Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 117 (2017) 19–26

Energy Procedia

www.elsevier.com/locate/procedia

1st International Conference on Power Engineering, Computing and CONtrol, PECCON-2017, 2-4 March 2017, VIT University, Chennai Campus

Modeling and Analysis of a Novel Boost Derived Multilevel Hybrid Converter

Jeyasudha.S[a]*, Geethalakshmi.B[b]

[a,b]Department of EEE, Pondicherry Engineering College, Puducherry - 605 014, India

Abstract

Multilevel inverters (MLI) offer high power capability connected with lower output harmonics and lower conduction and switching losses. Conventional cascaded H-bridge (CHB) MLI produces AC output which can be employed for a single load. But for smart residential nanogrid applications, dual load (AC and DC) is required concurrently. This paper has introduced a new topology of boost derived multilevel hybrid converter (BDMHC) which produces multilevel AC and DC output simultaneously. Thus the converter required the lesser number of switches to supply both AC and DC load. This proposed topology of BDMHC is constituted one H-bridge seven-level symmetrical MLI with three separate boost converters. State space mathematical model has been developed for the proposed converter and validated with simulated circuit using MATLAB/Simulink.

Peer-review under responsibility of the scientific committee of the 1st International Conference on Power Engineering, Computing and CONtrol.

Keywords:Multilevel Inverter; Boost derived hybrid converter; Boost derived multilevel hybrid converter; Switching sequence; State space analysis.

1. Introduction

The modern residential system involves different load types DC as well as AC from a single DC source (e.g., solar panel, fuel cell, battery etc) [1]. These loads are supplied for a system, which has separate power converters for each conversion type (dc-dc and dc-ac) as shown in Fig.1. A single power converter stage utilizes to perform both the conversions simultaneously, called hybrid converter. This hybrid converter is suitable for use in a compact system with both ac and dc loads. The compact system is often connected to non-conventional energy sources that have low terminal voltage and power ratings. To step up lower terminal voltage into a higher voltage, the boost converter is required for DC load and voltage source inverter (VSI) is required for ac load. A single power circuit can operate in both boosting and inverting mode concurrently, called boost derived hybrid converter (BDHC) as shown in Fig. 2. BDHC is implemented by replacing a single control switch of conventional boost converter into bidirectional single phase bridge network [2]. The hybrid outputs DC as well as AC are controlled by the same set of switches. Therefore it reduces lesser component count compare to the conventional power converter system, it protects the shoot-through inherently in the inverter stage, and it produces better power processing density and

* Corresponding author. Tel.: +91 8300064174.
E-mail address: jeyasudha_s@pec.edu.

1876-6102
Peer-review under responsibility of the scientific committee of the 1st International Conference on Power Engineering, Computing and CONtrol.
10.1016/j.egypro.2017.05.102

reliability. But for medium and high power applications, single stage topology is cascaded by two or more stages called multilevel converter. The multilevel inverter has more advantages such that it produces output voltages similar to the sinusoidal waveform, it operates with lower harmonic distortion and it reduces electromagnetic interferences [3]. Different MLI configurations have been suggested in [4]. Among all MLI topologies cascaded H-bridge MLI has seen wide use in applications such as solar PV system, hybrid electric vehicle and motor drives [5]. For high power solar PV system, the single BDHC is cascaded to produce the multilevel AC output with separate DC output which is referred as boost derived multilevel hybrid converter (BDMHC).

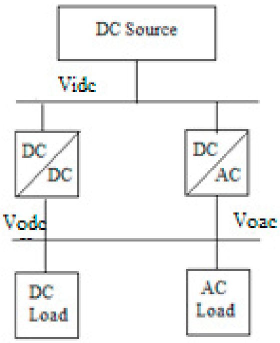

Fig. 1 Conventional power Converter

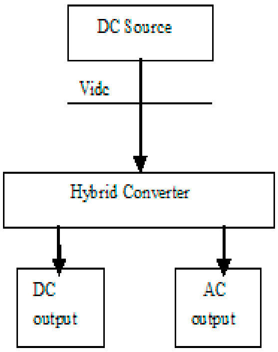

Fig. 2 Schematic of Boost derived hybrid converter

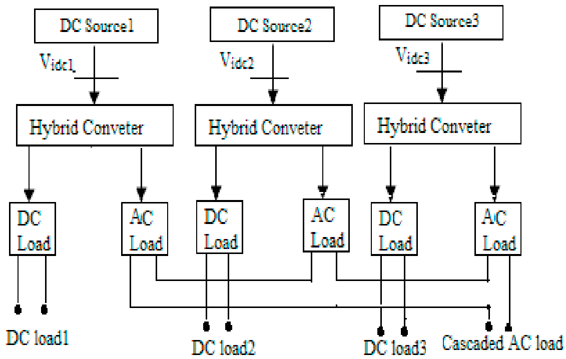

Fig. 3 Schematic diagram of Boost derived multilevel Hybrid Converter (BDMHC)

This paper introduces the BDMHC topology which is capable of supplying simultaneous multilevel AC and DC loads, The purpose of this paper is to give the averaged model that describe the dynamic behavior of a boost derived multilevel hybrid converter. Computer simulation using MATLAB/Simulink on a BDMHC are used to prove the validity of the developed model for the proposed converter. The developed model can be used for analysis and design of controllers for the proposed converter.

This paper is structured as follows. Section 2 describes the circuit explanation and output voltage of the proposed topology of BDMHC. Section 3 shows the switching scheme of BDMHC. Circuit operation and state space modeling of the BDMHC is discussed in the Section 4. Section 5 presents the simulation output and mathematical model validation of the BDMHC. Section 6 concludes the paper.

2. Proposed Converter Topology - Boost Derived Multilevel Hybrid Converter (BDMHC)

The basic circuit diagram and operation of BDHC are given in [2]. The proposed topology, BDMHC is developed by cascading three single BDHC, as shown in Fig. 3, to constitute seven-level symmetrical MLI with three separate boost converters. Fig. 4 shows the circuit diagram of BDMHC which contains 3 DC sources (V_{idc1} to V_{idc3}), 3 bridge networks to obtain the three boosting dc output (V_{odc1} to V_{odc3}) and a 7-level multilevel inverter output (V_{oac}). Each bridge contains 4 IGBT switches which share both operations of boosting and inverting. L_1 to L_3, C_1 to C_3, D_1 to D_3 and R_{dc1} to R_{dc3} involve the boosting operation and R_{ac} involves inverting operation.

2.1 Output voltage of BDMHC

The proposed topology is operated based on the single boost derived hybrid converter [2]. The AC output voltage and dc output voltage of single boost derived hybrid converter is expressed in equations (1) and (2)

$$\frac{V_{odc}}{V_{idc}} = \frac{1}{1-\delta} \qquad (1)$$

$$\frac{V_{oac}}{V_{idc}} = \frac{m_a}{1-\delta} \qquad (2)$$

The DC output of BDHC can be regulated by using the duty cycle of the converter denoted by δ similar to the boost converter and the ac output can be regulated by using the modulation index m_a ($0 \le m_a \le 1$) of the hybrid converter and its definition is similar to that of voltage source inverter. The AC gain increases with the increase of modulation