Design and Implementation of a Cockcroft-Walton voltage Multiplier circuit

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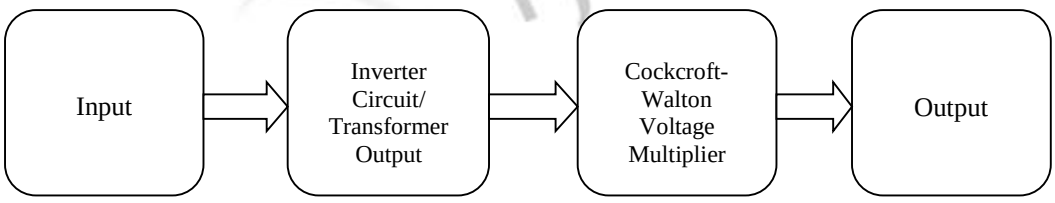
***Abstract*—This paper primarily describes a Cockcroft Walton voltage multiplier circuit. The objective of the project is to design a voltage multiplier which should be able to multiply voltage from an input as low as 12 Volts to a maximum output of approximately 200 Volts (For Project's application). Designing of the circuit is based on Cockcroft Walton Principle that consist of ladder network of Capacitor and Diodes. Hence, this project studies the application of multiplier circuit in high voltage application's implementation in which high discharge rate of capacitor is expected with low output current. Selection of Capacitors and proper diodes is one of the very important aspect considered while designing the circuit. Using the same principle, a relative study is done and results are discussed regarding stepping up of voltages from a single phase input to output voltage up to 3kV(Kilovolts).The hardware of the said circuit is studied and implemented after study of the ladder network. Finally, the results are compiled from the simulations done on MATLAB 2013-b.**

Keywords*— *Voltage Multiplier, High Voltage Generation, Cockcroft-Walton voltage multiplier circuit.

I. INTRODUCTION

Today, there are many devices and instruments requiring high voltages. Typically, a High voltage DC output is often required in various facets of research areas. Sometimes, high direct voltages are needed in insulation tests on cables and capacitors. Impulse generator charging units require 100 to 200 kV output. Many a times, output of the circuit is expected in a way such that a complete discharge of the capacitor should result in killing of a foreign material (conducting) coming in contact with it (When the output terminals are shorted by the conducting body) as done in case of a Mosquito zapper racket. On the basis of requirements, we have designed our circuit with due consideration to output voltage and current. For our project, we have constructed a circuit in which number of capacitors when initially arranged in series-parallel pattern, must produce a high discharge rate after their output terminals are shorted. Moreover, the output voltage must be high as compared to the low input voltage. The design of the complete circuit assembly is as depicted in the following block diagram. The input of the circuit is fed from a 12 Volts AC supply. This supply of 12 Volts can be achieved using two ways-Either by directly using a step down Transformer of rating 230V/12V; by using a 12 Volts DC supply and by connecting an inverter circuit, the output voltage can be obtained. In this case the first cited method is followed so that the circuit construction and implementation is cost effective. The output of the transformer is then given to the Cockcroft Walton Voltage Multiplier circuit, and the output is directly taken from the terminals as discussed later in the circuit diagram.



II. DESIGN OF CIRCUIT

A standard Cockcroft Walton Voltage Multiplier circuit is as shown in the adjoining figure. The Cockcroft Walton circuit is made up of ladder of Capacitors and diodes to give desired output. In this circuit, by use of only capacitor and diode itself, the output can be obtained to extremely high values from relatively low input voltages. The basic principle of a CW circuit is explained as-In voltage double circuit Fig. 'A' shown below gives a brief idea about the principle of negative voltage double where the diodes are rectifier grade diodes and the capacitor diode assembly acts like half wave rectifier. In the circuit during positive half cycle of input voltage first diode is forward biased and second one is reverse biased. Therefore the flow of current charges the capacitor to negative peak value and capacitor C1 is charged through diode D1 to –Vi .

Similarly, during negative half cycle of input voltage, the first diode is reverse biased and second one is in forward biased. Therefore the potential of capacitor C1 adds with that of the source, thus charging C2 to –2Vi through D2 and hence the voltage across first stage is obtained to be 2Vi. Similarly, as the number of stages are increased, the voltage across capacitors increase.

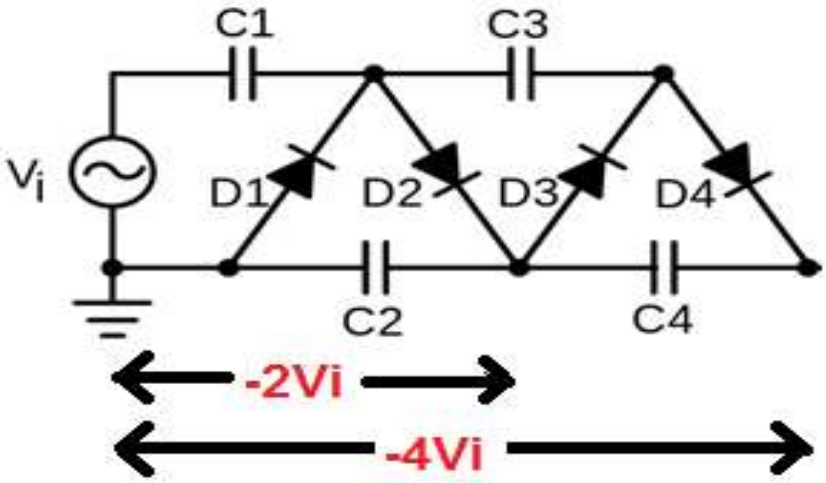
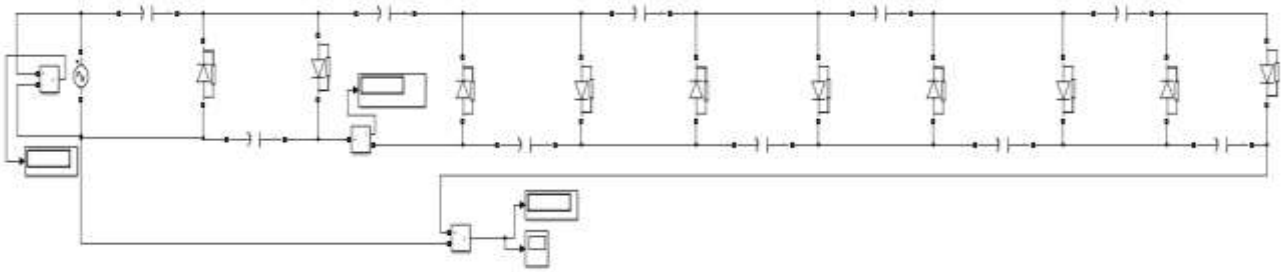


Figure A

III. SIMULATION

The simulation of the circuit is performed using MATLAB 2013-b version. The data is compiled according to the results obtained using the simulation and actual testing.



The initial capacitor values are set to C=470e-6 i.e. 470uf, whereas the diodes used are IN-4007. A scope is therefore used for measuring and studying patterns in output voltage obtained at different stages. The waveforms of the input and output are shown in Figure 1 and Figure 2, 3, 4 respectively.

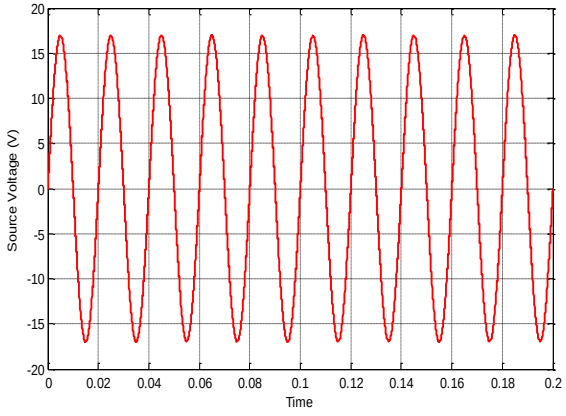


Figure 1

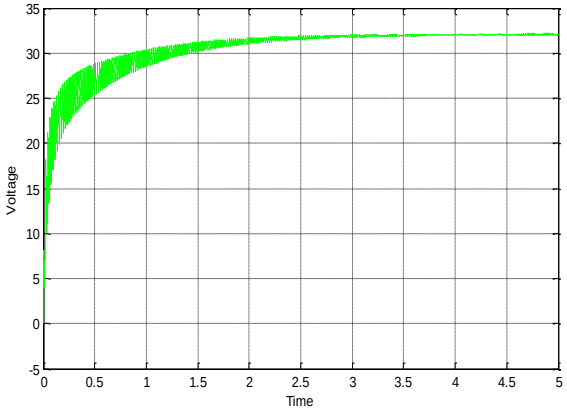


Figure 2

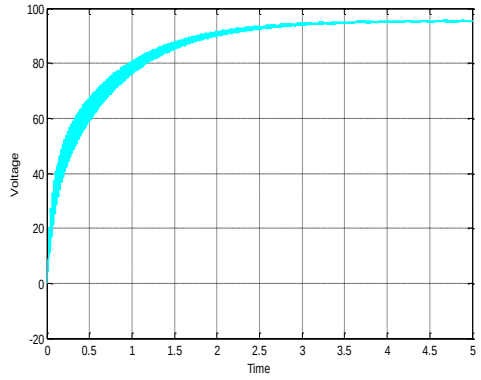


Figure 3

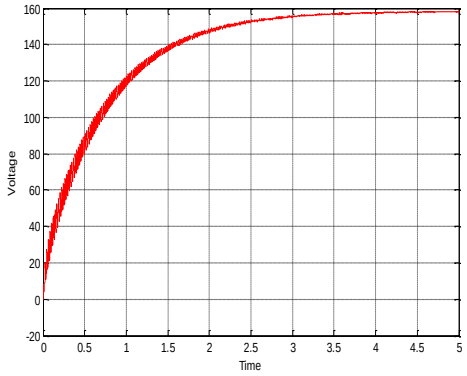


Figure 4

Hence, here Figure 1 depicts input given to the circuit. Figure 2, 3, 4 shows output of the Cockcroft-Walton voltage Multiplier circuit taken at stage 1, stage 3 and stage 5 respectively. The voltage obtained in the 5^{th} stage is found to be 158.12 volts. The circuit application for our project is found to be in line with the requirement.

IV. CIRCUIT IMPLEMENTATION

Figure 5

Figure 6

Figure 5 and Figure 6 depict the implementation of Cockcroft Walton circuit and its testing. From the simulation results, following table shows respective stage-wise output voltage:-

TABLE 1

No of Stage	***5 volt***	***12 volt***	***50 volt***	***230 volt***
Stage1	12.42	32.06	138.6	643.6
Stage2	23.65	63.82	276	1281
Stage3	34.89	95.36	389.6	1809
Stage4	45.9	126.8	512.8	2381
Stage5	56.84	158.12	635.1	2949

V. CONCLUSION

The given Cockcroft-Walton voltage Multiplier circuit has been successfully implemented. Since the project is successfully implemented using Electrolytic capacitors, the same circuit can be implemented if an input of 230 VAC is given to the circuit, then an output of 3kv is obtained, which can be implemented using Suppression type capacitors. Through simulations and practical testing circuit, the circuit is tested. The CW voltage Multiplier circuit is found to be beneficial for our application of using this circuit as a substitute for the buck-boost circuit which was earlier used in Mosquito zapper rackets. Since, size of the complete high voltage circuit is small and the developed system is cost effective, therefore it is User friendly as well as construction wise this circuit is easy to implement and is also reliable.

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