

A DESIGN OF AN AIR IONIZER USING THE COCKROFT-WALTON  
MULTIPLIER

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This report is submitted in partial fulfillment of the requirement for the award of  
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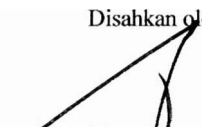
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Dedicated to abah, ibu, Nisah Fizah & Aush, fellow friends and for a better future...

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## ABSTRACT

This project is done in order to design a negative air ionizer using the Cockroft - Walton theory. The air ionizer will produced negative ions in the air for a small room such as the tutorial room in FKEKK. This project will develop an air ionizer which can produce the negative ions to the air. This ionizer is important because it can neutralize the ions in the air. Too much positive ions in the air will cause some health problem such as asthma, migraine and severe headache. Through this project, the characteristic of the Cockroft-Walton Multiplier circuit will be discussed and the related circuit will be simulated and constructed on board. The main objectives of this project are to use some basic knowledge of electronic and Cockroft-Walton theory and design an air ionizer. The air ionizer will be use built in order to solve the problem related to the low quality of air in a small area such as a lecture room. The scope of this project is to include the explanation about the Cockroft-Walton theory in the beginning of the project report. Then, using appropriate electronic workbench software, a high voltage multiplier circuit will be design and simulated to ensure the circuit can function correctly. Later, the circuit will be built on board and tested accordingly. By the end of the project, a negative air ionizer will be constructed and a prototype will be developed.

## ABSTRAK

Projek ini dibuat bagi mereka satu litar yang boleh digunakan untuk menghasilkan ion negatif didalam udara. Pengion negative ini akan digunakan bagi menghasilkan ion negatif untuk kawasan yang kecil seperti bilik tutorial di FKEKK. Pengion ini direka berdasarkan teori Cockroft-Walton yang membuktikan bahawa ion negatif dapat dipisahkna daripada udara sekiranya voltan yang tinggi dialirkan pada satu konduktor pada udara. Pengion yang direka ini akan menghasilkan negatif di dalam udara. Pengion negatif ini penting bagi mengurangkan ion-ion positif dalam udara yang mana sekiranya terlalu banyak dapat memberi kesan negative kepada kesihatan manusia. Antara masalah-masalah yang dihadapi kesan dari terlalu banyak ion-ion positif adalah seperti asma, migrain dan juga sakit kepala yang berterusan. Melalui projek ini, ciri-ciri pengganda Cockroft-Walton dapat dikenalpasti dan dibincangkan manakala litar yang terlibat akan dibuat simulasi dan dibina diatas papan projek. Objektif utama bagi projek ini adalah untuk mereka satu pengion negatif yang dapat menghasilkan ion-ion negatif dalam udara berdasarkan teori Cockroft-Walton. Skop kerja bagi projek ini adalah untuk menerangkan perihal teori Cockroft-Walton itu sendiri yang mana akan dibuat pada permulaan projek. Kemudian, megunakan perisian yang sesuai, litar yang direka akan disimulasikan bagi memperoleh voltan keluar yang memenuhi syarat teori tersebut. Akhir sekali, litar yang telah selesai disimulasi dan terbaik akan dibina diatas papan projek dah akan diuji untuk menentukan kebolehan nya menghasilkan ion negatif.



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## LIST OF ABBREVIATION

CW	-	Cockroft-Walton
UTeM	-	Universiti Teknikal Malaysia Melaka
FKEKK	-	Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer

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# CHAPTER I

## INTRODUCTION

This chapter is about the brief introduction of the Projek Sarjana Muda (PSM) thesis. This thesis will introduce what the whole project is all about. The project is to design an air ionizer using the Cockroft-Walton Multiplier. Chapter I is about the introduction of the project, the objectives of the project, problem statements and the scope of the project. It will give the overview on what is this project is all about.

### 1.1 Introduction of the Project

This project is done in order to fulfill the Final Year Project requirement for the Electronics and Computer Engineering Student of Faculty of Electronics and Computer Engineering. The project that had been done is to design a negative air ionizer using the basic Cockroft-Walton theory circuit. The ionizer will produced negatives ions in the air as the input is given to the circuit.

The negative ionizer works by producing the negative output voltage which exceeding 5kV at the end of the Cockroft-Walton multiplier circuit. The negative output voltage is produced by developing the negative Cockroft-Walton multiplier circuits where the diodes will be arrange at the different direction compared to the positive multiplier circuit.

Theoretically, the ionizer will charge the negative ions in the air at the end of the ionizer where a bunch of needles will be placed. The electrical charge on an object is greatest at the sharpest point, so if a high negative voltage is applied to a sharp needle then the charge at the tip is so high that the ions are literally thrown off and then repelled by the negative field of the needle.

The ionizer is important since the negative ions give many benefits on human productivity and life. Too many positive ions in the environment cause many health problems such as asthma, migraine and severe headache. Some experiment and science research had been done related to the effect of the negative ions in the air to human. Throughout this project, the characteristics of the Cockroft-Walton Multipliers will be discussed and the related circuit will be simulated and constructed.

Some believe that negative ions can improve the perceived atmosphere in a small room like an office, that has an unnatural high positive ions balance.

## **1.2 Objectives of Project**

The objective of this project is to use some basic knowledge of electronics and Cockroft-Walton high voltage multipliers theories to design an air ionizer which will produce negative ions. The ions will be measured using the 'air ion counter' which can be bought in the market.

On the other hand, this project will helps us deepen our understanding of the applications of the Cockroft-Walton voltage multiplier circuit. Cockroft-Walton voltage multiplier is widely used in high voltage application such as the CRT tubes, high-voltage power supplies, x-ray systems, traveling wave tubes, photocopy machine and others.

### **1.3 Problem Statement**

Nowadays, the quality of air is reducing and causing many health problems to mankind. Before the issue of air pollution became a hit, many scientists and researchers had noticed that the ionization of even clean air can improve the quality of air. Basically, the clean air consists of 78% nitrogen and 21% oxygen; typically contain negative and positive ions in approximately 4-to-5 ratio. Those researchers found that whenever this ratio is changing, it will affect the biological systems especially human.

The idea about the negative ions effect on human was popularized by a scientist named Fred Soyka, whom in 1970's had wrote a book title 'The Ion Effect'. In his book, he discussed about the natural occurrence of negative and positive ionized air. From his findings, he demonstrated that negatively ionized air had substantial health benefits. He summarized in his book that negative ions help elevate mood, enhance physical performance and training, and sterilized harmful airborne bacteria. On the other hand, the abundance of positive ions causing numbers of low grade medical problems, such as fatigue, headache and anxiety.

According to the research, many other scientists tried to see other effect of the negative and positive ions to human and all the results showed that negative ions give many benefits compare to positive ions which give more bad effect to human. Here, this report tried to discuss about developing negative ions in a very practical method using Cockroft-Walton voltage regulator circuit. The reason of this circuit is design is to solve the problem related to the low quality air in a small area such as in a tutorial room or an office.

### **1.4 Scope of Work**

This project includes the explanation of what the Cockroft-Walton high voltage multiplier really is at the beginning. The characteristics of Cockroft-Walton will also be explained, besides the comparison between other types of high voltage

multiplier circuits. The information will be based on books, journal and other written sources.

Later, the related circuit will be design according to the theory and will be simulate using the electronics workbench software such as MultiSim and PSpice. The voltage and the current produced by the simulated circuit must fulfill the requirement of the Cockroft-Walton theory to ensure that the circuit works properly. Other than these, the connection of each component will be checked using the software so that the designed circuit works according to the Cockroft-Walton high voltage multiplier characteristics.

By the end of the project, a prototype of the negative ionizer will be develop and tested accordingly. Here, the circuit will be tested in a tutorial room where the negative ions will be calculated and the effect of the negative ions to human will be testified.

## **1.5 Project Methodology**

To design a negative ionizer using the Cockroft-Walton high voltage multiplier circuit, ones must have a very good understanding on the theory of the multiplier circuit. The relationship between positive and negative ions in the air also need to be understand since it will give the answer for the effect of those ions to human.

Before the project start, some studies and readings must be done in order to get the correct view of Cockroft-Walton theory. Later, some literature review will take place to compare this project with previous experiments and projects related to this title. The review will take journals, reports and books as its main reference.

Furthermore, the high voltage multiplier will be constructed on board so it will proved that the circuit able to produce high voltage as the output and then develop enough negative ions to the sample room. Before that, the design circuit will be simulated using appropriate electronics workbench software. To design the

circuit, the calculation of the output voltage is very important since it will determine the sum of components and stages that the circuit required to get the right output voltage.

Moreover, this project will work on how to produce much negative ions and step taken to calculate the sum of ions and also to detect the appearance of the ions in the air. After the prototype is made, it will be tested accordingly. The diagram below will conclude the methodology taken in order to finish each task.

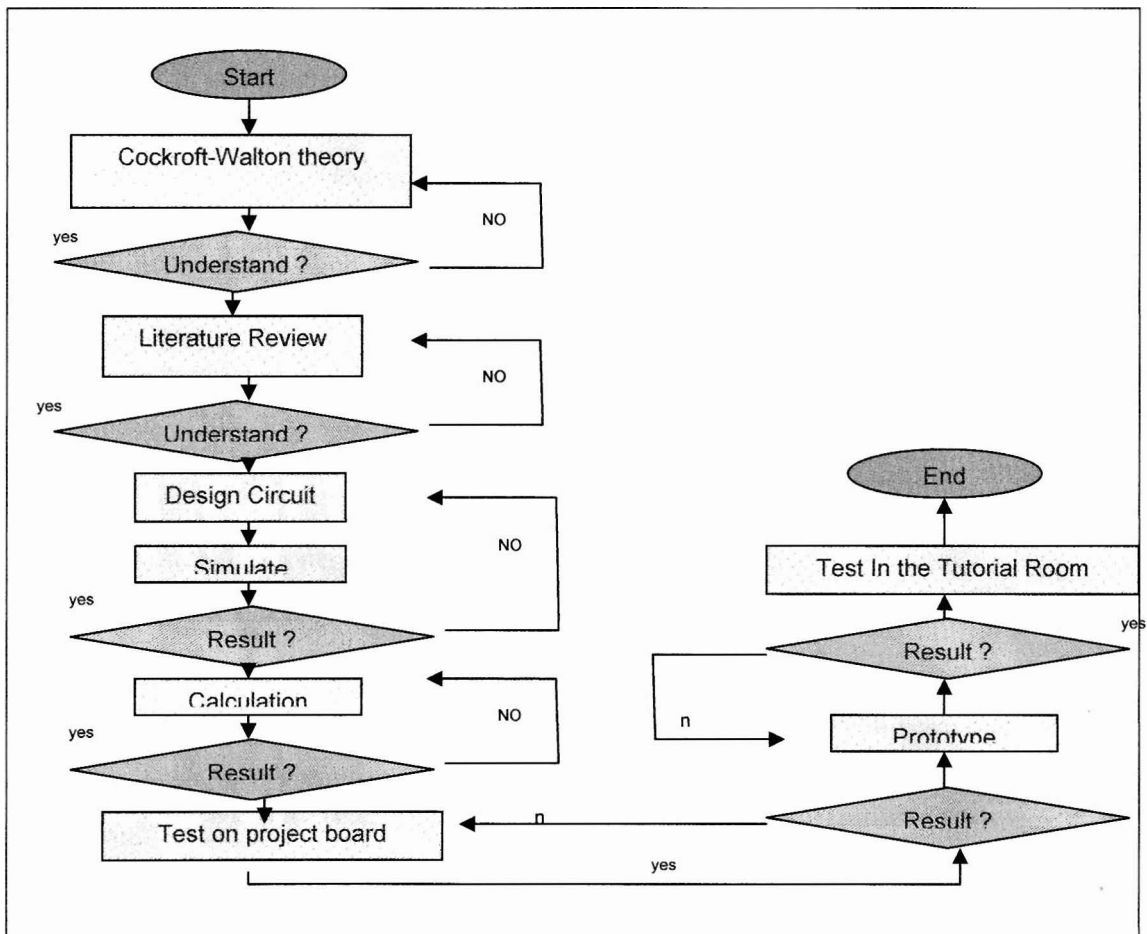


Figure 1.1: Flow Chart of Project Progress

## 1.6 Report Structure

This project is about developing a negative air ionizer using the Cockroft-Walton high voltage multiplier circuit. The project is for the requirement of Final

Year Project for 4<sup>th</sup> year students of FKEKK, UTeM. This project is chose because the ionizer that had been used today gives no detail on how many ions are produced in certain time and area. Here, one can easily been cheated by the ionizer manufacturer since the ions are very discreet and cannot be detect by our bare eyes. Other than that, the ionizers sell in the market today are not using the Cockroft-Walton high voltage multiplier, although it's the simplest way to produce a high voltage output to separate the particles of ions in the air. The ionizers are using more complicated and expensive components in order to works. Here, this report will reveal the fact why this is happening.

The objectives of this project are to use the basic knowledge of Cockroft-Walton theory and apply it in the electronics applications and design a negative air ionizer while proving that the theory is correct in terms of developing more negative or positive ions in the air using high voltages. Other than that, this project tried to deepen our understanding of the applications of high voltage multiplier circuit. High voltage multiplier circuit is on of the important elements in many high voltage applications such as the CRT tubes, power supply for high voltage applications and photocopy machines.

Developing a negative ionizer is very important because the quality of our air nowadays is decreasing. The negative ions contained in the air helps the environment become fresher. Too much positive ions in an area causing severe headache, lack of productivity, asthma and other illness related to the air. By developing the negative air ionizer, hopefully the problem that occurs in a small room like a tutorial room can be solved.

The working scopes of this project are to explain the Cockroft-Walton theory and relate it with the electronics field. Then, the electronic workbench software will be used to design and simulate the circuit. From the simulation, the output voltage can be determined and that will testify the circuit whether it works or not. Later than that, a prototype of the circuit will be done and tested accordingly. Throughout the project, some assumption had been made. First, the ionizer will develop negative ions only based on the Cockroft-Walton theory. Then, using the Cockroft-Walton theory, a high voltage multiplier will be developed. Then, we will assume that the

circuit is a success if the voltage multiplier manages to produce higher output voltage, whether it is double or triple of the input value.

Methods used in this project are having a very good understanding of the Cockroft-Walton theory and the relationship between positive and negative ions in the air. After that, the circuit will be constructed to identify its ability to produced negative ions in the air. Then, the project tried to decide a method to increased the negative ions in a sample room and calculate the sum of ions in it. Using appropriate devices, the appearance of the negative ions will be testified.

Overall, this report is about a project that will develop a negative ionizer using the Cockroft-Walton theory and the reports will elaborate each step taken and the results of each activity related to it. Chapter 1 acts as the introduction of the project and techniques used to make the project a success. Later in Chapter 2, the literature review used for the project will be detailed while the method taken to ensure of the success of this project will be told in Chapter 3. In Chapter 4, the result of each tests and simulations taken on the project will be stated while at the final chapter, is about the conclusions and suggestions to improved the ionizer.

## **CHAPTER II**

### **BACKGROUND OF PROJECT**

In Chapter II, the background of the project will be revealed. The past researches on the same topic and some scientific writings will be discussed and compared to this project. The literature review is made so that ones will understand the theory of the Cockroft-Walton and the high-voltage multiplier that been discussed.

#### **2.1 Cockroft-Walton Theory**

The Cockroft-Walton theory had been discovered by Dr. J.D Cockroft and Dr. E. T. S. Walton on 14<sup>th</sup> April 1932. In their first experiment, they were using their proton acceleration to bombard a target made of lithium which consists of 3 protons and 4 neutrons. The proton bombard induced the lithium nucleus to disintegrate into 2 alpha particles contained 2 protons and 2 neutron and little flashes of light on a scintillation screen [1].

The theory that been used by both the scientists is in ‘order to praise the nucleus open to examine its internal structure; ones must hit the nucleus with highly energetic particles of its own size or smaller’ [1]. The apparatus develop by both scientists at that time only can accelerate positively charged particles to a very high