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Boost Derived Hybrid Converter (BDHC)

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Abstract: This paper presents a family of hybrid converters which can supply simultaneous dc and ac loads from a single photovoltaic input. These topologies are realized by replacing the control switch of single-switch boost strategy by using a single phase or three phase voltage source inverter. The pulses are provided to the switches by using a technique termed as Unipolar sine-wave PWM. The proposed converter involves higher reliability using lesser number of switches to drive both AC and DC loads simultaneously. The higher reliability is due to essential shoot – through operation. Thus the higher reliability and better power processing density can be well suited for various nanogrid applications. In addition to the above advantages, the use of dead time circuitry prevents inherent shoot – through and electromagnetic interferences are also avoided.

I. INTRODUCTION

In this system there is DC power as well as AC loads supplied by different kinds of energy sources(example:solar power) using efficient power electronic converters. Fig (b) shows the schematic of the system in which single DC source supplies both AC and DC loads. Fig (a) shows the conventional architecture in which DC and AC loads are supplied by separate DC-DC converter and DC-AC converter from a single DC source respectively, whereas in Fig (b) a Boost Derived hybrid converter is used in which a single converter stage performs both ac and dc operaation. This hybrid converter has the property of higher improver reliability and power processing capability and resulting from the inherent shoot through protection. This paper investigates the steady state analysis and use of single boost stage architecture to supply hybrid loads.

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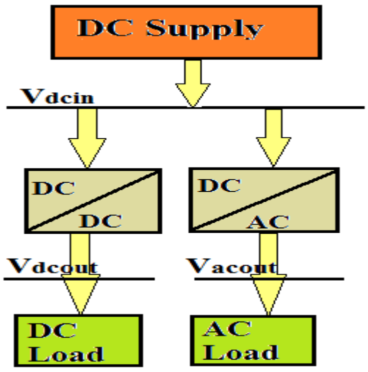
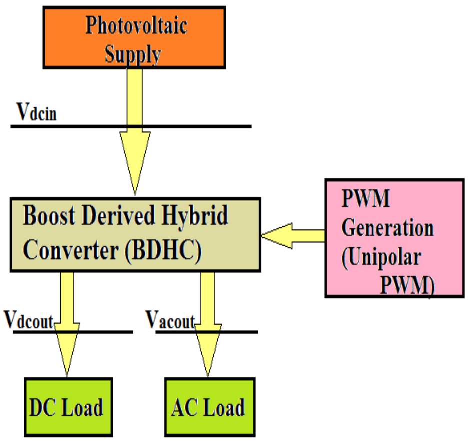
The conventional voltage source inverter in Hybrid converter would involve the use of dead time circuitry to avoid the shoot-through. Also turn-on of switches may take place due to spurious noise resulting in damaged the switches.. So VSI in such application need to highly reliable and fast response with appropriate measures against shoot-through and EMI induced misgating.



(a) CONVENTIONAL TYPE



(b) BOOST DERIVED HYBRID CONVERTER

II. BOOST-DERIVED HYBRID CONVERTER

A. Proposed circuit modification:

Boost Derived hybrid converter circuit is having two switches, one is a controllable switch (controls the duty cycle) and other can be implemented using a diode. Hybrid converter can be realized by replacing controllable switch in the boost circuit by using, either a single phase or three phase voltage source inverter (VSI). The resulting converter is called Boost Derived Hybrid converter.

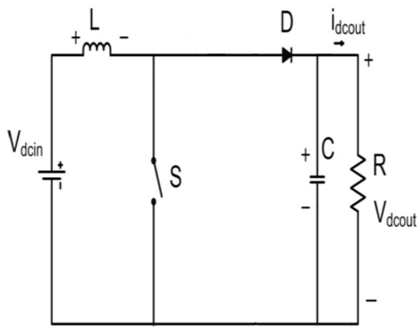


Fig. 1(a) Circuit Diagram of Conventional Boost Converter

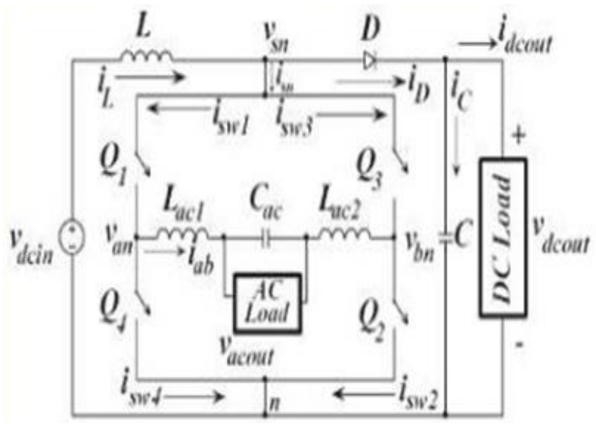


Fig. 1(b) Circuit Diagram of Boost Derived Hybrid Converter

B. Derivation of BDHC Topology:

The control switch S of a conventional boost converter [shown in Fig. 1(a)] has been replaced by the bidirectional single-phase bridge network switches (Q1–Q4) to obtain the BDHC topology [shown in Fig. 1(b)]. This proposed converter provides simultaneous dc output (vdcout) and ac output (vacout) in addition to the provided ac output (vacout) by the boost converter. For the BDHC, the Q1-Q4 switches are used to control the hybrid outputs

Thus, the challenges involved in the operation of BDHC are the following:

1) Defining the duty cycle for boost operation and the modulation index for the inverter operation
2) Determination of voltage stresses to currents through different circuit components and their design
3) Control and channelization of total input power to both ac power and dc power loads.

C. Operation of BDHC:

Each of the four bidirectional switches (Q1–Q4) of BDHC comprises the combination of a switch Si and an antiparallel diode Di (i=1 to 4). The boost operation of the proposed converter can be performed by turning on both switches of any one leg (either S1–S4 or S3–S2) simultaneously. This is equivalent to shoot-through switching condition as far as Voltage Source Inverter operation is concerned, and it is strictly forbidden in the case of a conventional VSI.Nonetheless, for the expected variation, this operation is equal to the switching "on" of the switch "Sa" of the conventional boost converter [see Fig. 1(a)]. The ac output of the BDHC is being controlled by an altered version of unipolar sine-PWM switching scheme. The Boost Dual Hybrid Converter, during inverter operation, has the same circuit states as a conventional VSI. In BDHC, the switch node voltage (vsn) acts as the input to the inverter to switch between the voltage levels—vdcout 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 vsn is clamped to the dc output voltage vdcout. The BDHC has three distinct switching intervals as described below.

1) Interval I—Shoot-through interval:

The equivalent circuit schematic of the BDHC during the shoot-through interval is shown in Fig. 2(a). The shoot-through interval occurs when the pair of switches (either Q1–Q4 or Q3–Q2) of any one leg is turned on at the same time. The shoot-through interval period determines the boost converter's duty cycle (Dst). The reverse biased diode during this period is "D". The inverter output current flows in the bridge network switches. Thus, the additional switching states are allowed in BLDC which are strictly not allowed in a VSI.

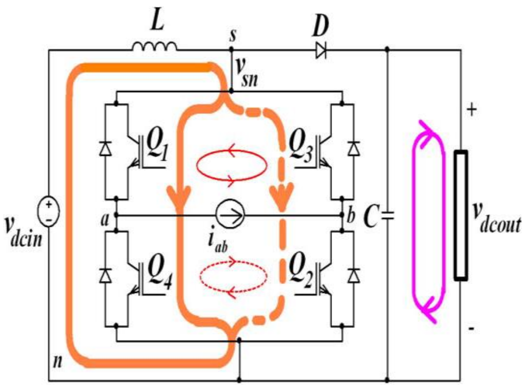


Fig 2(a) Shoot – through interval of BDHC

2) Interval II - Power interval:

In this interval, either Q1–Q2 or Q3–Q4 is turned on. The power interval shown in Fig. 2(b), 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. The reference directions for the voltages and currents have been shown in Fig. 2(b).

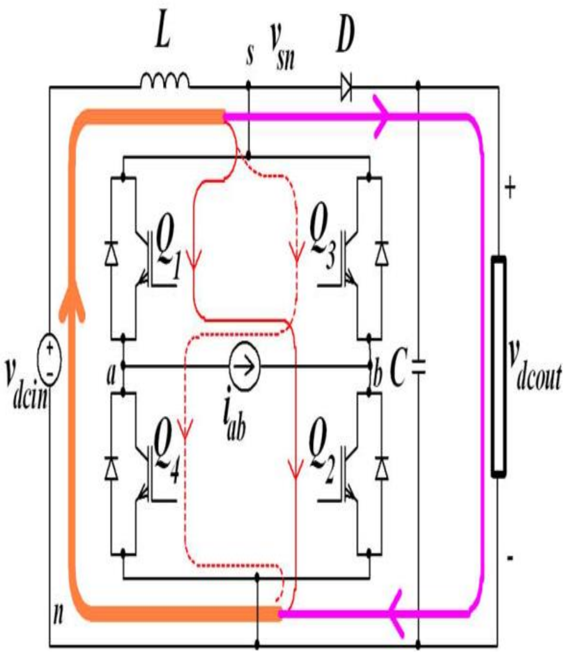


Fig. 2(b) Power Interval of BDHC

3) Interval III—Zero Interval:

The zero interval arises when the inverter current flows among the bridge network switches and is not sourced or sunk. The diode "D" conducts during this interval. Fig. 2(c) shows the equivalent circuit for this interval.

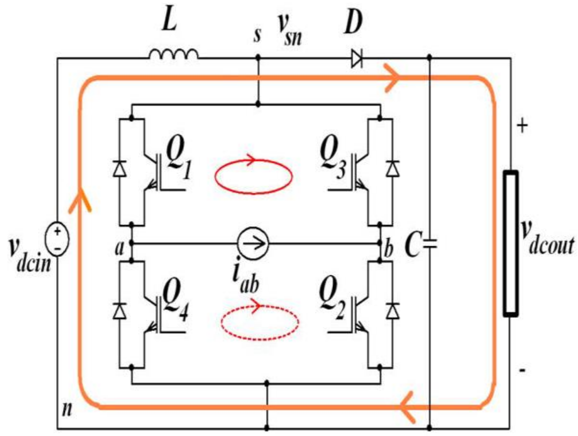
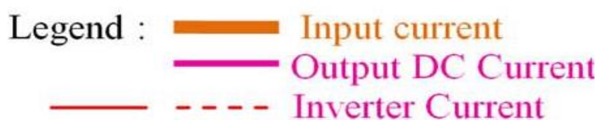


Fig. 2(c) Zero Interval of BDHC



III. CALCULATION

Let input dc voltage = 48V, output dc voltage = 100V, then,

Vdcout / Vdcin = 1 /(1 - Dst)

⇨ 100 / 48 = 1 / (1 - Dst)
1 – Dst = 48 / 100 = 0.48

Dst = 1 – 0.48 = 0.52

⇨ **Dst = 0.52**

Ma + Dst = 1

Ma = 1- 0.52

⇨ **Ma = 0.48**

Ma = Am / Ac

When Ac = 1,

Am = 1 * 0.48

⇨ **Am = 0.48**

Dst = Ton / T = 0.52

Ton = 0.52 * T

Where T is the total time period and T =

1 / F (F denotes frequency)

Let F = 20khz, then,

T = 1 / 20k

⇨ **T = 5 * E^{-5} sec**

Ton = 0.52 * 5 * E^{-5}

⇨ **Ton = 2.6 * E^{-5} sec**

Vacout / Vdcin = Ma / (1 - Dst)

Vacout = (0.48 * 48) / (1- 0.52)

⇨ **Vacout = 44.307 V**

IV. UNIPOLAR PWM TECHNIQUE

Since the electrical converter output voltage assumes 3 totally different values, the PWM (Pulse breadth Modulation) strategy is predicated upon unipolar sine-PWM theme, that provides 3 voltage levels for the output. during this theme, the triangular carrier wave shape is compared with 2 reference signals that ar positive and negative signal. In unipolar voltage change, the output voltage switches between zero and Vdc or change event is halved within the unipolar case from 2Vdc to Vdc. The effective change frequency is doubled and also the voltage pulse amplitude is halved. because of this, the harmonic content of the output voltage wave shape is reduced compared to bipolar change.

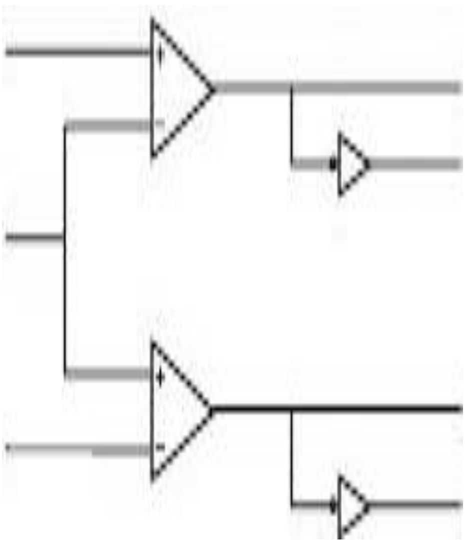


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Fig. 3 Unipolar Sine – Wave PWM

V. PWM - SIMULINK DIAGRAM

Fig. 4(a) shows the Simulink model for the modified unipolar PWM control strategy. The signals are provided to gates of the controllable switches S1-$S4$. (t) The shoot through interval is controlled using a DC signal, hence adjust the duty cycle for the boost operation.The inverter operation is controlled by (t) for modulation index. Fig. 5(a) and 5(b) shows the DC and AC output voltage waveform. DC voltage gain that can be achieved by BDHC is equal to boost converter, and is around four to five. Maximum value of AC voltage is comparable to input voltage.

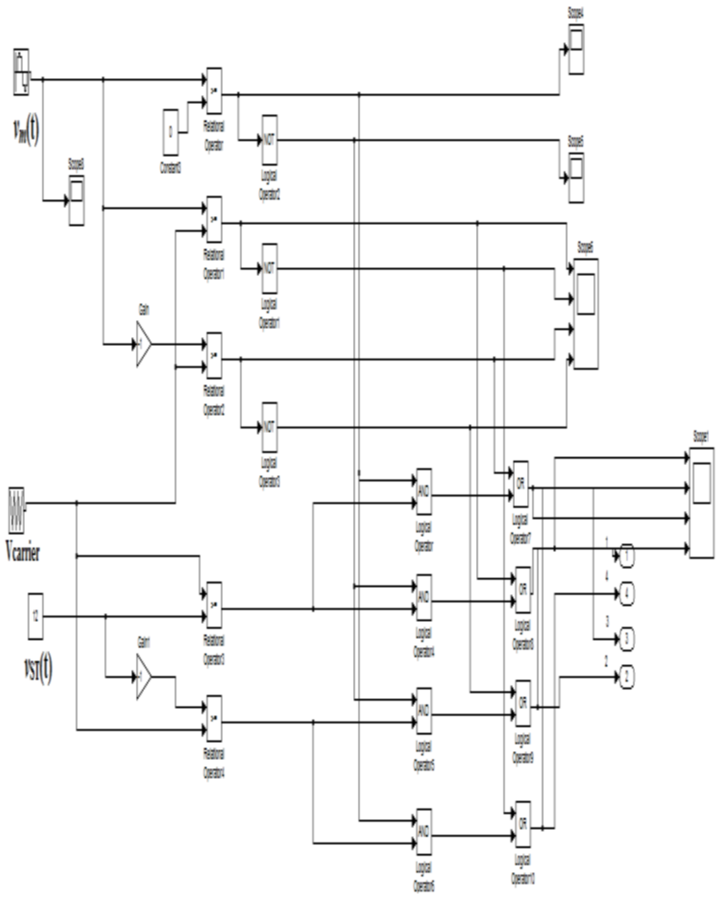

Fig. 4(a) PWM Simulink Diagram

VI. BDHC – SIMULINK DIAGRAM

For simulation of the proposed hybrid converter Parameters of the different circuit components are taken as: Input inductor (L) =5mH, DC capacitor (C) =1 mH, AC filter inductor (Lac = $Lac1$ + $Lac2$) =500μH, AC filter capacitor (Cac) =10μF, DC load Rdc = 20Ω, AC load Rac =10 Ω and Switching frequency is taken as 20 KHz.

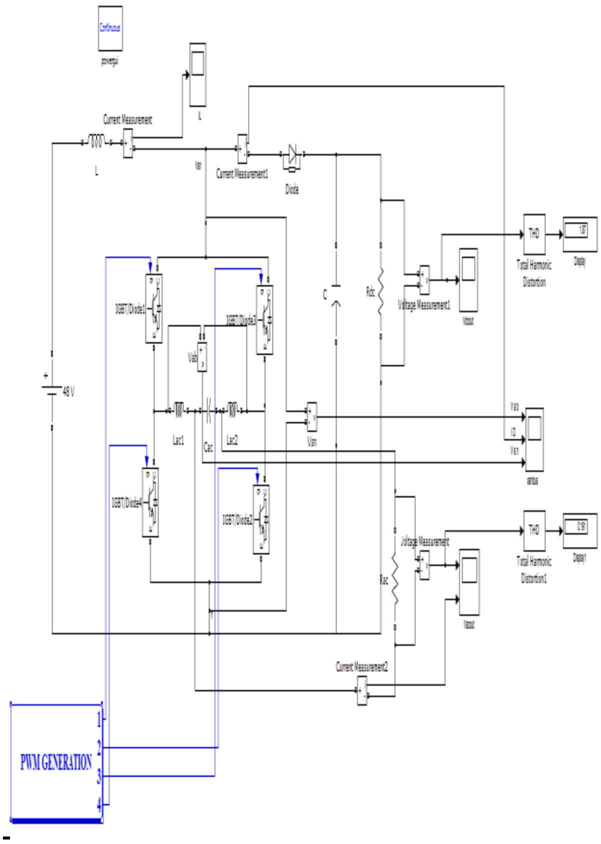

Fig. 4(b) BDHC SIMULINK DIAGRAM

Fig. 5(a) and Fig. 5(b) represent DC and AC output waveforms respectively as shown below

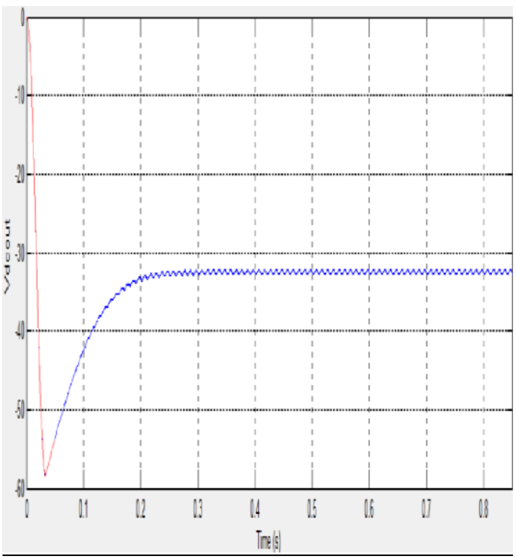

Fig. 5(a) DC Output waveform

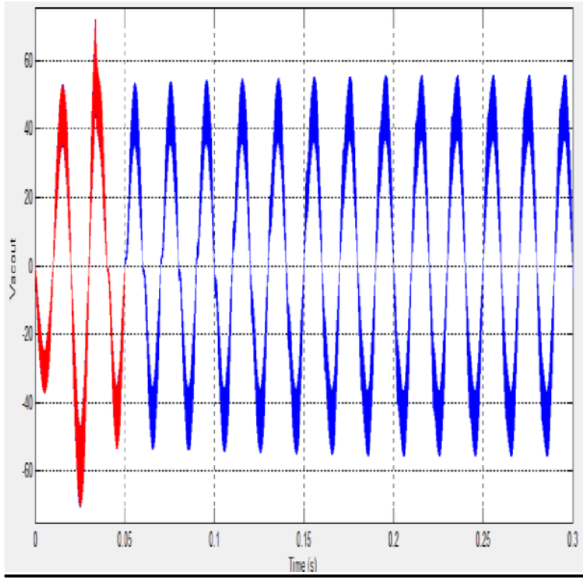

Fig. 5(b) AC Output Waveform

VII. Benefits OF BDHC

The planned device has following advantages:

- Higher power process density
- Improved responsibility
- Lesser usage of elements in comparison to standard device sorts
- Inherent shoot-through protection
- The range of manageable switches is reduced in comparison to a lift cascaded {inverter|electrical device} topology each the VSI and boost converter ar controlled victimization identical bridge configuration, so reducing negative feedback circuit.
- The device will provide each ac and dc masses from one dc input provide. The device may also be custom-made to come up with ac outputs at frequencies aside from line frequencies by an acceptable alternative of the reference carrier wave shape.

VIII. CONCLUSION

This paper proposes new Hybrid device topologies which may provide at the same time each DC and AC masses from one DC provide. the 2 hybrid device topologies mentioned during this paper ar Boost Derived Hybrid device (BDHC) and Buck-Boost Derived Hybrid device (BBDHC).The planned hybrid converters has the subsequent benefits, shoot-through condition doesn't cause any downside on operating of the circuit thus improves the responsibility of the system, Implementation of dead time electronic equipment isn't required, freelance management over AC and DC output and also the device may also be custom-made to come up with AC outputs at frequencies aside from line frequencies by an acceptable alternative of the reference carrier wave shape.

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