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GENERATION OF HIGH VOLTAGE WITH VOLTAGE MULTIPLIER

S. Saravanan[1] ,M. Rajkumar [2] , T.Balakrishnan [2] , T .Varshini [2], L. Sowndarya[2]

[1]Assistant Professor, [2]U G Student

Department of Mechatronics Engineering, M.A.M School of Engineering Siruganur , Trichy, Tamilnadu

Corresponding Author: sowndaryalakshamanan1999@gmail.com

ABSTRACT

DC high voltage is used in testing a variety of insulating material. To obtain higher D.C voltage with the low input source in small scale circuit a high step up D.C to D.C converter with voltage multiplier module is designed. Simulation of high step up D.C to D.C converter with 24 stage cascaded voltage multiplier module is designed and the multi-module circuit is developed by connecting the output voltage of each module in series is done using software MATLAB Simulink. The maximum D.C. output voltage of 50.93 k V is generated using this compact converter in simulation. Then the voltage divider is to divided the output voltage for the Insulation testing.

Keywords — *24 Stage Cascaded Voltage Multiplier, Voltage divider*

I. INTRODUCTION

D.C. high voltage is one of the means used in testing a variety of insulating material. In calculation, direct current high voltage transmission lines are used in electrical power. Thus, the DC high voltage is very essential existence. In the fields of electrical engineering and applied physics, DC high voltages are required for several tenders. For example, electron microscopes, railways and x-ray units require high D.C voltages, as well as electrostatic precipitators and particle accelerators in nuclear physics. For high voltage electrical engineers, the main concern of D.C. high voltages is for the insulation testing, circuit breaker testing of various components in power system. Hence, generation of high voltages in laboratories for testing purposes is essential [1]. Normally, in high voltage testing, the current under conditions of failure is limited to as small range. Sometimes, high direct voltages are required in insulation testing on cables, diodes and capacitors. Impulse generator charging components also require high D.C voltages. In earlier days the demand for high voltage was satisfied mainly by the usage of the transformer. However, the usage of transformer hinders the development for a compact Device. The use of transformer for high voltages in converter circuit reduces the overall operating efficiency due to leakage inductance as it results in high voltage stress which increases the losses in case of higher D.C voltages and also increases the operational cost [2].

II.DC TO DC CONVERTER WITH CASCADED VOLTAGE

In many applications, a DC/DC Converter is used to produce a delimited voltage or current, derived from an unfettered power supply, or from a battery. With the swelling demand for renewable energy, distributed power a power conversion circuit is necessary to interface the generated power to the effectiveness. In order to obtain high D.C voltage transformers are used which produces drip inductance problem, bulk insulation and heavy core results in high cost. It also delays the development of compact Device. This part preview the detailed study of boost converter with voltage multiplier suitable for insulation testing. The high step-up D.C to D.C converter is needed to boost low input voltage to high voltage output. Conventional methods using cascade D.C to D.C converters cause extra complication and higher cost. The conventional topologies to get high output voltage use fly back D.C/D.C converters [3]. They have the leakage components that cause stress and loss of energy that results in low competence. The combination of voltage multiplier with high step up converter increases the voltage conversion ratio and gain [4]. The voltage multipliers are provided with capacitors and diodes in the circuit for converting the input voltage to alternative high level output.

A. Boost converter

Renewable energy systems generate low output voltage, and thus, D.C to D.C converters have been widely used. Such systems transform energy from renewable sources into electrical energy and convert low voltage into high voltage DC-DC Converters are used to convert the unfettered DC voltage into delimited DC voltage as shown in figure 1 [5].As the name implies, the output voltage of Boost converter is higher than the input voltage.

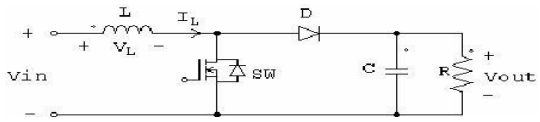

Fig.1 Schematic representation of boost converter

B. SMPS controller function

In many applications, a high step-up D.C/D.C converter is needed to boost low input voltage to high voltage output. Renewable energy systems produce low voltage output, and thus, high step-up D.C to D.C converters have been widely used [6]. The SMPS controller looks at the converter output, relates the output to a set point, makes a control algorithm and finally, applies the algorithm output to a modulator. The modulator output is then used to initiative the DC/DC Converter. The PIC microcontroller is used to implement the SMPS controller function, which includes the following functions: set point generation, error amplifier, control algorithm, and the modulator as shown in the figure 2.

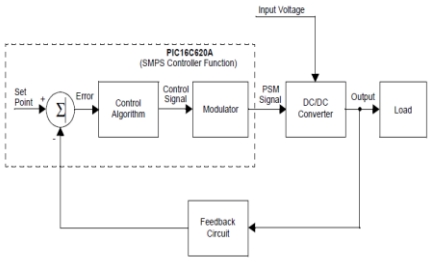

Fig.2 DC TO DC converter system

C. Boost converter with voltage multiplier

DC-DC converter using a transformer is being used for the voltage boost up but the converter section is complex and requires an seclusion circuit. The uses of the voltage multiplier in the standard D.C–D.C converters add new operation characteristics, becoming the subsequent structure well suited to implement high static gain step-up converters. The problem of using a transformer can be overcome by the usage of a suitable booster converter without a transformer and a multiplier circuit using cascaded connected multiplier unit. A high step-up converter based on Cockcroft Walton voltage multiplier [9] replacing the step-up transformer provides higher voltage ratio Boost converter with cascaded voltage multiplier is a pulse-width modulation based DC to DC converter, which combines the boost converter and the switched capacitor purpose to provide altered output voltages and a self-balanced voltage using only one driven adjustment and one inductor with cascaded diodes and capacitors as shown in figure 3. The major advantages of this topology are: a continuous input current, a large conversion without extreme duty cycle, which allow high switching frequency. It can be built in a modular way and more levels can be added without modifying the main circuit [10].

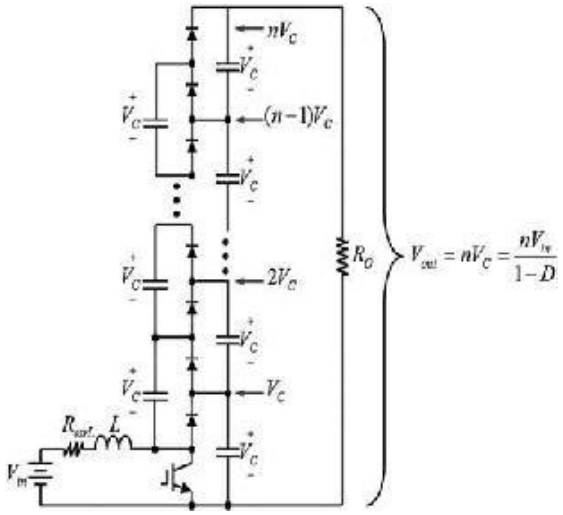

Fig.3 Circuit diagram for boost converter with voltage multiplier

The basic concepts of boost converter and cascaded voltage multiplier circuit were explained in this chapter. The PIC microcontroller used for SMPS controller function has been studied and the dielectric testing of insulating materials have been clearly discussed.

III.SIMULATION OF HIGH VOLTAGE WITH CASCADED VOLTAGE MULTIPLIER

The simulation of high step up converter with voltage multiplier module is developed in the MATLAB (version 7.10.0(R2016a)) Simulink which are efficient in determining D.C breakdown withstand capability of insulating materials. The parameters used in circuit such as inductor, capacitor and duty cycle values are calculated. The calculated values are used for simulation. The operating circuit is simulated in MATLAB Simulink

A. Simulation of the Converter

The theoretical calculation for the identification of inductor and capacitor values is found to be 380 µH and 2.02 µF respectively. The parameters used for cascaded voltage multiplier are Inductor=380 µH, No of stages=24, Resistance=1000kΩ, Capacitor=2.02µF. The results obtained from both module 1 and multi module

circuit are Inductor current=43A, Maximum output voltage(multimodule) =50.93kV, Maximum output voltage (module 1) = 12.73 k V, Maximum output current=0.53 A. The MATLAB Simulink model of muti module circuit is shown in the figure 6.

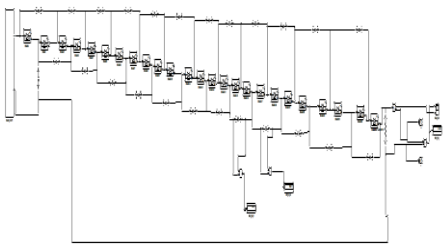

Fig.4 MATLAB Simulink model of 24 stage cascaded voltage multiplier module

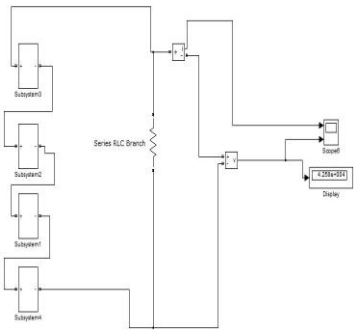

Fig. 5 MATLAB Simulink model of boost converter with 12 stage cascade voltage multiplier module

The simulated results of maximum output voltage and output current in both module 1 and multi module circuit is shown in the figure 6 and 7 respectively.

Table 1 Simulated results of output voltage and current for both cascaded voltage multiplier module and multi module circuit by varying duty cycle of the switch

Duty cycle	Output voltage(k V)		Output current(A)
	Module 1	Multi module circuit	
0.5	5.65	22.63	0.305
0.6	6.75	27	0.29
0.7	9.25	37.02	0.4
0.76	12.73	50.93	0.53

The simulated results of maximum output voltage and output current in both module 1 and multi module circuit is shown in the figure 6 and 7 respectively

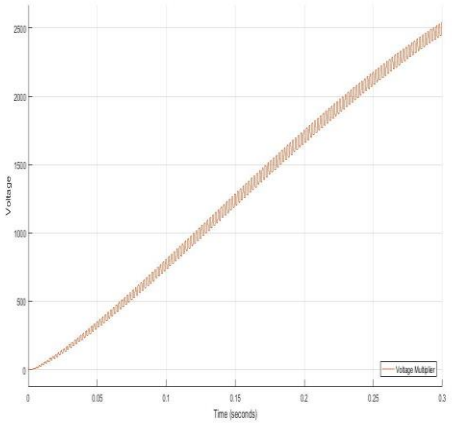

Fig. 6 Maximum Output voltage of 24 Stage cascaded voltage multiplier module.

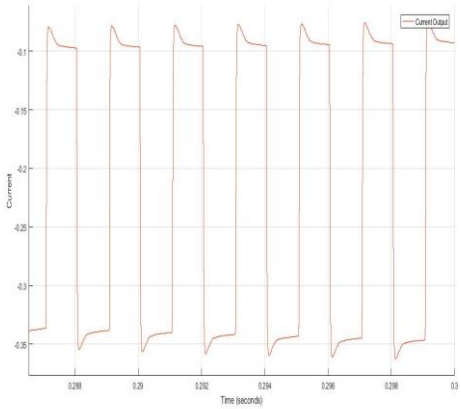

Fig. 7 Maximum Output Current of multi-mode circuit

The parameters required for boost converter with cascaded voltage multiplier module 1 is calculated theoretically for output voltage of 15 k V. The output voltage of 12.73 kV is obtained with duty cycle of 0.70 in voltage multiplier module 1 from simulation. The multi module circuit produces the maximum output voltage of 50.93 kV. The current rating and power rating is identified in simulation for hardware implementation.

IV.CONCLUSION

In this project simulation of high output D.C voltage generation using high step up D.C to D.C converter with voltage multiplier module is done using MATLAB software package. The main purpose of the project deals with the generation of high output D.C voltage for dielectric testing of insulating materials with compact size. It is concluded that the parameters required for designing the circuit is calculated theoretically and it is verified using MATAB Simulation. The high step D.C to D.C converter with 24 stage voltage multiplier module

is designed in simulation. The multi module circuit is developed by connecting the output voltage of each module in series. The maximum output voltage of 50.93 k V is obtained from the multi module circuit in simulation. The hardware model of the compact converter is fabricated which produces the output voltage of 6.5 k V. The potential required for dielectric testing of air and Kraft paper was generated by using this circuit. The insulation testing of air and Kraft paper has been conducted by using this compact converter. The insulation testing of air and kraft paper has been conducted both in HV lab and by using this compact converter. The D.C breakdown voltage of air and kraft paper is found to be same in both testing circuit arrangements.

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