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AC to High Voltage DC Voltage Multiplier

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Abstract-
The aim of this project is designed to develop a high voltage DC around 2KV from a supply source of 230V AC using the capacitors and diodes in a ladder network based on voltage multiplier concept. The method for stepping up the voltage is commonly done by step-up transformer. The output of the secondary of the step up transformer increases the voltage and decreases the current. The other method for stepping up the voltage is a voltage multiplier but from AC to DC. Voltage multipliers are primarily used to develop high voltages where low current is required. This project describes the concept to develop high voltage DC (even till 10KV output and beyond) from a single phase AC. For safety reasons our project restricts our multiplication factor to 8 such that the output would be within 2KV. This concept of generation is used in electronic appliances like the CRT's TV picture tubes, oscilloscope and also used in industrial applications. The design of the circuit involves voltage multiplier, whose principle is to go on doubling the voltage for each stage. As this is not possible to be measured by a standard multimeter, a potential divider of 10:1 is used at the output such that 200V reading means 2KV. Due to low input impedance of the multimeter, the reading would actually be approximately 7 times the input AC voltage. Further the project can be enhanced to generate the high voltage DC up to the range of 30-50KV by increasing the number of stages. It can then be used for required industrial and medical applications.

I. INTRODUCTION

Before discussing about the project let us understand some of the concept used in this project.

A. Resistor

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses.

Fig. 1 Resistors

B. Capacitor

A capacitor is a device that stores electrical energy in an electric field. It is a passive electronic component with two terminals. The effect of a capacitor is known as capacitance. While some capacitance exists between any two electrical conductors in proximity in a circuit, a capacitor is a component designed to add capacitance to a circuit.

Fig. 2 Capacitor

C. Transformer

A transformer is a passive electrical device that transfers electrical energy from one electrical circuit to another, or multiple circuits. A varying current in any one coil of the transformer produces a varying magnetic flux in the transformer's core, which induces a varying electromotive force across any other coils wound around the same core. Electrical energy can be transferred between separate coils without a metallic (conductive) connection between the two circuits. Faraday's law of induction, discovered in 1831, describes the induced voltage effect in any coil due to a changing magnetic flux encircled by the coil. Transformers are most commonly used for increasing low AC voltages at high current (a step-up transformer) or decreasing high AC voltages at low current (a step-down transformer) in electric power applications, and for coupling the stages of signal processing circuits. Transformers can also be used for isolation, where the voltage in equals the voltage out, with separate coils not electrically bonded to one another.

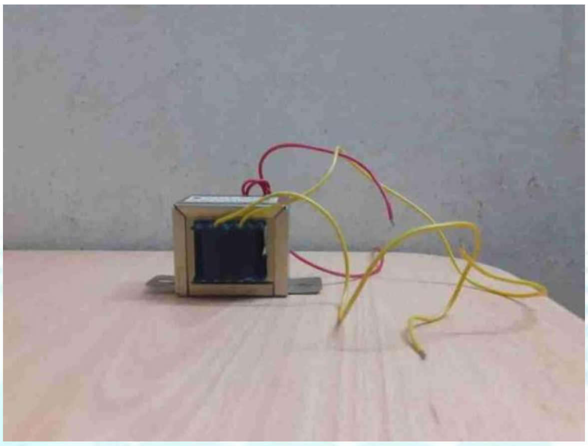
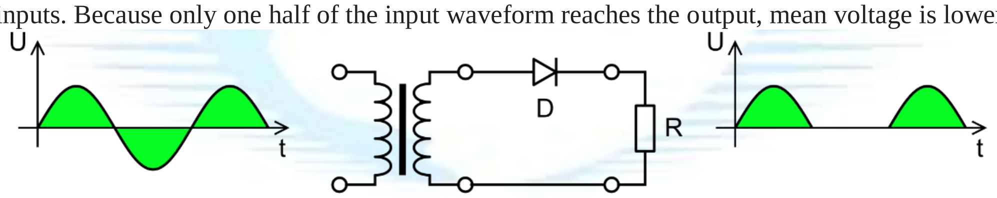


Fig. 3 Transformer

D. Rectifier

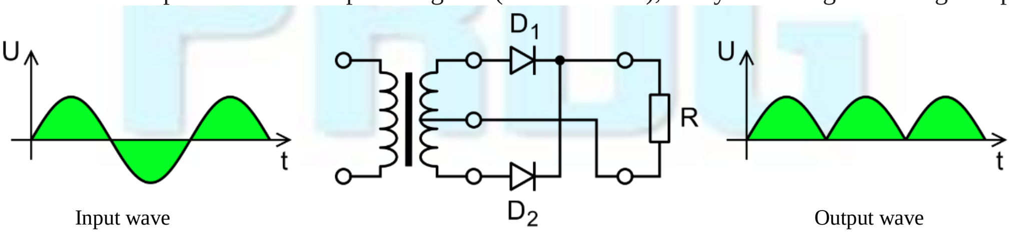
A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. Rectifier are f two types. They are

1) *Half Wave Rectifier:* In half-wave rectification of a single-phase supply, either the positive or negative half of the AC wave is passed, while the other half is blocked. Mathematically, it is a step function (for positive pass, negative block): passing positive corresponds to the ramp function being the identity on positive inputs, blocking negative corresponds to being zero on negative inputs. Because only one half of the input waveform reaches the output, mean voltage is lower.



Input wave | Fig. 4 Half Wave Rectifier Circuit | Output wave

2) *Full Wave Rectifier:* A full-wave rectifier converts the whole of the input waveform to one of constant polarity (positive or negative) at its output. Mathematically, this corresponds to the absolute value function. Full-wave rectification converts both polarities of the input waveform to pulsating DC (direct current), and yields a higher average output voltage.



Input wave | Output wave

Fig. 5 Full Wave Rectifier Circuit

E. Voltage Multiplier

A voltage multiplier is an electrical circuit that converts AC electrical power from a lower voltage to a higher DC voltage, typically using a network of capacitors and diodes. Voltage multipliers can be used to generate a few volts for electronic appliances, to millions of volts for purposes such as high-energy physics experiments and lightning safety testing. It works on a similar principle of rectifiers.

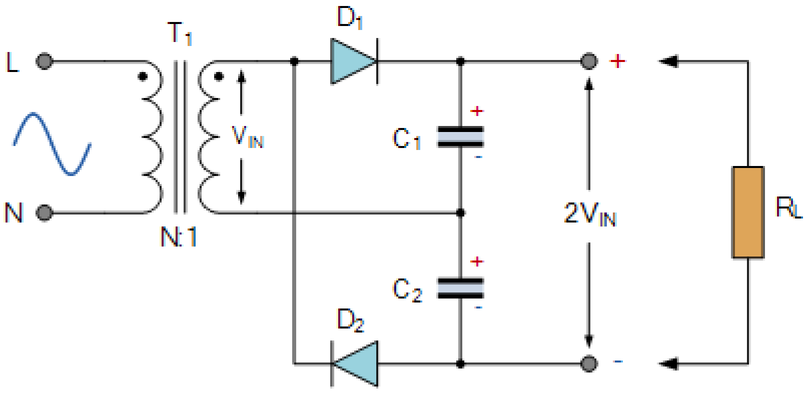


Fig. 6 Voltage Double Multiplier Circuit

II. Project Goal

A. Introduction to the Project

Transformers are being used for the high voltage AC generation which has to be rectified to DC. This technique is both bulky as well as expensive. The proposed system could be capable in both ways. Here we are producing high voltage DC with the help of basic components like capacitor and diodes. Sometimes an appropriate step-up transformer required for high voltage application may not always be obtainable. One other method is to employ a diode voltage multiplier circuit which boosts the voltage without the use of a transformer.

B. AC to High Voltage DC Using Voltage Multiplier Circuit

The hardware requirements of this high DC voltage from AC in voltage multiplier circuit include diodes, electrolysis capacitors, resistors, multimeter and lamp.

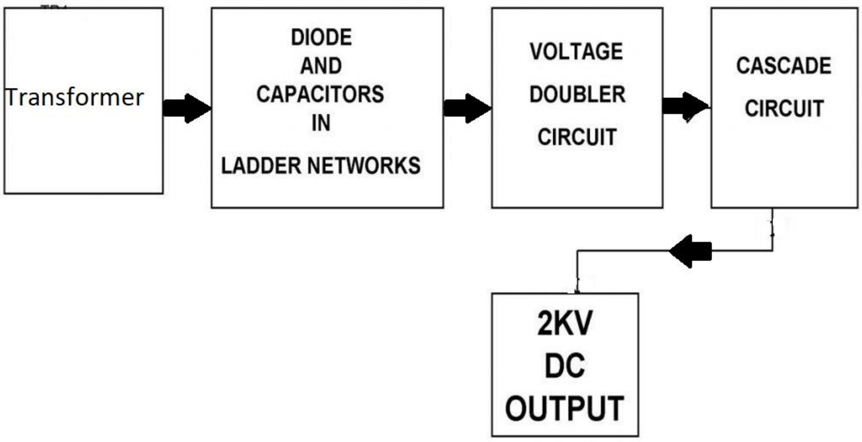


Fig.7 Schematic Diagram of AC to High Voltage DC Using Voltage Multiplier Circuit

Our project is designed to develop a high voltage DC approximately 2KV from a 230V AC supply using diodes as well as capacitors in the form of a ladder network based concept of the voltage multiplier. Our project gives an overview of how to design high voltage DC from a single phase AC. For safety reasons, this system controls the multiplication factor to 8 such that the output would be in 2KV. This generation theory concept is used in different electronic appliances, namely the TV Picture tubes, CRT’s, oscilloscope and also used in manufacturing applications.

Fig. 8 Voltage Multiplier Circuit

The circuit can be designed with a voltage multiplier, whose principle is to go on doubling the voltage for every stage. Therefore, the output from an 8-stage voltage multiplier can produce up to 2KV. As this is not potential to be calculated with a typical multimeter. At the output, a potential divider of 10:1 is used at the output such that 2KV. A potential divider of 10:1 is used at the output such that 200V reading means 2KV. Due to the small input impedance of the multimeter, actually, the reading would be about 7 times the input AC voltage.Further, this project can be developed to produce the high voltage DC up to the range of 30 to 50KV by enhancing the number of stages. The applications of this system can involve industrial and medical.

C. Advantages

The advantages of high DC voltage from AC in voltage multiplier circuit include the following.

1. Low cost, utilizes less space and is portable.
2. High voltage is generated.
3. Upto 50kV can also be produced by increasing the number of stages.
4. Minimum number of components are required.
5. Components are easily available.
6. Heavy equipment's are not needed.
7. Rectifiers are eliminated for AC to DC converters.

D. Application

The applications of a transformer are given below:

1. To check breakdown strength of transformer oil.
2. Used for metal cuttings.
3. Used in bio-medical field.
4. Used in industries.
5. Used in electrolysis process.
6. Used in electronic megger.
7. Used in laser guns.
8. Used in LCD.
9. Used in cameras.
10. Used in lighters.
11. Used in electric fencing.
12. Testing sparkplug.

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