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A NEW HIGH EFFICIENCY DC/AC HALF-BRIDGE GRID TIED INVERTER

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ABSTRACT

This paper proposes a new family of high potency DC/AC grid-tied inverter with a wide variation of input DC voltage. It is a single-phase half-bridge inverter in which only one power stage works at a high frequency so as to realize minimum switching loss.The minimum drop of the filtering inductance in the power loop is achieved to cut back the physical phenomenon power loss in each mode.Equivalent circuits of a half-bridge single-phase electrical converter is analyzed through the principle of operation. A prototype with an efficiency of 97% is proposed. The circuit operations are explained, and simulation results are presented.

Index Terms – *current source inverter(CSI), voltage source inverter(VSI), CL filter, LCL filter.*

I. INTRODUCTION

Due to the world energy challenge,grid-tied inverters for the renewable energy sources are getting wide used todays[5]. They will be divided into voltage source inverter and current source inverter, wherever the VSI is that the dominant converter. One of the reasons is that the VSI doesn’t need an outsized inductance, while the CSI ought to adopt a bigger inductance so as to stay the DC component for a correct modulation. The analysis associated with CSI mainly specializes in the management. So far, the way to decrease the total DC-link inductance for CSI may be a challenge, particularly within the low voltage and three-phase application space.

Since the VSI is a step-down electrical converter and CSI is a step-up electrical converter, the Z-source inverter(ZSI) was projected in [8] so as to completely utilize the essential attributes of VSI and CSI and the minimum semiconductors were used with the combined character of step-down and step-up electrical converter. However, compared to the CSI or the VSI, the ZSI has two further inductors within the power loop, which can sacrifice the potency. The control issue is additionally a demerit within the Z-source impedance.

In the non-conventional power generation system, the input DC voltage of the device could vary greatly. For example, the output DC voltage of an electrical converter can vary a lot under different temperature condition. To transfer this sort of DC energy into the Grid, a two or three-stage electrical converter is also needed because the power interface, especially for the VSI- based system. If all power stage works at high frequency, the potency of the electrical converter is inevitably affected. So as to decrease the switching frequency, many fascinating inverters are planned[4] and also the basic plan is to confirm that just one of the ability stages of the system works at high frequency. Still the most output filters of those inverters ought to be designed to satisfy the harmonic requirement within the "buck" mode, particularly once the DC input voltage is beyond the amplitude of the grid voltage. Thus, once they add the "boost" mode, over filtering may occur due to that the output filter could be a CL-CL filter. Since the excessive inductance is within the power loop, the grid current is not easy to control as excess conduction losses are present.

A half- bridge single-phase grid tied electrical converter with the various power sources are introduced in this paper. Next, a new type of three stage grid-tied electrical converter is projected and also the operating principle is illustrated through a half-bridge electrical converter with the equivalent circuits within the totally different working stages.. Finally, simulations are given to verify the theoretical analysis and also the principle of operation.

II. SINGLE-PHASE GRID TIED ELECTRICAL CONVERTER WITH THE VARIOUS POWER SUPPLY.

A).Single Stage Inverters

1*) Inverters with the only operate of step-down or step-up*:

The standard VSI with LCL-filter and the typical CSI with CL-filter are shown in fig.1 and fig.2. The VSI is a buck type electrical converter, which implies its DC voltage ought to be beyond the amplitude of the grid voltage.The CSI may be a boost-type electrical converter, which implies that its DC voltage should be less than the amplitude of the grid voltage [3]. Generally, the output DC voltage of the non-conventional power supply (for example, a PV panel) could vary in an exceeding massive range, and then the VSIs or CSIs have their own limitation as a renewable power conditioner connected to the grid directly, associated once an additional DC/DC converter is employed.

2) *Inverters with the operate of both step-down and step-up:*

a) ZSI: combined with the voltage characters of the VSI and the CSI, a ZSI was projected [8]. In theory, ZSI (as shown in fig.3) will add the change of magnitude and therefore the step-up states as needed and its responsibility may be improved a lot, due to its immunity to the magnetic attraction interferenceHowever, as result of the two extra conductors within the power loop, the conductivity power loss is high and over filtering may additionally take place, particularly once the input dc voltage is high. It's essentially a boost-buck sort converter and it's tough to understand the overall parameter improvement, once the DC input voltage varies.

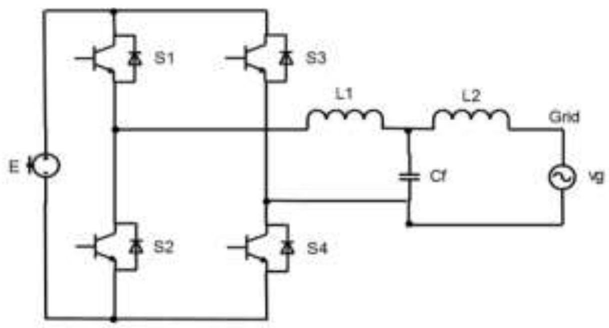

Fig.1. Single-phase grid-tied VSI

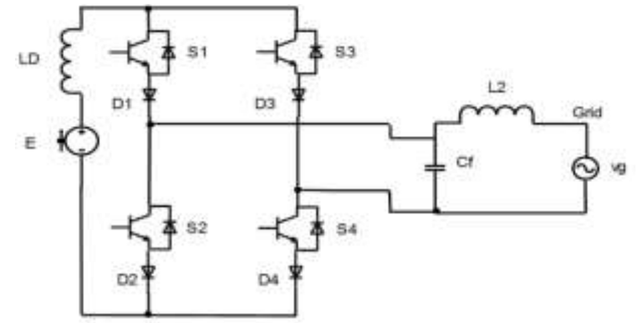

Fig.2. Single-phase grid tied CSI

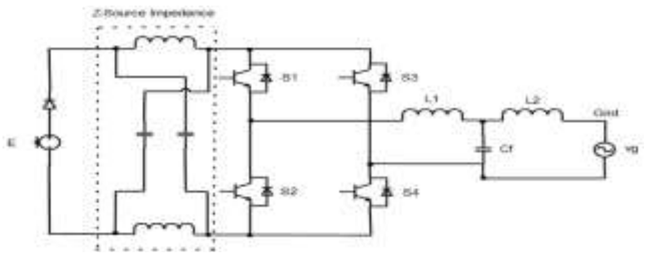

Fig.3. Single-phase grid-tied ZSI

b) ***Natural soft-switching electrical converter (NSSI):***

For a VSI, the reverse recovery power loss and, therefore the power losses caused by the tail current of insulated –gate bipolar semiconductor unit(IGBT) limit the shift frequency of the VSI. Compared to the CSI, the conduction power loss of the VSI is small. For the CSI, the main drawbacks associated with the potency are high conductivity power loss of the device. Even so, the CSI has no reverse recovery power losses.

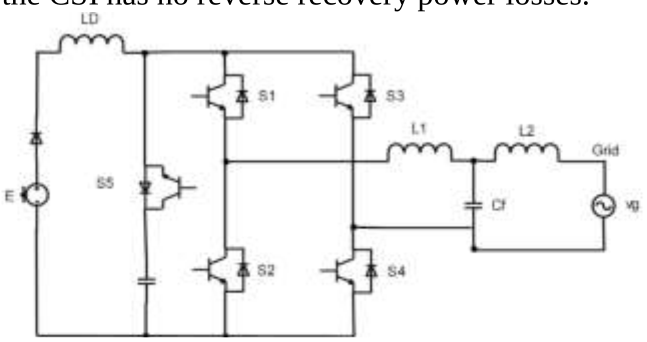

Fig.4. Single-phase grid-tied natural soft-switching inverter

Using the benefit of VSI and CSI and avoiding the demerit of them, a high potency electrical converter was projected as shown in fig.4(for a single phase application), named because the NSSI. When the extra switch of the S_5 is ON, the electrical converter works as a pure VSI with associate LC-type DC input filter associated an LCL sort of AC output filter, whereas S5 is OFF, it works sort of a CSI with a clamped voltage associated an LCL filter. Thus, this electrical converter will appropriate a wide variation of input DC voltage, particularly for the permanent magnet synchronous generator with a front-end diode rectifier. An improved NSSI was projected to extend the potency when it's used for the three-phase electrical phenomenon electrical converter application[13], whereas an extra boost DC/DC circuit had been inserted. Note that the NSSI could have the next potency than the traditional two-stage VSI, since a lot of switches will add the soft switching or quasi-soft switching state. A lot of potency analysis regarding this electrical converter is introduced . However, the inductance within the power loop still looks massive.

B. ***Two-stage electrical converter***

The conventional two-stage VSI adopts an input dc/dc boost converter to transfer a variable input dc voltage into a stable dc voltage and so injects the dc energy into the grid. So, both two stages of the ability device work high frequency, causing considerable shift losses. Fig.5 shows a standard two-stage dual-mode time-sharing high potency electrical converter used as a PV electrical converter[11]. Here, an LC filter is used as an L-filter to cut back the full inductance. In order to reduce the switching power losses, only one power stage is chopping at high frequency.

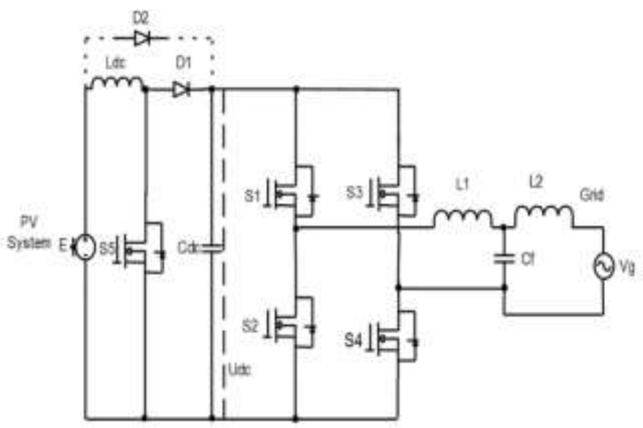

Fig.5. Conventional two stage electrical converter with LCL-filter

Further, so as to scale back the physical phenomenon power loss of the electrical device,a bypass diode D_2 is usually used. However, throughout the “boost” operating stage, the over filtering still takes place since the equivalent output filter of the boost circuit may be a CL-CL filter and also, the additional physical phenomenon loss of the inductor cannot be avoided.

III. PROPOSED DEVICE

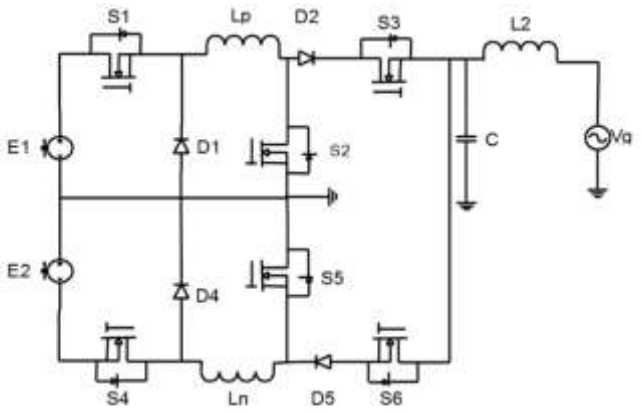

Fig.6. proposed half-bridge grid tied inverter

A).*Topologies of half-bridge electrical converter:*

As shown in Fig.6, the three stage half-bridge inverter was adopted to realize the higher potency by using MOSFET. One advantage of the electrical converter is that with the input LC-filter the current ripple of DC input supply is smaller than that of the conventional VSI. Note that because of the inserted and its capacitance is mainly hooked into the ripple energy balance, a large input smoothing capacitance ought to be current at the double line frequency, so this LC-filter has less facilitate to decrease the entire input capacitance. A “half-bridge” three-stage electrical converter is projected almost like the conventional two-stage electrical converter, only one power stage works at high frequency and also the output power stage work at the line frequency. The operation of the planned “half-bridge” electrical converter will be introduced parenthetically the fundamental principle of the half-bridge inverter very well.

B. *Modes of operation of half-bridge electrical converter.*

1) E_1 OR $E_2 \geq V_{gA}$: Once the input DC voltage (E_1, E_2) is larger than V_{GA}, the amplitude of grid voltage, the equivalent circuits are shown in Fig. 7. As shown in fig. 7, during the positive amount of the grid voltage, S_3 is ON, S_2 is OFF, S_1 works at a high-frequency so as to attain a curving grid-injected current, and E_1 provides the overall energy in the same way, as shown in fig. 8, throughout the negative amount of V_g, S_6 is ON, S_5 is OFF, S_4 works within the high frequency mode in order to stay the grid-injected current, and E_2 delivers the overall energy. The electrical converter works as a VSI connected to the grid through LCL-filter

2) E_1 and $E_2 \leq V_{gA}$: Once the input DC voltage (E_1, E_2) is lower than V_{GA}, the amplitude of grid voltage, the control becomes a bit a lot of difficulties. Fig.8 shows the working sequence of the planned “half-bridge” electrical converter, when the amplitude of the input DC voltage is lower than the AC grid voltage, wherever the sequence are often separated into six components during a full line frequency period.

Throughout T_1 and T_3, S_3 is ON, S_1 works at high frequency and the remaining switches are OFF. The equivalent circuits are shown in Fig.9 and it is often seen that it works like a pure buck converter with LCL-filter connected to the grid. In this case, the buck converter could be a classical VSI.

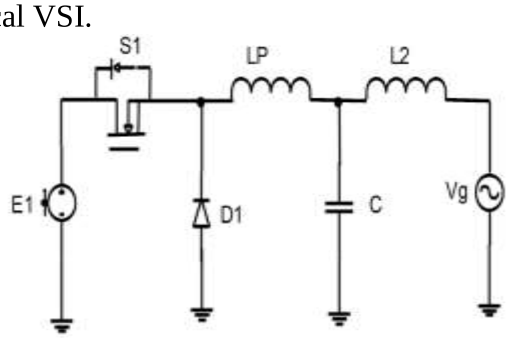

Fig.7. Equivalent circuit when E_1 and E_2 are higher than the amplitude of the grid voltage during positive period.

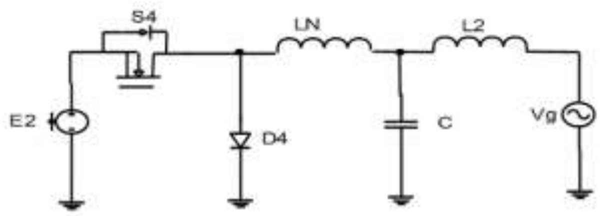

Fig.8. Equivalent circuit when E_1 and E_2 are higher than the amplitude of the grid voltage during positive period.

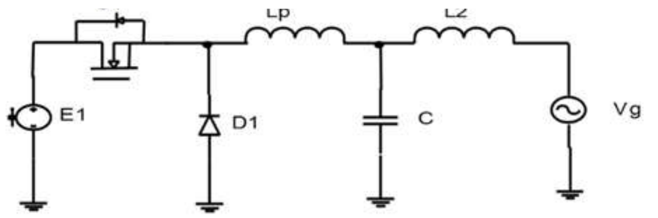

Fig.9. Equivalent circuit during positive period of the converter during T_1 and T_3

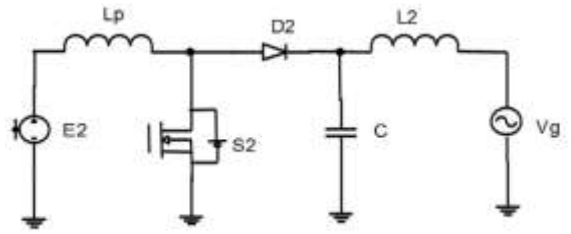

Fig.10. Equivalent circuit during positive period of the converter during T_2

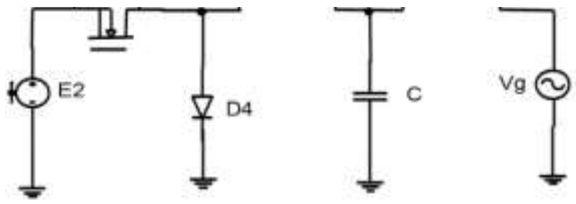

Fig.11. Equivalent circuit during negative period of the converter during T_4 and T_6

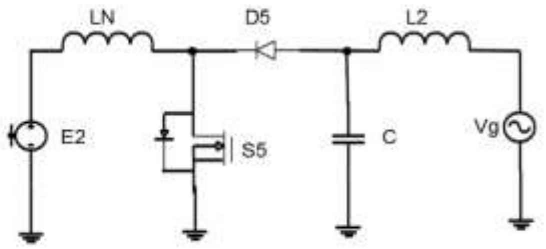

Fig.12. Equivalent circuit during negative period of the converter during T_5

Throughout T_2, S_1 and S_3 are ON, S_2 works with high frequency and the remaining switches are OFF. The equivalent circuit is shown in Fig.10 and it is often seen that it works sort of a pure boost converter with a CL-filter connected to the grid. If the current of the boost inductance are often totally controlled, this equivalent circuit is often seen as a CSI.

Similarly, throughout T_4 and T_6, S_6 is ON, S_4 works at high frequency and the rest of the switches are OFF. The equivalent circuit is shown in fig.11 and it is often seen that it conjointly works sort of a pure buck circuit with LCL-filter connected to the grid.

Throughout $T_{5,}$ S_4 and S_6 are ON, S_5 works at high frequency and the rest of the switches are OFF. The equivalent circuit is shown in fig.12 and it also can be seen as a CSI with a CL-filter connected to the grid. From the previous analysis, it may be seen that the projected inverter cannot merely be known as a traditional VSI or CSI. The foremost outstanding character of this sort electrical converter is that minimum filtering inductance within the power loop is adopted, and over filtering won't take place; therefore on paper, the projected inverter has the advantage to realize the higher potency than other inverters below constant condition of the input DC voltage.

IV. SIMULATION OF THE PROPOSED CONVERTER

The simulation is executed in the MATLAB R2010a version. The specifications of the different parameter in the simulation circuit are described below in the table 1. Simulated results are obtained from the proposed half bridge inverter circuit.

TABLE I

PARAMETER	SPECIFICATION
Input supply voltage	200-420V
Input frequency	50Hz
Inductor	600µf

Capacitor	600µf
Grid voltage	200-420V

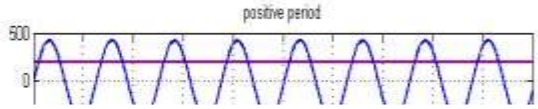

Fig.14. Pulse generated during positive period when input voltage lower than grid voltage

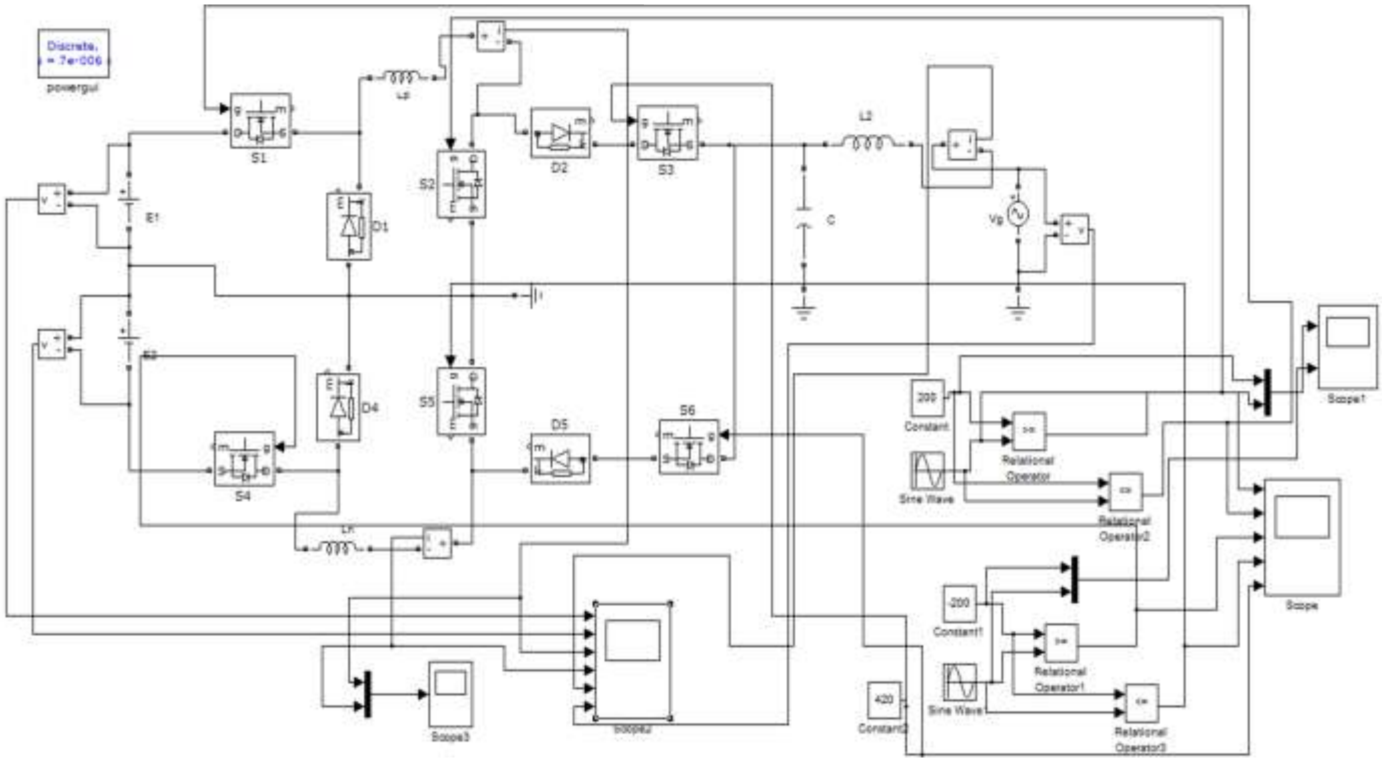

Fig.13. Simulation of proposed half bridge inverter circuit

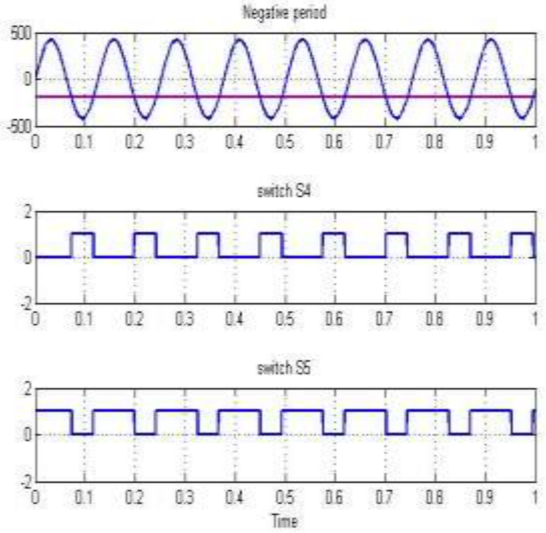

Fig.15. Pulse generated during negative period when input voltage lower than the grid voltage

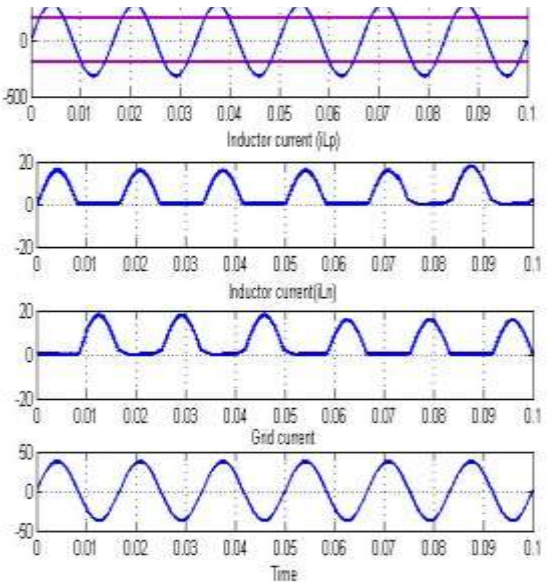

Fig.16. Simulated waveform when grid voltage is greater than input voltage.

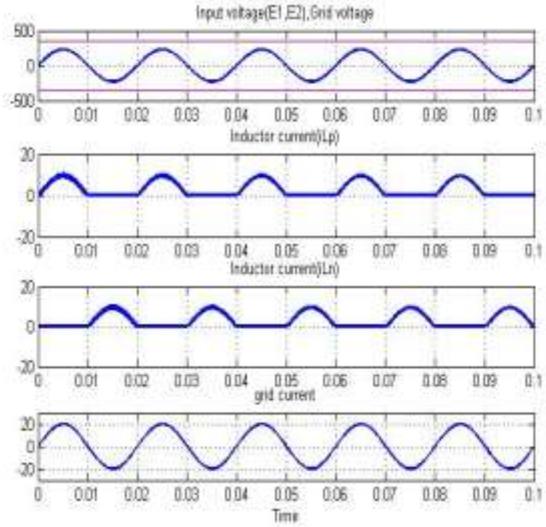

Fig.17. Simulated waveform when grid voltage is lower than the input voltage

The Simulated output of the input DC voltages (E_1,E_2), the grid voltage (Vg (t)), the DC currents of the DCinductance ($i_{LN}(t)$, $i_{LP}(t)$), and therefore the grid-injected current ($i_g(t)$) whereasE_1 = E_2 = 320 V are shown in Fig.16. It can be seen that the half-bridge inverter works as a pure VSI and the current of the DC inductance is a rectified Sinusoidal waveform, which is set according to.When E_1 = E_2 = 200 V, the simulated results are shown in Fig.17. It can be seen that the boost circuit works quite well,when the AC grid voltage is higher than the input DC voltage, according to the proposed control strategy. The average potency is 97% for 1000W operation and 220V.

V. CONCLUSION

A new type of three stage half-bridge grid-tied electrical converter is proposed. If all the power stages of the power converter work at high frequency, switching losses will be high. Here only one power stage works within the high frequency stage at anytime, which ends in minimum switching loss. LC filter is used to reduce the total inductance which will minimize the conduction power losses and over filtering is avoided. A 1000W prototype is proposed with a system and efficiency of 97%. Thus, the efficiency is improved, and the inverter has a minimum voltage drop of filtering inductor in the power loop at any time.

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