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Analysis of generation of High DC voltage

Meghana G Naik, CH.Jayavardhana Rao, Dr.Venugopal.N

PG Scholar, Department of Electrical and Electronics Engg, KEC Kuppam, JNTU Ananthapur, AP, India

Associate Professor, Department of Electrical and Electronics Engg, KEC Kuppam, JNTU Ananthapur, AP, India

Professor & HOD, Department of Electrical and Electronics Engg, KEC Kuppam, JNTU Ananthapur, AP, India

ABSTRACT: The energy consumption tends to grow continuously. The renewable energy sources such as PV modules, fuel cells generates low level of output voltage. To satisfy the demand for electric energy, one of the cheapest and popular ways of generating high voltages at relatively low Currents is the classic multistage diode/capacitor voltage multiplier, known as Cockcroft Walton Voltage multiplier is used. This paper utilizes step-up converter instead of transformer incorporated with CWVM to generate higher output voltage. This step-up converter operates power switches having two independent frequencies modulating (fsm) and alternating (fsc). The fsm operates at higher frequency of the output voltage and it is regulated by controlling the duty cycle of Sm1 and Sm2, while the fsc operates at lower frequency of the desired output voltage ripple and it can be adjusted by Sc1 and Sc2. It provides continuous input current with low ripple, high voltage gain, reduced switching losses, low voltage stress on the switches, diodes and capacitors and also improving efficiency of the converter

KEYWORDS: Modulating frequency; Continuous conduction mode; Cockcroft Walton voltage multiplier;Lower duty cycle; DC Voltage

I. Introduction

Due to the tremendous use of electrical equipment there is huge demand for generation of electrical energy. This led to the development of new methods for the generation of energy. For the generation of high voltages, the most popular method of diode- capacitor ladder network is used. The transformers were used as the input supply for the CWVM. Replacing the transformer with step-up converter helps to obtain high DC voltage .Unlike transformers this method eliminates the requirement of the heavy core and the bulk of insulation required. The high DC voltage is obtained is at far cheaper cost than transformers and the equipment being far lighter.

The proposed converter switches are operated at two different frequencies namely alternating frequency and the modulating frequency. The alternating frequency helps the converter to feed the alternating current to CWVM circuit which is then converted into DC Voltage with ladder networks of diode- capacitor. The modulating frequency controls the inductor energy to obtain high boost performance. The advantage of these circuit is it provides less stress on switches, less switching losses, higher efficiency, higher DC voltage compared to earlier methods.

II. Related work

In [1] presented a paper on isolated dc- dc converter to operate as a primary stage of an on board dc-ac power supply for diesel electric engines. To accomplish this push pull converter is used in this paper. This is a current fed converter. The condition for this boost converter works only for duty cycle greater than 50%. The output obtained from this is only for 200V without any possibility of obtaining higher voltage. The [2] paper uses the fuel cell converter system for power generation for residential purposes. This system consisted of isolated transformer which fulfils the isolation purpose as well as step-up operation. The system accommodates with full bridge on the L.V side and controlled voltage doubler on the H.V side In [3] this paper proposes a new full wave rectifier is presented. A Novel current fed dual boost converter with ripple cancellations an application is shown.This provides higher voltage gain with reduced stresses on the rectifier diodes, provides continuous input current as well as the continuous output currents, with recovery of the transformer secondary leakage energy. In [4] In this paper cascaded single switch step up dc- dc converter without transformer is proposed, which provides high gain with advantages of simplicity and cost efficiency. However capacitors of these topologies with higher voltage ratings are needed when higher number of stages deployed. In [5]

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this paper mainly focuses on the concept of voltage multiplier cell which is integrated with non-isolated dc- dc converter. The comparison of single phase voltage multiplier cell with multiphase voltage multiplier cell was discussed. These method improves voltage gain with the simpler structure but the stress on switches and passive elements depends on number of stages.In [6]this paper presented the concept of diode-capacitor network which is utilized as a DC voltage multiplier. This topology overcomes the disadvantage of the periodical shortening of part of the capacitors by the switch during operational process. The number of capacitor cells are not restricted and the efficiency of the systems high as the discharge pulses are not present, but the voltage across each capacitor in each switch increases with the increases in the number of stages.

III. PROPOSED TOPOLOGY

A. *Description of the Proposed Circuit :*

The proposed circuit is made up of step-up converter incorporated with the nine stage CW Voltage multiplier. The step-up converter consists of low input DC voltage provided by battery. This low input DC voltage is then passed through the boost inductor where the input voltage is boosted up. The proposed converter consists of four switches with two switches operated at alternating frequency and other two switches operating at modulating frequency. The switches work in complimentary mode. The stepped –up voltage is in the pulsed form which is then fed into nine stage CW Voltage multiplier. This CW Voltage multiplier produces high DC Voltage.

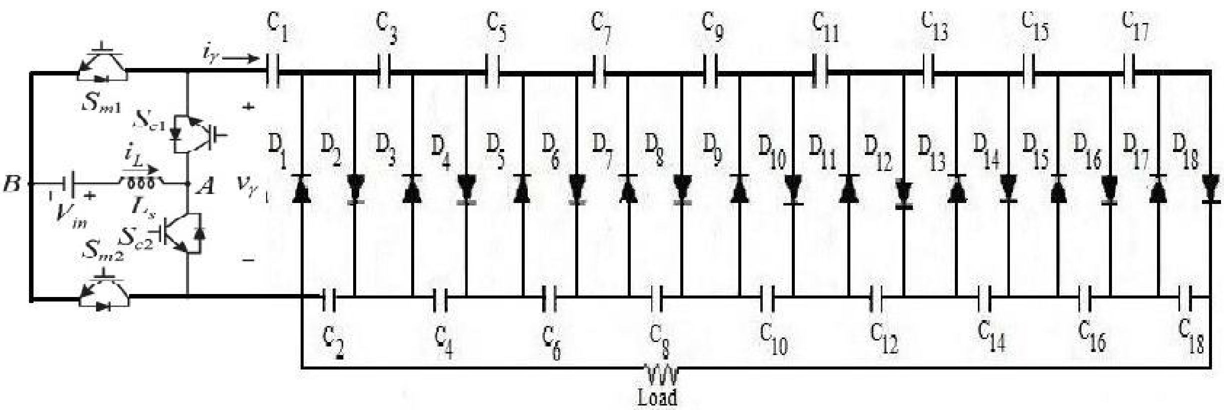

Fig.1 Proposed Circuit

B. *Mathematical Model:*

For the purpose of easy analysis, the equivalent circuit of the proposed converter can be divided into two parts namely.

- Source Side: The source side part consists of d_{sm}, dsc which represents the conducting states of the switches S_m, S_c. V_{in} is the input voltage, i_L is the input current, and $v_\gamma$is the terminal voltage of the CW voltage multiplier. As per the conducting states of d_{sc} and d_{sm}, the equation for the inductor current is given by eq.(6)

  $$\frac{di_L}{dt} = \frac{1}{L_s}\left[V_{in} - (d_{sc} - d_{sm})V_\gamma\right] \text{eq. (6)}$$

  As the converter operates in CCM, the current i_γ flowing into the CW voltage multiplier depends on d_{sm} and d_{sc} and can be expressed as

  $i_\gamma = (d_{sc} - d_{sm}).i_L$ eq.(7)The conducting states are given by the table.1 , which then applied in the eq.(7) which provides the i_γ value which is fed into CWVoltage multiplier.

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Table 1. Conducting states of switches

Conducting states		Strategy
d_{sc}	d_{sm}	$S_{c1}, S_{c2}, S_{m1}, S_{m2}$
0	0	0101
0	1	0110
1	1	1010
1	0	1001
1 or 0	1 or 0	-

- Load Side: The load side is the CW Voltage multiplier part. The mathematical model of load side is given by eq.(8)

$$v_\gamma = v_{cel} - v_{col}$$

$$v_o = v_{cel} + v_{cer}. \quad \text{eq. (8)}$$

C. *Design consideration:*

- Capacitor Voltage: The Capacitor Voltage is calculated with the eq. (1) and eq. (2) given below.

$$V_{ck} = \left\{ \frac{V_{in}}{(1-D)} \right\} fork = 1 \quad \text{eq. (1)}$$

$$V_{ck} = \left\{ \frac{2V_{in}}{(1-D)} \right\} fork = 2,3...2n \quad \text{eq. (2)}$$

- Output Voltage: The output voltage for the nine stage is calculated with the eq. (3). The output voltage is equal to the total voltage of all even capacitors, defined in the eq. (3).

$$V_0 = nVc \quad \text{eq. (3)}$$

- Output Power: The output power is dependent on the output voltage and the load R_L. It is given by the eq. (4).

$$P_0 = \frac{V_0^2}{R_L} \quad \text{eq. (4)}$$

- Output Current: The output current is calculated with the eq. (5) which is given below.

$$I_0 = \frac{P_0}{V_0} \quad \text{eq. (5)}$$

IV. SIMULATION RESULTS

The simulation model for the proposed circuit for nine stages is done by the Matlab.The input voltage provided is 48V. The capacitor voltage is 150V for even capacitor is 150V given by eq. (2). The output voltage calculated by the eq. (3) is1350V. The load used here is 1KΩ. The alternating frequency is 1 KHz and the modulating frequency is 60 KHz. The controller is used for modulating the output voltage.

The simulation model of the proposed converter is shown below in the Fig.2.The switching pulses of the switches is shown in the Fig.3.The output voltage is shown in the Fig.4.

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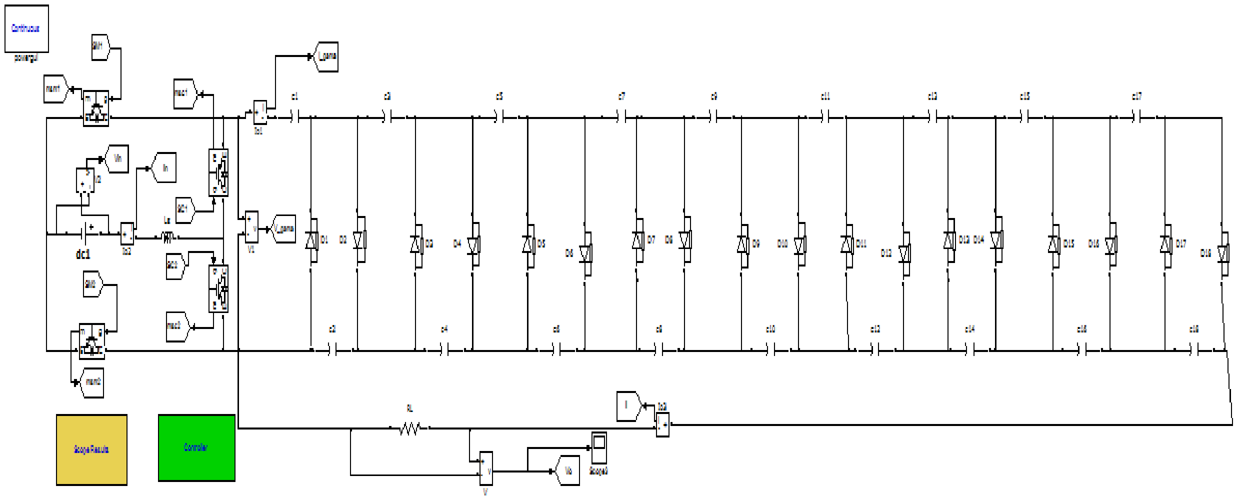

Fig. 2 Simulink Model of Proposed Circuit

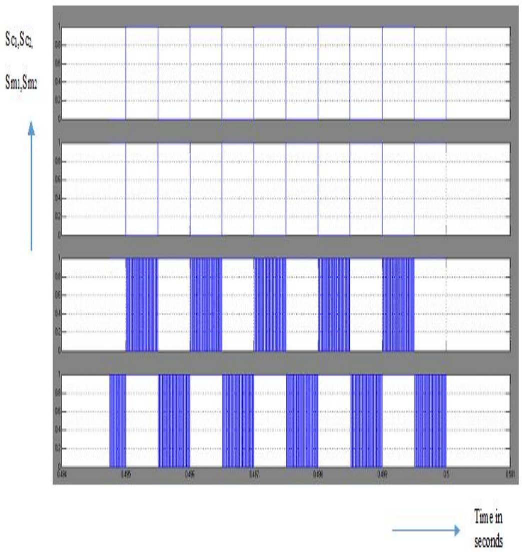

Fig.3 Switching pulses of switches

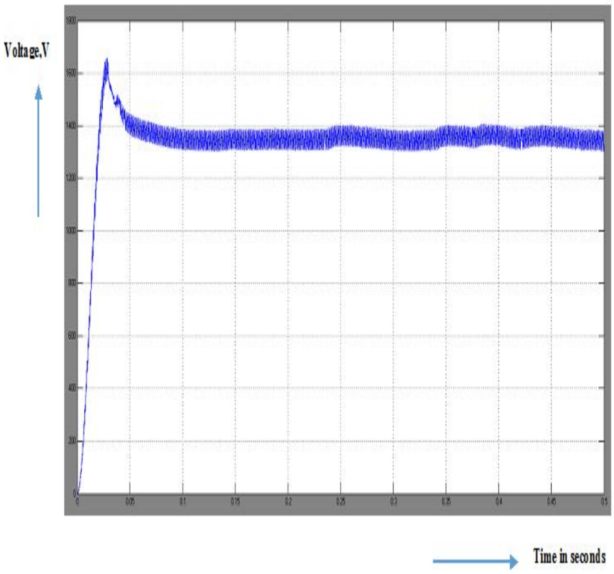

Fig.4 Output Voltage

V. CONCLUSION AND FUTURE WORK

In this paper high DC voltage has been obtained based on Cockcroft Walton Voltage Multiplier without the utilization of the transformer in the circuit.The mathematical modelling is done using MATLAB-SIMULINK .It is very evident from the simulation results of the proposed circuit that as we increase the number of the stages the output DC voltage also increases. The high DC voltage is obtained by just increasing the number of stages without increasing the passive components (Capacitor, Inductance, Diode) ratings and also no major changes has been done to the circuit .It has also not affected the switch voltage and diode voltage. The four IGBT switches used here are controlled by the average current mode control strategy which helps it operate in the continuous conduction mode and helps to obtain the higher gain at lower duty cycle. It can be observed that desired result has been obtained and it is suitable for high power application. The proposed circuit consists of nine stages with battery as the input supply. The proposed circuit with 9 stages can adapted with PV module and that would be scope of future work.

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BIOGRAPHY

Meghana G Naik has received the B.E degree in EEE from Sri Taralabalu Jagadguru Institute of Technology in the year of 2004 from VTU, Belgaum. Presently she is pursuing M.Tech in Power Electronics in Kuppam Engineering College, Kuppam**.**

CH. Jayavardhana Raohas obtained his B.Tech Electrical Engineering from JNTUH, Hyderabad in the year 2002, M.Tech in Power System emphasis on High voltage engineering from JNTUK, Kakinada in the year 2009. He has 5 years of industrial experience, 2 years Research experience and 5 years of teaching experience. Currently working as Associate Professor in Department of Electrical Engineering at Kuppam Engineering College, Kuppam, Chittoor district, Andhra Pradesh, INDIA his area of research include power systems, power electronics, high voltage engineering, renewable energy sources, industrial drives, HVDC & Facts technology.

Dr. Venugopal.Nhas obtained his doctoral degree from Dr. MGR. University Chennai. B.E. degree and M.E. Degree both from Bangalore University. He has 17 years of teaching experience. His research area is Digital Image Processing & Video sequence separation. Currently working as an HOD of EEE Department & Director, R & D in Kuppam Engineering College, Kuppam, and Chittoor Dist. Andhra Pradesh. His research area of interest includes Power electronics, Renewable Energy Systems and Embedded Systems.