iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** IV **Month of publication:** April 2020

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue IV Apr 2020- Available at www.ijraset.com

Impact of Voltage Multiplier Circuit on Voltage Stability of Network Connected with ESP

Vinay K M[1], Sharath D N[2], Dr. A D Srinivasan[3]
[1]Associate Professor, Department of Electrical & Electronics Engineering, JSS S&T University, Mysuru, India
[2]P.G. Student, [3]Professor, Department of Electrical & Electronics Engineering, JSS S&T University, Mysuru, India

Abstract: High voltage multiplier circuit is designed by the series connection of a large number of diodes and High voltage capacitors. The design of the power supply to the electrostatic precipitator was simulated using MATLAB SIMULINK. This paper is proposed to concentrate more on the Cock croft - Walton voltage multiplier so that output voltage obtained is more than the expected value compared with other types of voltage multipliers.
Keywords: Electrostatic Precipitator (ESP), High voltage Direct current (HVDC), Voltage Quadruppler, Villard voltage multiplier.

I. INTRODUCTION

The recent trends in electrical power distribution system, operation and management are aimed at improving the power quality to overcome all stability problems. The reforms in the distribution sector have given major scope for employment of dispersed generation resources which will boost the system performance. An electrostatic precipitator is a large industrial emission-control unit[1]. The industry process design electric field strength to trap and remove dust particles from the exhaust gas stream. We need Electrostatic Precipitators to minimize the particulate matters emitted into the atmosphere. Electrostatic precipitators are able to trap more than 99% of the particles matters in exhaust air [3].

The following are the industrial processes where Electrostatic Precipitators are used:
1) Coal power plants
2) Cement industry
3) Chemical industry
4) Metals fabrication
5) Paper mills

Voltage multiplier can be employ where low current and high voltage is needed such as picture tubes in TV receivers, oscilloscopes etc. To achieve higher output voltage the individual voltage multiplier stages are connected in series. VM is a combination of diodes and capacitors, by using the diodes and capacitors voltage is increased and converted from AC to DC.

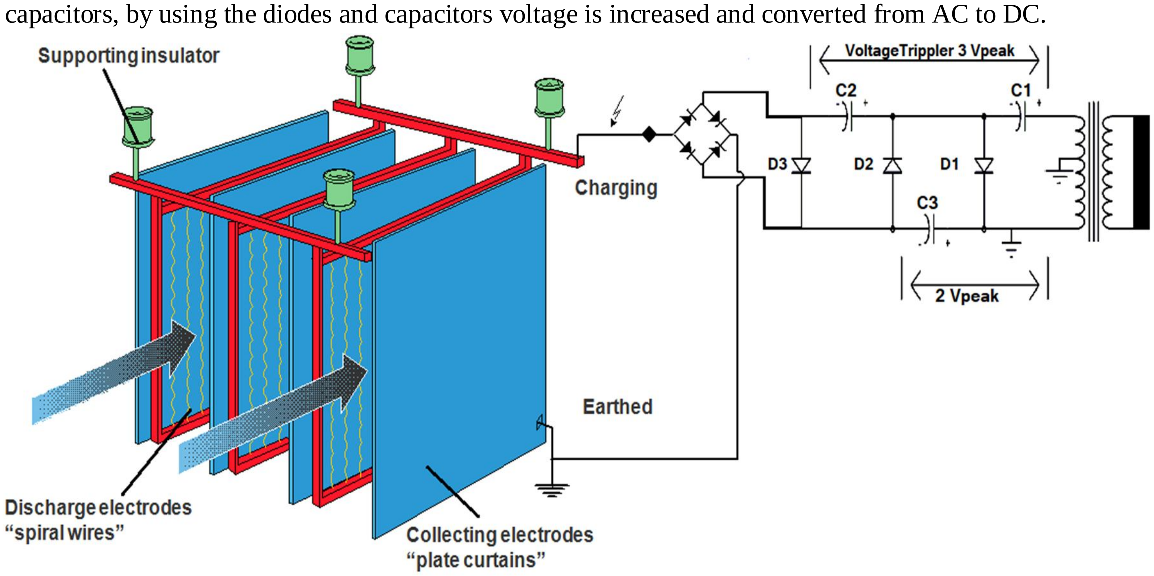


Fig 1: Layout of ESP and Voltage Multiplier

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue IV Apr 2020- Available at www.ijraset.com

II. OBJECTIVES

A. Design various voltage multiplier circuit using MATLAB software.
B. Evaluation of the impact of voltage multiplier circuit on voltage stability of network connected with ESP using MATLAB Simulink.
C. Developing suitable voltage multiplier model based on the evaluation.
D. To validate the simulation results with the practical model.
E. Developing prototype Electrostatic precipitator (ESP).

III. MODELING OF VOLTAGE MULTIPLIERS

These days air pollution has become one of the major concern.ESP is an industrial technology which removes toxic particles from industrial plants such as ascendant mass-production, chemical handling, generation of electric power and domestic air cleaning. The size of Particulate matters varies from the range of micrometer to nano meter sized. The effects of these nano particles emission on human health is more adverse compared with micro particles. The removal efficiency for a nano-particles is lesser compared to micro-particles from an ESP in industrial application[1] [2]. Awareness of the particle granulation distribution is condition to evaluate an ESP collection efficiency. . Modeling of electric field for an ESP and to study the impact of voltage stability of voltage multiplier when ESP's are connected is the major concern of this work. This work also includes studies on the problems which arise during the working of an Electrostatic precipitator.When Electrostatic Precipitator is operating, we may experience several problems like apparent dust resistivity,[8] re-entertainment and back corona which leads to poor performance of ESP.

According to the Heinrich Greinacher, the Diode-Capacitor topology is more suitable to obtain HVDC which can also be realized as "Greinacher voltage doubler"[6]. Heinrich Greinacher is the first person to present voltage doubler in the year 1920. It was one of the most popular diode capacitors topology and can also be called as "villard voltage - doubler". According to Heinrich Greinacher this circuit was a simple combination of the clamper circuit and the peak holder circuit.

Cock croft and Walton introduced a complex cascade voltage-doubler in 1932 and awarded with the Nobel Prize in 1951 for this work. In this work the circuit generates voltage three times greater than the applied voltage i.e, a steady potential of about 700 KV [10].

Voltage multipliers may also be used as primary power supplies where AC input of 230volts is rectified to pulsating DC. This output DC voltage may be increased (through the use of a voltage multiplier) to certain kilo-volts of DC.Voltage multipliers can be classified voltage doubler, voltage trippler and voltage quadruppler depending on the number of stages.

A. Voltage Doubler

The voltage doubler is a circuit where the output voltage is twice the input voltage. If the supply voltage is 20 volts, the output voltage will be twice input voltage which will be 40 volts. Generally transformers are used to step-up the voltage, but using transformers to obtain high voltage is not feasible because of its size and its maintenance cost[3]. The voltage doubler is classified as two types namely half-wave voltage doubler and full-wave voltage doubler.

1) *Half-wave Voltage Doubler:* In half wave voltage doubler circuit the +Ve half-wave cycle of the secondary voltage, diode D1 conducts and D2 is cut off. Now capacitor C1 charges to the peak rectified voltage Vm with the polarity shown in the figure 2. During the -Ve half-wave cycle, the secondary voltage comes in series with the voltage across the capacitor C1. Thus C2 will try to charge towards 2 times of Vm, After few cycles, the voltage across the capacitor C2 will be equal to 2 times of Vm. Since diode D2 acts as a short during the negative half-cycle (and diode D1 is open), we can sum the voltages around the outside loop.[7]

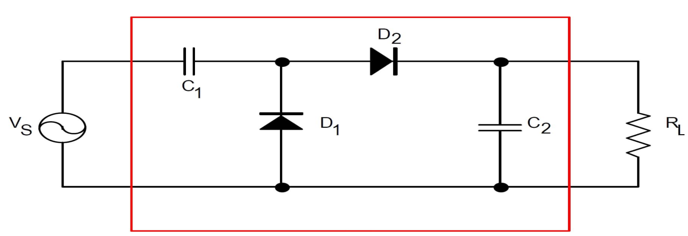


Fig 2: Half-wave voltage doubler

In the circuit capacitor C1 will discharge in the -Ve half cycle and again in the +Ve half cycle, it starts charging. In one-half cycles, the half-wave voltage doubler supplies the voltage to the load. So regulation of the half-wave voltage doubler control is poor. [5].

2) *Full-wave Voltage Doubler:* As shown in the figure 3, it is another voltage doubler circuit called as full-wave voltage doubler. During the +Ve half-wave cycle of the secondary voltage, diode D1 conducts charging the capacitor C1 to the peak voltage Vm. At this time diode D2 is open. During -Ve half-wave cycle diode D2 conducts, charging capacitor C2 to the peak voltage Vm, with polarity signs as marked, while diode D2 is open. Since both capacitors C2 and C1 are in series, the final output voltage is approximately 2times of Vm. This circuit is called as full-wave voltage doubler because one of the output capacitors is being charged during each half cycle of the input voltage[5]

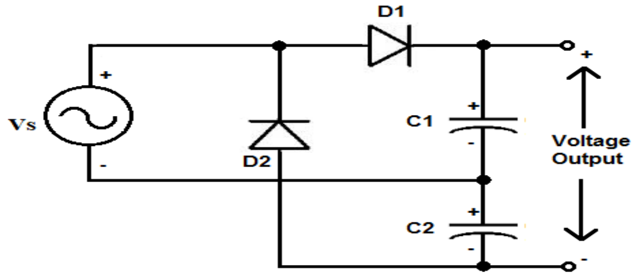


Fig 3: Full-wave voltage doubler

B. Voltage Trippler /Quadruppler

Voltage trippler/quadruppler develops a d.c. voltage equal to three or four times the input voltage. The trippler/quadruppler circuit is shown in the figure 4, it is a multiplication of the half-wave voltage doubler. During the +Ve half-wave cycle, the diode D1 conducts, charging the capacitor C1 to Vm with the polarity as shown. During the first -Ve half-wave cycle, the diode D2 conducts and charging the capacitor C2 to 2 times Vm. During the second +Ve half-wave cycle the diode D3 conducts in addition to D1, charging the capacitor C1 and the voltage across the capacitor C2 charges capacitor C3 to the same value 2 times of Vm. On the second negative half cycle diode D2 and D4 conduct and capacitor C3 charge C4 to 2 times of Vm. Thus the voltage across C2 is 2 times of Vm, across C1 and C3 is 3 times of Vm, and across C2 and C4 is 4 times of Vm. .

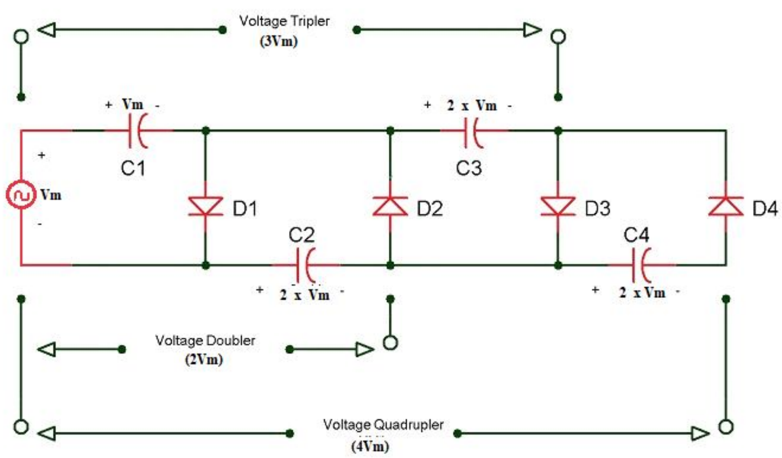


Fig 4: Voltage Tripler/Quadrupler

If an additional section of diodes and capacitors are used, each capacitor will be charged to 2 times of Vm. The odd multiples of Vm at the output is obtained when Measuring from the top of the transformer winding,[4] whereas the even multiples of the peak voltage Vm are obtained when measuring from the bottom of the transformer.

C. Cock croft-Walton

The Cock craft Walton is a voltage multiplier that converts alternating current or pulsing direct current electrical power from a low voltage level to an HVDC. It is made up of a voltage multiplier ladder network of diodes and capacitors to generate HVDC. Unlike transformers,[6][3] this method eliminates the requirement of the bulk of insulation/potting required. Using only the diodes and capacitors, these voltage multipliers can step up from low voltages to extremely high voltage in kilo-volts(KV), while at the same time being less weight and cost wise lower than transformers.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue IV Apr 2020- Available at www.ijraset.com

Half-wave rectifier circuit as an advantage, where voltage across each stage of the cascade is equal to twice the peak source voltage[9]. In the full-wave rectifier, the output voltage is three times the input voltage. It has the advantage of employing relatively economical feasible components and being easy to build circuit. Advantage of Cock Croft-Walton voltage multiplier comparing with half wave and full wave rectifier is,[7] we can tap the output from any stage.

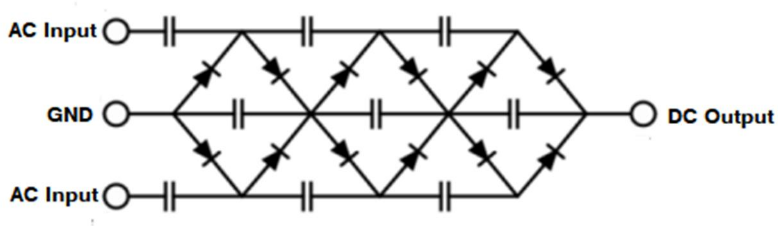


Fig 5: Cock croft - Walton

IV. SIMULATION RESULT AND ITS DISCUSSION

The high voltage multiplier circuit is designed using MATLAB/SIMULINK to the electrostatic precipitator. The electrical circuits containing linear and non-linear elements are simulated using Simscope power systems specialized technology and Simulink toolboxes.

A. Voltage Doubler

1) Half wave Voltage Doubler

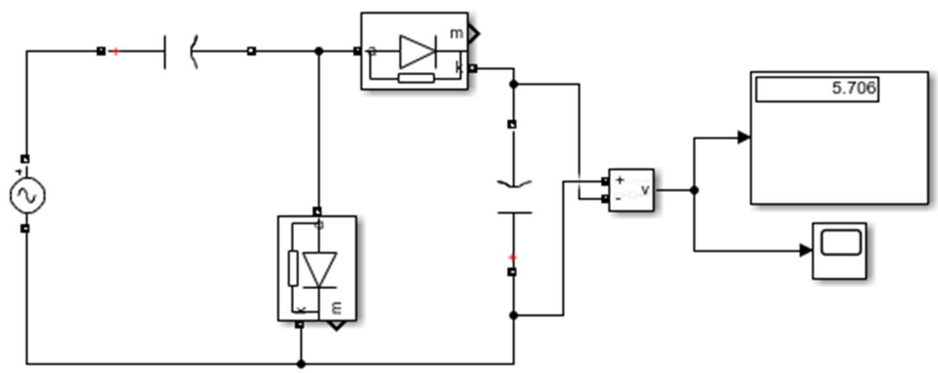


Fig 6: Half wave voltage doubler circuit

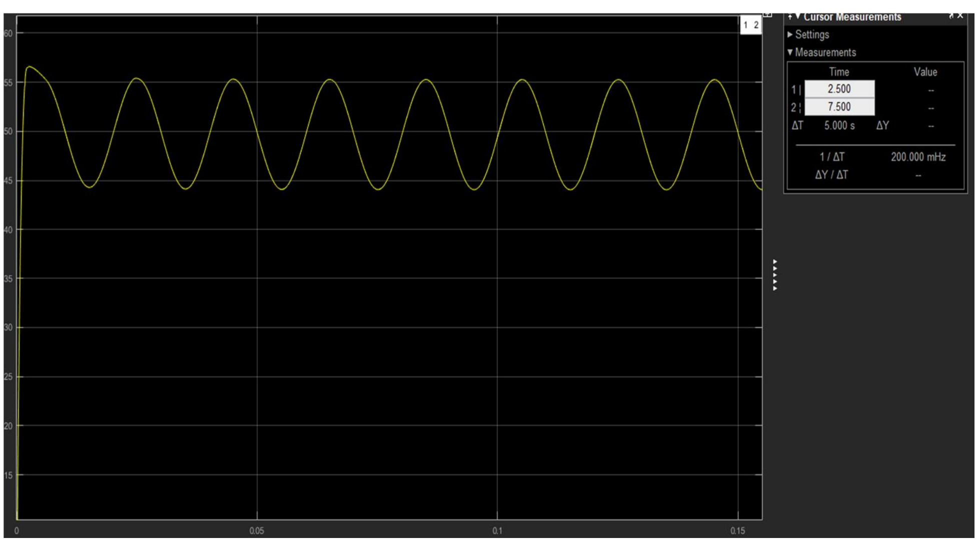


Fig 7: Half wave voltage doubler output

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue IV Apr 2020- Available at www.ijraset.com

2) Full wave Voltage Doubler

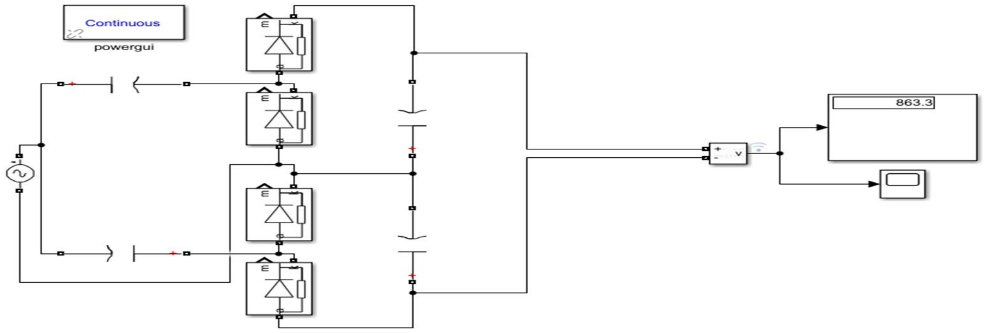


Fig 8: Full wave voltage doubler ckt

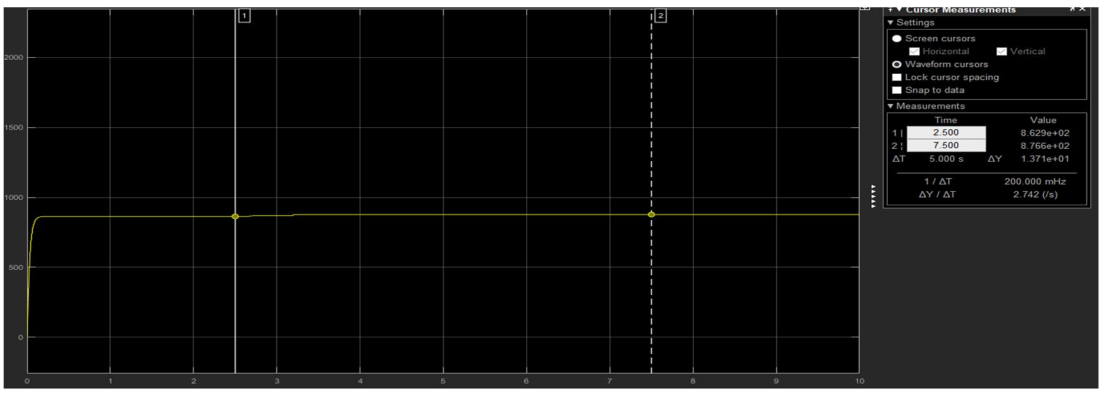


Fig 9 : Full wave voltage doubler output

B. Voltage Quadruppler

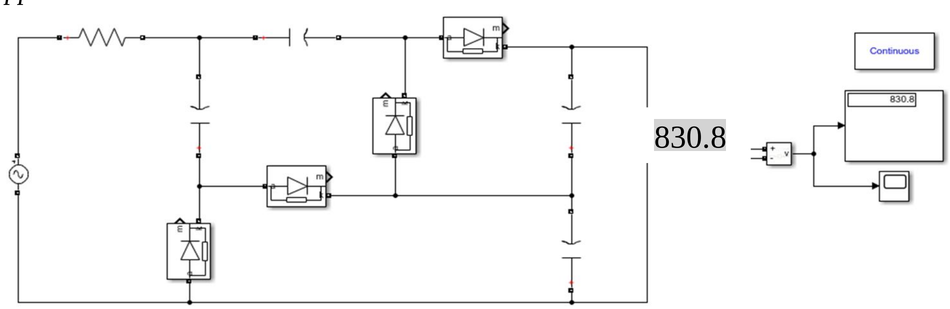


Fig 10:Voltage quadrupler ckt

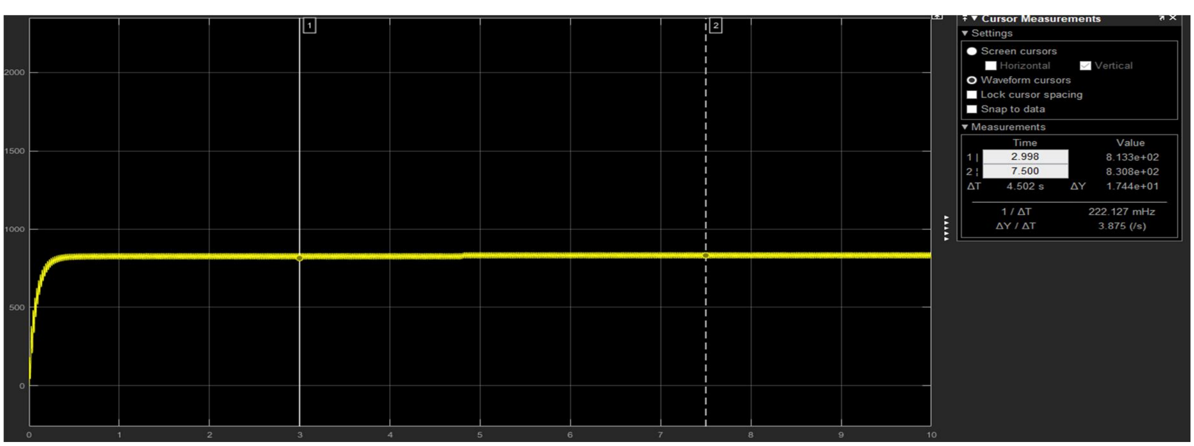


Fig 11: Voltage quadrupler output

C. Cock Croft-Walton Voltage Multiplier

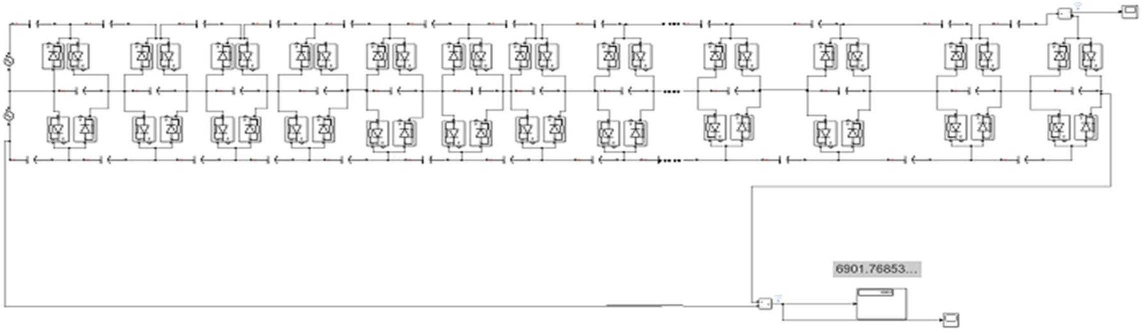


Fig 12: Cock Croft-Walton Voltage Multiplier ckt

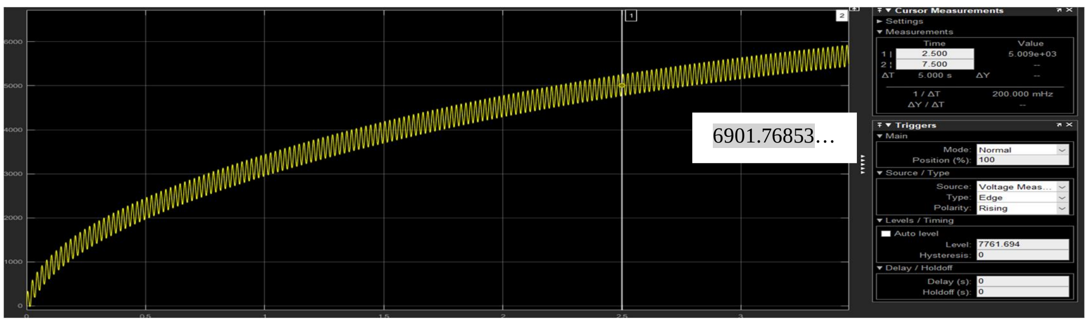


Fig 13: Cock Croft-Walton Voltage Multiplier output

V. CONCLUSION

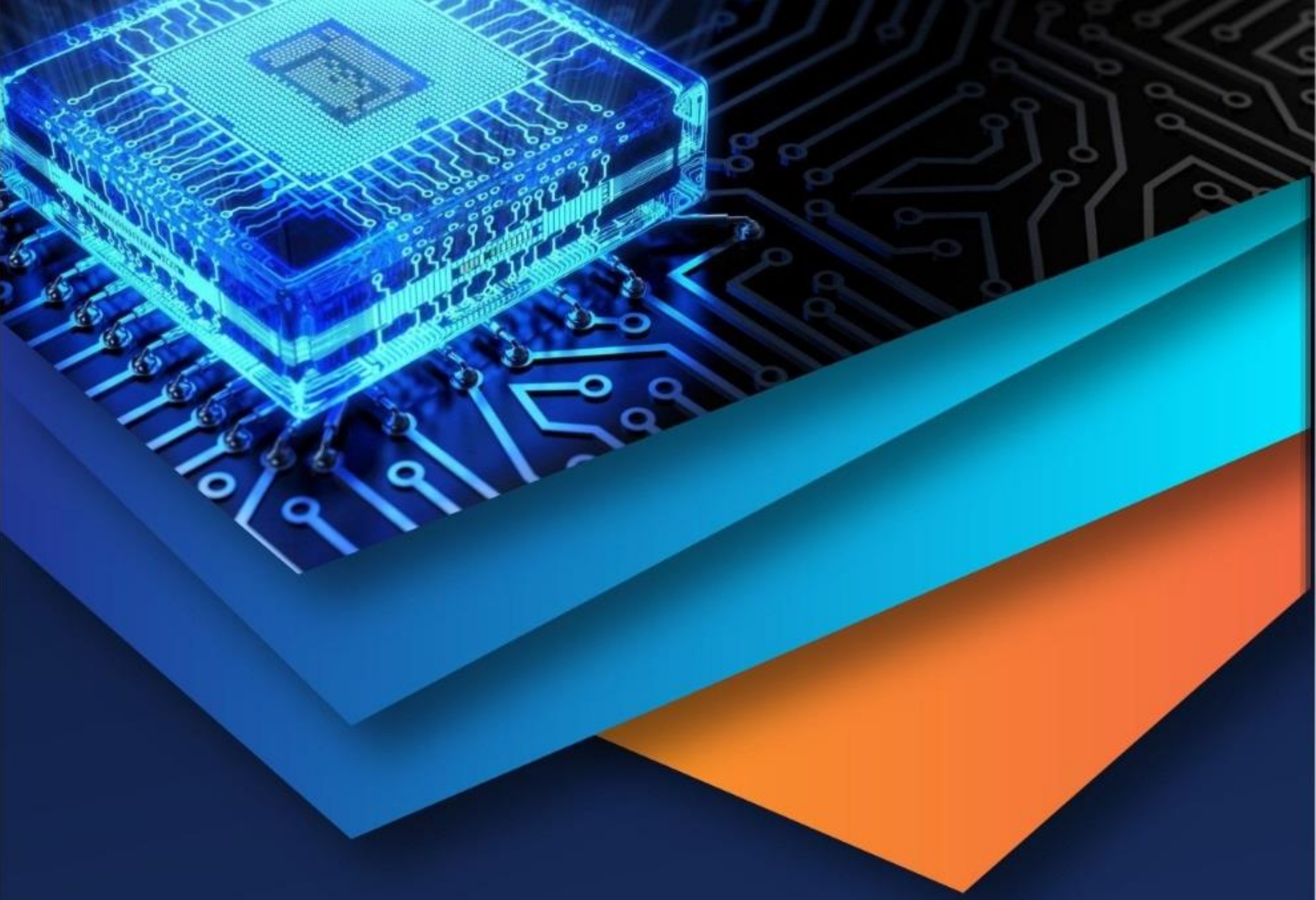
This work has shown the impact of voltage stability, construction and Simulation techniques for a different type of voltage multiplier design for the electrostatic precipitator. The ESP is energized by power electronic converters such as HV Capacitors and Power Diodes. A lab-scale electrostatic precipitator (ESP) is fabricated and collection efficiency is measured for different applied voltage using this Cock croft -Walton voltage multiplier.

VI. ACKNOWLEDGMENT

We would like to thank teaching and non-teaching staff of the Department of E&EE, JSS Science and Technology University, Mysuru for their moral support and encouragement

REFERENCES

[1] Xusheng Z., Feng T., Jianjun D. (2009) "Evaluation of HV Power Source for ESP". In: Yan K. (eds) Electrostatic Precipitation. Springer, Berlin, Heidelberg
[2] Garba Babaji, Department of Physics, Bayero University,"DESIGN AND CONSTRUCTION OF A 12 kV D.C. POWER SUPPLY" Bajopas Volume 2 Number 2 December, 2009
[3] Yan An Wang & Deng Ming Xiao (2010) "Design of an Electrostatic Precipitator Power Supply Based on Transformer Stray Capacitance Effects", Electric Power Components and Systems.
[4] Arash Toudeshki, Norman Mariun, Hashim Hizam, and Noor Izzri Abdul Wahab, "Development of a New Cascade Voltage-Doubler for Voltage Multiplication" Received 28 October 2013; Accepted 31 December 2013; Published 11 February 2014
[5] Mariun, N., D. Ismail, K. Anayet, N. Khan and M. Amran, 2006. "Simulation, Design and Construction of High Voltage DC Power Supply at 15 kV Output Using Voltage Multiplier Circuits". Am. J. Applied Sci., 3: 2178-2183.
[6] Ioannis C. Kobougias and Emmanuel C. Tatakis "Optimal Design of a Half-Wave Cockcroft – Walton Voltage Multiplier With Minimum Total Capacitance" IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 25, NO. 9, SEPTEMBER 2010
[7] C.K. Dwivedi ; M.B. Daigvane. "Multi-purpose Low Cost DC High Voltage Generator (60kV Output),Using Cockcroft-Walton Voltage multiplier circuit" 2010 3rd International Conference on Emerging Trends in Engineering and Technology.
[8] R. L. FORTESCUE, M.A., Associate Member, and P. D. HALL, B.Sc, Graduate. "THE HIGH-VOLTAGE ELECTROSTATIC GENERATOR AT THE ATOMIC ENERGY RESEARCH ESTABLISHMENT"{The paper was first received 25th September, 1948, and in revised form 1th January, 1949.)
[9] M. A. Razzak, Sajib Chakraborty and Zaima Tasneem, "Design of a Multistage 0.1/12 kV DC-DC Matrix Converter using Cockcroft-Walton Voltage Multiplier Topology", IEEE WIE International Conference on Electrical and Computer Engineering (WIECON-ECE), 19-20 December 2015, Dhaka, Bangladesh. Received the Best Track Paper Award (indexed in IEEE Xplore). \
[10] Md. Mohasin Siddique and supervisor Dr. Md. Raju Ahmed "Design and Implementation of an AC to High DC Voltage Generation Circuit Using voltage multiplier", this is project report https:// www.duet.ac.bd/wp-content/uploads/2019/09/Thesis,February, 2019



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY