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A Single Phase Single Stage Boost Inverter for 1-Ph Motor Drive System

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ABSTRACT: *Propose a high gain Single-Stage Boosting Inverter (SSBI) for alternative energy generation. As compared to the traditional two stage approach, the SSBI has a simpler topology and a lower component count. One Cycle Control was employed to generate AC voltage output. The output of inverter is used to control the speed of an induction motor.*

I.INTRODUCTION

Micro inverter topologies for PV power generation are classified into three major groups the single-stage, the two-stage and the multi-stage types. The multi-stage micro-inverters are usually comprised of a step-up DC-DC converter front stage, under Maximum Power Point Tracking (MPPT) control, an intermediate high frequency DC-DC converter stage, used to attain a rectified-sine waveform, and a low frequency unfolding stage to interconnect to the grid. However, the multi-stage power train and the associated high component count results in a costly product. The two-stage micro-inverter can be designed cascading a MPPT controlled step-up DC-DC converter and a grid tied high frequency inverter. Whereas the single-stage topology has to perform the voltage step-up, the MPP tracking, and the DC-AC inversion functions all in one stage.

In order to convert and connect the solar energy to the grid the low voltage of the PV panel first has to be stepped-up significantly to match the utility level. This poses a challenge to the designer of photovoltaic inverters as the traditional boost converter cannot provide the required gain at high efficiency. Therefore, an extensive research effort is dedicated to developing various topologies of high step up DC-DC converters that can be used in tandem with a half or full bridge inverter to implement a solar power generation system. The objective of this paper is to propose a new boosting inverter for PV applications. This topology is designed based on the boosting inverter technique and can be given single stage applications. In order to convert and connect the solar energy to the grid the low voltage of the PV panel first has to be stepped-up significantly to match the utility level. This poses a challenge to the designer of photovoltaic inverters as the traditional boost converter cannot provide the required gain at high efficiency. The two-stage micro-inverter can be designed cascading a MPPT controlled step-up DC-DC converter and a grid tied high frequency inverter. SSBI can be regarded as further improvement. SSBI can attain higher DC gain and, thus, operate off low DC input voltage of a single PV panel. By its concept of operation SSBI shares the switches of the power train in a manner that allows merging the DC-DC step up converter stage and the grid tied DC-AC inverter stage. The proposed system is a Single-Stage Boosting Inverter (SSBI) is proposed for alternative energy/solar power generation . Advantages of proposed technique switches used are reduced, High efficiency, Switching losses can be reduced.

II. DC-DC CONVERTER

The application of solid state electronics in which the electric power is controlled and converted is called power electronics. As it deals with designing, computation, control, and integration of electronic systems where energy is processed with fast dynamics which is non linear time varying,it is referred in electrical and electronic engineering as a research subject. Mercury arc valves are the first electronic devices with high power. The conversion is performed in modern systems with tryistors,diodes,transistors which are the semiconductor switching devices, pioneered in the 1950s by R.D.Middle Brook and others. In power electronics processing of substantial amounts of electrical energy is done in contrast to electronic systems concerned with transmission and processing of signals and data. The most typical power electronics device found in many consumer electronic devices,such as battery chargers,peronal computers,,television sets,etc is an AC/DC converter. Its power ranges from tens of watts to several hundred watts. The variable speed drive which is used to control an induction motor is the common application in industry.VSDs power ranges from few hundred watts to tens of mega watts.

2.1 Buck converter/stepdown converter:

In this circuit the transistor turning ON will put voltage V_{in} on one end of the inductor. This voltage will tend to cause the inductor current to rise. When the transistor is OFF, the current will continue flowing through the inductor but now flowing through the diode.

We initially assume that the current through the inductor does not reach zero, thus the voltage at V_x will now be only the voltage across the conducting diode during the full OFF time. The average voltage at V_x will depend on the average ON time of the transistor provided the inductor current is continuous.

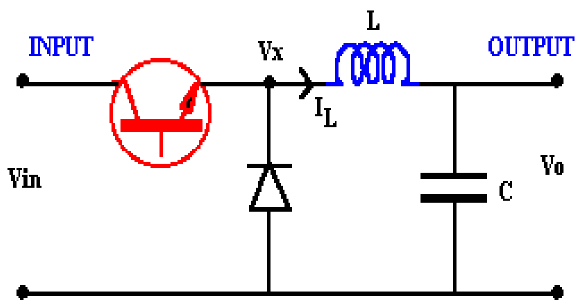

Fig 1 Buck Converter

2.2 Boost converter/stepup converter:

The schematic in Fig.2 shows the basic boost converter. This circuit is used when a higher output voltage than input is required.

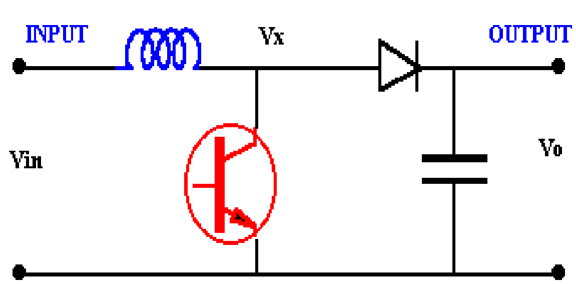

Fig 2 Boost Converter Circuit

While the transistor is ON $V_x = V_{in}$, and the OFF state the inductor current flows through the diode giving $V_x = V_o$. For this analysis it is assumed that the inductor current always remains flowing (continuous conduction). The voltage across the inductor is shown in Fig. 7 and the average must be zero for the average current to remain in steady state.

III. INDUCTION MOTOR

An induction motor (IM) is a type of asynchronous AC motor where power is supplied to the rotating device by means of electromagnetic induction. Other commonly used name is squirrel cage motor due to the fact that the rotor bars with short circuit rings resemble a squirrel cage (hamster wheel).An electric motor converts electrical power to mechanical power in its rotor.

There are several ways to supply power to the rotor. In a DC motor this power is supplied to the armature directly from a DC source, while in an induction motor this power is induced in the rotating device. An induction motor is sometimes called a rotating transformer because the stator (stationary part) is essentially the primary side of the transformer and the rotor (rotating part) is the secondary side. Induction motors are widely used, especially polyphase induction motors, which are frequently used in industrial drives.

The Induction motor is a three phase AC motor and is the most widely used machine. Its characteristic features are-

- Simple and rugged construction
- Low cost and minimum maintenance
- High reliability and sufficiently high efficiency
- Needs no extra starting motor and need not be synchronized
- An Induction motor has basically two parts – Stator and Rotor

The Stator is made up of a number of stampings with slots to carry three phase windings. It is wound for a definite number of poles. The windings are geometrically spaced 120 degrees apart. Two types of rotors are used in Induction motors - Squirrel-cage rotor and Wound rotor

As a general rule, conversion of electrical power into mechanical power takes place in the rotating parts of an electrical motor. In dc motor, the electrical power is conducted directly in armature the rotating part of the motor through brush or commutates and hence dc motor called as conduction motor but in case of induction motor the motor does not receive the electrical power by conduction but by induction in exactly same way as the secondary of a 2-winding transformer receives its power from the primary. That is why such motor known as induction motor.

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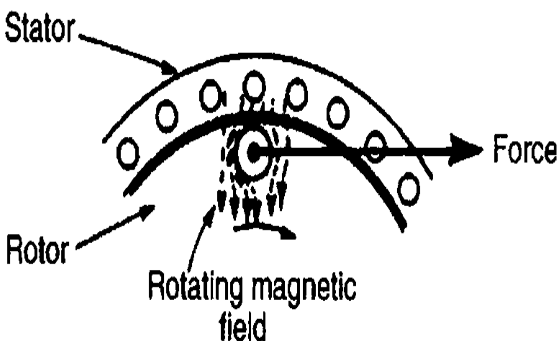


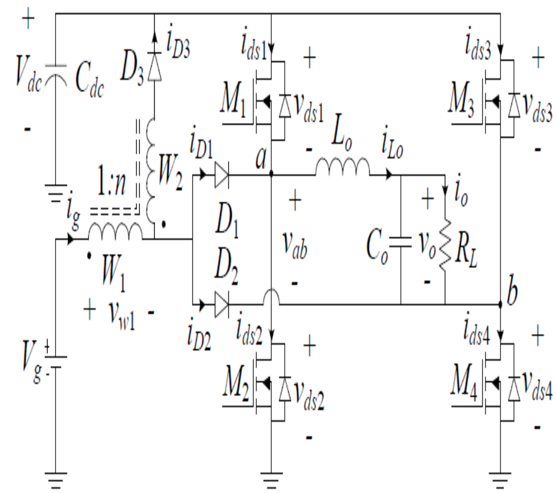
Figure3: showing production of magnetic field

IV. PROJECT DESCRIPTION

Micro inverter topologies for PV power generation are classified into three major groups the single-stage, the two-stage and the multi-stage types. The multi-stage micro-inverters are usually comprised of a step-up DC-DC converter front stage, under Maximum Power Point Tracking (MPPT) control, an intermediate high frequency DC-DC converter stage, used to attain a rectified-sine waveform, and a low frequency unfolding stage to interconnect to the grid. However, the multi-stage power train and the associated high component count results in a costly product. The two-stage micro-inverter can be designed cascading a MPPT controlled step-up DC-DC converter and a grid tied high frequency inverter. Whereas the single-stage topology has to perform the voltage step-up, the MPP tracking, and the DC-AC inversion functions all in one stage.

In order to convert and connect the solar energy to the grid the low voltage of the PV panel first has to be stepped-up significantly to match the utility level. This poses a challenge to the designer of photovoltaic inverters as the traditional boost converter cannot provide the required gain at high efficiency. Therefore, an extensive research effort is dedicated to developing various topologies of high step up DC-DC converters that can be used in tandem with a half or full bridge inverter to implement a solar power generation system.

4.1 CIRCUIT EXPLANATION



Topology of the proposed Single Stage Boosting Inverter.

Operation of Proposed Converter

In this project a Single-Stage Boosting Inverter (SSBI) is proposed for alternative energy/solar power generation. SSBI can be regarded as further improvement. SSBI can attain higher DC gain and, thus, operate off low DC input voltage of a single PV panel. By its concept of operation SSBI shares the switches of the power train in a manner that allows merging the DC-DC step up converter stage and the grid tied DC-AC inverter stage. Hence, SSBI is realized in a single stage. The power decoupling is performed at high voltage, thus, low value of DC link decoupling capacitor is required. The SSBI easily lends itself to application of One Cycle Control (OCC), which helps attaining high quality AC output regardless of low frequency ripple across the DC link. However, any other control method can be applied. The paper presents theoretical analysis, simulation and experimental results obtained from a stand-alone 200W prototype.The proposed schematic diagram of the proposed SSBI is given, which is an improvement of the scheme given. SSBI (single stage boosting inverter) is comprised of semiconductor switches M1…4, arranged in a full bridge configuration; steering diodes D1,2; DC link diode D3, the tapped inductor W1:W2; the decoupling capacitor Cdc; and the output filter Lo-Co. The load is represented by the resistor RL. The proposed SSBI is fed by a DC voltage source, Vg, considered to be derived of a single PV panel, and generates utility level AC output voltage Vo. Here, the input current is designated as ig, the output current is io and its average component is Io. Compared to the proposed SSBI topology has the advantages of a larger voltage step-up which can be achieved adjusting the tapped inductor turns ratio, and smaller decoupling

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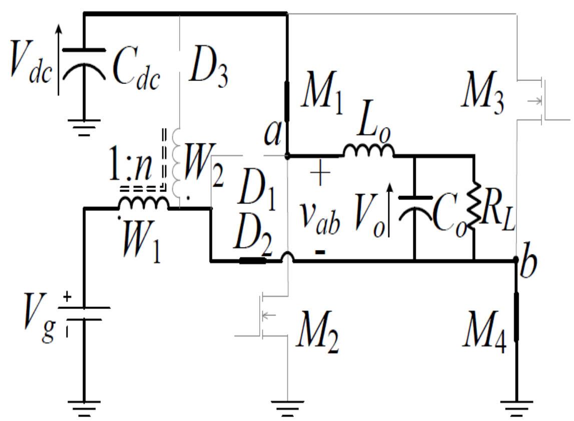
capacitor, which is placed on high voltage dc bus. Principle of operation of the proposed SSBI is hinged on implementation of a specialized switching pattern of the H-bridge. In order to generate output voltage of positive polarity, three topological states are created during the switching cycle as shown. Here, buck and boost sub-topologies can be identified.

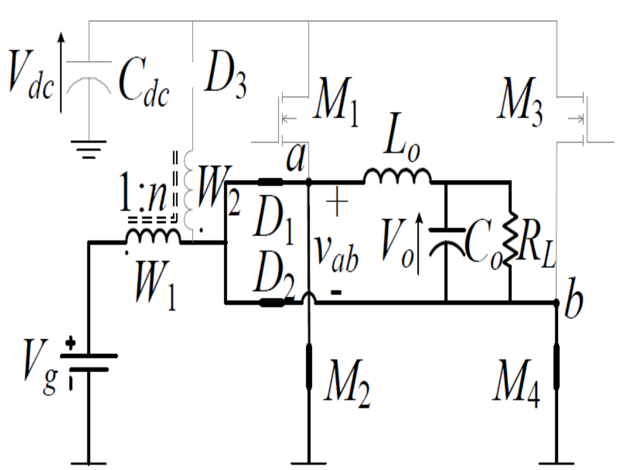
OPERATION MODES

A. STATE:A



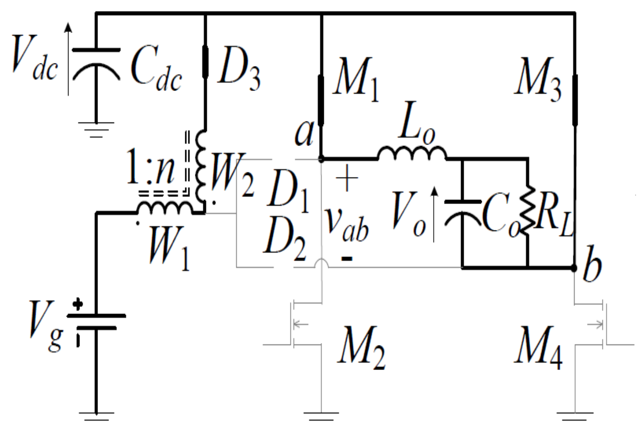
The switching cycle starts with State A, shown, which lasts for a duration of ta. Here, the switches M1 and M4 are on, whereas switches M2 and M3 are off, D2 conducts and D1, D3 are cut-off. During this state the tapped inductor primary magnetizing inductance, Lm, is charged from the input voltage source, Vg, while the DC voltage, Vdc, is applied to the input terminals of the output filter so the filter inductance, Lo, is charged feeding also the filter capacitor, Co, and the load RL.

B. STATE:B



State B, commences, as the switch M1 is turned off and M2 is turned on, whereas M4 keeps conducting. State B lasts for a duration of tb. Here, both D1 and D2 conduct while D3 is cut-off. As a result, the tapped inductor magnetizing inductance, Lm, continues charging from the input voltage source, Vg, whereas the input terminals of the output filter are shorted so the filter inductance, Lo, is discharged to the output capacitor Co and the load RL.

C. STATE:C



State C, begins as the switches M1, M3 are turned on and M2, M4 are turned off. State C lasts for duration of*tc*, and completes the switching cycle. Here, both *D*1, *D*2 are cut-off and *D*3 conducts; the tapped inductor magnetizing inductance, *Lm*, is discharged via both windings and *D*3 into the DC link capacitor, *Cdc*, while the input terminals of the output filter are shorted and the filter inductance, *Lo*, feeds the output capacitor, *Co*, and the load *RL*.

To facilitate the analysis approach the following assumptions are adopted:
(a) all semiconductors are ideal with zero on resistance and voltage drop;
(b) the decoupling capacitor and the output filter capacitor are sufficiently large and their voltage ripple is negligible;
(c) continuous current operation of both the tapped inductor and the output filter inductor is assumed.

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V. SIMULATION RESULTS

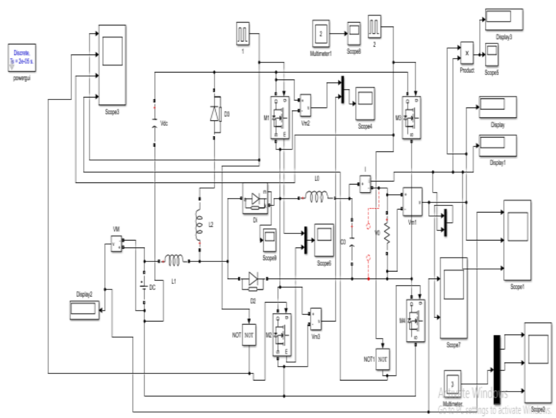

Fig4: Proposed Circuit diagram

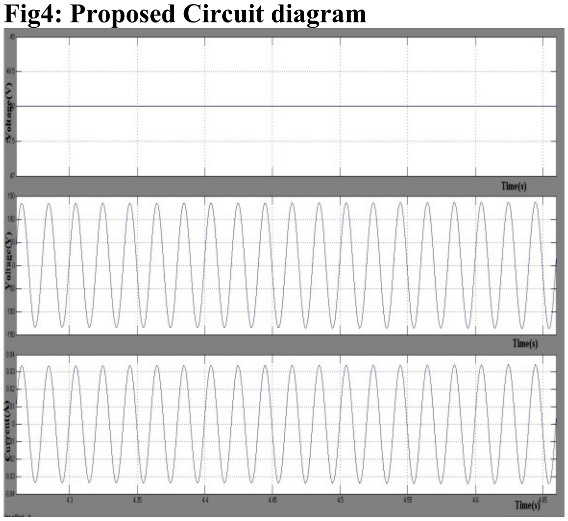

Fig5: OUTPUT CURRENT WAVEFORM

Fig6: OUTPUT VOLTAGE WAVEFORM

VI. CONCLUSION

A single-phase single power stage motor drive system based on the boost-inverter topology is proposed in this paper. The simulation results verify the operation characteristics of the proposed FC system with motors speed and torque variations. In summary, the proposed system has a number of appealing components, for example, single power change stage with high efficiency, simplified topology, low cost etc.

APPLICATIONS

- Industrial cranes
- HVDC transmission
- Electrolytic cells
- Solar Plants

FUTURE SCOPE

It will be implemented for high power application in future. According to literature survey, the base paper will be splited into division and project will be carried out.

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