



Simulation and Closed Loop Control of Multilevel DC-DC Converter for Variable Load and Source Conditions

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ABSTRACT: Power electronics converters are used in many field of electrical system. The converter has to face many problems in power conversions and other reliability and stability limits. In DC to DC converter the main problem is voltage regulation. This project presents a novel non-isolated negative output DC-DC multilevel converter CUK. The proposed converter topology is suitable for photovoltaic applications where two voltages are needed at the same time with opposite polarity. The proposed DC-DC converter topology is the multilevel CUK converter. Negative output voltage is obtained from multilevel CUK converter. The gain of the converter can be increases by adding appropriate number of capacitors and diodes without disturbing the main circuit. The proposed converter will be implemented for DC load and PI controller is used to control the output voltage according to the requirement. The Proposed converter topology is simulated in MATLAB/SIMULINK environment.

KEYWORDS: Multilevel Cuk converter; Close loop control; Design of converter

I. INTRODUCTION

Power electronics is the application of solid-state electronics to the control and conversion of electric power. It also refers to a subject of research in electronic and electrical engineering which deals with the design, control, computation and integration of nonlinear, time-varying energy-processing electronic systems with fast dynamics.

The first high power electronic devices were mercury-arc valves. In modern systems the conversion is performed with semiconductor switching devices such as diodes, thyristors and transistors, pioneered by R. D. Middlebrook and others beginning in the 1950s. In contrast to electronic systems concerned with transmission and processing of signals and data, in power electronics substantial amounts of electrical energy are processed. An AC/DC converter (rectifier) is the most typical power electronics device found in many consumer electronic devices, e.g. television sets, personal computers, battery chargers, etc. The power range is typically from tens of watts to several hundred watts. In industry a common application is the variable speed drive (VSD) that is used to control an induction motor. The power range of VSDs starts from a few hundred watts and end at tens of megawatts.

The power conversion systems can be classified according to the type of the input and output power

- AC to DC (rectifier)
- DC to AC (inverter)
- DC to DC (DC-to-DC converter)
- AC to AC (AC-to-AC converter)

DC to DC power converters like SMPS provides variable output voltage and current according to requirements. the main advantage of this converter is proper control. Control strategy of converter is very easy but voltage regulation of the system is very poor. Main problem of the system is variation in the voltage to lower to higher limit which can control by the control strategy. If proper control strategy is used to control the converter though voltage and current fluctuation affects load performance during lower to higher voltage regulation.

Multilevel converters are used to improve the voltage regulation of the output as well overcome the limitation of single converter. There are few advantages of the multilevel converter which as listed as below:

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- Bandwidth of output is high.
- Reduce the huge ratings of component as they are spited into small groups.
- Minimum to maximum value difference increases which can provides better voltage regulation.
- Output voltage and current ripples can bereduced.

A. Multilevel Topology

In this paper a novel non isolated dual output hybrid DC-DCmultilevel converter is proposed. The proposed converter topology provides a suitable solution to obtain two outputs with opposite polarity from a single DC source.

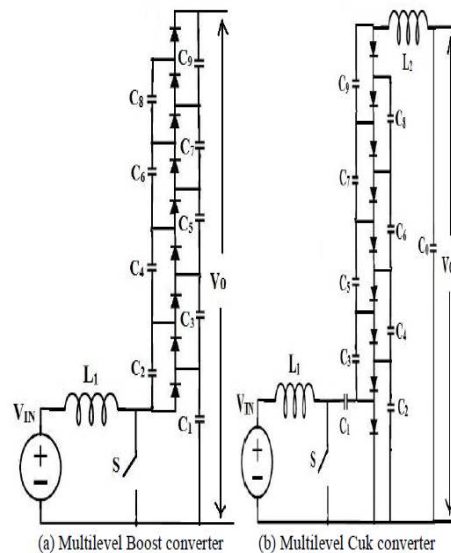


Fig.1 Multilevel converters^[3]

The proposed DC-DC converter topology is the combination of two high gain multilevel DC-DC converters, one is multilevel boost converter and another is multilevel cuk converter. DC-DC Multilevel boost converter provides positive polarity output voltage and DC-DC multilevel cuk converter provides negative polarity output voltage. Circuit diagrams of multilevel boost converter and multilevel cuk converter is shown in Fig1 (a)-(b). The main advantage of proposed topology is two output voltages are obtained by controlling single switch. Hence only one gate driver circuit is needed to drive the proposed converter. Voltage levels of both outputs can be increases by connecting more number of diode-capacitor stacks without modifying the main circuit. The voltage gain of proposed converter is depends upon the number of levels and duty cycle of switch.

B. Modes of operation

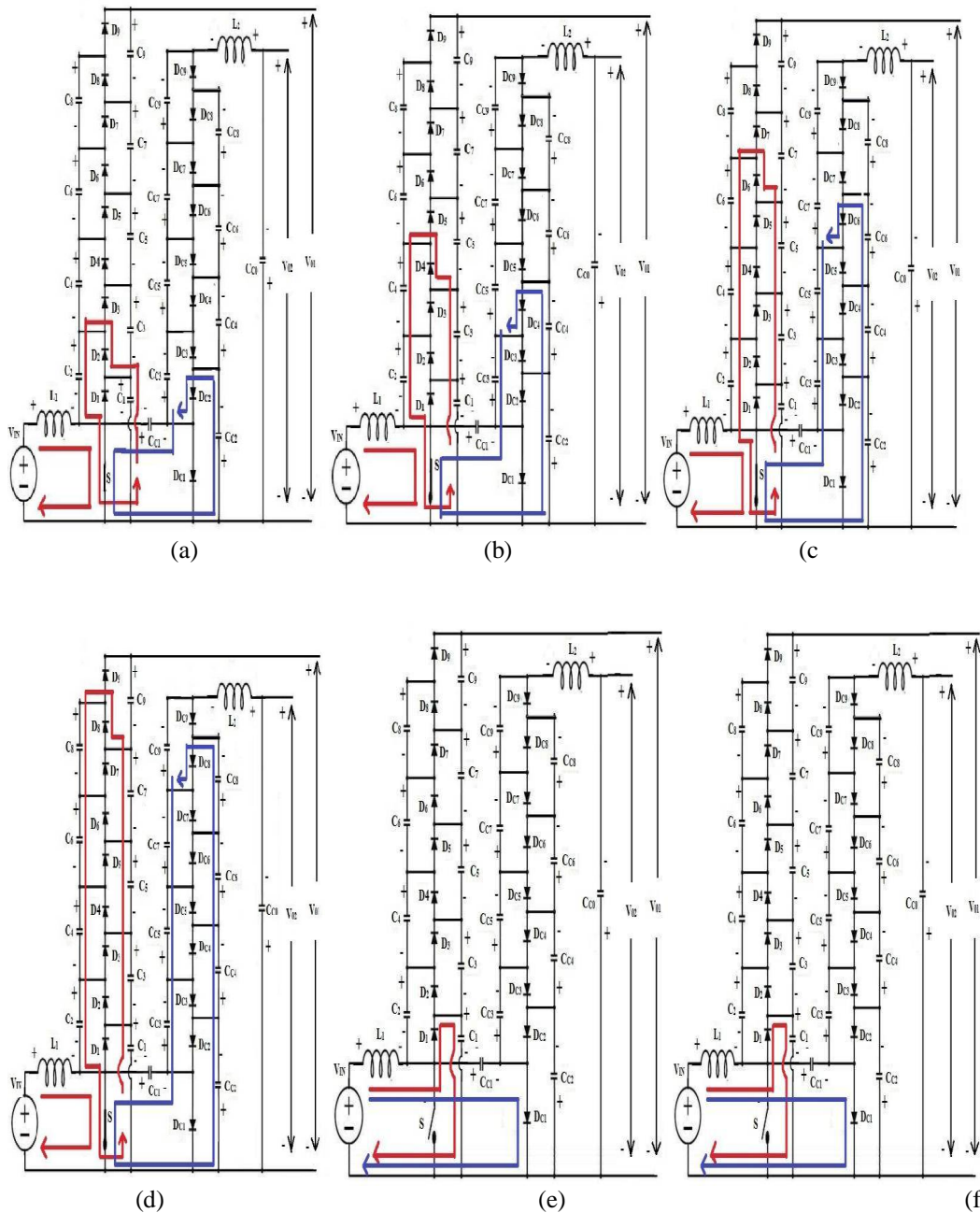
The operation of non isolated dual output hybrid DC-DCconverter can be divided into two modes, one when switch is conducting and another when switch is not conducting. When switch S is conducting, inductor L1 is charged by VIN. Capacitor C2 is charged by voltage across C1 through diode D2. At the same time CC2 is charged by voltage across CC1 through DC2. When D4 and DC4 is forward biased capacitors C2, C4 and CC2, CC4 are charged by C1, C3 and CC1, CC3 respectively. Capacitors C2, C4, C6 and CC2, CC4, CC6 are charged by voltage across C1, C3, C5 and CC1, CC3, CC5 respectively, when D6 and DC6 are forward biased. When D8 and DC8 are forward biased capacitors C2, C4, C6, C8 and CC2, CC4, CC6, CC8 are charged by voltage across C1, C3, C5, C7 and CC1, CC3, CC5, CC7 respectively. Finally L2 is charged by voltage across CC1, CC3, CC5, CC7 and CC9 through switch S. The operation modes and direction of current when switch S is conducting is shown in Fig.2 (a-e). When switch S is not conducting, capacitors C1 and CC1 are charged by input supply VIN and inductor L1. When D3 and DC3 are forward biased, capacitors C1, C3 and CC1, CC3 are charged by VIN, L1, C2 and VIN, L1, CC2 respectively. When D5 and DC5 are

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forward biased, capacitors C1, C3, C5 and CC1, CC2, CC5 are charged by VIN, L1, C2, C4 and VIN, L1, CC2, CC4 respectively. When D7 and DC7 are forward biased, capacitors C1, C3, C5, C7 and CC1, CC3, CC5, CC7 are charged by VIN, L1, C2, C4, C6 and VIN, L1, CC2, CC4, CC6 respectively. When D9 and DC9 are forward biased, capacitors C1, C3, C5, C7, C9 and CC1, CC2, CC5, CC7, CC9 are charged by VIN, L1, C2, C4, C6, C8 and VIN, L1, CC2, CC4, CC6, CC8 respectively. At the same time inductor L2 is discharged. The operation modes and direction of current when switch S is not conducting.^[3]



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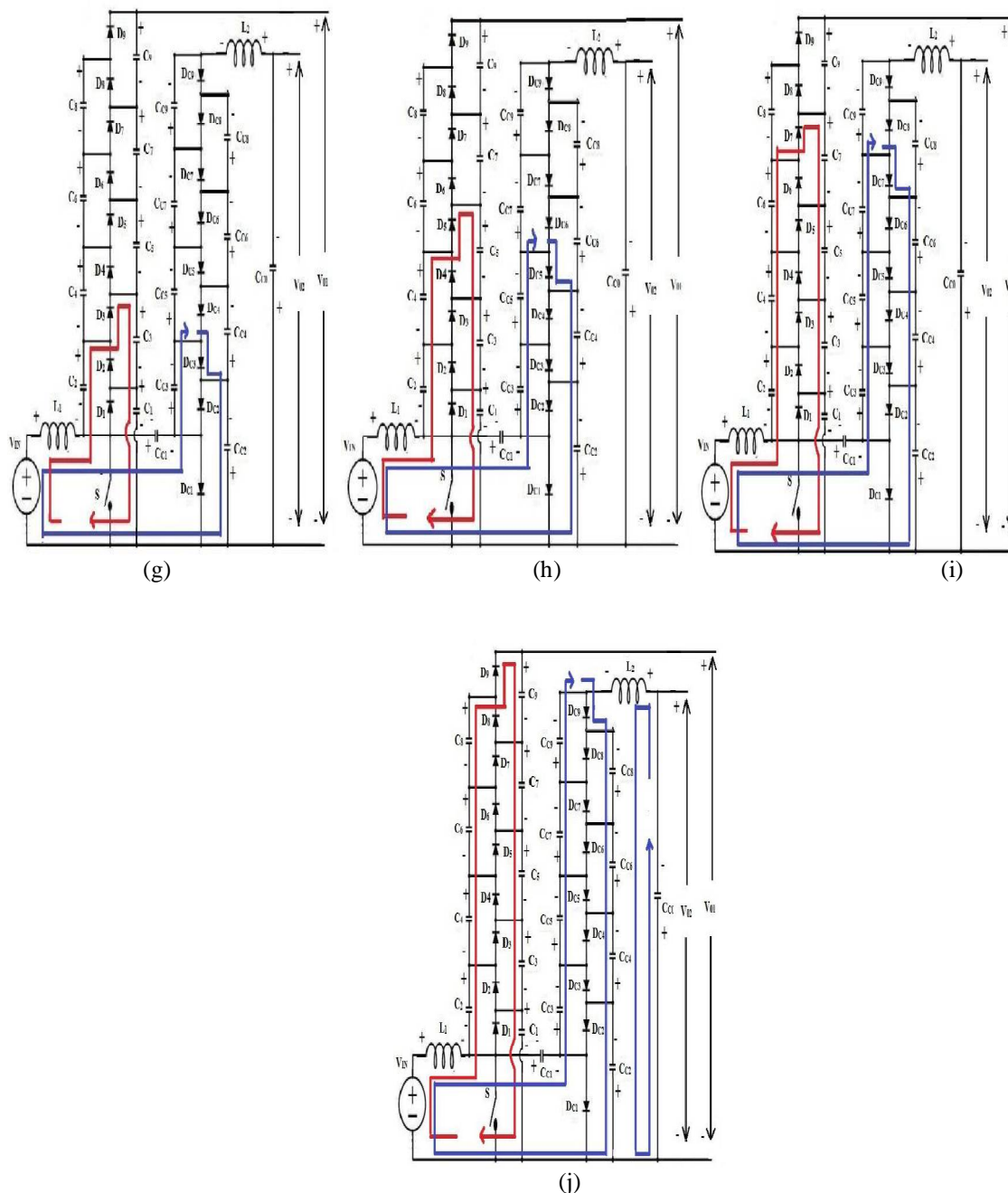


Fig.2 (a-c) Operation modes and direction of current when switch S is conducting. (d-e) Operation modes and direction of current when switch S is conducting. (f-j) Operation modes and direction of current when switch S is not conducting^[3]

II. SIMULATION OF CUK CONVERTER

Controller design for any system needs knowledge about system behaviour. The MATLAB/SIMULINK software package can be advantageously used to simulate power converters. This study aims at development of the models for all basic converters and studying its open loop response, so these models can be used in case of design of any close loop scheme. Circuit diagram of open loop CUK converter is shown in fig.3.

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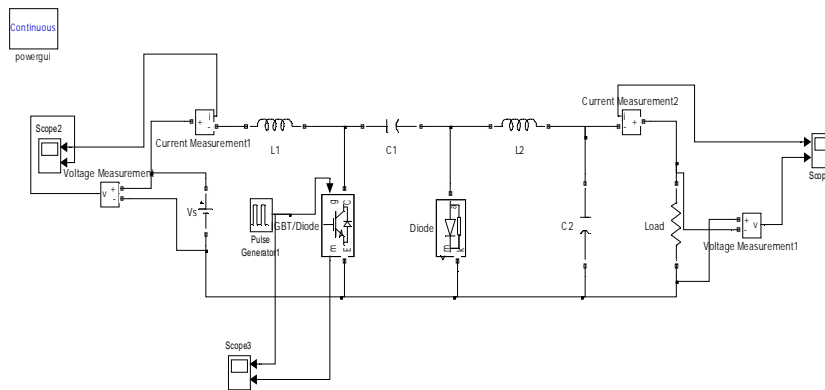


Fig.3 Simulation of open loop CUK converter

Simulation circuit of CUK converter is shown in figure above. This simulation is prepared in MATLAB environment and results of the simulation is shown in this chapter. Values of the simulation are shown in the table below:

Name of parameter	Value	Name of component	Value
Input Voltage	12V	Inductor I1	180 μ H
Output voltage	24V	Capacitor C1	200 μ C
Output current	5A	Inductor L2	150 μ H
Switching frequency	25KHz	Capacitor C2	220 μ C

Table1. List of parameter

Simulation Results:

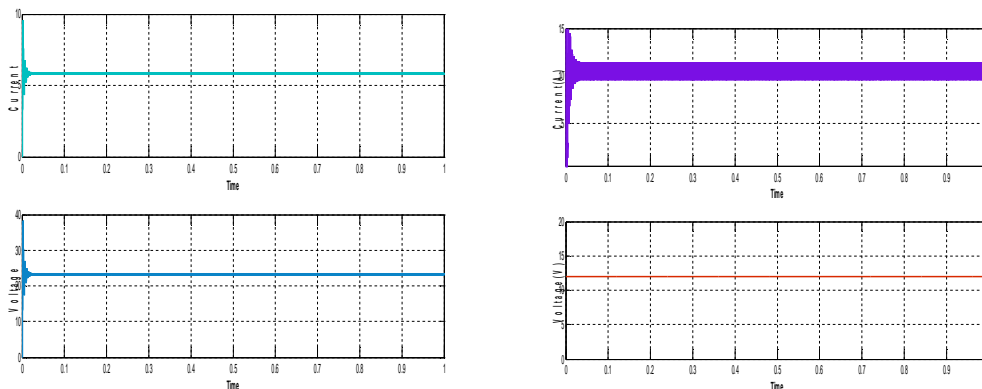


Fig.4 Output current and output voltage of Fig.5 Input Current and Input Voltage of Cuk

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Cuk converter converter

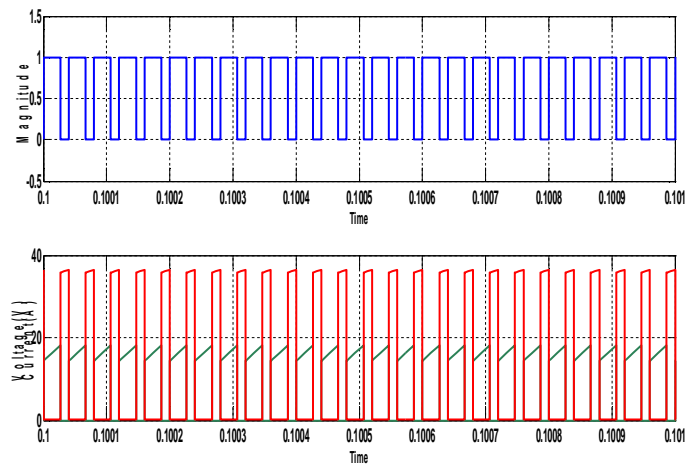


Fig.6 (a) Duty Cycle generation (b) Voltage across the switch and current through switch

III. CLOSED LOOP MULTILEVEL CUK CONVERTER

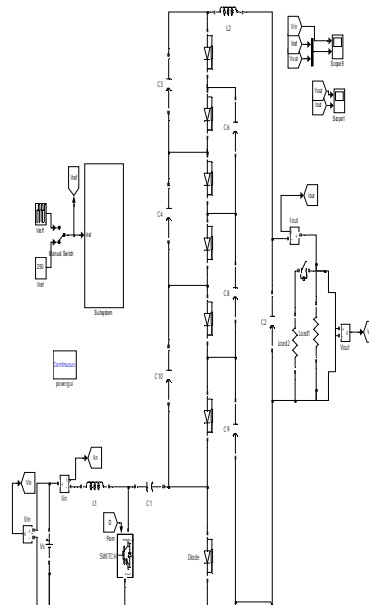


Fig.7 Simulation of closed loop multilevel CUKconverter

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Simulation Results

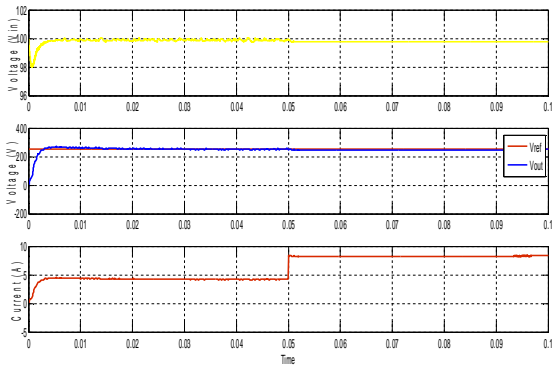


Figure 8: (A) Input voltage (B) Ref. voltage and load voltage (C) Load current in constant input variable load condition

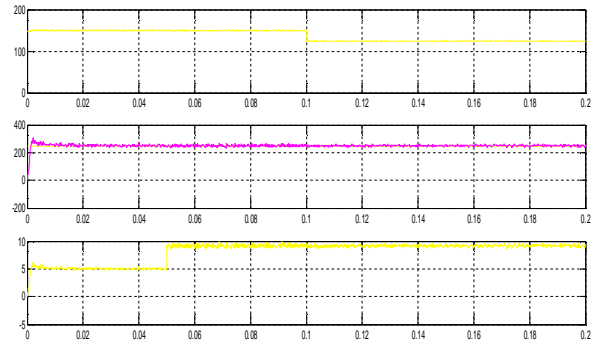


Figure 9: Figure 1: (A) Input Voltage (B) Ref. voltage and load voltage (C) Load current in variable input and variable load condition

IV. RESULTS ANALYSIS

From the results shown, the output voltage remains constant in every variable conditions. In the first condition the load condition is varied but the output voltage remains same. Same way in second results the variation of input voltage with respect to output is shown with variable load conditions. Our output voltage will remain constant as reference provided to it.

Multilevel topology for CUK converter is much more reliable system which is used in any variable DC voltage application. This converter provides fine voltage regulation to meet the voltage requirement and control the speed of DC motor. There are some more objectives which are listed as below:

- To achieve high voltage regulation.
- Decrease ratings of component
- Decrease the size of converter.
- Decrease number of component.

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