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Simulation of Efficient Drift Free MPPT Based Dual Boost PV Micro inverter

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Abstract: This paper proposes a dual boost micro inverter configuration with an efficient and simple Maximum Power Point Tracking (MPPT) technique for eliminating the problems of drift phenomenon. With this scheme, the PV module is connected to a dc-dc converter and a dc-ac inverter stage before being connected to the grid. These two converter stages are tucked in for boosting up the efficiency of the PV panel to around 20 percentages than in the conventional configuration. The solar tracker incorporates a modified Perturb and Observe (P&O) MPPT algorithm for a double check in the efficiency of the overall system. Simulation is provided to validate the proposed configuration.

Keywords: Photovoltaic micro inverter, boost converter, Maximum Power Point Tracking (MPPT), PV panel, single-stage boost conversion, double-stage boost conversion

I. INTRODUCTION

For the past few years' man is facing a grave threat to his extinction itself, due to the significant decline in the conservative sources of energy. But this indeed can be considered as a blessing in disguise, as it has led to the exploration of one of the most indigenous sources of energy "the solar energy". The renewable energy is coming as an advanced technology for meeting the demands of energy consumption to reduce pollution and to reduce the use of fossil fuels. They are also called eco-friendly technology due to the sustainability and pollution free nature. Hence the need of the hour is to switch over to solar energy for a considerable decrease in the pollution level and electricity bills. Thus we see a change in the mind set of man towards renewable energy. Efficient energy management is one of the prime requirements of photovoltaic system. The major disadvantage with renewable energy is that the output varies with climatic condition. The most important decision while going solar is the selection of the inverter stage. Micro inverters in contrast to conventional solar inverter operate at a lower power level. This will overcome majority of the design problems involved in the conventional system such as the need of a high frequency transformer or cooling fans etc. are eliminated by using the micro inverter topology. Another highlight of micro inverters is that if one solar panel is effected by some amount of shading effect it will not affect negatively the overall output of the solar array which is seen in case of conventional inverters. For a better energy harvest from the solar panel a Maximum Power Point Tracking (MPPT) technique is also implemented. The existing grid connected PV system contains a high frequency transformer in the secondary side which tends to reduce the efficiency and increase the weight of the entire system[1]. The inverter used is an H bridge configuration which performs only dc-ac inversion. The existing system implements a conventional P&O MPPT algorithm. But this algorithm has a drawback in identifying the cause for drift occurrence. There always exists confusion whether drift has occurred due to increase in insulation or due to some perturbation.

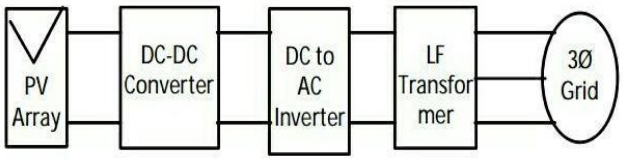

Fig.1. Block diagram of existing system

A. Proposed System: The controller proposed in this uses a single processor to generate control signals for inverter, converter and PV module. To overcome this problem we have proposed an efficient drift free dual boost micro inverter which combines the advantages of both modified perturb and observe algorithm and dual boost micro inverter in one platform. The proposed micro inverter consists of two steps up converters in between which the load is differentially connected. With this configuration voltage elevation is equally distributed between two converter sections. Also the step up ratio is divided between the converter and the inverter section, thereby increasing overall efficiency. The

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modified P&O algorithm eliminates the drift problem by checking for an additional parameter i.e,change in current, in addition to change in voltage and change in power from the PV panel characteristic curve. This paper is arranged as follows

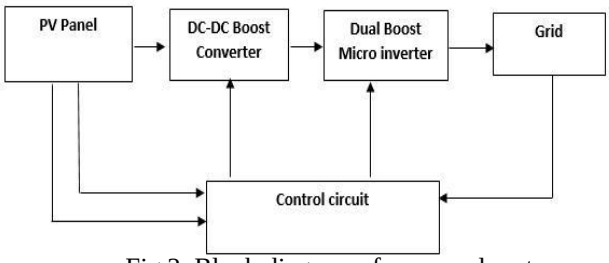

Fig.2. Block diagram of proposed system

II. TOPOLOGY DESCRIPITION

The proposed block diagram is illustrated in figure 1. An advantage of this system is that the need for a high frequency transformer in the first stage is not necessary. This advantage is benefited in reducing the voltage step ratio in the first stage which in turn excessively reduces the switching losses. But the need to perform voltage elevation calls for the use of a dual boost inverter.

A.DC-DC Boost Converter: The position of the boost converter on the whole installation makes all the difference. This is because the boost converter act as a medium of power transmission thereby maintaining the energy balance (i.e absorption and injection of energy) from the pv module to the grid connected inverter. This is performed with the help of a combined working of components like the inductor, a single mosfet, diode and a capacitor in parallel with the load. A simple dc-dc boost converter is shown in figure.3

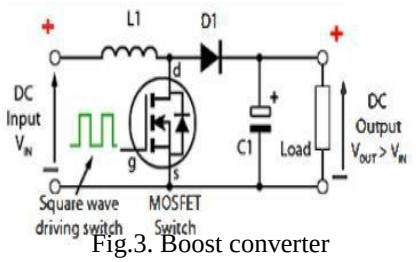

Fig.3. Boost converter

When the mosfet / switch are closed current flows through the inductor and stores some energy. When the switch is open, though initially the inductor shows some hindrance to flow the current stored in it, the current flows to the capacitor through the diode with the inductor polarity being reversed. The output voltage hence becomes greater than the input voltage which is given by;

$$V_O = \frac{1}{1-D} V_{IN} \qquad (1)$$

B. DC-AC Dual Boost Inverter: Solar panels may be on the top, but it is the inverter that does all the real work. Thus choosing the inverter topology is of prime importance. The topology selected over here is a voltage source inverter as explained in[2]. This topology produces an output voltage higher than the input voltage depending on the instantaneous cycle. The full bridge inverter is considered as two half bridge inverter.

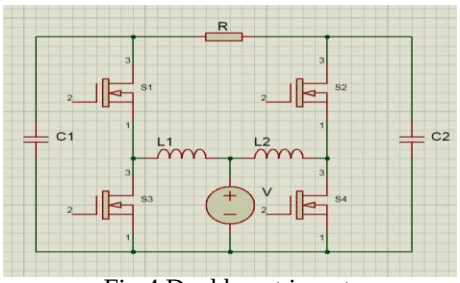

Fig.4.Dual boost inverter

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The output voltage of inverter is given by

$$V_0 = V_1 - V_2 \quad (2)$$

$$V_O = \frac{V_{IN}}{1-D} - \frac{V_{IN}}{D} \quad (3)$$

$$V_O = \frac{2D-1}{D(1-D)} \quad (4)$$

D. **Modified perturb and observe MPPT algorithm:** P&O algorithm is most commonly used MPPT for solar cell due to its very simple arrangement and small measured parameters. The module voltage is continuously perturbed and compared with the previous voltage. When a slight perturbation is introduced power of the module varies. If the power is found to increase, then the perturbation is seen to increase in that direction. After reaching the maximum power point the power starts decreasing. Hence the perturbation reverses in that direction. Modified perturb and observe (P&O) algorithm is proposed to avoid drift problem which occurs in conventional P&O algorithm due to the confusion in knowing whether the increase in power is due to increase in insolation or due to perturbation.[4]. The drift problem is avoided by checking an additional parameter dI (change in current) in addition to change in voltage (dV) and change in power (dP). Fig 6a shows the I-V characteristics of the module from where it can be see that at the same time at point 4 dv and di are positive. Thus all the three parameters are positive for an increase in insolation only. Thus the confusion whether the drift occurrence is due to perturbation or increase in insolation can be avoided by using an additional parameter dI.

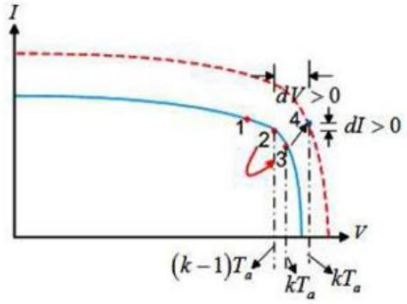

Fig.6a. I-V characteristics of the PV module

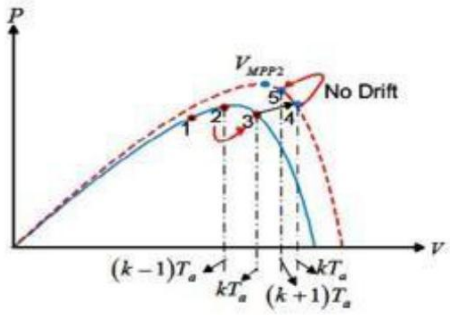

Fig. 6P-V characteristics of the PV module

Fig 6 b shows the P-V characteristics of the module and the change in point due to increase in insulation. The operating point will shift towards a new point 4 if an increase in insulation occurs while operating at point 3. At point 4 the decision is taken by the algorithm where, Dv, dP are greater than zero which means all the parameters are positive at point 4

III. SIMULATIONS

Simulations of the power electronic devices used in the design were conducted in MATLAB/SIMULINK software.

A. DC-DC Boost converter

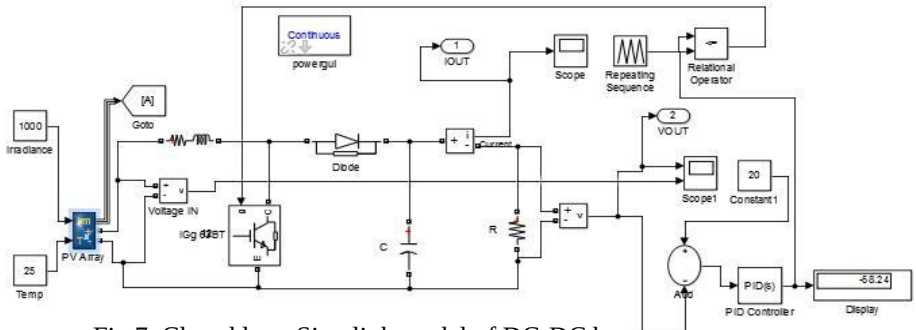

Fig.7. Closed loop Simulink model of DC-DC boost converter

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B. Dual Boost DC-AC Inverter

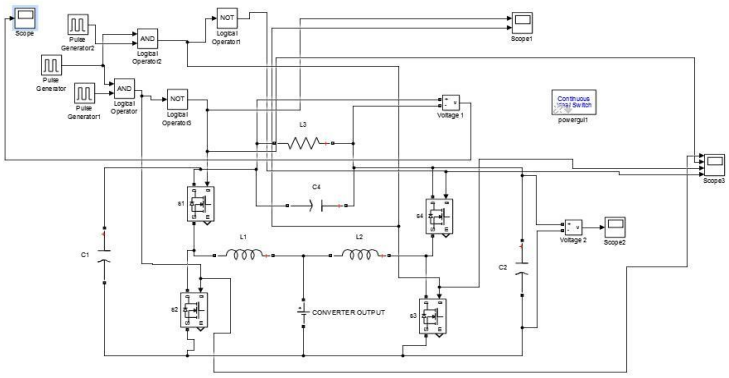

Fig.8. Simulink model of DC-AC inverter

C. Modified P&O MPPT System

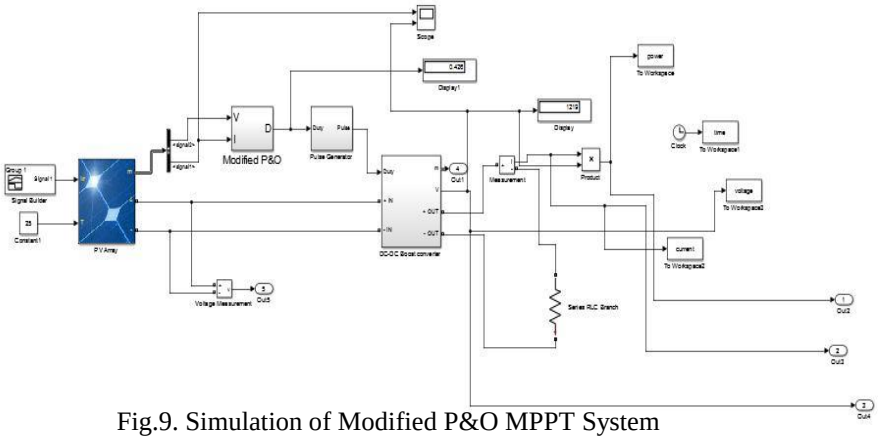

Fig.9. Simulation of Modified P&O MPPT System

SIMULATION RESULTS

A. PV Panel

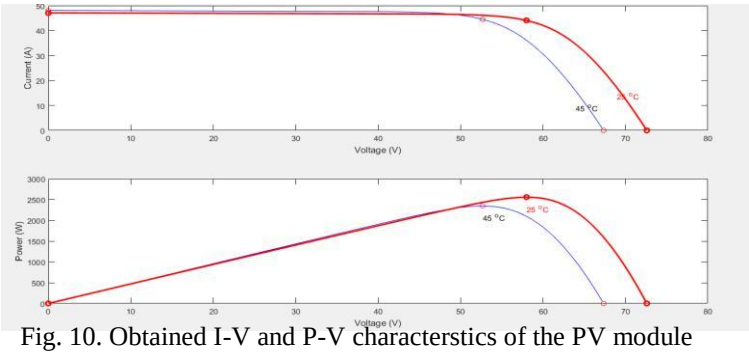

Fig. 10. Obtained I-V and P-V characterstics of the PV module

B. DC-DC Boost Converter

The output equation of the boost converter is given by,

$$V_O = \frac{1}{1-D} V_{IN} \quad (5)$$

Also,

$$\Delta I_l = \mathrm{D}\frac{V_{IN}}{fL} \quad (6)$$

$$\Delta V_o = \mathrm{D}\frac{I_O}{fC} \quad (7)$$

Where, V_{in} = 12V and V_o = 24V

On solving, the capacitor and inductor value to be selected are found to be:

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C=90mF,

L=1.6µH

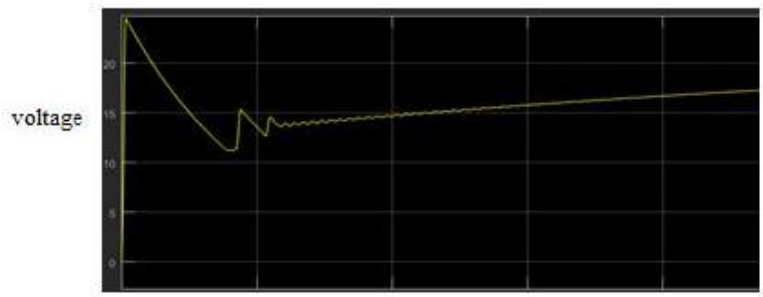

Fig.11. Output waveform of boost converter

The simulation result shown in fig. 11 gives the output waveform of the boost dc-dc converter. The converter takes the input as 12V from the PV panel and gives the step up voltage as 24 V.

C. Dual Boost Inverter

Design equation are given by

$$L_1 \frac{di_1}{dt} = V_{pv} - (1\text{- d1})\, V_1 \qquad (8)$$

$$L_2 \frac{di_2}{dt} = V_{pv} \text{-}(1\text{- d2})\, V_2 \qquad (9)$$

$$C_1 \frac{dv_1}{dt} = (1\text{-d1})\, i_1 - i_s \qquad (10)$$

$$C_2 \frac{dv_2}{dt} = (1\text{-d})\, i_2 + i_s \qquad (11)$$

Input voltage, Vpv = 24V

V1 and V2 are the voltage of the capacitor C1 and C2 respectively

i1 and i2 are the current of the inductor L1 and L2 respectively

is – output current

d1 and d2 –duty cycle of converter 1 and 2 respectively

On solving the design equations inductor and capacitor values produced where :

L1, L2= 60µH
C1, C2=66µF

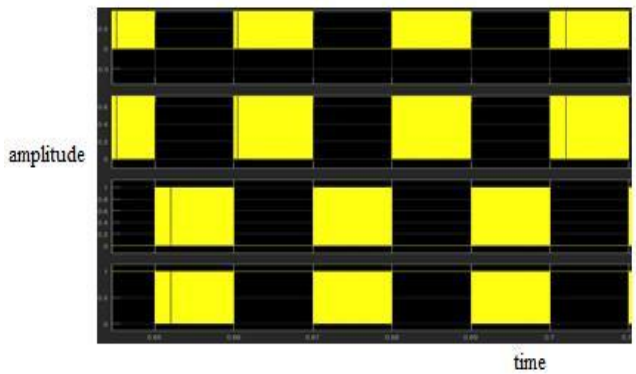

Fig.12. PWM signal to inverter switches

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Fig.13.Output waveform of dual boost inverter

In order to verify the feasibility of the proposed topology simulation result is provided in fig. 8. The fig. 13 shows the voltage output of the micro inverter. Under the input voltage of 24V and the duty ratio of 50% the output voltage of the proposed system reaches 110V

C. Modified Perturb and Observe MPPT Algorithm

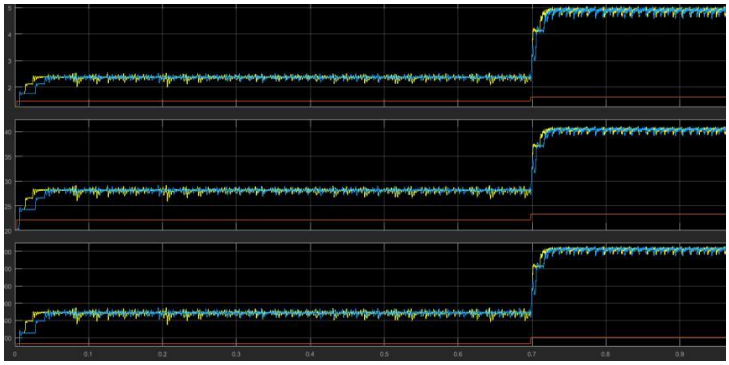

Fig.14. Effect of drift without MPPT, in Modified P&O, Conventional P&O

A characteristic of voltage for without MPPT, Modified P&O, and Conventional P&O is shown in fig. 14 when irradiance is increased to700W/ ^{2}. The problem with conventional P&O technique is that the slow response in reaching the maximum power point and hence to overcome this problem the modified perturb and observe algorithm is selected. The modified perturb and observe algorithm have only small oscillations and the drift is reduced to an extent than the conventional P&O method. Thus the efficiency of modified perturb and observe is improved.

Table1. Simulation Parameters

Parameter	Value
DC-DC Stage	
Boost inductor	1.6µH
output capacitor	90mF
DC-AC Stage	
Boost inverter capacitors	66µF
Boost inverters inductors	60µF

V. CONCLUSIONS

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A modified perturbs and observes MPPT method have been studied and simulated. The maximum power point is successfully obtained by using this algorithm. This paper presents a two stage micro inverter configuration. The proposed system is simulated in Matlab programming language. The matlab simulation shows a total boost of 20% in efficiency of the overall system. The proposed system is reliable and efficient and greatly reduces switching losses. The further losses can be reduced by using high frequency signals and using protection circuit which is given in paper [2]. Therefore, the proposed configuration converts sun powered vitality to electrical vitality efficiently.

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