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Design and Simulation of Boost Derived Hybrid Converter for Domestic Applications

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Abstract

Converters are used in a wide range of applications, from small switching power supplies in computers, to large electric utility high- voltage direct current applications that transport bulk power. Boost derived hybrid converter is use to supply both AC and DC load from the single input. The report of the project is based on the performance of MOSFET based model for boost derived hybrid converter with Sine-PWM technique. Unipolar Sine -PWM technique is apply for boost derived hybrid converter. Switching logic for generation of pulses on the basis of Sine-PWM is developed and simulated. Simulation of boost derived hybrid converter with resistive load is covered. A control card of pulse generation for boost derived hybrid converter is developed LM 324 Op-Amp and logical gate IC and tested. The main features of controller for SPWM generation are simpler in design, low in cost, and maximum range of voltage control and compact in size. Better accurate results are achieved in switching logic. Boost derived hybrid converter is simulated in PSIM software. The driver circuit is fabricated with required protection. The obtained results show the required performance of that circuit. Open loop testing of boost derived hybrid converter is done in proto type. The waveform at each stage of power circuit and control circuit are observed for verifying the required output and results obtained are as per requirement.
Keywords: Boost Derived Hybrid Converter (BDHC), MOSFET, Sine-PWM, PSIM

I. INTRODUCTION

In the area of the uninterrupted power supply like fuel cell application, solar photo voltaic voltage source, inverter is widely used. In modern power system nano-grid architecture is connected with inter connected power system. Nano grids are small power supply used to serve the separate -building or house. In this system different sources of energy with power electronics converter used to supply ac and dc loads. In conventional converter has only two conversion stage are used to supply both ac and dc output. Conventional converter use the dc-dc converter to supply the dc load and dc-ac converter for supplying ac load. But in hybrid converter there is only one conversion stage to supply both ac and dc loads [1].

In this paper suggest that there are wide changes in power system. Generator unit having both renewable and non-renewable energy sources are inter connected at distribution level in power system. Using the power electronics electrical power utilized efficiently. In power electronics different devices are available like ac-ac converter, dc- dc converter, filter etc. In the interconnected system power electronics conversion is essential part. Traditional voltage source inverter operation required dead time circuit to provide protection in shoot trough operation in which both switches of one leg in on at same time. And also because of electromagnetic interference (EMI), miss gating result into turn-on of the inverter leg Switches damage the switches. Hence the voltage source inverter required highly reliable with proper measurement of EMI and miss gating[2].

In this paper present hybrid converter presented which is called Boost Derived Hybrid Converter supply dc and ac loads from a single dc input. In this technique single control switch of converter is replaced by the H-bridge inverter. It has lesser number of switches. It has the essential shoot-through protection hence output has the high reliability. A proper pulse width modulation control strategy is designed using the fuzzy logic for BDHC in this paper. It is implemented by using output voltage as feedback. Which improve the performance of BDHC. The simulation and result of dc and ac output voltages shown in this paper [3].

This paper introduces new hybrid converter which can supply simultaneously both type of load. This new Converter is designed from the single traditional Boost and Buck-Boost converter. In this traditional switch is replaced by the H bridge inverter. It has advantages of reduced number of switches for supplying both loads, provide both outputs with an increased reliability, it provides the shoot through protection in the inverter stage. PWM control, based upon unipolar Sine-PWM is used to control switches. Simulation of boost and buck boost derived hybrid converter perform in the MATLAB [4],[5].

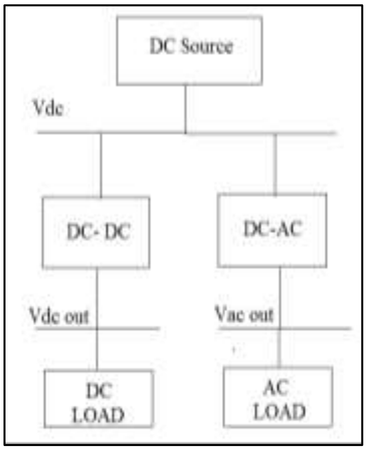

Fig. 1: Conventional converter

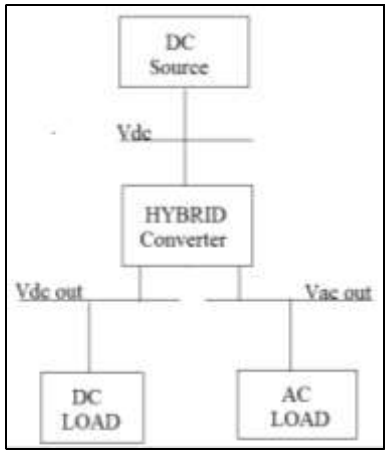

Fig. 2: Hybrid converter

Shoot through operation in inverter prevent by switching the both switch simultaneously. Shoot-through operation in inverter because of the EMI in a voltage source inverter prevent by using the Z- source inverter. In the Z- source inverter unique impedance network at the input which allows a both the switches of an inverter leg can be turned on simultaneously [6]. For the clean energy renewable energy sources are connected in the smart residential systems. Because of the limited space, these energy sources are highly localized and have terminal voltage is small and have hundred watt power rating. Conventional converter consists two converters, a dc–ac converter and dc-dc converter provide both dc and ac outputs at vdc and vac, Z –source inverter provide the unique output which is not provided by the conventional voltage source and current source [7]. The Z-source inverter use single –stage buck –boost inverter topology it popularity increases. But boosting capacity of the converter restricted therefor it is not suitable for the boosting up very high voltage where many dc-dc boost converters are connected. This will result into loss of efficiency. For the higher gain achieved by the extended boost Z source inverter which utilized the z-source topology [8], [9].

The Z source inverter control method and their relationships between the boost voltage and modulation index. A maximum boost control is presented to produce the maximum voltage boost under a given modulation index. The relationships of voltage gain versus modulation index and voltage stress versus voltage gain are analyzed. Two constant boost-control methods for the Z-source inverter are proposed, which obtain maximum voltage gain at any modulation index without producing any ripple. Which indicate the relation between the output frequency and stress voltage. There for the Z-network need will be independent of the output frequency and the switching frequency is use to determined it. Voltage gain to modulation index relationship is analyzed and verified by simulation and experiments [11],[12].

Cascaded boost controller design methodology is given. Cascade boost converter with a single switch using current-mode control is studied in this paper. The control scheme is basically depend on the switch current sensing and apply for feedback purposes. In this method current loop is introduced, and the fourth-order dynamics of the converter is changed to a dominant first-order, which make controller design simple. A conventional controller is designed for current loop[16].

This paper suggests a bidirectional dc converter which has the high conversion ratio. Therefor is has the capability of bidirectional power flow. There are two stages of the boost conversion which result into high voltage step-up conversion. And in this converter low voltage step-down conversion is used to achieve power flow direction. Compare to the traditional boost converter the proposed converter has wide conversion ratio which result in higher or lower output voltage. Active snubber is implemented to decrease the switching losses and limit the voltage stress on the power switch [17].

II. BDHC AND SWITCHING SCHEME

DC-DC converter is used for the conversion of the DC voltage of one level to another level using of filters. Output voltage of the dc converter depends on type of the converter like Boost, Buck, and Buck-Boost. Boost converter also called as step up converter. It provides output voltage more than its input voltage. Buck converter is step down converter. Its output voltage is less than input voltage. Buck-Boost converter provides the output voltage more or less than its input voltage. They are belonging to the class of switch mode power supply with two semiconductor device and one energy storage element. In the dc converter voltage ripple.

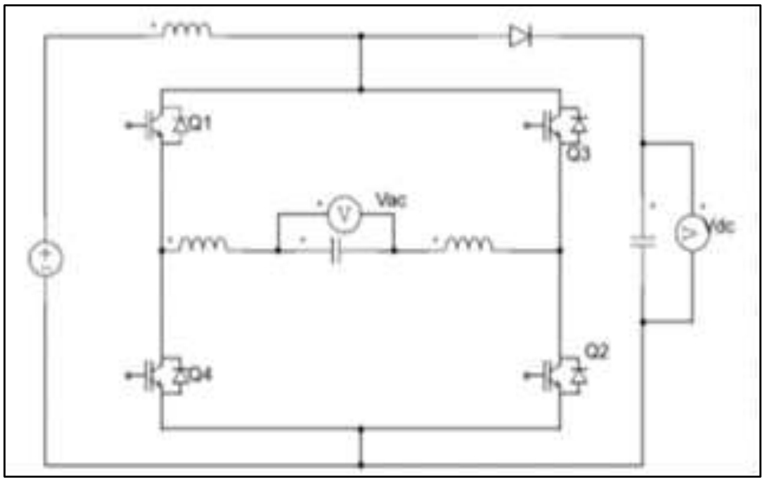

Fig. 3: Boost Derived Hybrid Converter

Normal Boost converter use to supply the dc load only for higher or lower output voltage. But the hybrid converter is use to supply the both ac as well as dc load. This is due to its design. In conventional Boost converter only one switch is used but in this converter it is replaced by the voltage source inverter bridge connection of four switch. It is required less number of switch for the dual ac and dc output. Hence it is called Boost Derived Hybrid Converter because it derived from the conventional converter. Unipolar sine PWM technique employ with proper modulation index to control switches.

A. Switching Scheme

The basic principal of operation of BDHC converter is based on condition that positive voltage must connect to the inverter bridge in the mode of power inverter. Inverter output voltage modulated when switching node voltage is not equal to zero and when inverter output voltage equal to zero boost operation occur. Consider the inverter output voltage have three different values. Therefor unipolar sine- PWM scheme, which provides three voltage levels for output is used.

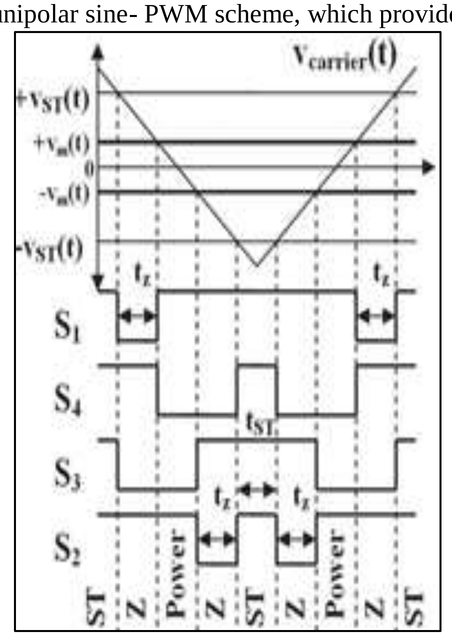

Fig. 4: PWM scheme

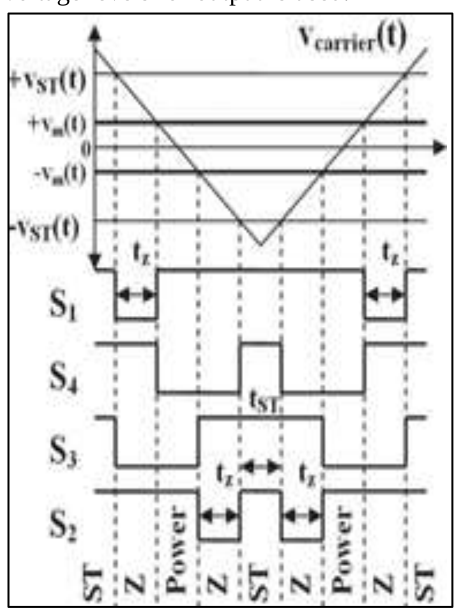

Fig. 5: Shoot through mode

For deciding the switching scheme shoot through operation is important. Shoot operation of the inverter occurs when the two switches of the one lag is turn on. It will indicate the power inverter operation of the converter. In this type of operation inverter current circulate through the one leg of the inverter. Figs 4 indicate this technique. And another operation of the switching scheme to turn on all the switches at same time. Fig 5 indicates this technique. But in this mode of operation all the switches need to conduct at same time. This will result in to circulation of inverter current through the bridge only. And this will result into the increase the stress on the switch and reduce the efficiency and increase losses in the converter. There for switching scheme in which only on leg of the inverter is conduct is selected to generate the switching signal.

III. WORKING OF BDHC CONVERTER

Operation of the boost converter realized by switching on the switch of the particular lag ($S1-S4$),($S2-S3$).Operation of the boost converter is equivalent to the conventional boost converter control the switching operation of the controllable switch. In this converter unipolar sine PWM technique is use to control the ac output. During the inverter operation BDHC converter has the same circuit as the voltage source inverter.

BDHC has three interval of operation:

A. *Shoot – through interval*

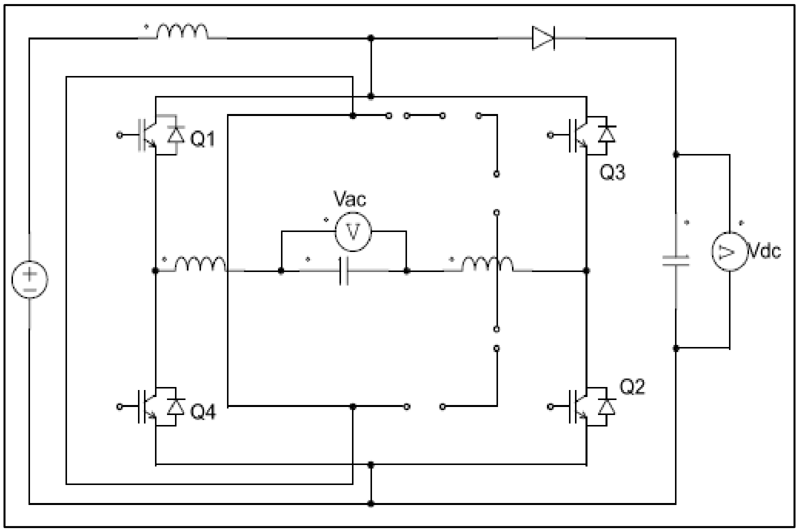

Fig. 6: Shoot – through interval

Figure shows the shoot-through operation of the boost converter. In the shoot through operation two switches of any particular lag is turn on. In this mode of converter operation any one lag of the converter is conducting and other is non -conducting. Duty cycle of the boost converter decided by the shoot through operation of the converter. Diode is reverse biased in this mode hence there is no dc output in this mode. Output current circulate in the bridge network of the inverter. In the VSI there is no such operation when switches from any particular lag are turn on. Such type of operation is provided by this converter.

B. *Power interval model*

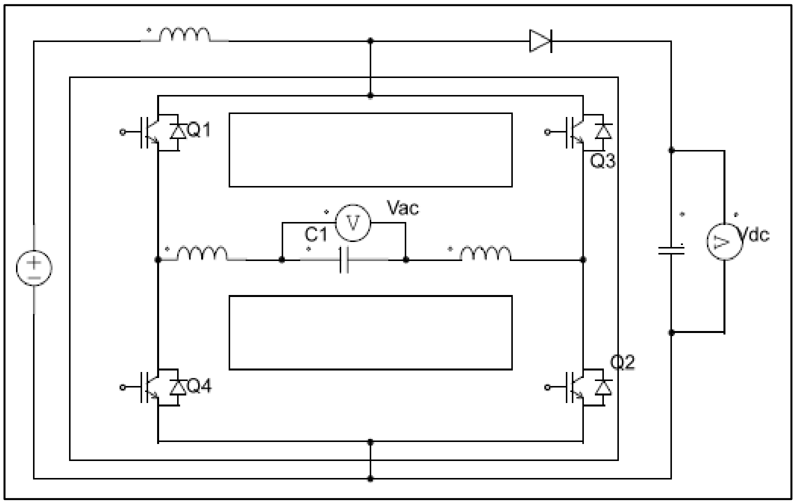

Fig. 7: Power interval

Figure shows the power interval operation of the boost converter. Inverter current enters or leaves the switch node in this mode of operation. Diode is conducting in this mode of operation so the dc output is available in this mode of operation. DC output available in power interval mode is equal to the switching node voltage. In this mode of operation only one switch from any particular lag is turn on. These modes of operation provide the dc output voltage.

(3) Zero interval mode:

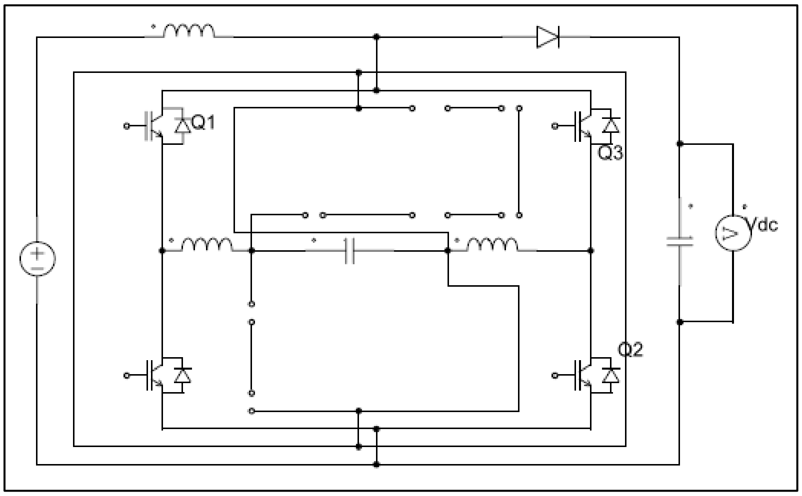

Fig. 8: Zero interval

Figure 8 shows the Zero interval operation of the boost converter. In zero interval mode of operation inverter is not sourced and inverter current circulates through the bridge network. In this mode diode is conducting.

IV. SIMULATION

For the simulation of control logic triangular wave is use as the reference signal. Two dc voltage signals Vm, Vst are used. In first part of the switching logic Boost Derived Hybrid Converter for AC and DC Output triangular wave is compared with V, and output of system are taken as the inputs of the logic gates. There are three logic gates are utilized in simulation AND, NOT and OR signal.

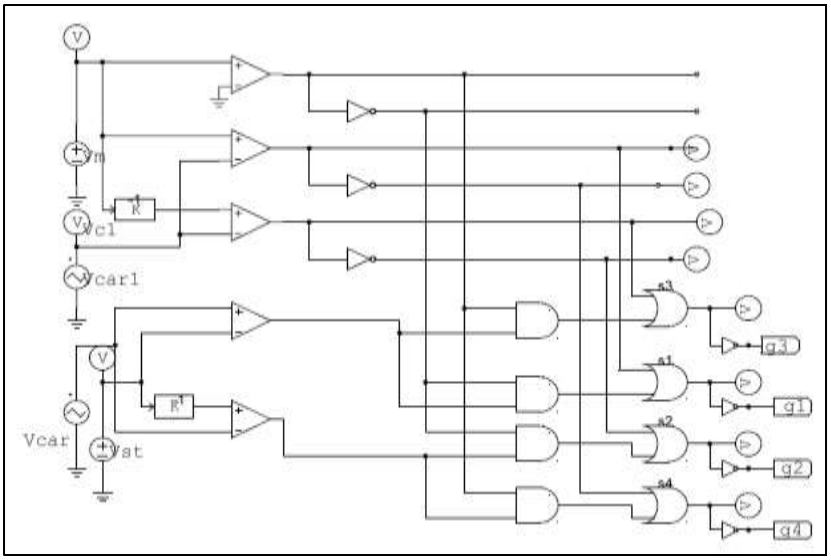

Fig. 9: PWM scheme

A. Waveform of PWM Scheme

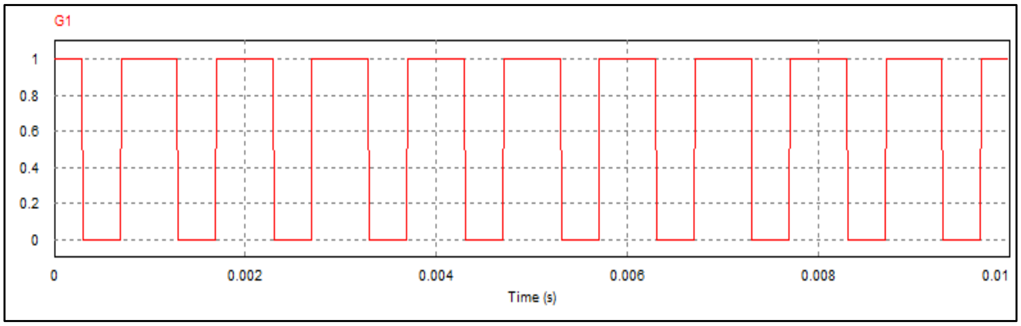

Fig. 10: Gate pulse G1

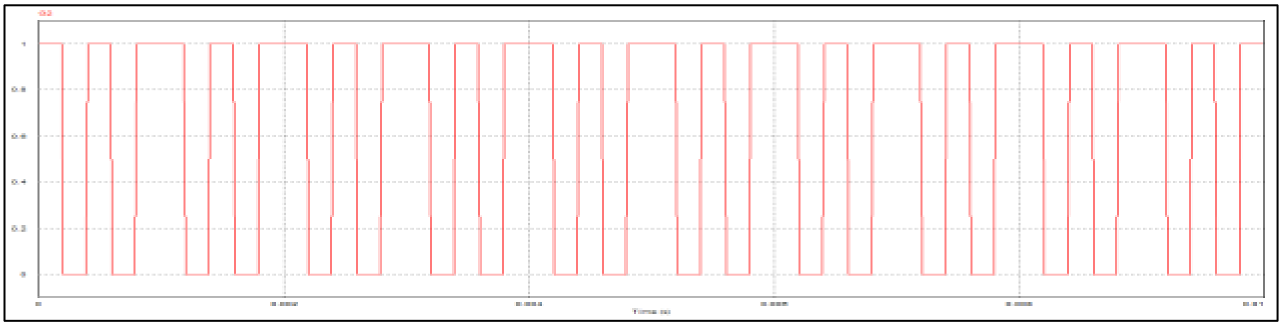

Fig. 11: Gate pulse G2

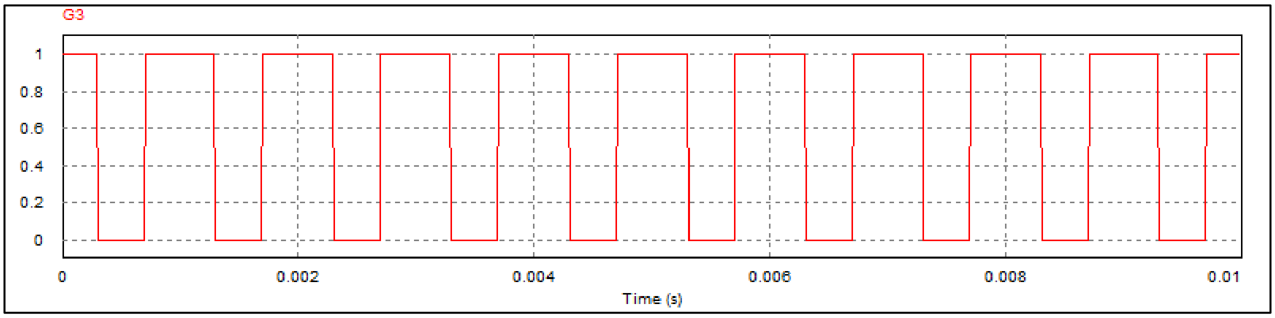

Fig. 12: Gate pulse G3

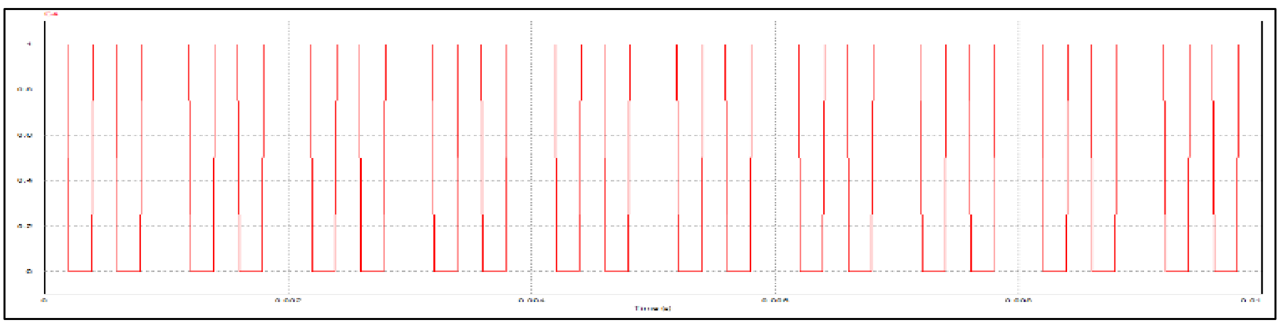

Fig. 13: Gate pulse G3

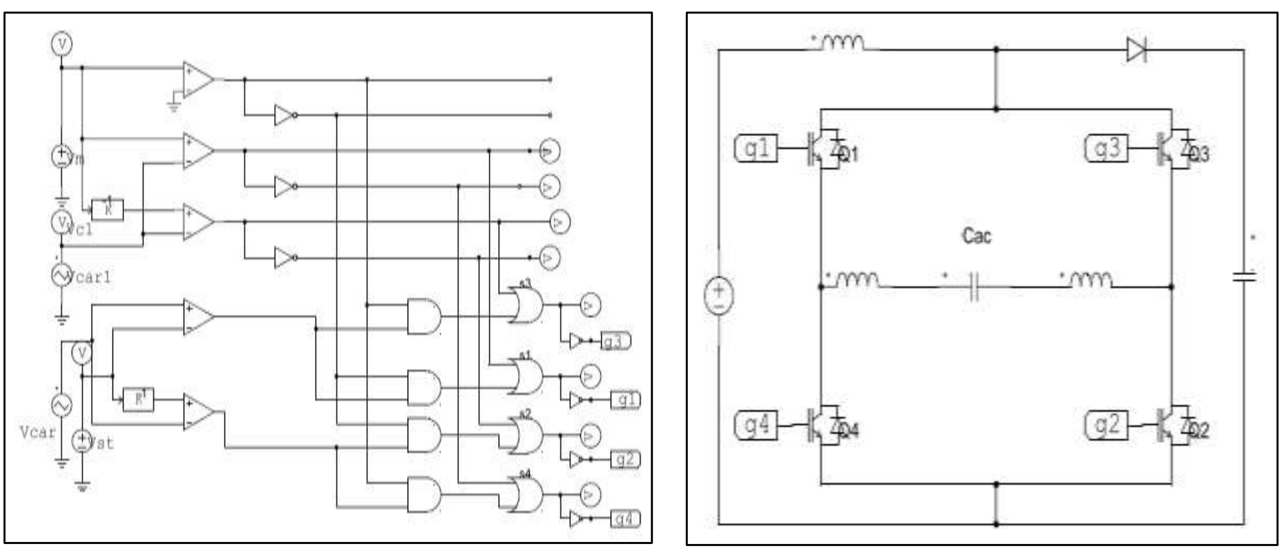

Fig. 14: Simulation of BDHC

B. Output of the Simulation

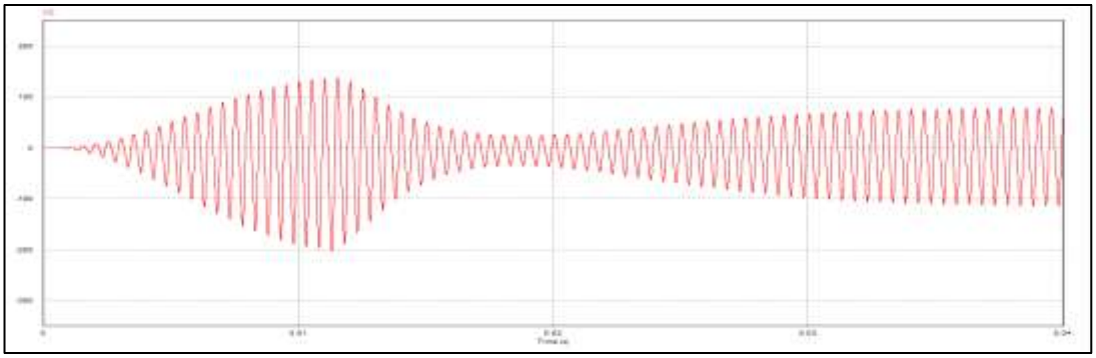

Fig. 15: AC output of converter

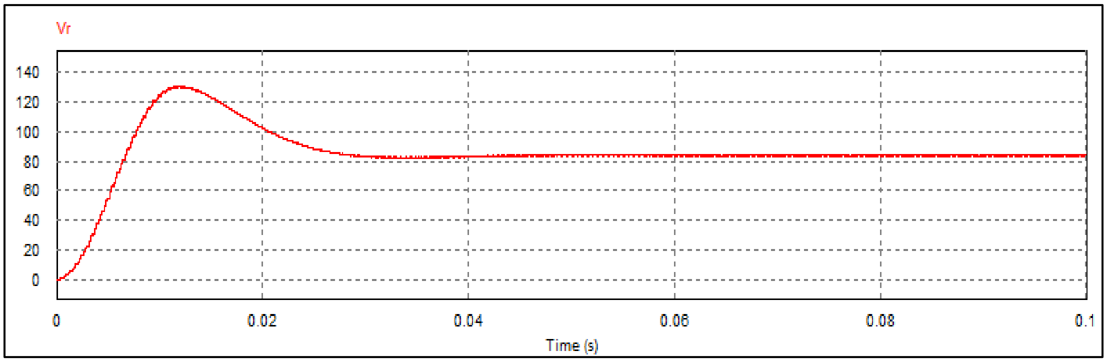

Fig. 16: DC output of converter

V. EXPERIMENTAL VERIFICATION

In this section hardware of the converter is tested for AC and DC output. And testing set up image of the converter and output images are shown in this section. Table of the components use in this project work also given this section.

Table - 1
List of Components

Sr. No.	*Name of Components*	*Model*
1	*MOSFET*	*IRF540N*
2	*Driver IC*	*MCT2E*
3	*OP-Amp*	*LM-324*
4	*Gate IC*	*CD 4093*
5	*Boost Capacitor*	*470uF*

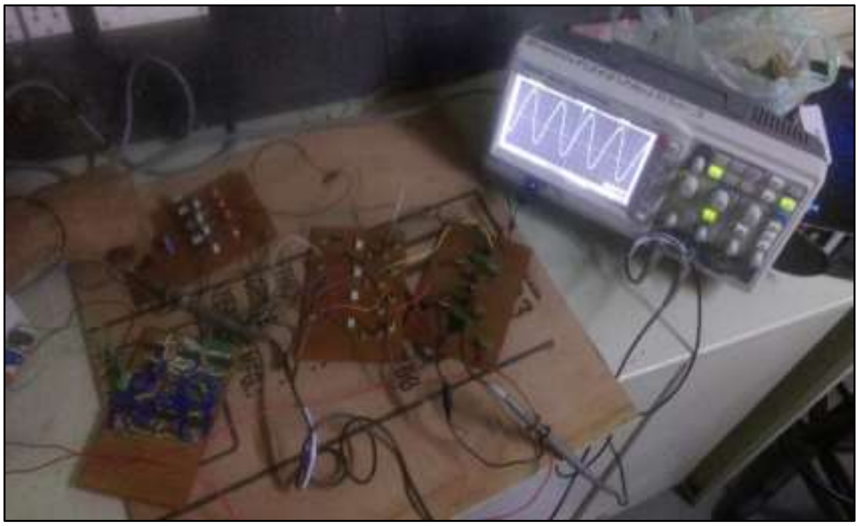

Fig. 17: Testing of AC output of BDHC

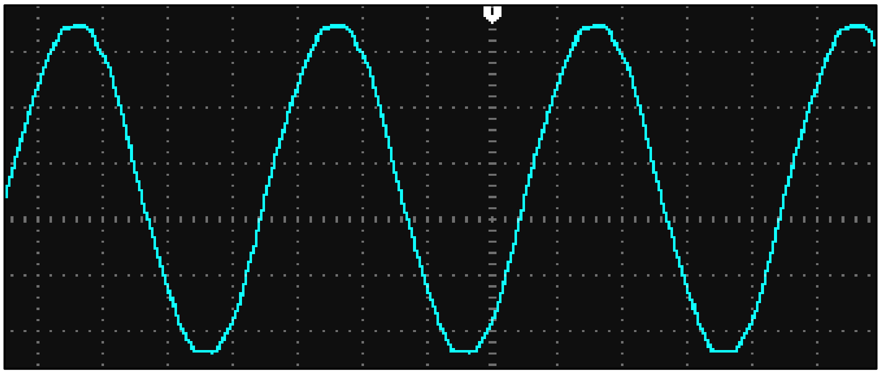

Fig. 18: AC output of BDHC

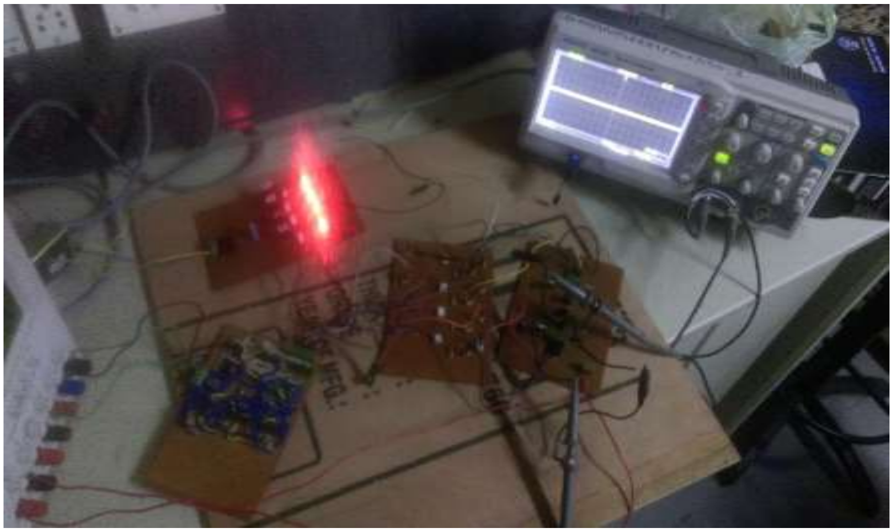

Fig. 19: Testing of DC output of BDHC

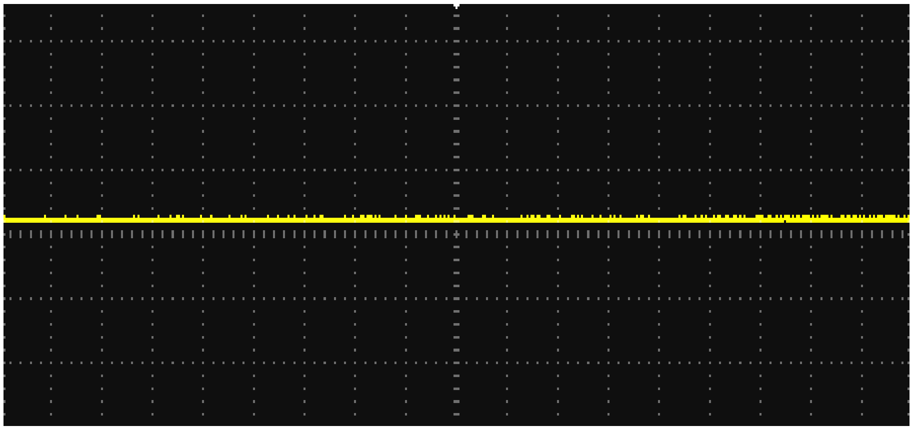

Fig. 20: DC output of BDHC

VI. Conclusion

Different topologies are referred for final selection of Boost derived hybrid converter.. Finally Unipolar sine-PWM topology boost derived hybrid converter selected. After topology selection, required components according to given specification for proposed MOSFET boost derived hybrid converter is designed. Using design data, simulation is performed in PSIM 9.0.3 software. A LM 324 op-amp is used to generate unipolar sine-PWM waveforms required for gate triggering pulses boost converter. From simulation of boost derived hybrid converter, it is found that dc and ac voltage is almost constant after initial fluctuation. It provides the AC output voltage 24 V and DC output voltage upto 40 v. In proto type, open loop testing is done till 30 volt DC with satisfactory results.

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