BOOST DERIVED HYBRID CONVERTER WITH MULTIPLE OUTPUTS USING BPWM

VidhyaSenapati[1],Student,Rajalakshmi Engineering College, Vishnu Priya.S[2], Student, Rajalakshmi Engineering College, Padmavathi.R[3], Sr. Assistant Professor, Rajalakshmi Engineering College

Abstract--- **This paper presents a hybrid converter topology which can supply multiple ac and dc loads from one dc input. Conventional design involves two separate converters, a dc-dc converter, a boost and a voltage source inverter, connected either in parallel or cascade supplying dc and ac outputs. The proposed model requires less number of switches to supply ac and dc outputs with increase in reliability from its inbuilt shoot-through protection. The converter used in this paper is boost derived hybrid converter (BDHC) as it is derived from the conventional topology. A suitable pulse width modulation (PWM) control strategy, based on bipolar sine-PWM, is portrayed. The converter is able to supply ac and dc loads at 300V and 220V respectively from a 48V dc input. The simulation and experimental results both confirm the feasibility of the proposed converter.**

Index Terms--- **voltage source inverter, boost derived hybrid converter (BDHC), bipolar sine pulse width modulation.**

I.INTRODUCTION

Nano grids are small micro grids, typically serving a single building or a single load. They are being increasing used in modern power systems. These power systems include different load types such as ac and dc. Nano grids mimic the innovation that is rising up from the bottom of the pyramid and capturing the imagination of growing numbers of technology vendors and investment capital, particularly in the smart building and smart transportation spaces. The Fig 1 shows the schematic diagram of the system, where in a single dc source gives ac and dc loads. Fig 1 (a) depicts the conventional model in which dc load is supplied by dc-dc converter and ac load is supplied by ac-ac converter separately. Fig 1 (b) depicts hybrid converter where in a single converter stage achieve both the operations.

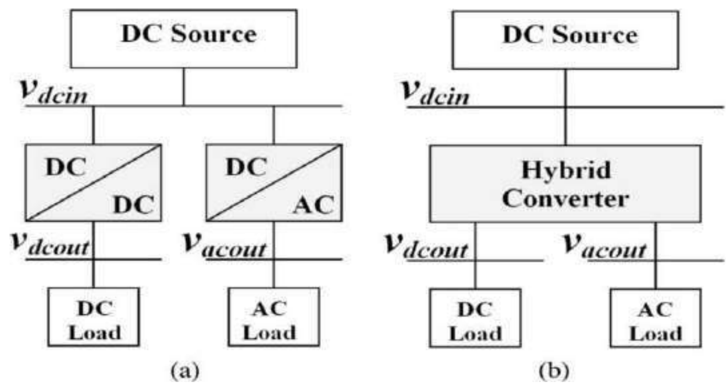
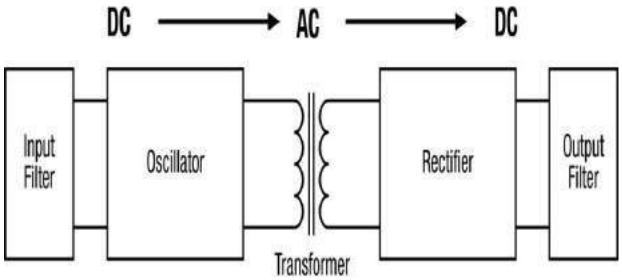


Fig 1 Schematic diagram of the system.(a) Conventional converter based model. (b) Hybrid converter based model.

The multi output converter circuits provide isolation in several output voltages using one high frequency isolation transformer as opposed to individual power modules for each output as it is frequently done in distributed power systems. Generally, any isolated topology with several secondary windings in the transformer can provide multiple output voltages. These circuits employ a single primary side power stage including the input filter, energy storage capacitor, a high frequency power switch, usually a MOSFET transistor and a PWM controller. On the secondary side, isolated by the transformer, are the output components, rectifiers, energy storage capacitors and output inductors. Its output provides the feedback signal which is transmitted to the primary side over the isolation barrier. On the primary side, the feedback signal is received by the PWM controller and ultimately determines the duty-cycle of the power switch. The main objective of static power converters is to produce an ac output waveform from a dc



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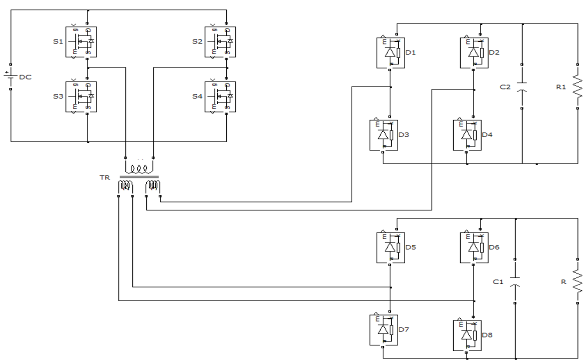

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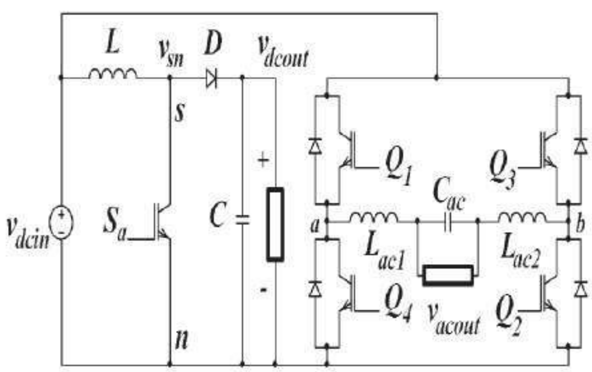


(c)

Fig 2 (a) Basic layout of a dc-dc converter. (b) Conventional circuit diagram (c) Conventional boost converter with a VSI in parallel

power supply. For sinusoidal ac outputs, the magnitude, frequency, and phase should be controllable. According to the type of ac output waveform, these topologies can be considered as voltage source inverters (VSI), where the independently controlled ac output is a voltage waveform. Similarly, these topologies can be found as current source inverters (CSIs), where the independently controlled ac output is a current waveform.

A Z-source inverter is a type of power inverter, a circuit that converts direct current to alternating current. It functions as a boost inverter without making use of DC-DC converter bridge due to its unique circuit topology. This converter can reduce the problem of shoot through protection.

II. BDHC

A. *Conventional model*

The conventional model consist of a separate an inverter and a dc-dc converters circuit. dc-dc converter or in

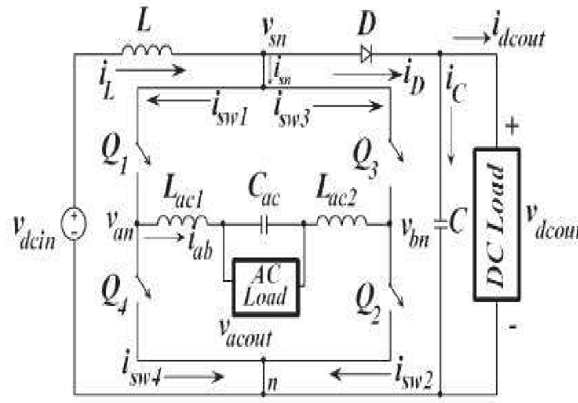


Fig 3 Proposed BDHC

other words they are act as a transformer but with constant voltage supplies instead of ac supply. This leads to increase in number of switches which in turns increases the switching losses and reduce the reliability. A conventional boost converter and a voltage source inverter have been used to implement the system which are connected in parallel or cascade form. The disadvantage of this model is electromagnetic interference (EMI) or other spurious noise may be produce. Mis-gating turn-on of the inverter leg switches may take place, resulting in damage to the switches.

B. *Proposed model*

The proposed topology is realized by replacing the controlled switch boost converter with a VSI bridge network. The resulting hybrid converter requires less number of switches to provide simultaneous multiple outputs with an increased reliability, owing to the inherent shoot through protection in the inverter stage. The operation of VSI in the hybrid converter would involve the use of dead time circuitry to prevent shoot through.

C. Explanation of the proposed model

The four bidirectional switches (Q1–Q4) of BDHC comprises the combination of a switch Sa and an anti parallel diode D. The boost operation of the converter can be comprehend by turning on both the switches of any particular leg. This is equivalent to shoot-through switching condition of VSI operation and it is not used in the case of a conventional VSI. However, for the proposed modification, this operation is equivalent to the switching on of the switch Sa of the conventional boost converter. The ac output of the BDHC is controlled using a modified version of bipolar sine-PWM switching scheme. In the BDHC, the switch node voltage (v_{sn}) acts as the input. It oscillates between the voltage levels v_{dcout} and zero. The switching scheme should ensure that the interval for power transfer with the source occurs only when vsn is positive, i.e., when v_{sn} is clamped to the dc output voltage v_{dcout}.

D. Modes operation of BDHC

Mode 1: During the positive mode of conduction the MOSFET switches S1 & S4 Conducts, thus the current flow in the primary of the transformer induces current in the secondary tapings 1 and 2. From the secondary tapings 1, D1 and D4 are forward biased and thus supply the load. From the secondary tapings 2, D5 and D8 are forward biased and thus supply the load. This mode ends when the MOSFET switches S1 &S4 are turned off. This interval is known as shoot through interval as it occurs when switches in the same leg are switched on at the same time. The duration of this decides the duty cycle. During this period the diode is in reverse bias.

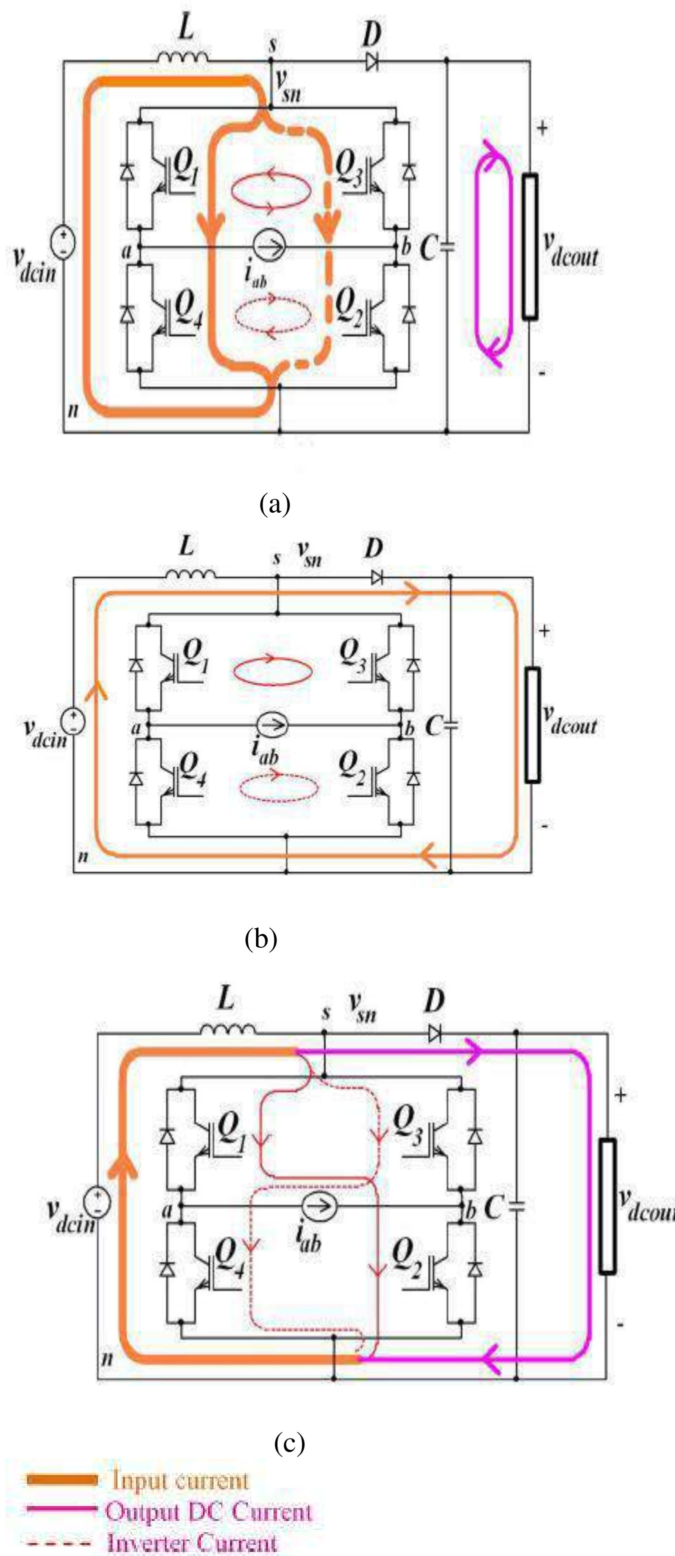


Fig 4 Modes of Operation (a) Shoot through interval, (b) Power interval (c) Zero interval.

Mode 2: During the negative mode of conduction the MOSFET switches S2 & S3

Conducts, thus the current flow in the primary of the transformer induces current in the secondary tapings 1 & 2. From the secondary tapings 1, D2 and D3 are reverse bias and thus supply the load. From the secondary tapings 2, D6 and D7 are reverse bias and thus supply the load. This mode ends when the MOSFET switches S2 &S3 are turned off. This interval is known as power interval. The diode is in forward bias in this period and is conducting.

Mode 3: This interval is known as zero interval. It occurs when the inverter current circulates along the bridge network. In this state it does not act as a source or a sink. The diode is in forward bias in this interval.

E. Mathematical Analysis

The dc output of the converter can be given by

$$\frac{V_{\mathrm{dcout}}}{V_{\mathrm{dcin}}} = \frac{1}{1 - D_{st}}.$$

where D_{st} is the duty cycle of the converter. The modulation index is M_a which is in the range of 0-1. The modulation is used to regulate the ac output voltage of the converter. The gain gets affected due to change in modulation index value. The relation between duty cycle and modulation index can be defined by,

$$\mathrm{M_a} + \mathrm{D_{st}} \leq 1.$$

Power expression for the dc and ac load is given by,

$$P_{dc} = \frac{V_{\mathrm{dcin}}^2}{R_{dc} * (1 - D_{st})^2}$$

$$P_{ac} = \frac{0.5 * V_{\mathrm{dcin}}^2 * M_a^2}{R_{ac} * (1 - D_{st})^2}.$$

III. CONTROL STRATEGY

B. Bipolar Pulse Width Modulation(BPWM)

Boost derived hybrid converter works when the input of the inverter bridge is in the power interval, as the diode conducts in the power interval. The inverter outputs assume more than one output, and hence, PWM modulation technique used is based upon bipolar PWM scheme. The bipolar PWM technique is inherently a 4-quadrant technique. The advantage of the bipolar PWM technique is that it only requires one PWM signal from the processor (two if the dead-time is generated within the PWM module itself). Assuming that dead-time is provided externally by the FET gate drivers, this means that on a processor with six independent PWMs can drive up to six DC motors using bipolar PWM.

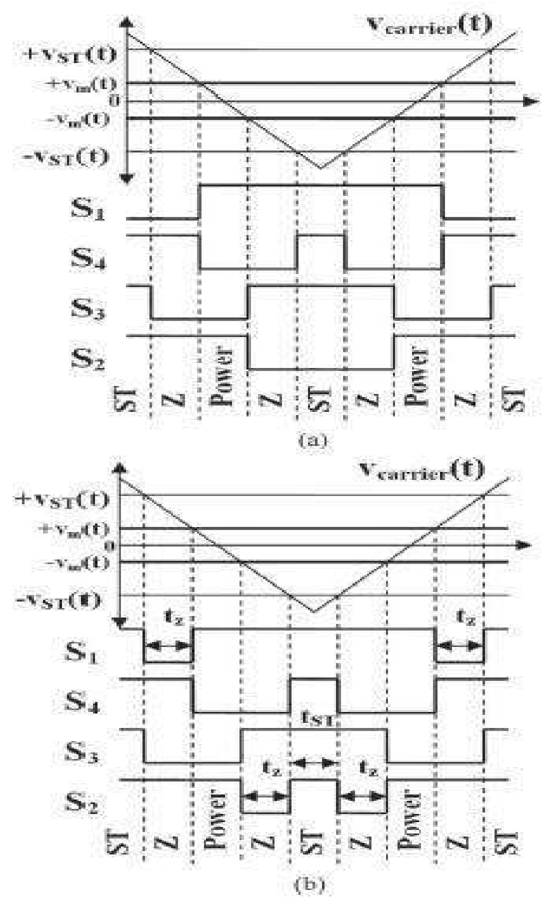
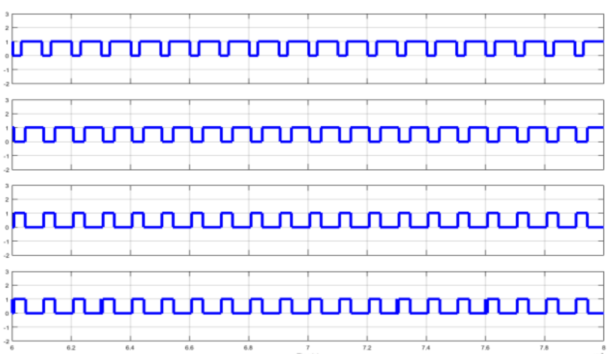


Fig 5 (a) Proposed BPWM scheme (b) Shoot through interval

IV. SIMULATIONS RESULTS

The simulation used is MATLAB. The Voltage Measurement block acts as an interface between the Sim Power Systems blocks and the Simulink blocks. The Voltage Measurement block converts the measured voltages into Simulink signals. Similarly, the Current Measurement block from the Measurements library of power lib can be used to convert any measured current into a Simulink signal. The input given is 48V and the dc output is 220V and the ac output is 300V. The pulse generator is based on bipolar PWM scheme.



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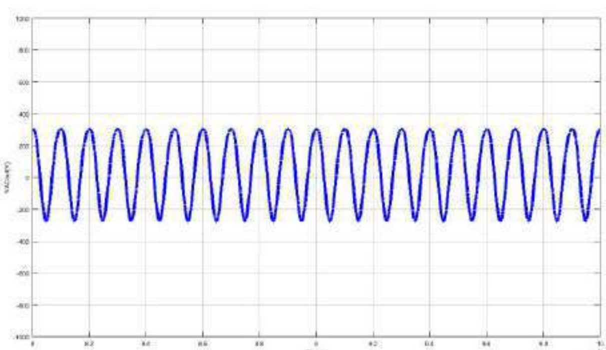

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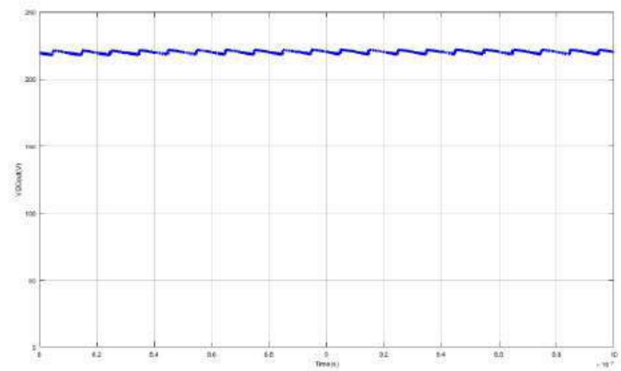

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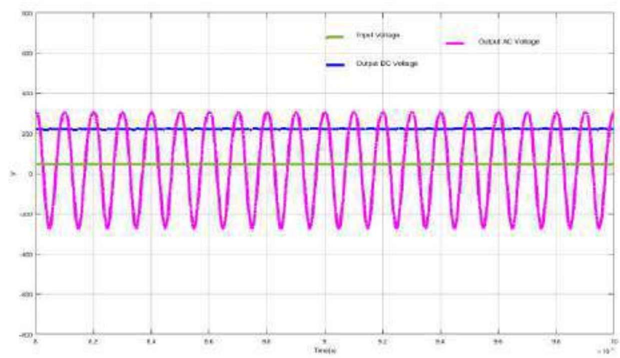

(d)

Fig 6 (a) Gate pulse given to the converter (b) ac output (c) dc output (d) Multiple output and input.

V. CONCLUSION

In this paper hybrid converter topologies which supplies multiple dc and ac loads from a single dc input has been proposed. It has the advantage of using single converter stage with shoot-through protection which has been described and compared to traditional VSIs. Using BDHC topology a high gain output has been obtained. The simulation results have been presented above.

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