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Hybrid Buck Boost Converter For Simultaneous DC And AC Applications

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Abstract-This work proposes a family of hybrid converter topologies which can supply simultaneous dc and ac loads from a single dc input. These topologies are realized by replacing the controlled switch of single-switch boost converters with a voltage-source-inverter bridge network. The resulting hybrid converters require lesser number of switches to provide dc and ac outputs with an increased reliability, resulting from its inherent shoot-through protection in the inverter stage. Such multi outputconverters with better power processing density and reliability can be well suited for systems with simultaneous dc and ac loads, e.g., nanogrids in residential applications. The proposed converter, studied in this paper, is called boost-derived hybrid converter (BDHC) as it is obtained from the conventional boost topology. The steady-state behavior of the BDHC has been studied in this work,and it is compared with conventional designs. A suitable pulse width modulation (PWM) control strategy, based upon unipolar sine-PWM, is described. A DSP-based feedback controller is designed to regulate the dc as well as ac outputs. A 600-W laboratory prototype is used to validate the operation of the converter. The proposed converter is able to supply dc and ac loads at 100 V and 110 V (rms), respectively, from a 48-V dc input. The performance of the converter is demonstrated with inductive and nonlinear loads. The converter exhibits superior cross-regulation properties to dynamic load-change events. The proposed concept has been extended to quadratic boost converters to achieve higher gains.

Index terms-Boost-Derived hybrid converter, PWM, Multi output converters, Hybrid Converter, Quadratic boost converter, Nanogrid, DC-Dc converter

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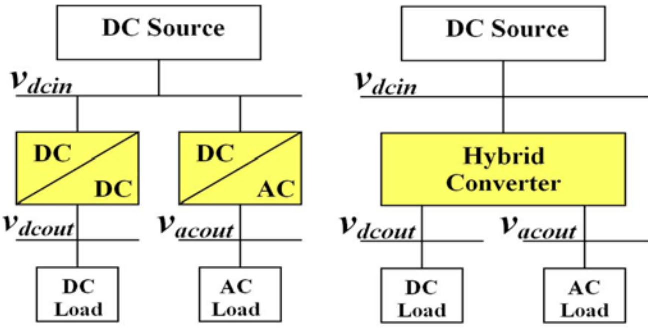
1 INTRODUCTION

NANOGRID architectures are being increasingly incorporated in modern smart residential electrical power systems. These systems 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 Fig. 1(a) uses separate power converters for each conversion type (dc–dc and dc–ac) while Fig. 1(b) utilizes a single power converter stage to perform both the conversions. The latter converter, referred to as a hybrid converter in this paper, has higher power processing density and improved reliability (resulting from the inherent shoot-through protection capability). These qualities 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 nonconventional 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 or in cascade , 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 paper 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.



(a) (b)

Fig1 (a).Conventional block diagram

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Fig1 (b).Proposed block diagram

2 PROPOSED CONVERTER TOPOLOGY

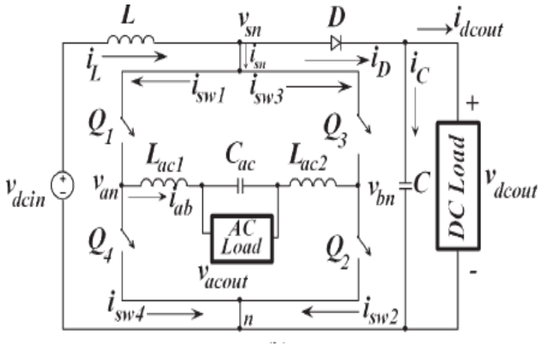

Fig 2(a) Proposed converter topology

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. 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 .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 realized by turning on both switches of any particular leg (either S1–S4 or S3–S2) 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 “Sa” of the conventional boost converter .

The ac output of the BDHC is controlled using a modified version of unipolar sine-PWM switching scheme. The BDHC, during inverter operation, has the same circuit states as a conventional VSI. The reason for this is as follows: For conventional VSIs (shown in Fig. 2a), although the input to the bridge is a voltage stiff dc bus, the input dc voltage is required only during the power intervals, i.e., when there is apower transfer with the source. In the other intervals, the current freewheels among the inverter switches and these states do not require the input to be at a fixed dc value and hence can be zero. In the BDHC, the switch node voltage (*Vsn*) acts as the input to the inverter; it switches between the voltage levels—V_{dc}out 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 V_{dc}out

3 SIMULATION MODEL

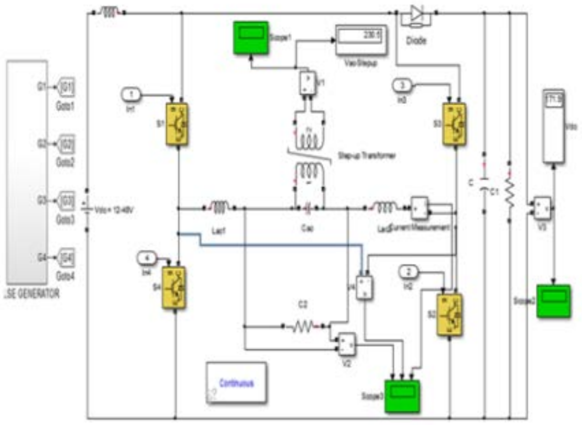

Fig 3(a) Simulink model of proposed converter

Fig 3(a) shows SIMULINK model of proposed converter topology which feeds dc and ac loads simultaneously. The following specification are used in simulation V_{dcin}=48V, L_{min}=72μH, C_0=1000μF, R_{dc}=20ohm, C_{ac}=6.41μF, L_{ac1}=L_{ac2}=1.95mH, R_{ac}=10. Resonant inductor (L_{ac}) and (C_{ac}) is determined by

$$L_{ac} = L_{ac1} + L_{ac2} = \frac{Q.R_{ac}}{\omega 0} \qquad (1)$$

$$C_{ac} = \frac{1}{Q.\omega 0.R_{ac}} \qquad (2)$$

4 SIMULATION RESULT

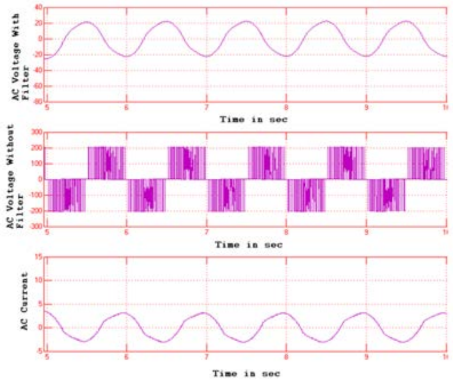

Fig 4(a) AC output voltage and current

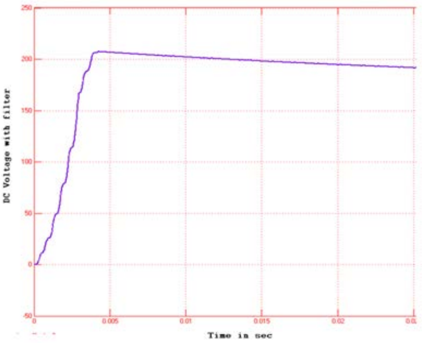

Fig 4(b) DC output voltage

From the above simulation result we can say that the proposed converter can feed both AC and DC load simultaneously form single dc source. Where in conventional converter separate DC-DC converter and inverter are required to feed dc and ac load respectively.

5 CONCLUSION

The proposed new converter topology which feed dc and ac load simultaneously from a single dc source is simulated using MATLAB/SIMULINK. The simulation results shows that it can perform as boost converter as well as single phase inverter without any problem of shoot–through condition and absolute control over AC and DC output and the converter can also be suitable to generate AC outputs at frequencies other than line frequencies by a proper choice of the reference carrier waveform and also transformer used across the AC outputs to get a desired AC output.

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