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PERFORMANCE ANALYSIS OF BOOST INVERTER FOR PHOTOVOLTAIC SYSTEM

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Abstract -For inverter-based PV systems in grid-connected applications as distributed generators (DG), variable sources often cause wide changes in the inverter input voltage above and below the output ac voltage, thus demanding a buck-boost operation of inverters. In this paper we have analyzed the performance of a boost inverter and the effect of varying input voltage and modulation index on voltage and current output is observed. A mathematical relation for inverter output voltage as a function of modulation index at a particular input voltage is also proposed in this paper.

Keywords: **Boost Inverter, Photo voltaic system, Modulation Index, Boost regulator, Curve fitting.**

I. INTRODUCTION

For inverter-based PV systems in grid-connected applications as distributed generators (DG), resources often cause wide variations in the input voltage to inverters above and below the output ac voltage. This is particularly true for PV and wind systems. This then demands the buck-boost (i.e., step-down and step-up) operation of inverters. A general structure of the grid-connected PV systems is shown in Figure 1.

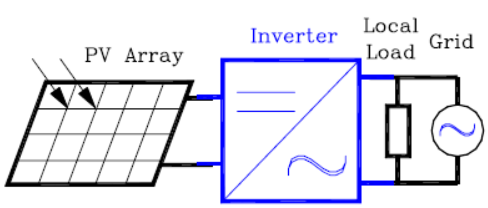

Fig 1: PV system

Traditional full-bridge buck inverters as shown in Figure:2 do not have the flexibility of handling a wide range of input dc voltage, and require heavy line frequency step-up transformers [Xue et al., June 2004]. Although this topology currently has the largest market share of the commercial PV system market due mainly to its simplicity and electrical isolation, it is gradually replaced by advanced topologies using "more silicon and less iron". This leads to the pursuance of compact designs with wide input voltage ranges and improved efficiency [1-3].

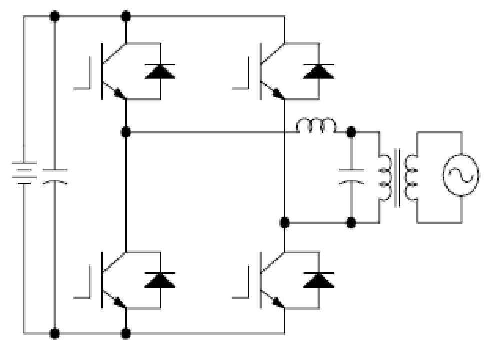

Fig 2. Buck inverter with a low frequency transformer.

II. THEORY OF BOOST INVERTER

Each converter is a current bidirectional boost converter as shown in fig 2. The boost inverter consists of two boost converters as shown in fig:2. The output of the inverter can be controlled by one of the two methods: (1) use a duty cycle D for converter B or (2) use a differential duty cycle for each converter such that each converter produces a dc-biased sine wave output. The second method is preferred and it uses controllers A and B to make the capacitors voltage V1 and V2 follow a sinusoidal reference voltage [4].

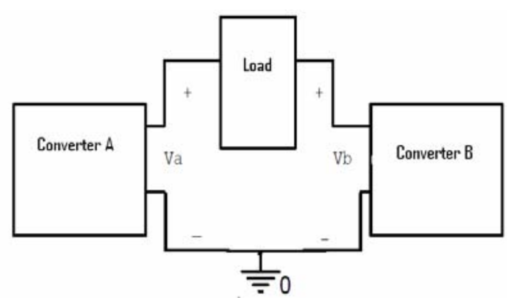

Fig 3. Principle of boost inverter

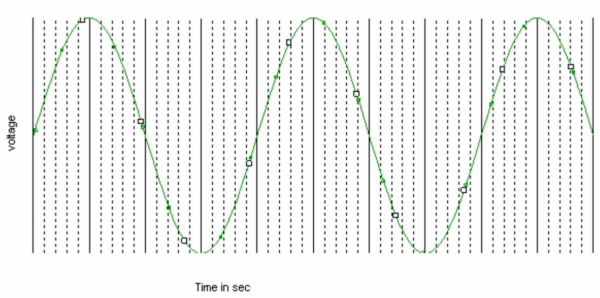

Fig: Output of inverter A

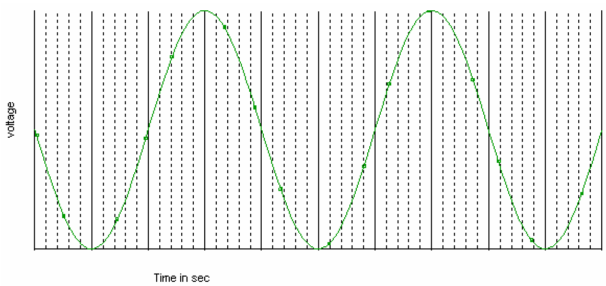

Fig: Output of inverter B

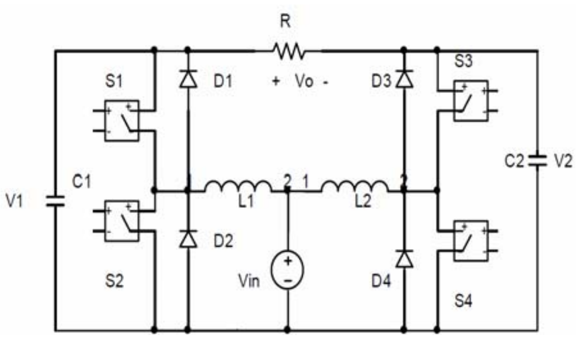

Fig 5: The Proposed DC-AC converter

III. CIRCUIT OPERATION OF BOOST INVERTER:

Inverter operation can be explained by two modes which are mentioned below-

Mode 1: when the switch S_1 is closed & S_2 is open as shown fig 7(a), the inductor current i_{L1} rises quite linearly, diode D_2 is reverse biased, capacitor C_1 supplies enegy to the load, and voltage V_a decreases.

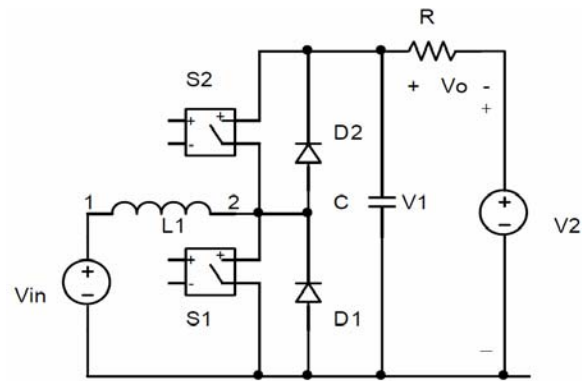

Fig 6: Equivalent circuit for boost inverter

Mode 2: when the switch S_1 is open & S_2 is closed as shown fig 7(b), the inductor current i_{L1} flows through capacitor C_1 & the load. The current i_{L1} decreases while capacitor C_1 is recharged.

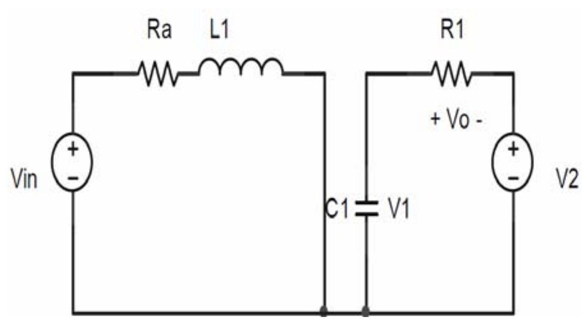

Fig 7(a):mode 1 : S_1 is closed & S_2 is open

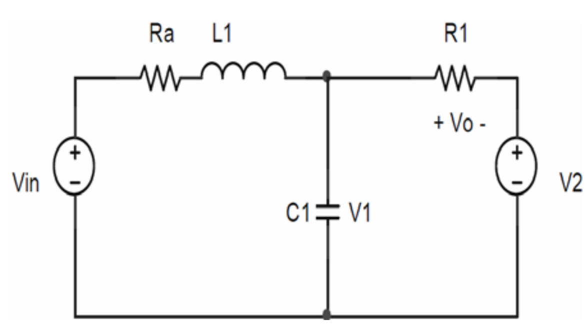

Fig 7(b):mode 2: S_1 is open & S_2 is closed

The average output of converter A, which operates under the boost mode, can be found from

$$\frac{V_1}{V_{in}} = \frac{V_2}{1-D} \quad \ldots\ldots\ldots\ldots(4)$$

The average output of converter B, which operates under the buck mode, can be found from

$$\frac{V_2}{V_{in}} = \frac{1}{D} \ldots\ldots\ldots\ldots\ldots (5)$$

Therefore, the average output voltage is given by

$$V_o = V_1 - V_2 = \frac{V_{in}}{1-D} - \frac{V_{in}}{D} \ldots\ldots (6)$$

This gives the dc gain of the boost inverter as

$$G_{dc} = \frac{V_o}{V_{in}} = \frac{2D-1}{D(1-D)} \ldots\ldots (7)$$

Where D is the duty cycle. It should be noted that V_0 becomes zero at D=0.5. if the duty cycle D is varied around the quiescent point of 50% duty cycle, there is an ac voltage across the load. Because the output voltage in equation in (3) is twice the sinusoidal component of converter A, the peak output voltage equals to

$$V_{o(pk)} = 2V_m = 2V_1 - 2V_{dc} \ldots .(8)$$

Because a boost converter cannot produce an output voltage lower than the input voltage, the dc component must satisfy the condition $V_{dc} \geq (V_m + V_{in})$

Which implies there are many possible values of V_{dc}. However, the equal term produces the least stress on the devices. From the equation (4), (7), (8) we get

$$V_{o(pk)} = \frac{2V_{in}}{1-D} - 2\left(\frac{V_{o(pk)}}{2} + V_{in}\right)$$

It gives the voltage gain

$$G_{ac} = \frac{V_{o(pk)}}{V_{in}} = \frac{D}{1-D}$$

Thus, $V_{0(pk)}$ becomes V_{in} at D=0.5.

IV. CIRCUIT SIMULATIONS AND RESULTS

The conversion structure used in this paper is shown in Fig6. It consists of the cascade connection of two stages. The first stage is a boost-regulator and the second stage is the boost inverter.[5]

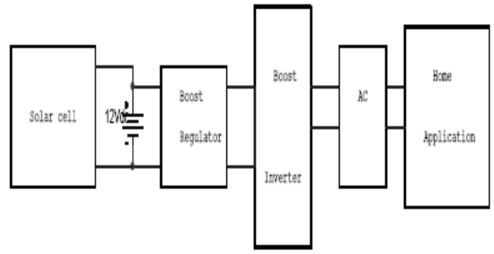

Fig 8: The conversion structure from solar cell to home

In our work we tried to focus on the behavior of the PWM modulator on the when the modulation index and the input voltage is varied.

In this simulation the circuit parameters are chosen as L=10mh, C=400uf, R=100 ohm. The diodes are MUR850f and the switches are IRGBC40u. The input voltages are chosen to be 12V, 24V, 48V and 100V.In each setting the modulation index is varied from 0.1 to 1.5.

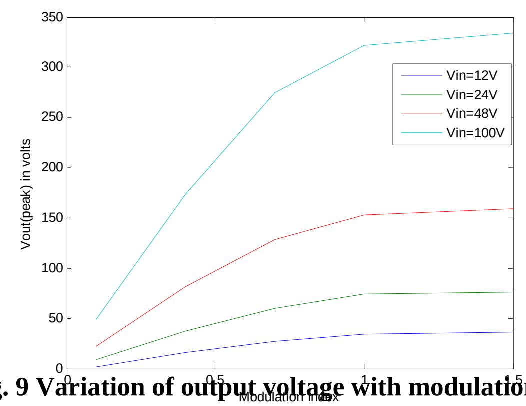

Fig. 9 Variation of output voltage with modulation index and input voltage

The results obtained from pspice are plotted using MATLAB to get a clearer view of how out put voltage is effected by variation of those two parameters. The result is shown in Fig 9.

The symmetry in the output voltages shows that they are closely related with each other. It is tested by using curve fitting tool of MATLAB. It is found that the output voltage can be satisfactorily expressed by the following equation.

$$V_{out} = P_1 m^2 + P_2 m + P_3$$

Where ,**Error! Bookmark not defined.** $P_1 = -22a, P_2 = 59.73a, P_3 = -3.986$

Error! Bookmark not defined. $a = \frac{V_{in}}{12}$

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V. CONCLUSION

In our work, our findings are that the output is greatly affected by the modulation index and input voltage. The equation obtained will be very helpful to get desired output range for this type of inverters also. In our next work we intend to develop a robust close-loop control scheme for a boost inverter.

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