cell is connected to an electrical circuit. This term is calculated using the ratio of maximum power P_m divided by input light irradiance E in W/m^2 under standard test conditions (STC) and A is area of the solar cell.

MAXIMUM POWER

The load for which the cell can deliver maximum electrical power at the level of irradiation. The equation (1.2) states P_m is maximum power, $V_m$is maximum voltage, and I_m is the maximum current

$$P_m = V_m I_m \qquad (1.2)$$

SOLAR MODULE AND ARRAY MODEL

Since a typical PV cell produces less than 2W at 0.5V approximately, the cells must be connected in series-parallel configuration on a module to produce enough high power. A PV array is a group of several PV modules which are electrically connected in series and parallel circuits to generate the required current and voltage. The equivalent circuit for the solar module arranged in N_p parallel and N_s series. The terminal equation for the current and voltage

The mathematical equation (1.3) of generalized model can be described as, we get

$$I = N_p I_{ph} - N_p I_s \left[\frac{q\left(\frac{V}{N_s} + \frac{IR_s}{N_p}\right)}{kT_c A} - 1 \right] \qquad (1.3)$$

The equivalent circuit is described on the following equation (1.4) is

$$I = N_p I_{ph} - N_p I_s^{\left[q\left(\frac{V}{N_s k T_c A}\right) - 1\right]} \qquad (1.4)$$

Where, N_s- is series number of cells for a PV array. N_p- is parallel number of cells for a PV array.

CONVENTIONAL METHOD

The fig 2.1 shows that circuit diagram for conventional method.This conventional structure must be oversized to cope with the wide PV voltage variation derived from changes of irradiation and temperature

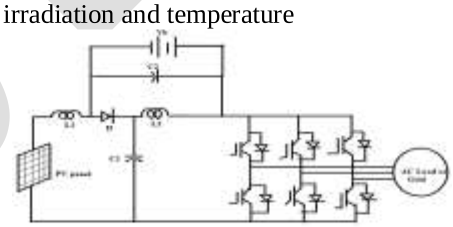

Fig 2.1 Circuit diagram for conventional method

The two-stage inverter topology applies a boost dc/dc converter to minimize the required KVA rating of the inverter and boost the wide-range input voltage to a [11] constant desired output value. However, the switch in the dc/dc converter will increase the cost and decrease the efficiency. Most of the existing ESS system that may act as bidirectional dc / dc converter to manage the batteries, which makes the system complex, increase its cost, and decreases its reliability.

PROPOSED METHOD

The fig 3.1 shows that circuit diagram for proposed method. This proposed system, as structurally the battery is connected to capacitor. It will be drawn a dc constant current and voltage

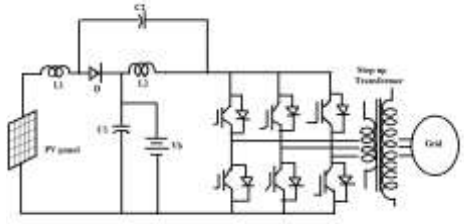

Fig. 3.1 Circuit diagram for proposed method

Normally the Z-source inverter (ZSI) presents a new single-stage structure to achieve the voltage boost/buck character in a single power conversion stage, [9] this type of converter can handle the PV dc voltage variations over a wide range without overrating the inverter. The component count and system cost are reduced, with improved reliability due to the allowed shoot-through state. Recently proposed quasi-Z-source inverters (qZSI) have some new attractive advantages more suitable for application in PV systems follows

- The qZSI draws a constant current from the PV panel, and thus, there is no need for extra filtering capacitors
- The qZSI features lower component (capacitor) ratings
- The qZSI reduces switching ripples

Modes of Operation

The quasi-Z-source inverter has the two operating modes during battery charging, discharging and energy stored in photovoltaic power system. i.e. continuous conduction mode (CCM) and discontinuous conduction mode (DCM). Pulse width modulation (PWM) methods are essential to properly operate the qZSI. The sinusoidal PWM (SPWM)-based techniques of qZSI can be divided into simple boost control, [8] maximum boost control and maximum constant boost control. They are simple to implement, but have defects of high switching frequency and additional switching operations, resulting in the incremental losses [3]

Mode 1

This mode will make the inverter short circuit via any one phase leg, combinations of any two phase legs, and all three phase legs which are referred to[7] as the shoot-through state. As a result, the diode D_z is turned off due to the reverse-bias voltage. During this time interval, the circuit equations are presented as shown in fig 3.2

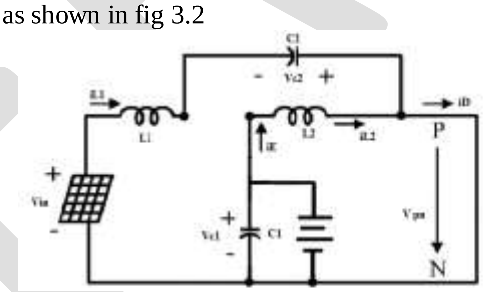

Fig 3.2 Mode 1 operation

- Charging the inductor i_{L1}
- Voltage drop is in capacitor V_{c2}
- Diode is not conducted, so the i_{L1} current is not injected
- It leads the current to V_{c1} capacitors the maximum output voltage is controlled by V_b.

Mode 2

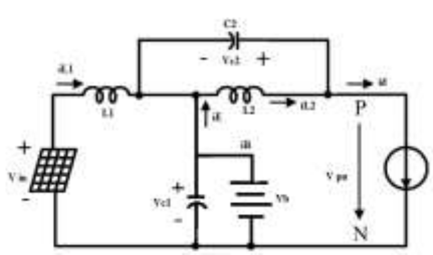

Fig 3.3 mode 2 operation

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- Diode conducted because $i_{L1} - i_{C2} - i_{L2}$.
- E_b or V_b is battery power less.
- V_{C1} voltage on capacitors 1 is fall on V_b diode is conducted
- Output is shorted, so the current flows through i_E.

RESULTS AND DISCUSSION

OVERALL SIMULATION CIRCUIT

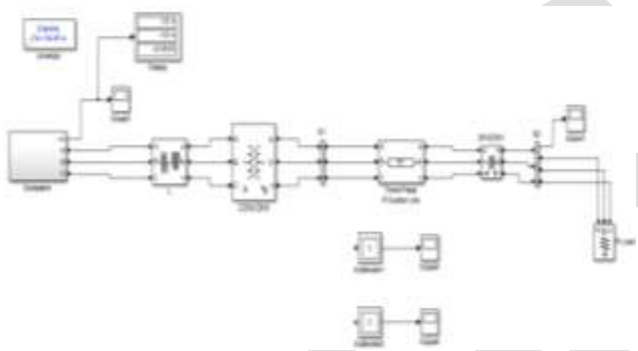

Fig 4.1 Simulation circuit for QZSI output grid tie

The qZSI output is compared with the sinusoidal PWM and energy balance is to be maintained during continuous conduction. The step-up transformer is used to maximize the power with the rating of 125V/2KV. In the qZSI output is possibly connected to the grid for distribution [9] as shown in fig 4.1

WAVEFORM FOR QZSI OUTPUT

The output from qZSI is 131.4V as shown in fig 4.2. It is measured and the three phase supply is not directly tied with grid. Because of the energy imbalance is carried out from the PV power. This will be optimized during the shoot-through state. Now the PV power can be controlled by the duty cycle and inverter output is controlled by modulation index for stable, smooth and to enhance the large power.

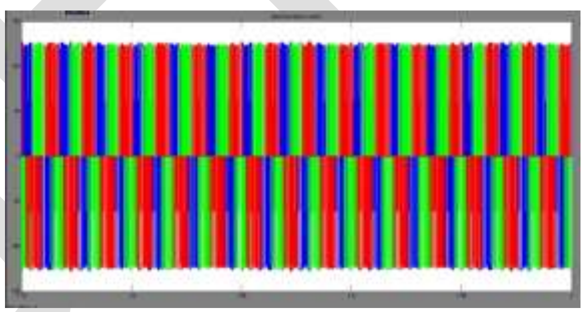

Fig 4.2 Waveform for qzsi output

WAVEFORM FOR VOLTAGE ACROSS AT SECONDARY

The fig 4.3 shows the transformer voltage at secondary. This output voltage is maximum by shoot-through duty cycle with low switching losses are obtained the result.

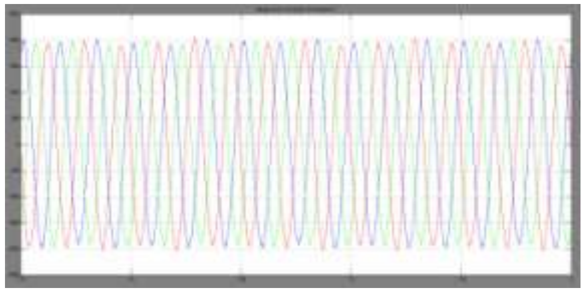

Fig 4.3 Waveform for voltage across at secondary

WAVEFORM FOR LOAD CURRENT

The load current waveform is shown in fig 4.4 The real and reactive power is limited by the load current under different state of charging in the battery.

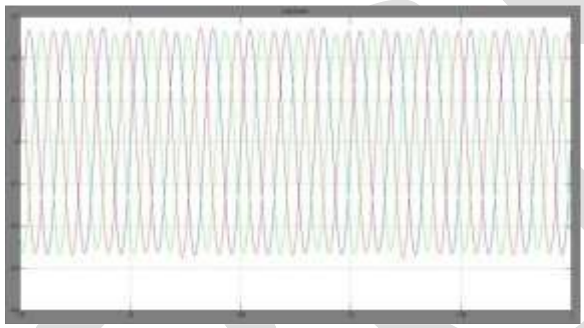

Fig 4.4 Waveform for load current

WAVEFORM FOR VOLTAGE ACROSS LOAD

The output voltage across the load is shown in fig 4.5. This output voltage causes the high voltage stress from secondary of step up transformer with the rating of 230V/2KV.

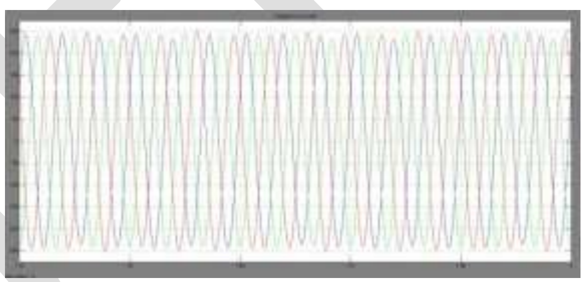

Fig 4.5 Waveform for voltage across load

CONCLUSION

This paper deals with an energy-stored qZSI achieved by new technique has been proposed to overcome the shortcoming of the existing solutions in PV power system. Two strategies have been proposed to control the new circuit topology, and their design methods have been presented by employing a small signal model. The proposed energy stored qZSI and two control methods, it is being implemented under different operating conditions. The theoretical analysis and simulations results presented in this paper clearly demonstrate that the proposed energy stored qZSI and the suggested two control methods in the PV module and inject the active and reactive power into the grid by the inverter, independently, as well as control the battery power flow. These are mostly applicable for various PV power systems. It is ensuring the system accuracy and proving the maximum output

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