

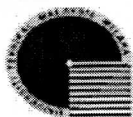
**REALIBILITY IMPROVEMENT OF COCKROFT-WALTON HIGH VOLTAGE
MULTIPLIER**

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**This report is submitted in partial fulfillment of requirements for the award of
Bachelor's Degree of Electronics Engineering (Industrial Electronics) with Honours**

**Faculty of Electronics and Computer Engineering
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UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek: REALIBILITY IMPROVEMENT OF COCKROFT-WALTONHIGH VOLTAGE MULTIPLIER
Sesi Pengajian: 2007/08

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To my beloved family

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ABSTRACT

This project is about Reliability Improvement of Cockroft-Walton High Voltage Multipliers. The Cockroft-Walton High Voltage Multipliers is the multiplier high voltages at relatively low currents are the classic multistage diode and capacitor voltage multiplier. By 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 circuit is that the voltage across each stage of this cascade is only equal to twice the peak input voltage, so it has the advantage of requiring relatively low cost components and being easy to insulate. Once can also tap the output from any stage, like a multi tapped transformer. By modified the current of Cockroft-Walton High Voltage Multiplier circuit, it will be decrease the maintenance cost especially the quality of the component and make the voltage to the optimum to the exactly value.

ABSTRAK

Projek ini bertujuan untuk menambah baik litar pendarab bervoltan tinggi 'Cockroft-Walton'. Pendarab bervoltan tinggi 'Cockroft-Walton' ialah Pendarab bervoltan tinggi pada keadaan arus yang rendah berdasarkan diod pembahagi peringkat dan capacitor pendarab bervoltan. Dengan hanya menggunakan capacitor dan diod, pendarab bervoltan ini membantu untuk melangkah naik voltan yang rendah kepada nilai ekstrim tinggi dan dalam masa yang sama lebih mudah dan murah berbanding dengan transformer. Kelebihan utama litar seperti ini adalah voltan yang melintasi setiap peringkat dalam setiap 'cascade' di mana bersamaan dengan kedua-dua voltan puncak pada input voltan, maka litar ini mempunyai kelebihan dalam memerlukan perbandingan dalam penggunaan komponen yang murah dan mudah untuk dipisahkan dari litar. Pada suatu ketika output juga boleh di tingkatkan pada mana-mana peringkat seperti dengan menggunakan 'transformer muti tapped'. Dengan melakukan perubahan pada litar sebelumnya, ia akan membantu mengurangkan kos dalam penyelenggaraan terutama dalam kualiti komponen dan mengoptimumkan voltan kepada nilai yang sebenarnya.

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LIST OF ABBREVIATIONS

AC	-	Alternating Current
CR	-	Coil Relay
CW	-	Cockroft-Wlaton
DC	-	Direct Current
kV	-	Kilo Volt
M	-	Motor
mm	-	Milimeter
nF	-	nanoFarad
PSM	-	Projek Sarjana Muda

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CHAPTER I

INTRODUCTION

1.1 Introduction of the Project

The main emphasis has been given up at first stage on the simulation, design and development of the high voltage DC power supply. At the second stage, the DC power supply is constructed based on hardware implementation and it can be used for multiple purposes. At the first stage of this work is to study the voltage multiplier circuits and the component that involved in these circuits. Then, simulated the Cockcroft-Walton (C-W) voltage multiplier circuits using the component involve. Finally, based on that multiplier circuits, construct a prototype DC power supply in the laboratory at the output range of 10 kV. The main components of the DC power supply are rectifier diodes and capacitors. The conventional technique is used because the designed multiplier circuit is intended to be applied either for impulse generator charging units or for laser excitation. This prototype design as training kit which the variable capacitor port changing.

The Cockcroft- Walton High Voltage multiplier was first succeeding in design in 1932 by James Douglas Cockcroft and Ernest Thomas Sinton Walton. In fact, this voltage multiplier cascade for research which later made them winners of the 1951 Nobel Prize in physics for “Transmutation of atomic nuclei by artificially accelerated atomic

particles". Unlike transformers, this method eliminates the requirement for the heavy core and the bulk of insulation and potting required. By using the capacitors and diodes, these voltage multipliers can step up relatively low voltages to extremely high value, while at the same time being far lighter and cheaper than transformers.

The biggest advantage of this circuit is that the voltage across each stage of this cascade is only equal to twice the peak input voltage, so it has the advantage of requiring relatively low cost components and being easy to insulate. One can also tap the output from any stage, like multi tapped transformer. The various practical applications and find their way in laser systems, CRT tubes, HV power supplies, LCD backlighting, x-ray systems, traveling wave tubes, ion pumps, electrostatic systems, air ionizers, particle accelerators, scientific instrumentation, oscilloscopes and many other applications that utilize high voltage DC.

1.2 Project Objectives

The high voltage equipment is required to study the insulation behavior under all conditions, which the apparatus is likely to encounter. Tests are also made with voltages higher than the normal working voltage to determine the factor of the safety over the working conditions and to ensure that the working margin is neither too high nor too low. The conventional forms of high voltage in use can be divided into the following classes:

- i. Alternating current voltages
- ii. Direct current voltages
- iii. Transient voltages.

At the end of this project, the all multi stage must fulfill. This is to complete another objective that relates relationship. The objectives of this project are:

- i. To learn about the basic things that transform a voltage multiplier, the concept, circuit, characteristic of the output and the type of the multiplier that related to the improvement of the project.

- ii. To learn and construct the Cockroft Walton voltage multiplier.
- iii. To create a prototype of a Cockroft Walton voltage multiplier

The main objective is to learn about the fundamental of voltage multiplier such as the principal, concept, types, and characteristics of each type of component that involve in this circuit. This is the first stage is the introduction to the voltage multiplier that will give the idea and first view of the project. It is very important to learn about the activity of this circuit and the related equation that involve in this circuit especially to calculate the stage of voltage amplified.

After the comparison has been completed in the first objective, the second objective will be followed by designing of the High Voltage of Cockroft – Walton circuit base on the on the characteristic of that have choose in Cockroft-Walton multiplier. The characteristic of the component that involve in this circuit is very important because a lot of factor especially the power that involve in that component. Then design, simulate and construct the multiplier circuit to prove the theoretical that has been covered and prove the characteristic of this circuit. The consideration of the designed circuit is to get the amplified voltage to 10kV from the actual supply voltage. As known, this is the improvement project, so the modification of this circuit has been doing in this stage to discover the optimum accurate value follow the theoretical value

At the end of this project, the last objective and completed this project is build up the prototype of a Cockroft-Walton voltage multiplier .this prototype design as the training kit to show the previous design and the modification design with tested component in the slot of this training kit. Then, the output of the circuit will be compared with the simulation result and the percentage different between the result will be calculated to prove the theoretical that has been learned about the characteristics of Cockroft-Walton voltage multiplier.

1.3 Problem Statement.

This project is solving the problems that have been creating in the current High Voltage Cockroft-Walton Multiplier circuit. The major problem of previous project is how to stabilize this High Voltage Cockroft-Walton Multiplier circuit. The stabilization depends to the capacitors and diodes that used in this circuit.

The previous research, when the 50kV cannot reach the voltage and the current in that circuit, it make the spark in that circuit and burning the circuit. In this case, one of sub station of 600kV was burning. Each of sub-station of this High Voltage Cockroft-Walton Multiplier circuit was produced 50kV.

To research this problem, the current circuit is design to produce output load around 50kV (Figure1.1). It is very difficult to build the large circuit, so this prototype circuit has been redesign which is the output voltage must in range around 10kV. In this case, the values of each stage are tested to detect and analyze the stability of this circuit especially the connection capacitor and diodes in line of circuit. Each stage will produce the gain to step up the voltage in every stage that is including realizing the objective.

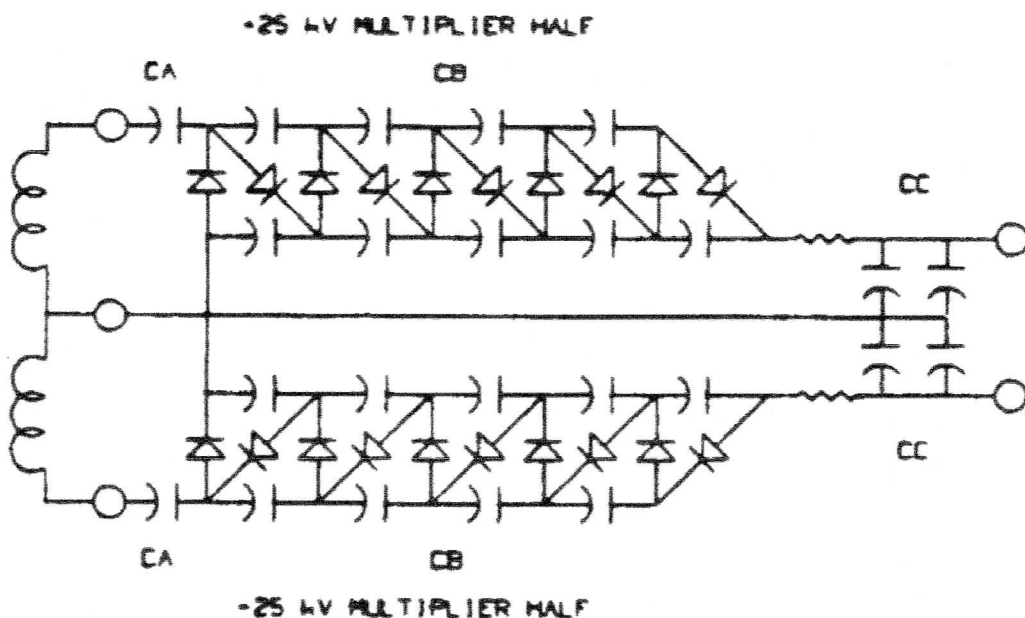


Figure1.1: The High Voltage Cockroft-Walton Multiplier circuit

1.4 Scope of Work

The scope of this project consists of hardware, design and manipulation software and makes a prototype for this High Voltage Cockroft-Walton Multiplier circuit. The prototype is build base on the software designing. The entire step shown in below:

1. To analyzed the fundamental of multiplier:
 - i. Advantages and disadvantages.
 - ii. The output waveform.
2. Redesign the circuit.
 - i. Change the value of component used.
 - ii. Calculate the expected output.
3. Simulate the redesign circuit.
 - i. Using Multisim or other simulation programming.
 - ii. Get the output waveform.
 - iii. Determine the advantage and disadvantage of the circuit.
4. Construct the circuit.
 - i. Construct the prototype of the circuit.
 - ii. Compared the output with the simulation result.
 - iii. Calculate the percentage different.

In this research of High Voltage Cockroft-Walton Multiplier circuit, the circuit redevelops back from 50kV High Voltage Cockroft-Walton Multiplier circuit to 10kV High Voltage Cockroft-Walton Multiplier circuit. This modification circuit is design with the laboratories equipment. The designing and simulation will use the multisim software which shows the result.

After succeed in simulation, build and test the hardware for High Voltage Cockroft-Walton Multiplier circuit. The circuit builds in stripe board. The component

that used in this circuit will be tested for confirmed their accuracy and good condition before transfer to prototype circuit. The simulation program and the source are used to limit the current research is based on voltage multiplier and Cockcroft-Walton voltage multiplier.

When the hardware tested succeeds, the entire component will be assembled in the circuits that have etching in positive board. Make sure all the components will assemble follow their stage to increase their gain. This Figure 1.2 shows the example for the final complete prototype of circuit.

This scope also will give the advantages and disadvantages of each type of voltage multiplier and will be proven with simulation and hardware experimental. This research is about using high voltage in electronic circuit and equipment such as oscilloscope, television and many more electronic devices that need high voltage to operate.

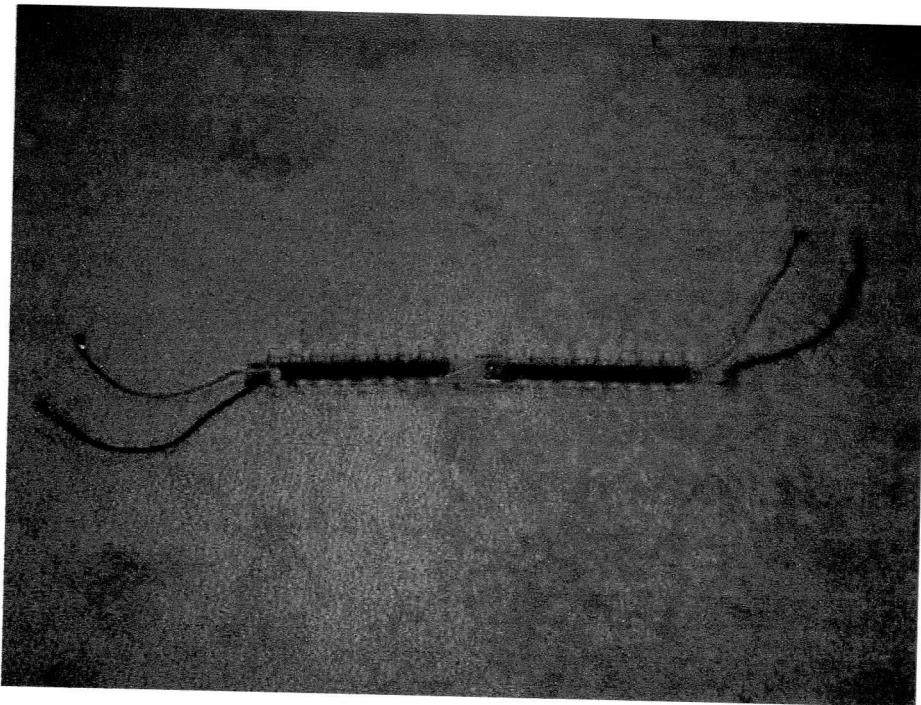


Figure 1.2: The complete Prototype

Methodology of Project

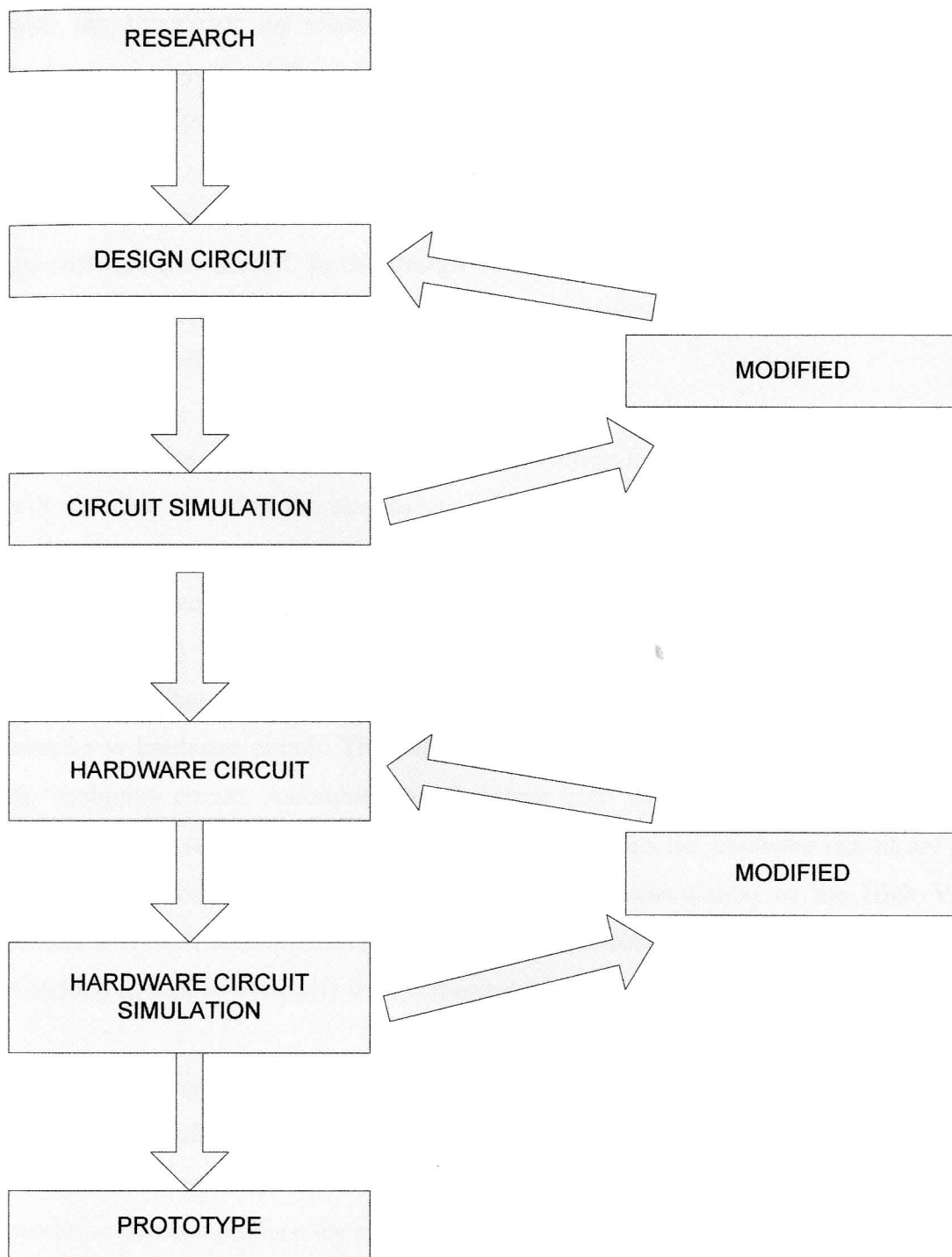


Figure 1.3: Block Diagram of Methodology of Project

From starting, the methodology starts from searching information about the High Voltage Cockroft-Walton Multiplier circuit project. Share the information and research with the supervisor for ideas with him and consult the relate problem. Study the background project and the theoretical involve for this project. After that make scope for the system and prepare layout for easy to understand.

After that, design the High Voltage Cockroft-Walton Multiplier circuit with using the software that needed. In this design, all the characteristic of the component and the circuit that have been research are taken into consideration when designing the High Voltage Cockroft-Walton Multiplier circuit.

After designing is complete, the High Voltage Cockroft-Walton Multiplier circuit will simulate by using the simulation software that been chosen. The simulation will prove the characteristic of this High Voltage Cockroft-Walton Multiplier circuit especially the output load voltage that can produce in virtual circuit.

After that, the designing the High Voltage Cockroft-Walton Multiplier circuits transfer to hardware circuit. The entire component will assemble stage by stage follow the designing circuit. Assemble stage by stage until all the stage complete, tested will make stage by stage and the modification making when the hardware circuit are fail to function or produce the output that needed by the calculation of the High Voltage Cockroft-Walton Multiplier. The modification will continue until the circuit shows the matching assemble especially the component that used.

After complete, make the prototype of this High Voltage Cockroft-Walton Multiplier circuit and this prototype were design as the training kit. Used the correct component when designing especially the capacitor and make sure that circuit in good condition that can produce the optimum performance when this circuit tested.