# Multi-Purpose DC High Voltage Generator using Cockcroft-Walton Voltage Multiplier Circuit

**Mr. Sachitanand S. Tijare[1] Mr. Gaurav D. Thakare[2] Mr. Rahul P. Argelwar[3]**
[1,2,3]Department of Electrical (Electronics & Power) Engineering
[1,2,3]DES's COET, Dhamangaon (Rly)

*Abstract*— The project is designed to develop a high voltage DC around 1KV from a supply source of 230V AC using the capacitors and diodes in a ladder network based on Cockcroft voltage multiplier concept. Voltage multipliers are primarily used to develop high voltages where low current. This project describes the concept to develop high voltage DC from a single phase AC. For safety reasons our project restricts the multiplication factor to 8 stages such that the output would be within 1KV.

***Key words:*** Cascading circuit, Cockcroft-Walton multiplier, High voltage, Voltage divider

## I. INTRODUCTION

The requirement of high voltage is increases day by day. As more need of high voltages in various applications, because the demand of power for increasing consumers is increased day by day. As in modern times high voltages are used for wide Varity of application covering the power systems, industry and research laboratories. Such applications have become essential to sustain modern civilization.

The Cockcroft-Walton is a voltage multiplier that converts AC or pulsing DC electrical power from a low voltage level to a higher DC voltage level. It is made up of a voltage multiplier ladder network of capacitors and diodes to generates high voltages. Unlike transformers, this methods eliminates the requirement for the heavy core and bulk of insulation. Using only capacitors and diodes, these voltage multipliers can step up relatively low voltages to extremely high values, while at the same time being far lighter and cheaper than transformers. The biggest advantage of such circuits is that the voltage across each stage of cascade is equal to twice the peak input voltage. Thus, the high voltage dc generates by using Cockcroft voltage multiplier circuit. There are several application of D.C. high voltage, in the field of electrical engineering and applied physics such as electron microscope, X-rays, electro- static precipitators, particles accelerator in nuclear physics, dielectric testing and so on.

## II. VOLTAGE MULTIPLIER CIRCUIT

As it is already known how a transformer functions to increase or decrease voltages. It is also known that a transformer's secondary may provide one or more A.C. voltage output which may be greater or lesser than output voltage, when voltages are stepped up current decreases and when voltages are stepped down current increases. There is another method to increase voltage that is voltage multiplier. Voltage multiplier circuits are used primarily to develop high voltages where low current is required. The output voltage of Voltage multiplier circuits may be several times more than the input voltage. For this reason, Voltage multipliers are used in special applications where load is constant and has high impedance or where input voltage stability is not critical. The classification of voltage multiplier depends on the ratio of output voltage to input voltage such as doubler, triplen, quadruples and n-plex.

The Voltage multiplier circuit which has the ratio of output voltage to input voltage depending on number of stages is called Cockcroft-Walton Voltage multiplier circuit which is used to develop high voltages in order of several kV. An output voltage, from any stage, can be taken out through tapings. In this work, the input voltage, for Cockcroft-Walton voltage multiplier, has been taken from the secondary of single phase step-up transformer.

## III. COCKCROFT-WALTON VOLTAGE MULTIPLIER CIRCUIT

The Cockcroft-Walton voltage multiplier is an electrical circuit that converts AC or pulsing DC electrical power from a low voltage level to a higher DC voltage level. It is made up of a voltage multiplier ladder network of capacitors and diodes to generate high voltages. Unlike transformers, this method eliminates the requirement for the heavy core and bulk of insulation. Using only capacitors and diodes, these voltage multipliers can step up relatively low voltages to extremely high values, while at the same time being far lighter and cheaper than transformers. The biggest advantage of such circuits is that the voltage across each stage of cascade is equal to twice the peak input voltage.

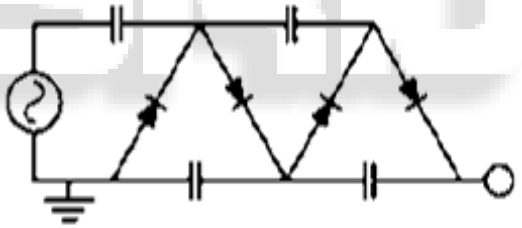

Fig. 1: COCKCROFT-WALTON Voltage Multiplier Circuit

The operation of Cockcroft-Walton voltage multiplier is quite simple. Considering the simple cascade network of Cockcroft-Walton voltage multiplier circuit. Which is attached to an AC power source, at the time when the AC input reaches its negative pole then the first diode is in forward bias is allowing the current to flow from it due to this the first capacitor is charge.

When the same AC signal reaches to positive polarity then the first diode is in reverse bias and the diode second is in conduction mode in cascade circuit. As the second diode is in forward bias then the second capacitor is charge through these diode. Thus, the all capacitors in cascade network are charges through respective diodes. As all capacitors are charge this gives the high voltage DC at output

 

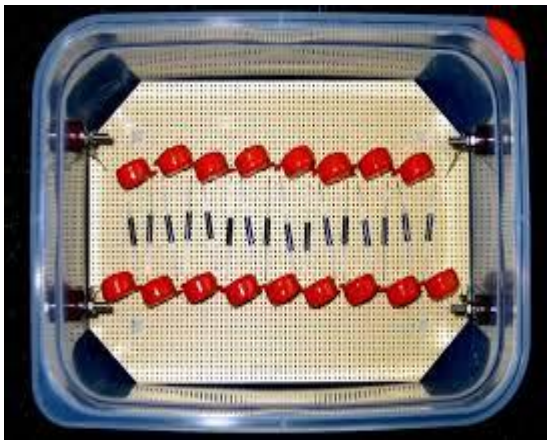

Fig. 2: Positive Polarity

## IV. DESIGN CRITERIA

### *A. Capacitor Selection:*

The size of capacitors used in multiplier circuit is directly proportional to the frequency of input signal. Capacitor used in off line, 50 Hz application is usually in the range of 1.0 to 200 microfarad. While those used in high frequency applications, say 10 kHz are typically in the range of 0.02 to 0.06 microfarad.

Fig. 3: Design Criteria

The voltage rating of capacitor is determined by the type of multiplier circuit. The capacitor must be capable of withstanding a maximum voltage depending upon the numbers of staged used. A good thumb rule is to select capacitor whose voltage rating is approximately twice that of actual peak applied voltage. For example a capacitor which will see a peak voltage of 2Em should have a voltage rating of approximately 4Em.

### *B. Diode selection:*

Prior to selection of diode basic device parameter must be considered.

*1) Frequency of Input Signal:*

While selecting rectifier diode, the frequency of input signal to multiplier circuit must be taken into account. For symmetrical input signals, the device chosen must be capable of switching at speed faster than the rise and fall times of the input. If the reverse recovery time is too long the efficiency and regulation of the device will suffer. In the worst case insufficient recovery speed will result in accessing heating of device. And in this case permanent damage of device will take place. The reverse recovery time is very dependent upon the circuit and the condition being used to make the measurement. Reverse recovery Time specification should be used for qualitative, not quantitative purposes since condition specified for the measurement rarely reflects those found in actual real life circuit operation. Decreasing current flow in the multiplier circuit makes it possible to use higher input frequency. An increase in current flow has been the opposite effect. Ideally the multiplier network load should draw no current.

*2) Forward Current:*

Ideal multiplier circuit, the load will draw no current. Ideally significant current flow through the rectifier occurs during capacitor charging. Therefore, device with very low current rating (100 mA). It comes to micro amperes can be used. It must be noted that forward current and forward surge current rating are related. Since both are the function of silicon die area. It is truly speaking that devices with a high surge current rating.

Fig. 4: Forward Current

## V. PROPOSED METHODOLOGY

The operation of this project for generation of high is very simple. We can generate the high voltage DC up to 1kv by using single phase AC supply. The functional block diagram of this project is as shown below.

It consists of rectifier circuit which converts ac supply into dc, amplifier circuit these amplifies the converted dc power, The Cockcroft-Walton voltage multiplier circuit made up of ladder network of diode and capacitors circuit that converts AC electrical power from a low voltage level to a higher DC voltage level and potential divider with 10:1.

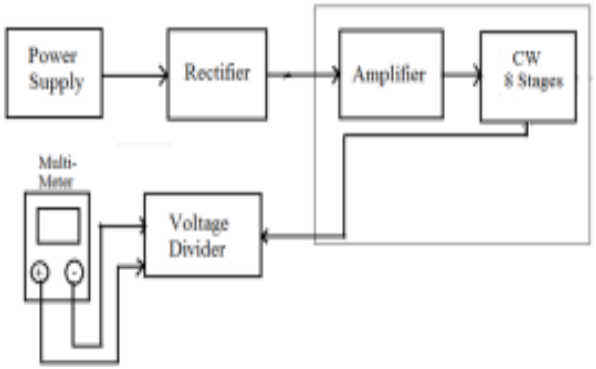


Fig. 5: Operational block diagram

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When 230V ac is supplied to rectifier. Rectifier is converting ac into dc. These dc is amplifies. This amplified voltage is given to the voltage multiplier circuit, these voltage multiplier steps up relatively low voltage into extremely high voltage values. Because the biggest advantage of such circuit is that the voltage across each stage of cascade is equal to twice the peak input voltage.

i.e. Vmax = 2*Vmax

The high voltage is generates at output of multiplier circuit is very high. So it does not measure by simple volt meter. Thus, by using 10:1 potential divider the output voltage is measure.

## VI. CONCLUSION

The Cockcroft-Walton Multiplier surface mount and design in which high voltage generate without use transformer is a beauty of the high voltage Cockcroft-Walton circuit. There for size of the complete high voltage circuit is small and cost is also less. This small size circuit gives high voltage at the end of multiplier circuit. Because of the light weighted circuit it is portable it gives high reliability. Construction of whole circuit is simple and robust in nature. This multiplier circuit is useful for a scientific instrument, TV sets and CRTs, Oscilloscope, x-ray and photomultiplier tubes and field testing of HV cables.

## VII. EXPERIMENTAL SETUP

In this experiment used 1 to 250 microfarad capacitor are used and IN 4007 Diode which is cascading in the Cockcroft Walton multiplier circuit. Digital multimeter which is used to measure the High Voltage at the end of multiplier circuit.

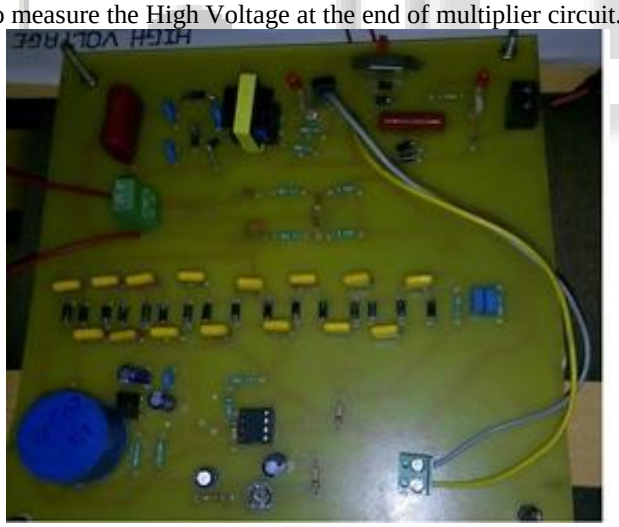

Fig. 6: Prototype setup of Cockcroft-Walton multiplier circuit

## REFERENCES

[1] C. K. Dwivedi ,M. B. Daigavane," Multi-purpose low cost DC high voltage generator (60 kV output), using Cockcroft-Walton voltage multiplier circuit‖, International Journal of Science and Technology Education Research Vol. 2(7), pp. 109 - 119, July 2011.
[2] G.S. Senthil Raaj, G.T. Sundar Rajan," Simulation and Implementation of Single-Phase Single-Stage High Step-Up AC–DC Matrix Converter based of Cockcroft–Walton Voltage Multiplier‖, International Conference on Innovations In Intelligent Instrumentation, Optimization And Signal Processing "ICIIIOSP-2013"
[3] Adinath Jain, Simith E," AC-DC Matrix Converter Based On Cockcroft-Walton Voltage Multiplier‖, IOSR Journal of Engineering (IOSRJEN), Vol. 04, Issue 07 (July. 2014). PP 16-23
[4] Naidu MS, Kamaraju V (2004),‖High Voltage Engineering‖, Third Edn. McGraw- Hill Company Ltd. pp. 146-156
[5] C. L. Wadhwa, ―High Voltage Engineering ‖.New Age International Publication. pp. 56-63.
[6] Mazen AS, Radwan R (2000). High Voltage Engineering Theory. Sec. Edn. Revised and Expanded, Marcel Dekker, Inc. Am. J. Appl. Sci., 3 (12): 2178-2183, 2006 2183.
[7] I. C. Kobougias and E. C. Tatakis, Optimal Design of a Half-Wave Cockcroft Walton Voltage Multiplier With Minimum Total Capacitance, IEEE Trans. Power Electron., vol. 25, no. 9, pp. 24602468, Sep. 2010.
[8] R. Kalaivani and R. Prince. 'DC-DC converter based on cascade Cockcroft- Walton voltage multiplier for high voltage gain without using transformer'. International journal of engineering Science and innovative technology (IJESIT) volume 2, issue 2, March 2013.
[9] Chung-Ming Young, Kuo-Hwei You, Ming-Hui Chen and Shou-Heng Yeh. 'A single-phase single-stage high step-up ac–dc matrix converter based on cockcroft– walton voltage multiplier with PFC'. IEEE transactions on power electronics, vol. 27, no. 12,Dec. 2012

 