

Cascade Cockcroft – Walton Voltage Multiplier for Transformerless High Step – Up AC-DC Converter

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ABSTRACT: This paper proposes a transformerless high step-up ac-dc converter based on Cockcroft – Walton Voltage Multiplier. The low input ac voltage is boost up by an ac-dc converter and the output is given to the Cockcroft –Walton voltage multiplier. The voltage multiplier provides high dc output voltage. The n-stage CW voltage multiplier output is suitable for dc source for n+1 level multilevel inverter. In this paper front end is provided with a bridgeless converter, half bridge inverter and is connected to CW voltage multiplier. The proposed system is validated by MATLAB and experimental results demonstrated the validity of the proposed converter.

KEYWORDS: Cockcroft-Walton (CW) voltage multiplier, AC-DC Converter.

I. INTRODUCTION

In recent years extensive use of electrical devices and energies has imposed severer demands for electrical energy. For mitigating natural energy consumption and environmental concerns variable energy sources like photovoltaic cells (PV), and fuel cells are widely considered these days. The output from these energy sources is very low, so high step – up dc-dc converters is necessary in the power conversion systems. Step up dc-dc converters with isolated transformers and coupled inductors are used to obtain high voltage ratios without extreme high duty cycle. Design of high frequency transformers coupled inductors for these converters is complex compared to conventional dc-dc converter. So step-up dc-dc converters without step-up transformers are used by cascading diode capacitor or diode inductors modules, these dc-dc provide high voltage gain and simples robust structure.

Cockcroft – Walton voltage multipliers are multipliers which produce high dc voltage from a low ac voltage r pulsating input. Conventional CW voltage multiplier provides high voltage dc application. For several professional and commercial applications high dc voltages are required. Examples are CRT, X-ray, cyclotrons, electro rheological fluid (EFW), laser supplies, UHV electron microscope and LCD back lighting. In this paper step up transformer is replaced by a bridgeless pseudo boost ac-dc converter, the proposed converter provides higher voltage ratio than that of the conventional CW voltage multiplier.

II. RELATED WORK

Conventional cockcroft-walton voltage multipliers with high step-up dc-dc transformers provide high voltage ratios without extremely high duty cycle. Voltage-fed type high step-up dc-dc converters sustains high input current ripple, current -fed types are more superior to their counterparts. Due to the high number of winding turns, leakage inductance of the transformer is increased in order to achieve high voltage gain. This leads to the burdening of switch at the turn off point. So higher voltage rating switches are required. On the other hand designing of high frequency transformers, coupled inductors for the converters are complex and costlier. As a result step – up dc-dc converters without step-up transformers were presented by cascaded diode-capacitor or diode-inductor modules. These dc-dc converters provide

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high voltage gain and are simple and robust in structure. COCKCROFT-WALTON obtains high dc voltage from low ac input or from a pulsating dc input. The structure of cockcroft-walton is a combination of diode-capacitor. Fig 1 shows high step-up dc-dc cockcroft-waltonvoltage multiplier.

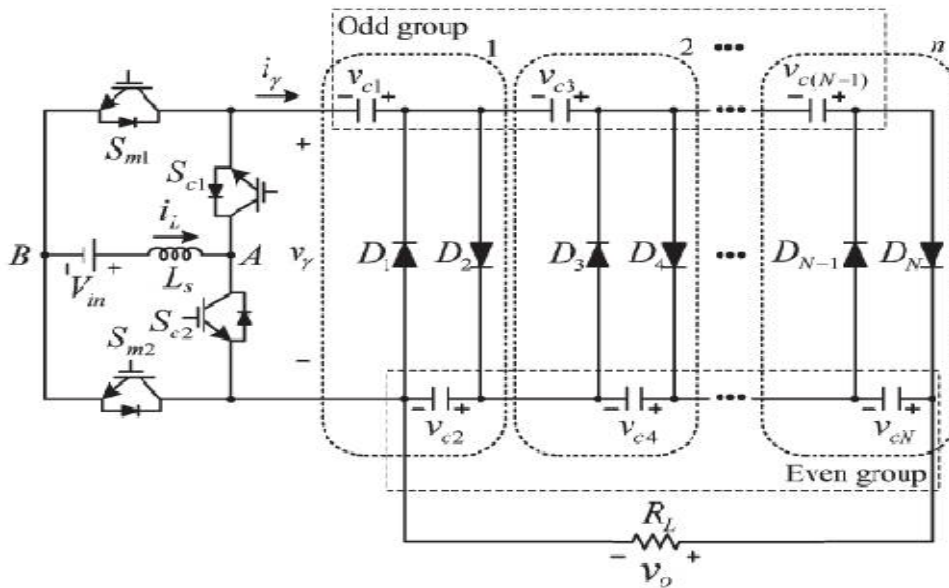


Fig 1.High step-up dc-dc cockcroft-walton voltage multiplier.

In this CW voltage multiplier control strategy employs two independent frequencies; one operates at high frequency to minimize the size of the inductor while the other operates at relatively low frequency according to the desired output voltage ripple.

III. PROPOSED SYSTEM

Fig 3 shows the circuit diagram of proposed system. Front end of the system consist bridgeless pseudo boost ac-dc converter and an half bridge inverter, and the output is given to the 3 stage Cockcroft-walton voltage multiplier.

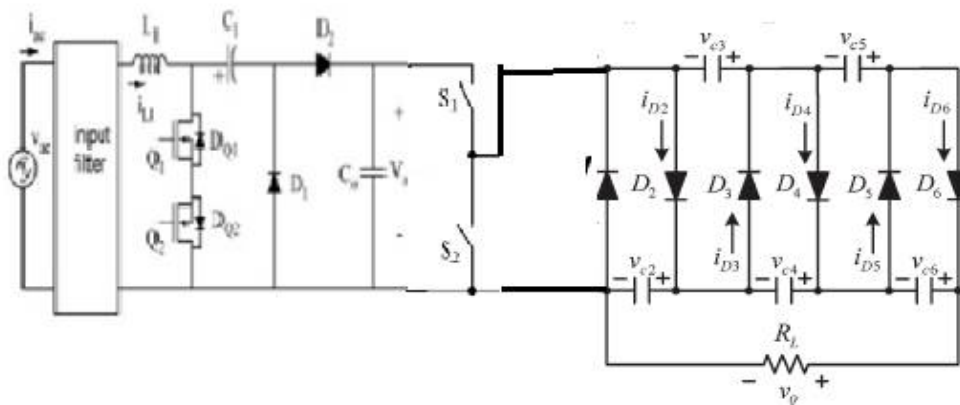


Fig 3 proposed system.

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Bridgeless pseudo boost converter is provided with an ac voltage supply. This converter compared with conventional converters has low component count, a single signal control and non floating output.

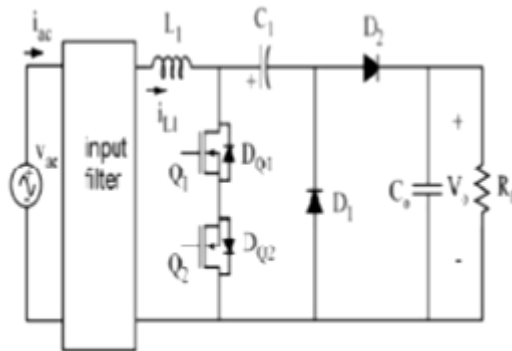


Fig 4 bridgeless pseudo boost converter.

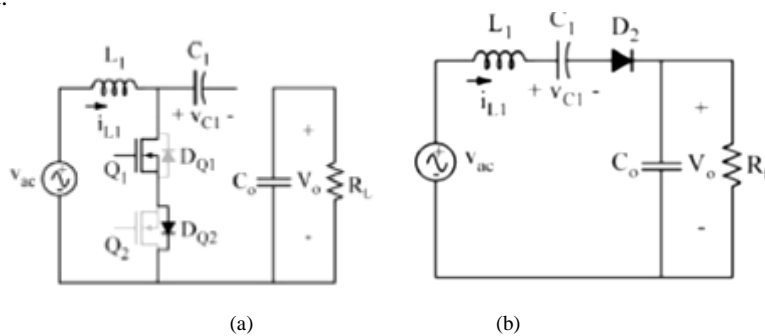
The pseudo boost converter is designed to operate in discontinues conduction mode during the switch turn on interval and in resonant mode during the switch turn off interval. The switching conduction mode is as follows:

Mode 1: This stage [Fig 5 (a)] starts when the switch Q_1 is turned on. The body Diode of Q_2 is forward biased by the inductor current i_{L1} . Diode D_1 is reverse biased by the voltage across C_1 , while D_2 is reverse biased by the voltages $V_{C1} + V_o$. In this stage, the current through inductor L_1 increases linearly with the input voltage, while the voltage across capacitor C_1 remains constant at voltage V_x .

Mode 2: This stage [Fig 5 (c)] starts when switch Q_1 is turned OFF and diode D_2 is turned ON simultaneously providing a path for the inductor currents i_{L1} . As a result, diode D_1 remains reverse biased during this interval. The series tank consisting of L_1 and C_1 are excited by the input voltage V_{ac} through diode D_2 . The stage ends when the resonant current i_{L1} reaches zero and diode D_2 turns OFF with zero current. During this stage, capacitor C_1 is charged until it reaches a peak value.

Mode 3: During this stage[Fig 5 (b)] diode D_1 is forward biased to provide a path during the negative cycle of the resonating inductor current i_{L1} . This stage ends when the inductor current reaches zero. Thus, during this stage diode D_1 is switched ON and OFF under zero current conditions. Assuming the constant input voltage over a switching period, the capacitor is discharged until it reaches a voltage V_x .

Mode 4: During this stage [Fig 5 (d)] all switches are in their off-state. The inductor current is zero, while the capacitor voltage remains constant.



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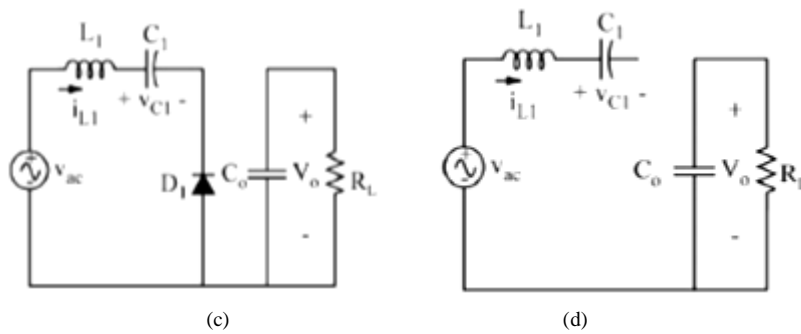


Fig 5. (a),(b),(c),(d) Modes of operation of bridgeless converter.

Fig 6 shows proposed 3 stage Cockcroft –Walton voltage multiplier.

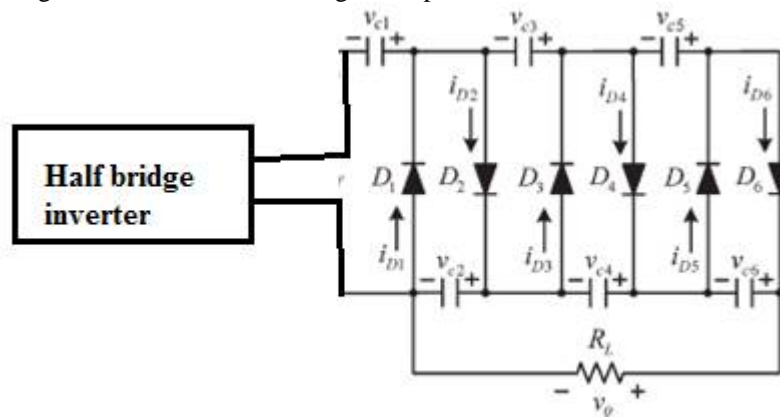


Fig 6. 3 stage Cockcroft-Walton voltage multiplier.

Mode 1: During i_γ is zero, and all CW diodes are turned off, as shown in Fig.7(a). the even group capacitors C_6 , C_4 , and C_2 supply the load, and the odd-group capacitors C_5 , C_3 , and C_1 are floating.

Mode 2: During i_γ is positive. The input source transfer energy to the CW voltage multiplier through different even diodes, as shown in Fig. 7(b)–(d). In Fig. 7(b), D_6 is conducting; thus, the even-group capacitors C_6 , C_4 , and C_2 are charged, and the odd-group capacitors C_5 , C_3 , and C_1 are discharged by i_γ . In Fig. 7(c), D_4 is conducting. Thus, C_4 and C_2 are charged, C_3 and C_1 are discharged by i_γ , C_6 supplies load current, and C_5 is floating. In Fig. 7(d), D_2 is conducting. Thus, C_2 is charged, C_1 is discharged by i_γ , C_6 and C_4 supply load current, and C_5 and C_3 are floating.

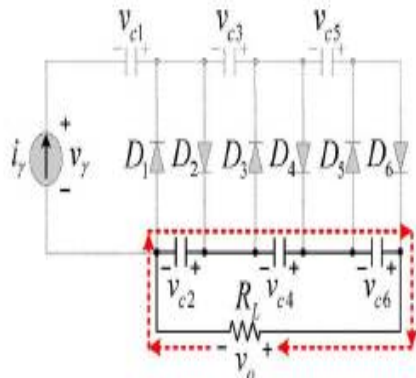
Mode 3: During i_γ is zero, and all CW diodes are turned off, as shown in Fig. 7(e). the even group capacitors C_6 , C_4 , and C_2 supply the load, and the odd-group capacitors C_5 , C_3 , and C_1 are floating.

Mode 4: During current i_γ is negative. The boost inductor and input dc source transfer energy to the CW voltage multiplier through different odd diodes, as shown in Fig. 7(f)–(h). In Fig. 4.9(f), D_5 is conducting. Thus, the even-group capacitors, except C_6 which supplies load current, are discharged, and the odd-group capacitors C_5 , C_3 , and C_1 are charged by i_γ . In Fig. 7(g), D_3 is conducting. Thus, C_2 is discharged, C_3 and C_1 are charged by i_γ , C_6 and C_4 supply load current, and C_5 is floating. In Fig. 7(h), D_1 is conducting. Thus, C_1 is charged by i_γ , all even capacitors supply load current, and C_5 and C_3 are floating.

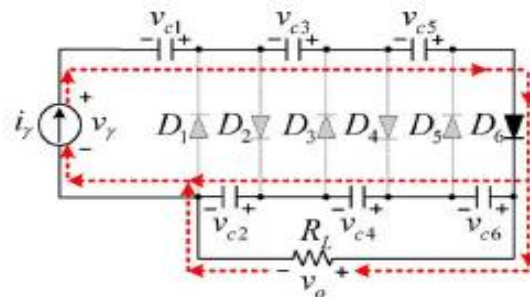
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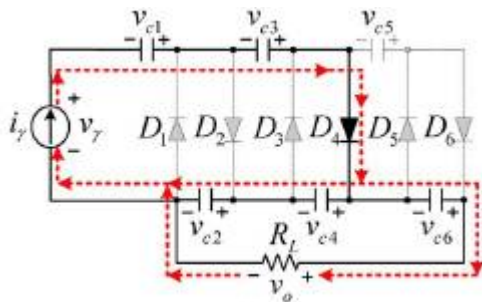
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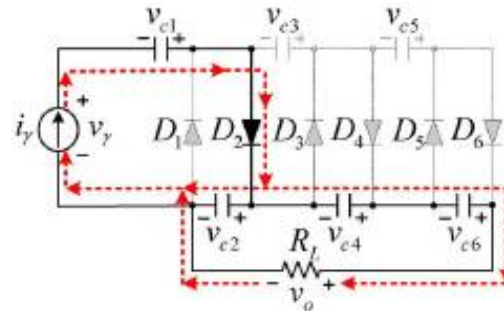
(a)



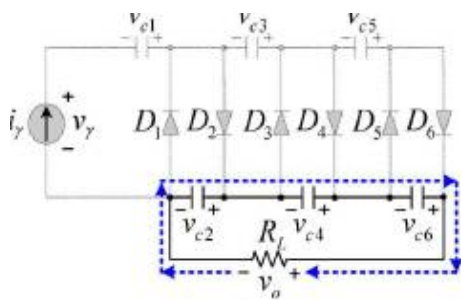
(b)



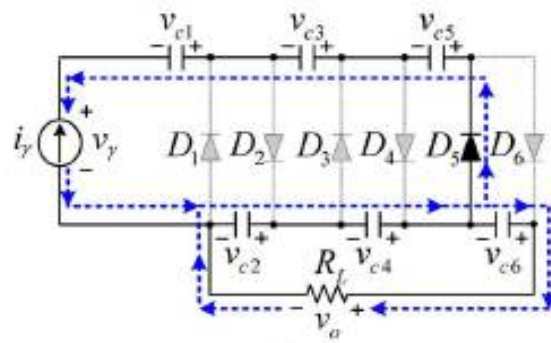
(c)



(d)



(e)



(f)

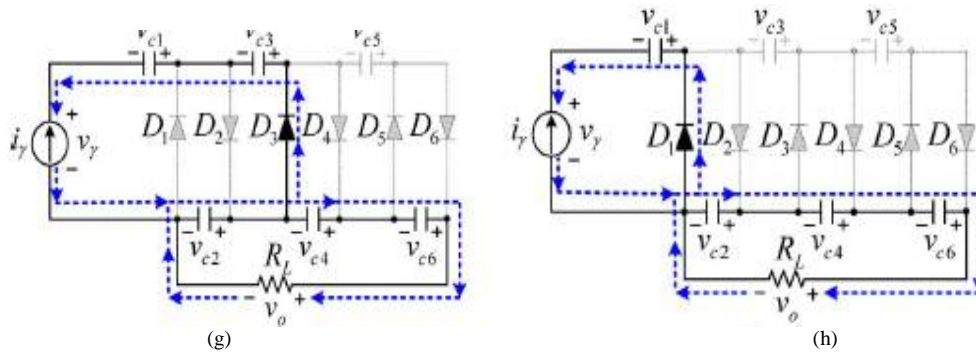


Fig 7. Modes of operation

IV. EXPERIMENTAL RESULTS

Figures show the simulation results of the 3 stage Cockcroft – Walton voltage multiplier using Mat lab. Fig 8 shows the simulation circuit of the Cockcroft-Walton voltage multiplier. Fig 9 shows the input voltage waveform. Fig 10 shows the switching pulses. Fig 11 shows the output voltage waveform obtained from the 3 stage Cockcroft-Walton voltage multiplier.

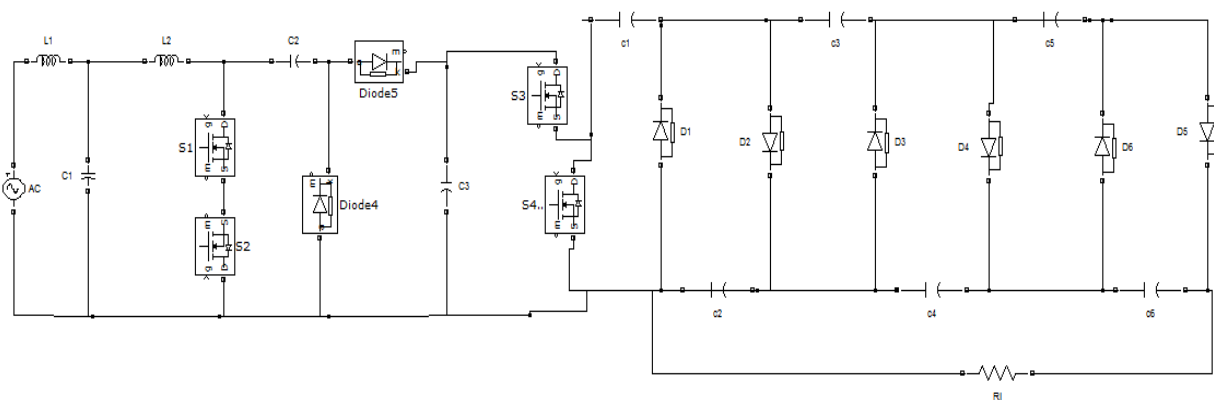


Fig 8. Simulation circuit of the Cockcroft-Walton voltage multiplier.

This fig 8 shows the simulation of the proposed system. Proposed 3 stage voltage multiplier is simulated using Matlab and results are obtained. Results obtained are shown below.

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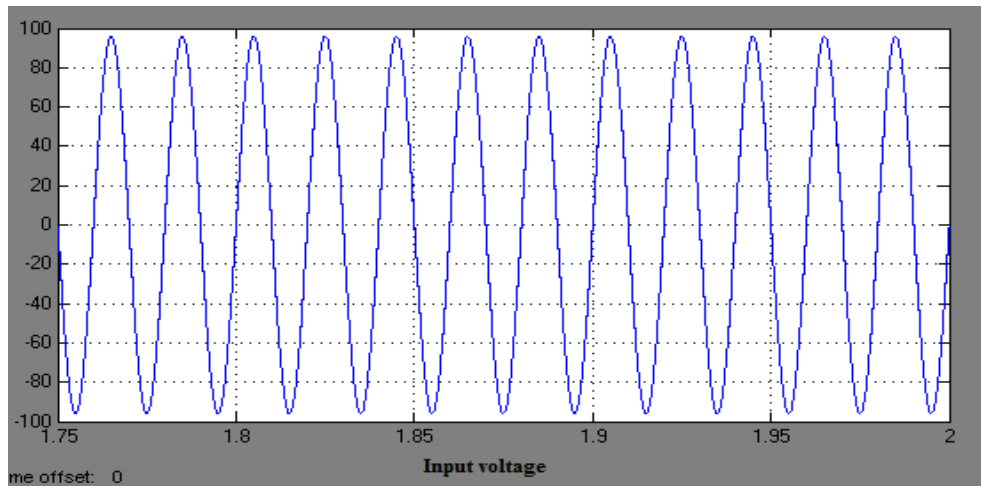


Fig 9 Input voltage waveform

Input ac of 96 voltage is given as the source for the system. AC voltage is given to the pseudo boost converter at the front end of the proposed system. Fig 9 shows the waveform of the AC voltage given to the simulation.

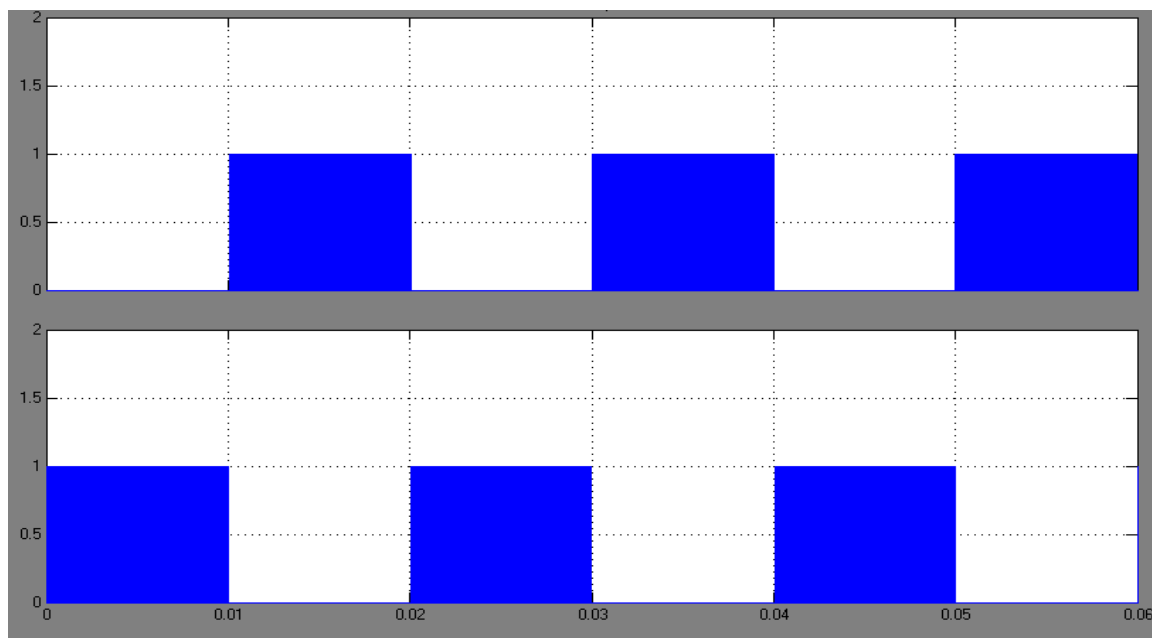


Fig 10. Switching pulses.

Fig 10 shows the pulses given to the circuit. These pulses are given to the switches through gate driver circuits. And provide different operation modes according to the converter .

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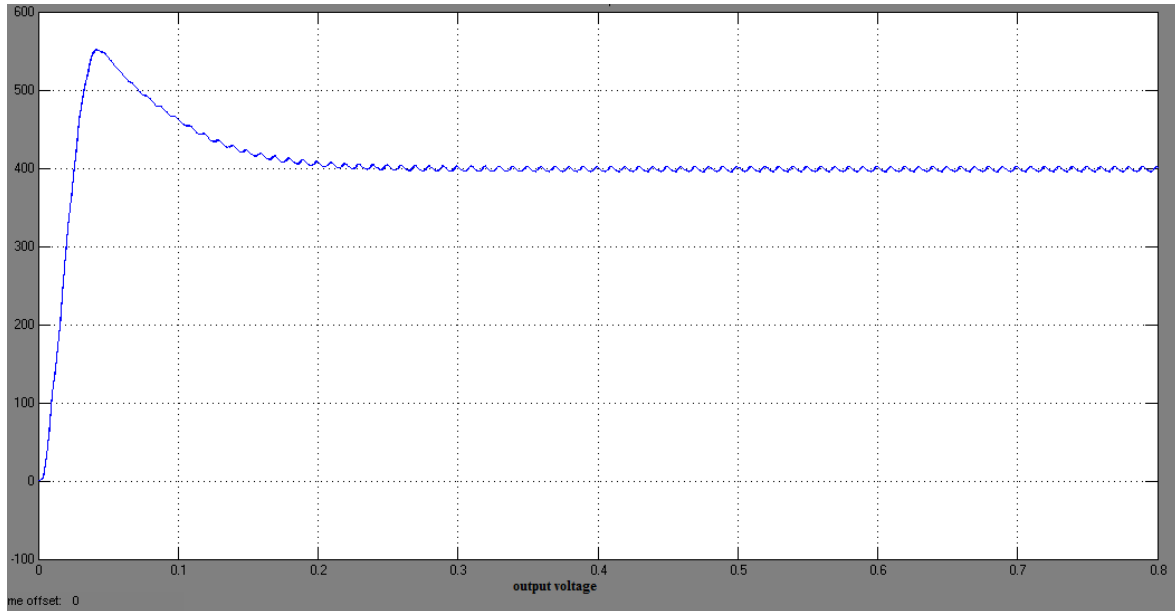


Fig 11. Output voltage obtained from the 3 stage Cockcroft-Walton voltage multiplier.

Output of 400 v dc is obtained from the 3 stage Cockcroft Walton voltage multiplier. The obtained voltage is shown in the fig 11. The simulation parameters used for the simulation of the proposed system is shown in table 1

Table 1.Parameters for simulation

Parameters	Values
Tank Inductor, L_1	100uH
Tank Capacitor, C_1	65nF
Filter Inductor, L_F	1mH
Filter capacitor, C_F	1uF
Load	1Khz
Input voltage	96V
Output voltage	400V
Output Filter, C_0	470uF

V. CONCLUSION

In this project, a high step-up ac-dc converter based on the CW voltage multiplier without a line- or high-frequency step-up transformer has been presented to obtain a high voltage gain. Since the voltage stress on the active switches, diodes, and capacitors is not affected by the number of cascaded stages, power components with the same voltage ratings can be selected.

CW voltage multiplier provide Continuous input current with low ripple, high voltage ratio, low voltage stress on the switches, diodes, and capacitors. This system is suitable for low-input-level dc generation systems.

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BIOGRAPHY



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