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Photovoltaic based single phase single stage boost inverter

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The aim of this paper is to model and simulate a boost inverter control method for implementing DC to AC power conversion method. The photovoltaic based load connected system depends up on the number of components and stages involved in the power conversion .The proposed scheme is applicable to any single –stage, single- phase grid connected inverter operating in continuous conduction mode. Only one current sensor is used for shaping the boost inductor current with a simple structure. In this present work a solar energy system with boost inverter is presented by controlling the inductor current excess current is released to the load. Simulation is carried out using MATLAB/SIMULINK software and the result are presented for the boost inverter and the output voltage is increased effectively.

Keywords: *Current sensor, Electromagnetic Interference (EMI) grid-connected, inverter, Maximum Power Point Tracking (MPPT), Photo Voltaic (PV), single-stage, Energy Storage Period (ESP), Energy Release Period (ERP), MATLAB*

1.0 INTRODUCTION

In general recent years renewable sources such as solar, wave and wind are used for the generation of electricity. Photo Voltaic (PV) source has achieved global attention as an alternative power source due to the environmental concerns. As the energy from the sun is free, the major cost of solar modules and the inverter interface system also called as the power conditioning system. With the recent development of solar cell technology, the price of solar modules has dropped dramatically. A recent worldwide survey shows that in the last ten years, the retail price of solar modules has dropped.

In order to transfer energy from PV arrays to utility grids, Proposed converter systems have to fulfil the following three requirements,

- To convert the photovoltaic DC voltage in to AC grid voltage.
- To obtain a boosted voltage, If the PV array voltage is lower than the grid voltage. In order to maintain constant AC supply.
- To ensure maximum utilization of power from the PV modular

2.0 TRADITIONAL INVERTER

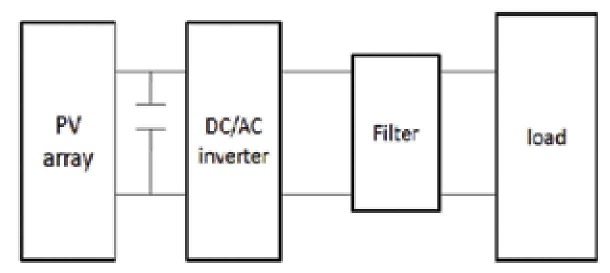

FIG. 1. THE SIMPLIFIED BLOCK DIAGRAM OF CONVERTER SYSTEM

The block diagram of PV-array converter system and control scheme for the single stage Boost inverter based circuit.

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The filtered output from PV is fed to the inverter as shown in Figure 1. Inverted output is fed to the LC filter to reduce the ripples in the output voltage.

The control scheme for the boost inverter method is shown in the Figure 2 . PV cell output is fed to the filter. The filtered out put voltage is fed to the MPPT block where gate voltage is produced .The inductor current produced by the MPPT block is fed to the hysteresis controller which is used to control the bandwidth of the current generated .The Logical and driver circuit gives the gate single to the inverter .The inverted output is fed to the load.

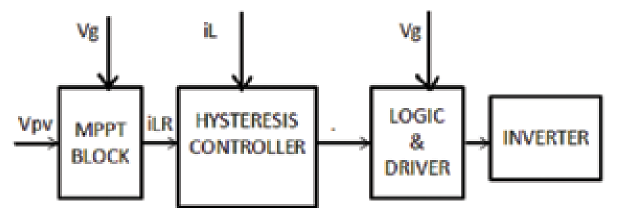

FIG 2 : THE CONTROL SCHEME BLOCK DIAGRAM OF THE ONE CURRENT SENSOR METHOD

3.0 THE SALIENT FEATURE OF THE MPPT SCHEME

It is a current-controlled scheme, applicable to any inverter operating in continuous current mode,This Operation significantly reduces the stress on various components of the system and reduces electromagnetic interference (EMI).It does not require the DC current sensor that is used for sensing the PV array current in some schemes. As a result, cost of the system reduces. The proposed scheme supports boosting, Inversion, and MPPT in a single stage .No extra stage is required for inversion or current shaping. It does not involve any complex analysis or computations. Hence it can be easily implemented with general purpose micro controllers.

4.0 COMPLETE DESCRIPTION OF THE PROPOSED CIRCUIT

4.1. Maximuim Power Point Tracking

Maximum Power Point Tracking is algorithm that included in charging of controllers used for extracting maximum available power from PV module under certain conditions. The voltage at which PV module can produce maximum power is called 'maximum power point'. Maximum power varies with solar radiation, ambient temperature and solar cell temperature,clouding conditions,dust on the surface of solar module.

5.0 HYSTERESIS CONTROL

The hysteresis mode is used for controlling a digital output with in the higher and lower limit. Hysteresis control is when a controller changes output states only when a given input goes below the lower limit, Or it goes above the higher limit. This method of control is frequently used when the input has high response to the output, or when the input may fluctuate rapidly between the higher and lower order with in a single set point.

6.0 PROPOSED CIRCUIT DIAGRAM

6.1. Circuit Description

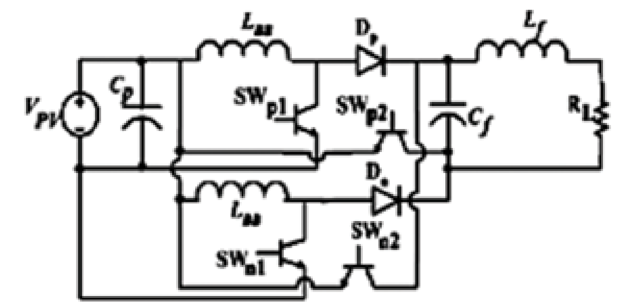

FIG 3: CIRCUIT DIAGRAM OF BOOST INVERTER

The boost inverter consist of the two of source side filter to reduce the ripples in the input side, Inductors L_1 and L_2 , Two diodes D_1 and D_2 . DC voltage from the PV array is fed to the inductor and diode. C_f And L_f are the filtering capacitor and the inductor which is used to filter out the ripples from the conversion . Pure AC voltage is fed to the load. High frequency switching devices like MOSFET is used as switches.

6.2 Modes of Operation

Inductor under goes two types of operation such as energy storage and energy release period.

There are four modes of operation for the boost inverter circuit. In mode 1 the switchs S_1 and S_2 were turned ON. The inductor current increases and the energy storage period (ESP) takes place in the inductor L_1. Were as in mode 2 the switchs S_1 is turned OFF and S_2 is turned ON. The inductor current decreases. The energy release period (ERP) takes place in the inductor. In Mode 3 The switches S_3 and S_4 were turned ON. The inductor current increases. The energy storage period (ESP) takes placein the inductor.In mode 4 The switches S_3 is turned OFF and S_4 is turned ON. The inductor current decreases and the energy release period (ERP) takes place in the inductor.

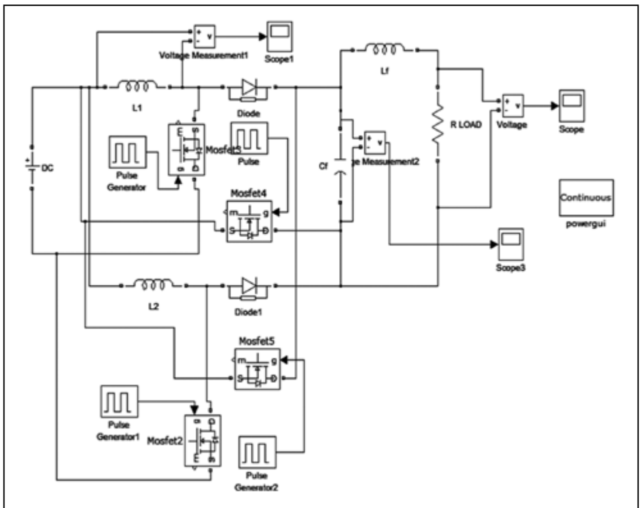

FIG 4: SIMULINK MODEL OF SINGLE PHASE BOOST INVERTER WITH R LOAD

7.0 SIMULATION AND EXPERIMENTAL RESULTS

The boost inverter is simulated using sim power system tool box which consists of 4 MOSFET sitches, 2 inductors and 2 diodes are connected as shown in Figure 4. The purpose of boost inverter is to boost up the output voltage depending on the boosting factor.

7.1. Open Loop Control of Boost Inverter

The open loop model of boost inverter feeding R-load is shown in Figure 4. In the open loop circuit output voltage is 48 V for the input voltage of 12V without any disturbance in the input side. The output voltage is boosted up as in the proposed circuit.

The output voltage waveform as observed is shown in Figure 5, with the peak amplitude of 48V.

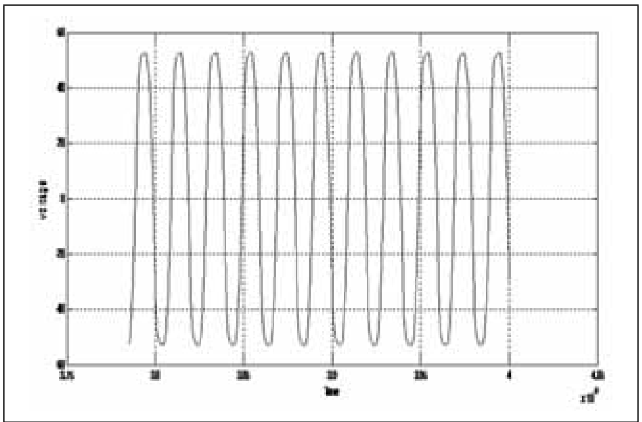

FIG 5: OUTPUT VOLTAGE WAVE FORM OF THE BOOST INVERTER.

The input voltage is normally obtained from the solar panel but here we use an ideal DC for the purpose of input voltage, 12V input is given. The input waveform is shown in Figure 6.

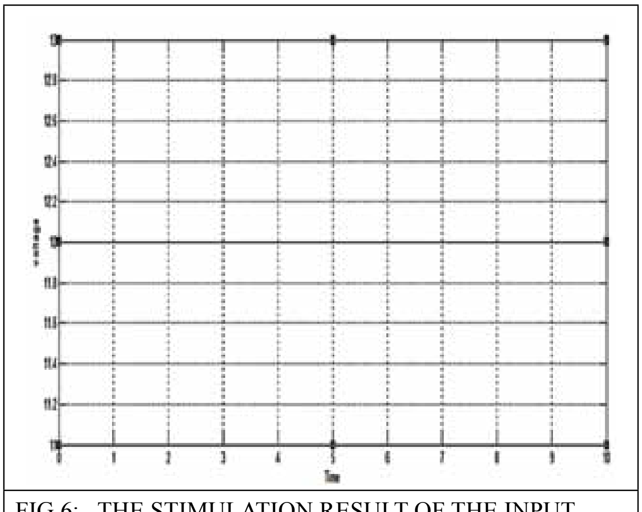

FIG 6: THE STIMULATION RESULT OF THE INPUT VOLTAGE OF OPEN LOOP SINGLE PHASE BOOST INVERTER

7.2. Closed Loop Control of Boost Inverter

The closed loop model of the boost inverter feeding R- load is shown in Figure 7. PI controller is used for desired single phase single stage boost inverter circuit.

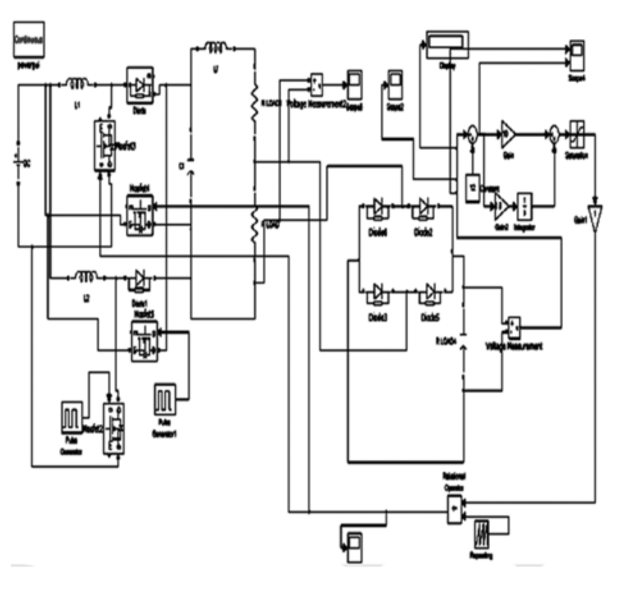

FIG 7. CLOSED LOOP OF SINGLE PHASE BOOST INVERTER.

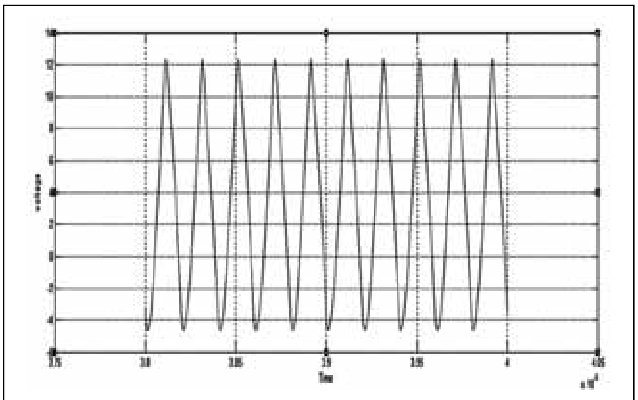

FIG 8. OUTPUT VOLTAGE OF CLOSED LOOP SINGLE PHASE BOOST INVERTER

The load is split in two by using the potential divider there by the voltage is reduced to 12V. It is then converted in the DC voltage by diode rectifier. Then DC supply is given to the PI controller. After the saturation and repeating sequence. The signal is then given to the relational operator were the output is compared. The output of relational operator is given to the MOSFET .Thus the closed loop is formed and the error are rectified within the feedback system .The output voltage of 12V is obtained as the sinusoidal wave as shown in the Figure 8.

7.3. Source Side Disturbance With R-Load

The closed loop with source side disturbance simulation circuit of the boost inverter system is implemented using the proportional and integral controller to obtain a desired output voltage waveform. which is shown in the Figure 9.

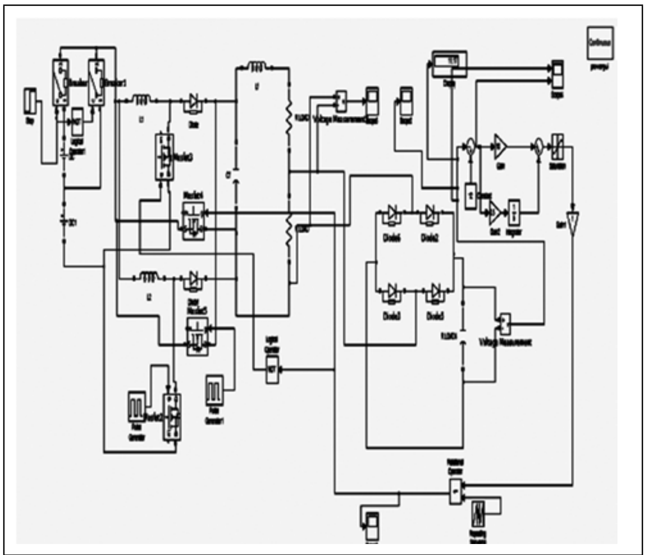

FIG 9. CLOSED LOOP OF SINGLE PHASE BOOST INVERTER WITH DISTURBANCE.

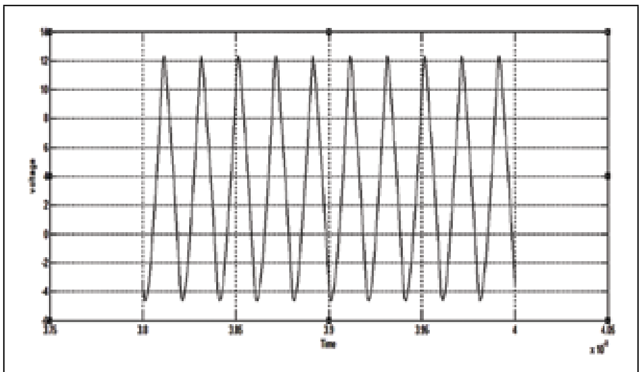

FIG 10. OUTPUT VOLTAGE OF CLOSED LOOP SINGLE PHASE BOOST INVERTER WITH SOURCE SIDE DISTURBANCE.

The output voltage of closed loop system with source side disturbance is shown in the Figure 10. It is observed that even through there is some distrubance in the input source, this inverter system is able to produce the desired output. The output may be around 12V because of using the potential divider across the resistive load. Some distrubance across input because of rise in temperature rise or fall,dust or dirt on the solar panel.

8.0 CONCLUSION

In this paper, the open loop and close loop models of single phase single stage boost inverter were simulated using MATLAB. Closed loop model involves PI controller and the gain values are tuned to achieve the desired output voltage. The operating principles of boost inverter and the control system are analyzed. The boost inverter system can produce an output voltage greater than the DC input voltage by controlling the boost factor, which is impossible for the traditional inverter. The modified system is very promising for residential solar energy system. In spite of conventional PV systems needing two stage of power converter, were as in proposed system needed only single stage boost inverter for direct DC-AC conversion. Less number of power switches associated with less switching losses is achieved.

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