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Boost Derived Hybrid Converter with Simultaneous Ac and Dc Outputs by Using VSI

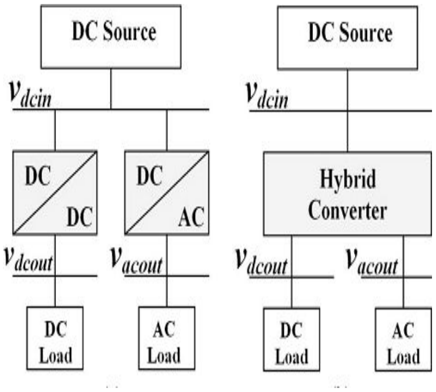
K.Naveen, S.Sridhar, T.Ravi Kumar, N.Venkateswarlu

***Abstract*— This development proposes a family of hybrid converter topologies which can supply simultaneous AC and DC output loads from a single dc input source . These topologies are realized by replacing the controlled switch of single-switch boost converters with a voltage-source-inverter bridge circuit. The resulting hybrid converters require very lesser number of switches to provide simultaneous AC and DC outputs with an increased reliability, resulting from its intrinsic shoot-through protection in the inverter period. Such multi-output converters with better power processing density and reliability can be well suited for systems with concurrent dc and ac loads.**

***Index Terms*— Boost-derived hybrid converter (BDHC), dc nanogrid, pulsewidth-modulated inverters**

I. INTRODUCTION

Nan grid architectures are being increasingly incorporated in current smart residential electrical power system. This system involve different load types—dc as well as ac—efficiently interfaced with different kinds of energy sources(conventional or nonconventional) using power electronic converters. Fig. 1 shows the schematic of a system, where a single dc source (*v*dcin) (e.g., solar panel, battery, fuel cell, etc.) supplies both dc (*v*dcout) and ac (*v*acout) loads. The architecture of below Fig. uses separate power converters for each conversion type (dc–dc and dc–ac) while below figure utilizes a single power converter stage to perform both the conversions



The latter converter, referred to as a hybrid converter in this project, has higher power processing density and improved reliability (resulting from the inherent shoot-through protection capability). These equalities make them suitable for use in compact systems with both dc and ac loads. For example, an application of a hybrid converter can be to power an ac fan and a LED lamp both at the same time from a solitary dc input in a single stage. Smart residential systems are often connected to non conventional energy sources to provide cleaner energy. Due to space constraints, these dedicated energy sources are highly localized and have low terminal voltage and power ratings (typically, on the order of a hundred watts). Conventional designs involve two separate converters, a dc–dc converter (e.g., boost) and a voltage source inverter (VSI), connected either in parallel supplying dc and ac outputs at *v*dcout and *v*acout, respectively. Depending upon the requirements, topologies providing higher gains may be required to achieve step-up operation. This project investigates the use of single boost-stage architecture to supply hybrid loads. The operation of conventional VSIs in hybrid converters would involve the use of dead time circuitry to prevent shoot through. In addition, due to electromagnetic interference (EMI)or other spurious noise, misgating turn-on of the inverter leg switches may take place, resulting in damage to the switches. In residential applications, due to the compactness of the overall conversion system, the generation of spurious noise may be commonplace. Thus, the VSIs in such applications need to be highly reliable with appropriate measures against EMI-induced misgating.

The Z-source inverter (ZSI) can mitigate the problem of shoot-through due to the EMI in a VSI. The use of a unique impedance network at the input of the ZSI allows a shoot-through state in which both the switches of an inverter leg can be turned on simultaneously. Extended boost ZSI has been proposed where a higher gain is achieved utilizing this Z-source topology. However, ZSI cannot supply both dc and ac loads simultaneously. This is due to the fact that it has two capacitors which have to be matched with equal loads across them. Unmatched loads on the capacitors might lead to dynamic instability.

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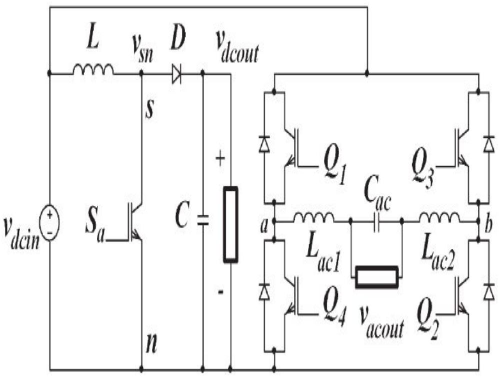
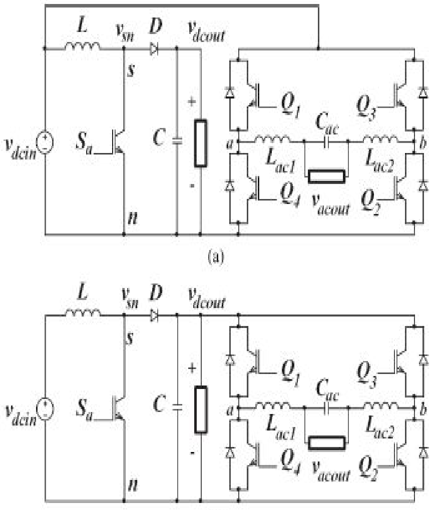




(a)

(b)

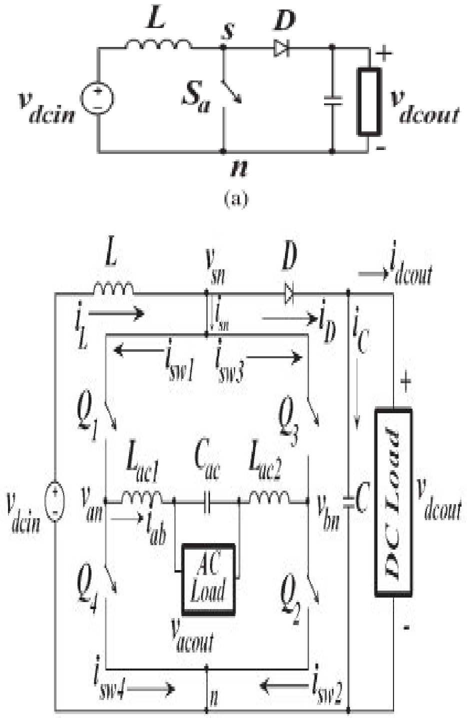
Fig. 2. Schematic of power converter topologies with simultaneous dc and ac loads. A conventional boost converter and a VSI have been used to implement the system. System (a) when both are connected in parallel and (b) when connected in cascade.

The switched boost inverter (SBI) , is a hybrid converter topology, which can achieve similar advantages as a ZSI with lesser number of passive components and supply simultaneous dc and ac loads. This inverse Watkins–Johnson (IWJ) converter-derived topology is a converter based upon the first-order four-switch converter cell. The proposed hybrid converter is derived from a two-switch converter cell based step-up converter, such as the boost converter. Therefore, it involves lesser component count compared to the IWJ converter. The proposed converter is denoted as boost-derived hybrid converter (BDHC).

Boost converters comprise complementary switch pairs, one of which is the control switch (controls the duty cycle) and the other capable of being implemented using a diode. Hybrid converter topologies can be synthesized by replacing the controlled switch with an inverter bridge network, either a single-phase or three-phase one. Since, the proposed hybrid converter is derived from a two-switch converter cell based step-up converter, such as the boost converter, it involves lesser component count compared to the IWJ converter. The proposed converter is denoted as boost-derived hybrid converter (BDHC).

The objectives of this paper are the following: 1) to introduce a family of hybrid converter topologies capable of simultaneously supplying ac and dc loads; 2) to characterize the steady-state behavior of the BDHC topology; 3) to develop a PWM control scheme for the BDHC; 4) to compare the performance of the BDHC with conventional designs; 5) to validate the static and dynamic performance of the BDHC using an experimental prototype; and 6) to extend the proposed philosophy to higher order boost converters in order to achieve a higher conversion ratio.

This paper is organized as follows. The proposed circuit modification principle is described next in Section II, and its application to a boost converter is shown. The steady-state char- acterization of the converter is given in Section III. The PWM control strategy and the closed-loop implementation to regulate both ac and dc outputs are described in Section IV, followed by a comparative study of the BDHC in Section V. Section VI extends the circuit modification principle to higher order boost converters. The converter and its control strategy have been validated using an experimental prototype in Section VII.



(a)

Fig.3 (a) Conventional boost converter. (b) Proposed BDHC obtained by replacing S_a with a single-phase bridge network. The switch realization for the bridge can be done using bidirectional switches—either IGBTs with antiparallel diodes or MOSFETs

II. BDHC

A. Proposed Circuit Modification

Boost converters comprise complementary switch pairs, one of which is the control switch (controls the duty cycle) and the other capable of being implemented using a diode. Hybrid con- verter topologies can be synthesized by replacing the controlled switch with an inverter bridge network, either a single-phase or three-phase one. The proposed circuit modification principle, applied to a boost converter, is illustrated in the next section. The resulting converter, called

BDHC, is the prime focus area of this paper. Section VI extends this principle to higher order converters.

B. Derivation of BDHC Topology

The control switch S_a of a conventional boost converter [shown in Fig. 3(a)] has been replaced by the bidirectional single-phase bridge network switches (Q_1 –Q_4) to obtain the BDHC topology [shown in Fig. 3(b)]. This proposed converter provides simultaneous ac output (v_{acout}) in addition to the dc output (v_{dcout}) provided by the boost converter.

For the BDHC, the hybrid (dc as well as ac) outputs have to be controlled using the same set of four controlled switches Q_1 –Q_4 . Thus, the challenges involved in the operation of BDHC are the following: 1) defining the duty cycle (D_{st}) for boost operation and the modulation index (M_a) for inverter operation; 2) determination of voltage stresses and currents through different circuit components and their design; and 3) control and channelization of total input power to both ac and dc loads. In the subsequent sections, all the aforementioned challenges will be discussed.

III. OPERATION OF BDHC

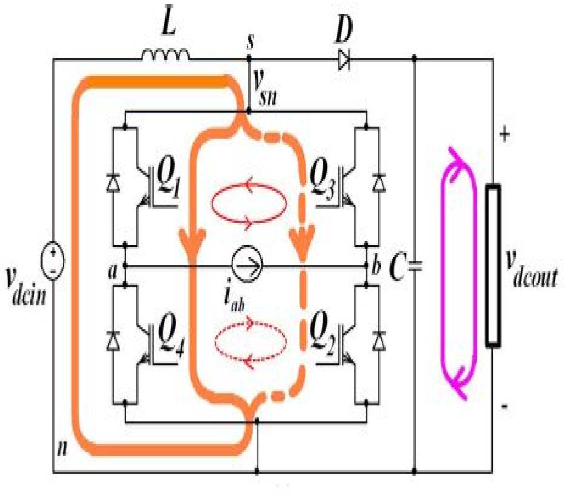
The schematic of the BDHC with the reference current directions has been shown in Fig. 3(b). In this paper, the continuous conduction mode of operation has been assumed (the boost inductor current (i_L) never goes to zero). In this paper, lower case letters represent instantaneous values, upper case letters represent dc or rms values, lower case letters with tilde (˜) rep- resent the ac component, and lower case letters with ( ) repre- sent the peak value of the variable.

A. Operating Principle

Each of the four bidirectional switches (Q_1 –Q_4) of BDHC comprises the combination of a switch S_i and an antiparallel diode D_i (i = 1 to 4). The boost operation of the proposed converter can be realized by turning on both switches of any particular leg (either S_1–S_4 or S_3–S_2) simultaneously. This is equivalent to shoot-through switching condition as far as VSI operation is concerned, and it is strictly forbidden in the case of a conventional VSI. However, for the proposed modification, this operation is equivalent to the switching “on” of the switch “S_a ” of the conventional boost converter [see Fig. 3(a)].

MODES OF OPRATION:

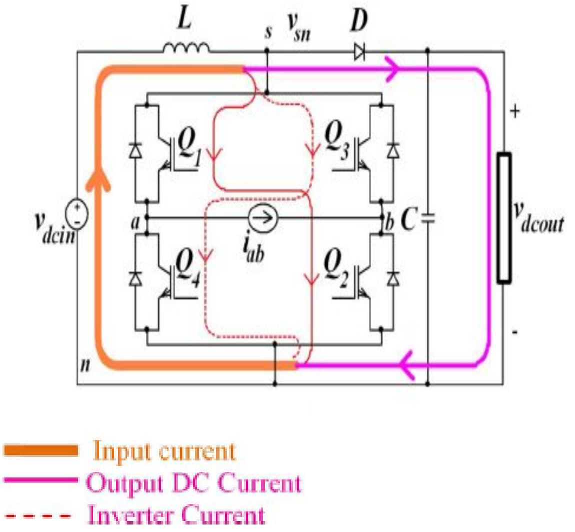
MODE1(Shoot-throughinterval):-



The shoot-through interval occurs when both the switches (either Q1–Q4 or Q3–Q2) of any particular leg are turned on at the same time.The duration of the shoot-through interval decides the boost converter duty cycle (Dst).The diode “D” is reverse biased during this period.

The inverter output current circulates within the bridge network switches.Thus, BDHC allows additional switching states which are strictly forbiddeninaVSI.

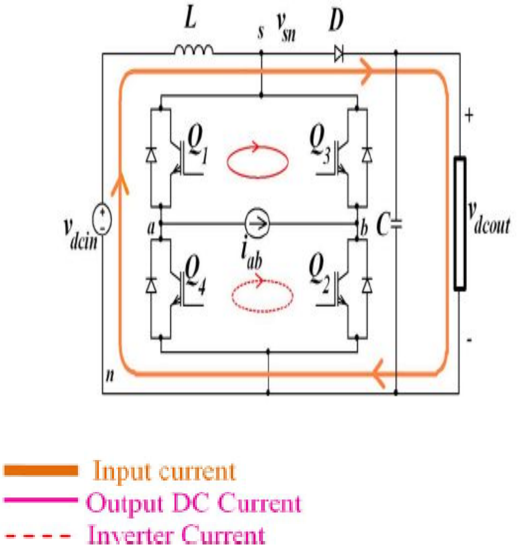
MODE2(Powerinterval):-



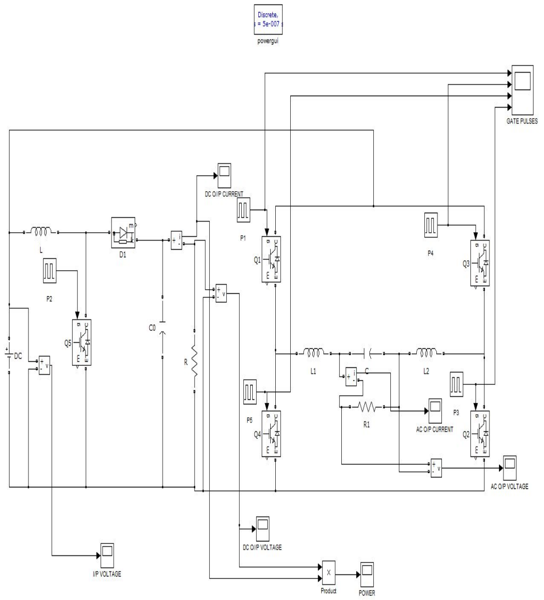
The power interval occurs when the inverter current enters or leaves the bridge network at the switch node “s.”The diode “D” conducts during this period, and the voltage at the switch node (vsn) is equal to the vdcout (neglecting the diode voltage drop).In this interval, either Q1–Q2 or Q3–Q4 is turned on.

MODE 3(Zero interval):

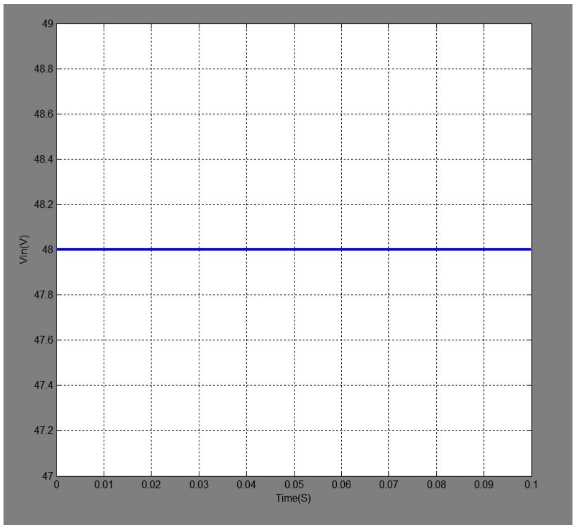
The zero interval occurs when the inverter current circulates among the bridge network switches and is not sourced or sunk.The diode “D” conducts during this interval.



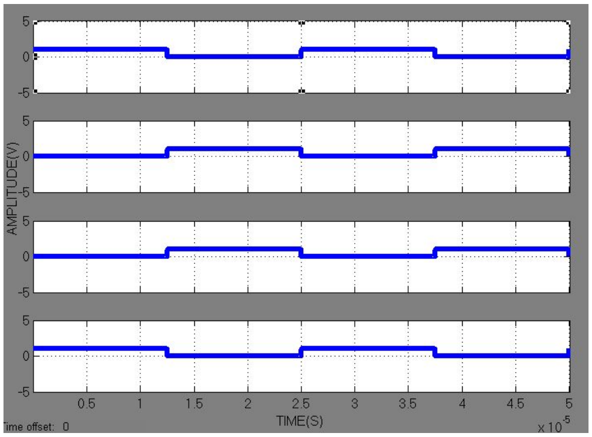
SIMULATION RESULTS:
CONVENTIONAL METHOD:-



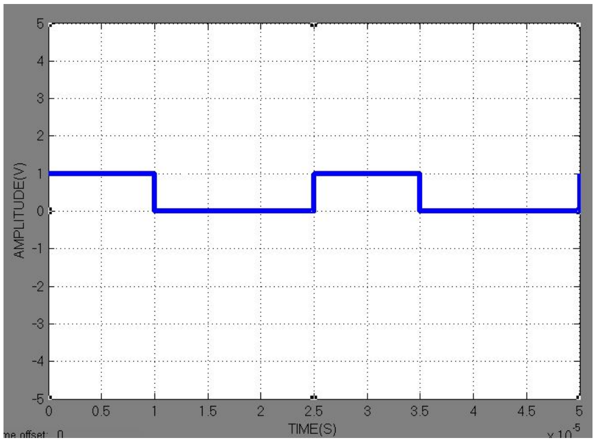
RESULTS:
INPUT VOLTAGE :-



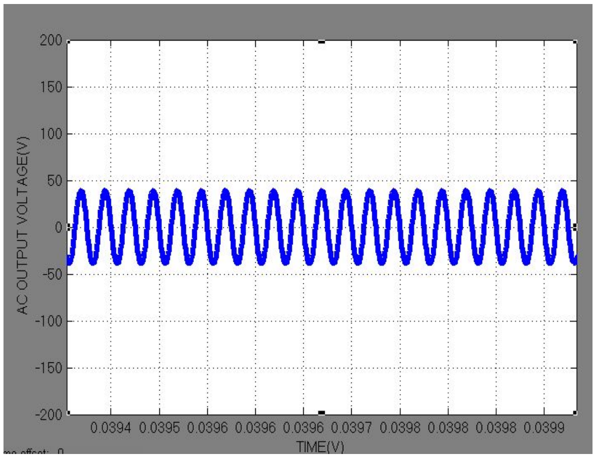
TRIGGERING PULSES FOR INVERTER:



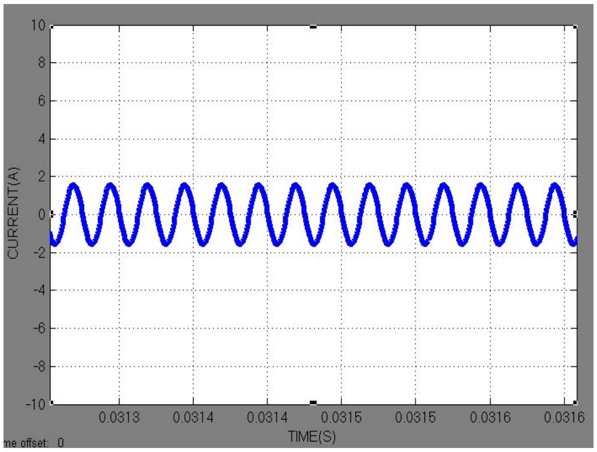
TRIGGERING PULSE FOR CONVERTER:



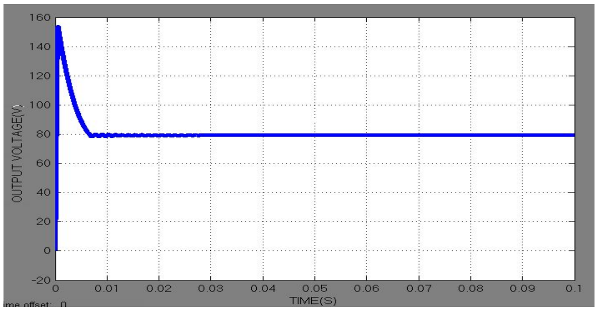
AC OUTPUT VOLTAGE:



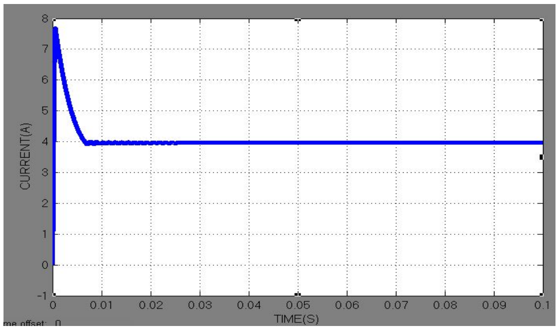
AC OUTPUT CURRENT:



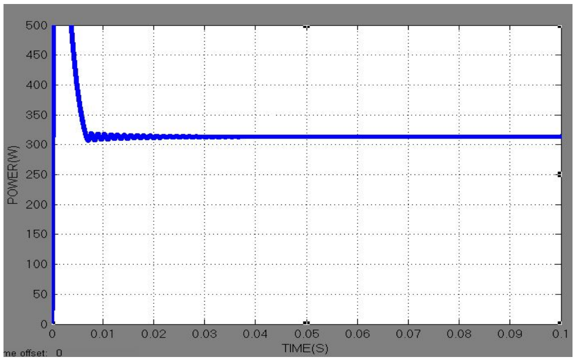
DC OUTPUT VOLTAGE:



DC OUTPUT CURRENT:

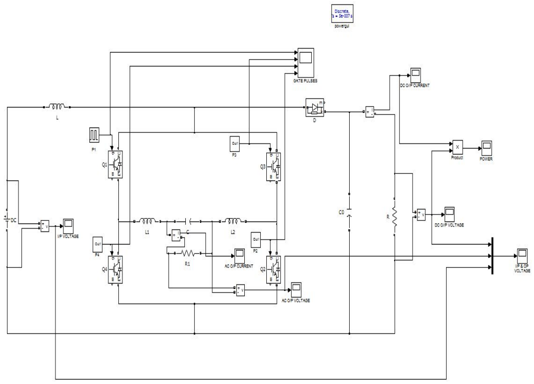


OUTPUT POWER:

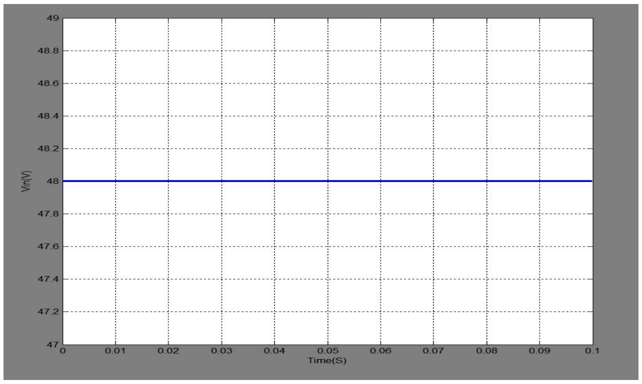


PROPOSED METHOD:

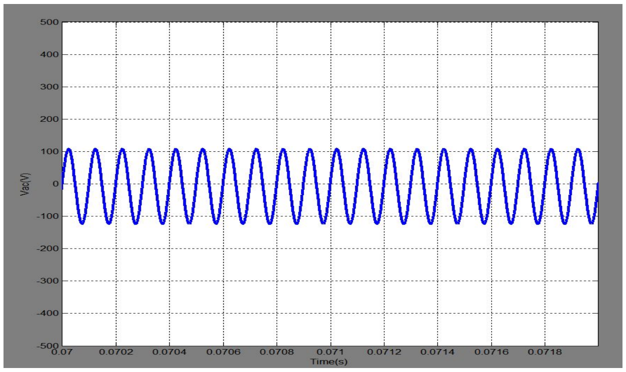
SIMULATION CIRCUIT DIAGRAM:-



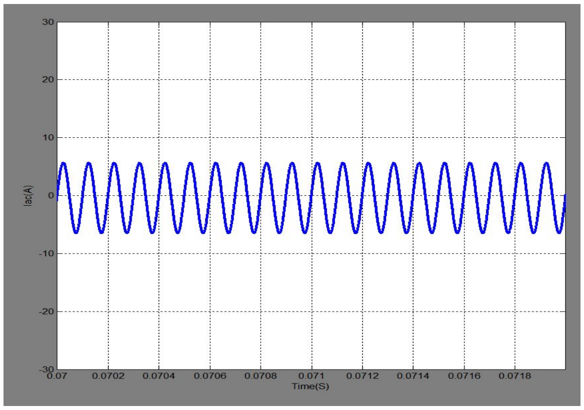
DC INPUT VOLAGE



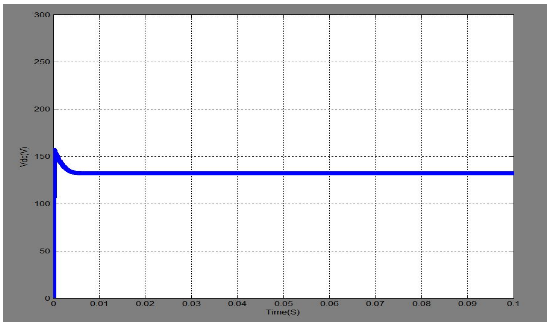
AC OUTPUT VOLTAGE:



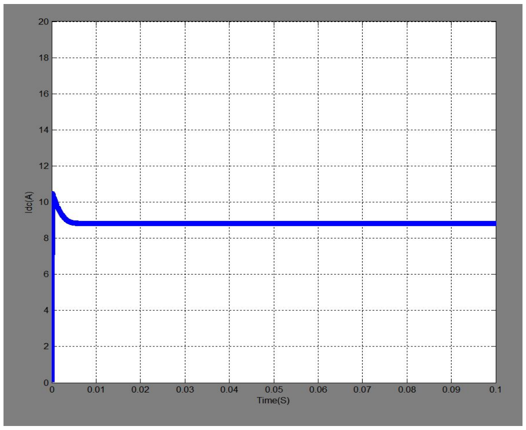
AC OUTPUT CURRENT:



DC OUTPUT VOLTAGE:



DC OUTPUT CURRENT:



ADVANTAGES:

Lesser number of passive components.

The number of controllable switches is reduced when compared to a boost cascaded inverter topology.

Higher switching frequency for the boost converter, thus reducing the magnetic size and improving the dynamics of the system.

The converter can also be adapted to generate ac outputs at frequencies other than line frequencies.

APPLICATIONS:

Nanogrids in residential applications and Drives

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