A Novel Converter Topology for Nanogrid Application

D. Sharmitha, S. Lalitha, B. Jeevitha

Abstract: ***In recent times, the use of standalone systems with renewable sources to meet individual energy demand is more encouraged by the government due to the following reasons: 1. Green Energy 2. Abundant 3.Fossil fuel depletion and Co2 emission. A new hybrid converter which can simultaneously provide buck, boost and inverted outputs from a single DC source for residential application is introduced in this paper. The proposed converter is a combination of two leg voltage source inverter (VSI) bridge network and a buck circuit, which replaces the switch (S) of a conventional boost converter. PWM control is employed to control the MOSFET switches. The proposed converter topology is simulated in MATLAB and the results are validated with the prototype. The reliability and number of switches employed compares favorably with alternate methods. This converter is capable of supplying AC and 2 DC loads at 110V (rms), 120V and 65V respectively from a DC source of 48V.***

Keywords: ***Voltage Source Inverter (VSI), Pulse Width Modulation (PWM) and Boost Derived Hybrid Converter (BDHC)***

I. INTRODUCTION

One of the prime objective of 12th five year plan (2012-2017) of INDIA is to provide electricity to all villages.Ministry of new and renewable energy (MNRE) have a target of achieving 175 GW of renewable installed capacity within the year 2022.MNRE has given a press report stating that a total of 62 GW of renewable power will be installed by November 2017, of which 27 GW installed since May 2014 and 11.79 GW since January 2017. In India, modern residential application use nano grid to meet their energy demand locally [1]. Thanks to power electronics conversion technology, which paved the way for the grid to supply AC and DC proficiently irrespective of the type of resource viz. Renewable & Non Renewable [2]. It can be seen from the Fig. 1 (a), (b) the basis of DC- DC, DC-AC power conversions delivering DC and AC load from a single DC source. The proposed hybrid converter topology is shown in Fig. 1(c). The merits of using hybrid converter are 1) Increased Energy Density 2) Harmonic minimization 3) Simple design 4) Consistency 5)

Flexibility. A hybrid converter can be employed in homes to operate AC/DC loads, Electric vehicles, etc. This paper aims to: 1) To implement a hybrid converter topology to supply AC and DC loads instantaneously. 2) To relate the performance of the proposed converter with BDHC 3) to justify with an experimental prototype the MBDHC static and dynamic performance.

Fig-1(a). Basic DC-DC converter

Fig-1(b). Basic AC_DC converter

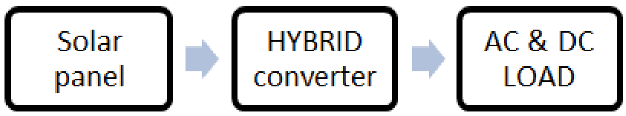


Fig-1(C).Hybrid Converter

The BDHC with single converter stage is compared with traditional VSIs is proposed in [3]. To relate the performance of the proposed topology with BDHC 3) to justify the outputs obtained from the MBDHC using an experimental prototype. Fig-1(a).Basic DC-DC converter Fig-1(b).Basic AC_DC converter Fig-1(c).Proposed converter. A single stage BDHC is related with traditional VSIs is presented in [3]. It describes how a class of converters are derived, with the use of BDHC and quadratic BDHC (QBDHC). [4] Proposed the Z-source inverter (ZSI), in order to mitigate the shoot-through problem due to VSI converter. A High gain enhanced ZSI topology is explained in [5]. A single stage four-switch switched mode converter is presented in [6]. [7] explained the implementation of forward-fly back converter topology to a PV System. This topology is capable to offer increased step-up voltages and efficiency.

This paper is organized as follows. Section 2 explains the structure of BDHC topology, its operating modes. Section 3 the implementation of BDHC in MATLAB and the results are discussed. Section 4 the implementation of Modified Boost Derived Hybrid Converter (MBDHC) in MATLAB and the results are discussed and validated with a prototype. Section 5 compares BDHC with MBDHC and last section concludes the paper.

Revised Manuscript Received on December 08, 2018.

D. Sharmitha, Department of Electrical and Electronics Engineering,Kumaraguru College of Technology, Coimbatore, Tamil Nadu, India

P. Maithili, Department of Electrical and Electronics Engineering,Kumaraguru College of Technology, Coimbatore, Tamil Nadu, India

J. J. Nandhini, Department of Electrical and Electronics Engineering,Kumaraguru College of Technology, Coimbatore, Tamil Nadu, India

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

II. EXISTING SYSTEM

In BDHC, the switch (S) of a conventional boost converter is changed to work as a single-phase bridge network having four switches (Q1–Q4) as shown in Fig-3. This existing converter can effectively supply AC and single dc output provided by the boost converter. The Pulse width modulation (PWM) strategy is used to control the switches (Q1–Q4).

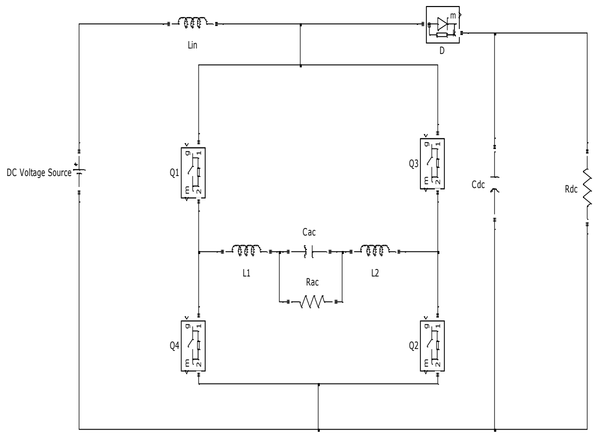


Fig-3 Boost Derived Hybrid converter Topology

Modes Of Operation

The BDHC will operate on three modes which are explained as follows.

Mode I: Shoot Through Interval

Shoot through interval operation of BDHC is shown in Fig-4 (a). In this mode, the switches are operated in two ways.

1. The switches in one specific leg of the bridge network either (Q1, Q3) or (Q4–Q2) is turned ON at that instant.
2. All the switches are turned ON is proposed in [10], [11].

The duty cycle (Dt) of the boost converter is determined by the time lapse of the shoot through interval. The diode (D) is reverse biased during this interval. The inverter current free wheels within the bridge network while supplying DC loads. Hence extra switching states is possible in MBDHC than VSI.

Mode II: Power Interval

When the current from the inverter passes in or out of Switch (S) in the bridge,the converter is said to function in the power interval mode. Here, either (Q1,Q2) or (Q3,Q4) is ON. The Diode(D) is forward biased. The direction of current flow is indicated in Fig-4 (b). The node vode is equal to VDC out.Thus, MHBDC supplies AC & DC loads instantaneously.

Mode III: Zero Interval

When the inverter current flows as shown in fig 4 (c) or when not used the hybrid converter operates in this interval. The Diode(D) is ON.

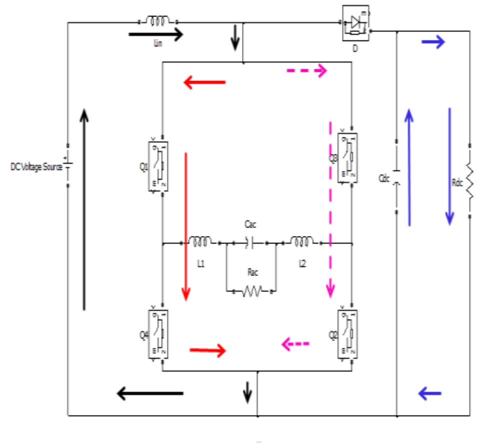


Fig-4(A) Shoot-Through Interval Mode

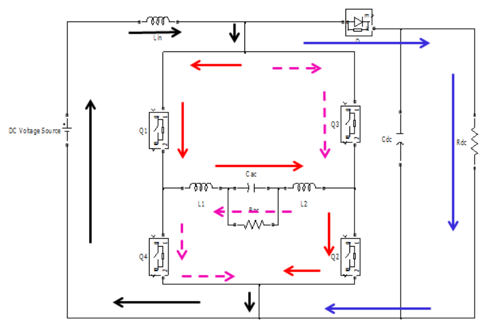


Fig-4(B) Power Interval Mode

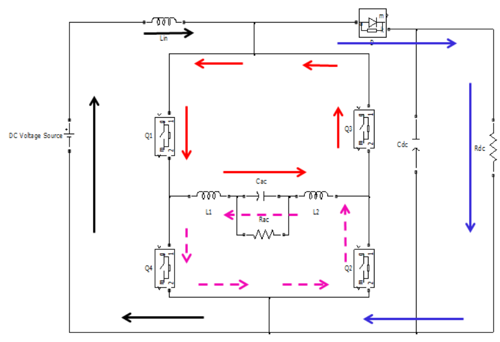
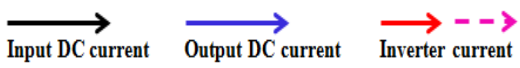


Fig-4(C) Zero Interval Mode



III. SIMULINK MODEL OF BDHC

The simulation of BDHC is carried out using MATLAB software. Fig-5 shows a simulation circuit diagram for BDHC which provides AC and DC instantaneously.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

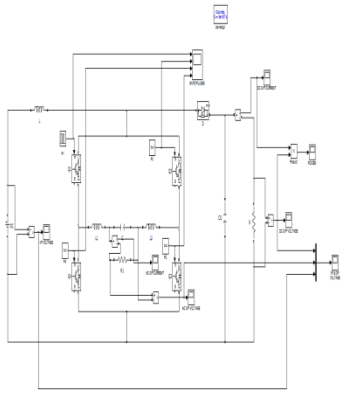


Fig-5 Simulation Diagram

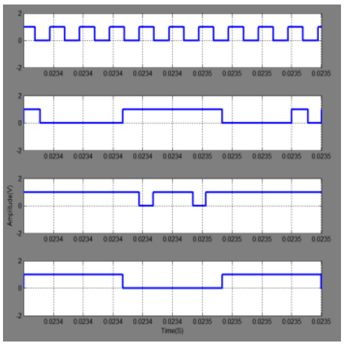


Fig-6 PWM Pulses

Fig-6 shows output of PWM controller circuit. It is clear from Fig-6 that the thyristor switches are triggered alternately.

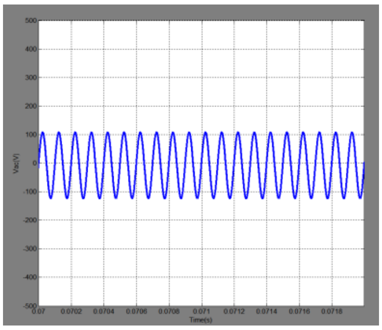


Fig-7(a).AC Output voltage.

It can be seen from Fig-7(a) that a uninterrupted AC Output voltage of 110 Vrms from the BHDC.

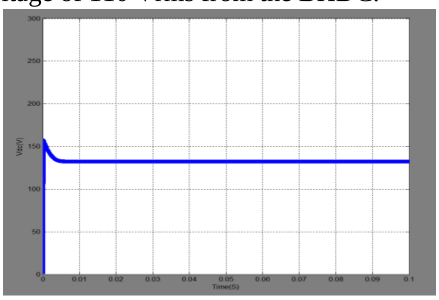


Fig-7(b).DC Output voltage.

Fig-7(b) shows that the 160 V_{rms} DC Output voltage output from the BDHC Simulink model.

IV. PROPOSED SYSTEM

The block diagram of MBDHC is shown in Fig-8. In order to trigger the thyristor switches for selective time interval, microcontroller is used. Buffer for current amplification. Gate driver is employed to separate power circuit and controller. Fig-9 shows the hardware design for MBDHC. The MBDHC model is simulated in MATLAB and the results are related with a prototype as shown in Fig-10. The reliability and number of switches employed compares favorably with alternate methods.

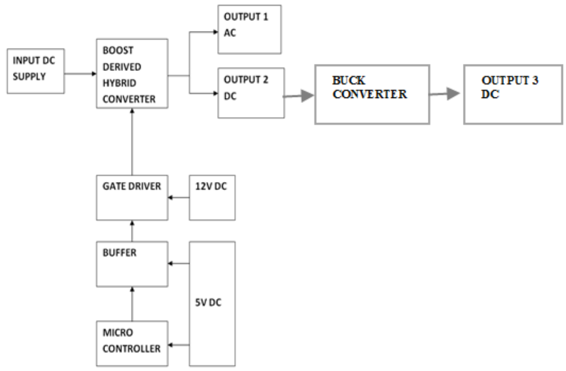


Fig-8 Block Diagram

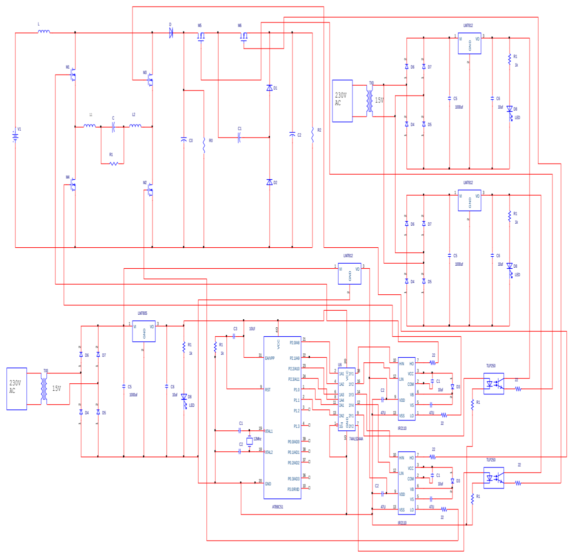


Fig-9. Hardware Design

This converter is capable of supplying AC and 2 DC loads at 110V (rms), 130V and 65V respectively from a DC source of 48V. Fig-11(a) shows the output waveform of MBDHC. It can be seen from the Fig-11(a) 48V DC is stepped to 110V rms (AC), DC output of 130 V from boost converter and buck converter output of 65V DC. Fig- 11(b) shows the boosted DC voltage output waveform, Fig-11(c) shows the extended converter is referred as b uck converter output in which boosted DC voltage is bucked to 65V.

*Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication*

Fig- 10. Prototype Model

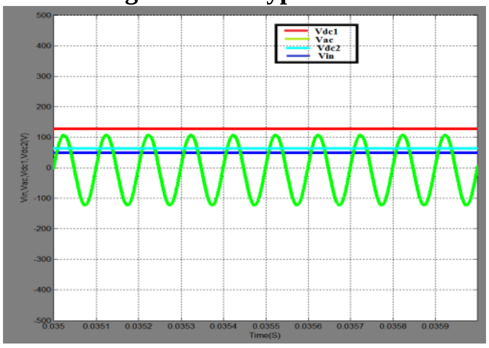


Fig-11(A). Output Waveforms

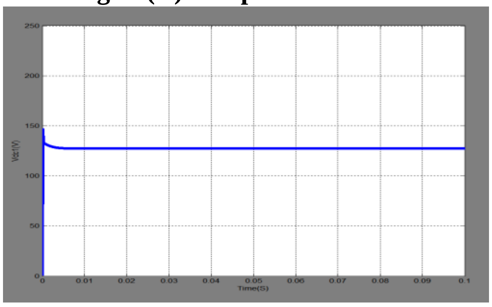


Fig-11(B) Boosted Dc Output Voltage

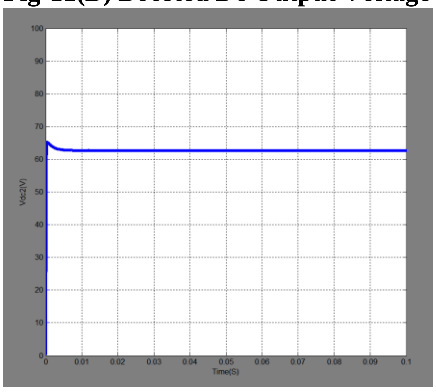


Fig-11(C) Bucked Dc Output Voltage

V. COMPARISON OF MBDHC WITH BDHC

The comparision of outputs of MBDHC with BDHC is shown in Table 1. Thus, the proposed hybrid converter topology is capable of supplying one AC load and two DC loads simultaneously with single DC source when comparedwith BDHC.

Output Variable	BDHC	MBDHC
V_{AC}	110 Vrms	110 Vrms
V_{DC1}	160V	130 V
V_{DC2}	-	65 V

VI. CONCLUSION

A novel Hybrid converter topology which can source instantaneously both DC and AC loads from a single DC source is proposed. The simulation results compromises favorably with hardware output. The future work can be extended to overcome harmonic mitigation on operating a heavy load at a given large input current ripple using a hybrid power filter as explained in [12].

The Modified hybrid converters has the following advantages:

- Shoot-through condition improves the reliability.
- The number of controllable switches is reduced.
- Simultaneously three outputs can be taken which is not possible in any other converter topology.

REFERENCES

1. D. Boroyevich, I. Cvetkovic, D. Dong, R. Burgos, F. Wang, and F. Lee, “Future electronic power distribution systems—A contemplative view,” in Proc. 12th Int. Conf. OPTIM Elect. Electron. Equip., Brasov, Romania, May 20–22, 2010, pp. 1369–1380.
2. F. Blaabjerg, Z. Chen, and S. B. Kjaer, “Power electronics as efficient interface in dispersed power generation systems,” IEEE Trans. Power Electron., vol. 19, no. 5, pp. 1184–1194, Sep. 2004.
3. O. Ray, S. Mishra, A. Joshi, V. Pradeep, and A. Tiwari, “Implementation and control of a bidirectional high-gain transformer-less standalone inverter,” in Proc. IEEE Energy Convers. Congr.Expo, Raleigh, NC, USA, Sep. 2012, pp. 3233–3240.
4. F. Z. Peng, “Z-source inverter,” IEEE Trans. Ind. Appl., vol. 39, no. 2,pp. 504–510, Mar./Apr. 2003.
5. C. J. Gajanayake, F. L. Luo, H. B. Gooi, P. L. So, and L. K. Siow,“Extended-boost Z-source inverters,” IEEE Trans. Power Electron.,vol. 25, no. 10, pp. 2642–2652, Oct. 2010.
6. R. Tymerski and V. Vorperian, “Generation, classification and analysis of switched-mode dc-to-dc converters by the use of switched-inductor-cells,” in Proc. Int. Telecommun. Energy Conf., Oct. 1986, pp. 181–195.
7. Sharmitha.D.Maithili.P,” Three Port Dc-Dc Converter For Standalone Photovoltaic System” in International Journal of Pure and Applied Mathematics, vol. No. 117, pp. 67–71, 2017.
8. R. Adda, S. Mishra, and A. Joshi, “A PWM control strategy for switched boost inverter,” in Proc. IEEE ECCE, Phoenix, AZ, USA, Sep. 2011, pp. 991–996.F. Z. Peng, M. Shen, and Z. Qian, “Maximum boost control of the Z-source inverter,” IEEE Trans. Power Electron., vol. 20, no. 4, pp. 833– 838, Jul. 2005.
9. M. Shen, J. Wang, A. Joseph, F. Z. Peng, L. M. Tolbert, and D. J. Adams, “Constant boost control of the Z-source inverter to minimize current ripple and voltage stress,” IEEE Trans. Ind. Appl., vol. 42, no. 3, pp. 770–778, May/Jun. 2006.
10. R. Adda, O. Ray, S. Mishra, and A. Joshi, “Synchronous-reference-frame based control of switched boost inverter for standalone dc nanogrid applications,” IEEE Trans. Power Electron., vol. 28, no. 3, pp. 1219–1233, Mar. 2013.
11. P.Thirumoorthi, N.Yadaiah, “Design of current source hybrid power filter for harmonic current compensation”, ELSEVIER Journal, Simulation Modelling Practice and Theory, Vol.52, 2015, pp. 78–91.
12. Press Information Bureau Government of India, Ministry of New and Renewable Energy, 27-December-2017 11:28 IST Year End Review 2017 –MNRE.
13. L.Latha, K.GayathriDevi,”A New Approach To Image Retrieval Based On Sketchesusing Chamfer Distance”, Journal OfAdvanced Research In Dynamical And Control Systems, Vol. 9. Sp– 6 / 2017, Pp.1959-1968.
14. K.PradeepMohankumar,M.Saravanan, Andm.Aramuthan,” Hybrid Network Intrusion Detection System Based On Gann Models”, International Journal Of Pure And Applied Mathematics, Vol.116,No. 11,2017, pp.31-39
15. k.TharaniPriya, v.Karthikeyan,” Detect The Incredible Action In Eventful Environments Using Swarm Interlligence”, International Journal Of Innovations In Scientific And Engineering Research, Vol.4, Issue.1, 2017, Pp.36-39.