DIGITAL CONTROL OF HIGH DC VOLTAGE CONVERTER BASED ON COCKCROFT WALTON VOLTAGE MULTIPLIER

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This report is submitted in partial fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Industrial Electronics) With Honours

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FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
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Sesi Pengajian	:	2007/ 2008

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To my beloved father Mr. Mamat bin Yahaya and mother Mrs. Wan Mariam binti Wan Awang, my supervisor Mr. Zulakarnain bin Zainudin and all my lovely friends.

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ABSTRAK

Melalui projek ini, satu cara baru untuk mengawal arus terus yang bervoltan tinggi menggunakan kaedah gandaan voltan diperkenalkan iaitu melalui litar 'Cockroft-Walton'. Kaedah ini turut menggunakan 'Modul PWM' sebagai pengawal litar secara digital. Sistem yang dicadangkan menggunakan arus ulang alik satu fasa sebagai bekalan arus yang masuk. Transistor yang digunakan sebagai 'Power Switching' pula dikawal oleh 'Pulse Width Modulation' (PWM) 3 fasa untuk meminimumkan bilangan harmonic yang dihasilkan pada bahagian arus ulang alik untuk sistem 'Converter'.

Litar 'converter' yang dibina secara konvensional juga dapat menghasilkan vlotan yang berarus tinggi dengan membina banyak litar konvensional secara selari atau dengan menggunakan transformer yang mempunyai gandaan yang tinggi namun kaedah ini memerlukan kos yang tinggi dan litar yang menggunakan terlalu banyak komponen.

Objektif projek ini adalah untuk menghasilkan arus terus yang bervoltan tinggi dengan menggunakan litar voltan gandaan Cockroft-Walton.

Terdapat beberapa cara untuk mengawal penghasilan arus daripada litar Cockroft-Walton seperti mempelbagaikan index modulation bagi 'switching pulses', frekuensi bagi arus yang masuk dan mempelbagaikan kitaran 'duty' bagi 'switching pulses'.

Hasil akhir akan menunjukkan nisbah transformer sebanyak 1:1, gandaan voltan Cockroft-Walton sebanyak 4 tahap boleh meningkat sehingga 100. Arus terus yang keluar akan dikawal oleh 'Modulation index'.

ABSTRACT

A new method of controlling high DC voltage based on Cockcroft Walton Voltage Multiplier circuit by using digital controller is presented. The digital controller is developed using Complex Programmable Logic Devices (CPLD). The proposed system utilizes a single-phase AC as an input supply. The power switching devices in the controlled bridge are controlled by the multiple-pulse Pulse Width Modulation (PWM) switching technique so as to minimize the low order harmonic present on the AC side of the converter system.

The conventional converter circuit also can produce the high voltage by cascading many stages of conventional DC supply or use higher step-up transformer for fewer stage DC supplies but it is costly and bulky. This project is producing the high voltage using the PWM technique or Cockcroft-Walton Voltage Multiplier. This method is cheaper and smaller size.

The objective of this project is to Use Cockroft-Walton Voltage Multiplier in order to produce a high DC voltage.

There is a few methods to control the output of the Cockcroft Walton circuit such as varying the modulation index of the switching pulses, frequency of the input voltage, varying the duty cycle of the switching pulses.

The results will demonstrate that with a 1:1 transformer ratio, the voltage gain of Cockcroft Walton with four stages can be boost up to 100. The DC output voltage is regulated externally using a modulation index. PWM signal will provides a convenient way to vary the width of PWM and regulate the output of high DC voltage.

TABLE OF CONTENT

II PROJECT BACKGROUND

III METHODOLOGY

LIST OF FLOWCHART

LIST OF TABLE

LIST OF FIGURE

CHAPTER I

INTRODUCTION

1.1 OVERVIEW

This project is about to produce the high DC voltage using Cockroft-Walton voltage multiplier circuit and Pulse Width Modulation (PWM) technique. The conventional DC voltage converter is producing a high DC voltage. This high DC voltage is commonly used in logic controls, motors, solenoid valves, lamps and sensors. The conventional DC voltage converter can also produce high DC voltage using some techniques. A high DC voltage is important for the laboratory test which is die electric stress threshold, ESD generation and IC package stress threshold. Besides, it is use for anode of cathode-ray tubes (CRT) and electron beam (TV picture tubes).

This project use 3 circuits which is IGBT's circuit, Cockroft-Walton voltage multiplier circuit and pulse width modulation generator circuit. Isolated gate bipolar transistor (IGBT) switches "ON" and "OFF" the input current of AC main. Input of the IGBTs is driven by pulse width modulation (PWM) signal. This signal is the resultant of the AC main and triangle wave signal. When triangle wave signal is equal or higher than the AC main, the IGBT switch "ON". Output of the IGBTs fed the modulated AC signal to the primary coil of the transformer. Secondary coil charge up energy with voltage so it

equal to primary voltage when the IGBTs is first switch "ON". This voltage will be add up in series during the next switch "ON" signal. This process repeats many times and number of times depend on the PWM frequency. Transformer coil ratio is 1:1 but the secondary coil voltage is much higher than the primary coil because of the PWM techniques employ. The Cockcroft-Walton voltage multiplier at the secondary section of the transformer boost up the output signal to achieve even higher DC voltage.

1.2 PROJECT OBJECTIVE

The objective of this project is specified below:

a. To produce high DC voltage by using Cockroft-Walton voltage multiplier circuit.
b. To show the function of Cockroft-Walton voltage multiplier circuit, this is to boost up the voltage to get the high DC voltage.

1.3 PROBLEM STATEMENT

There are few methods in produce high dc voltage which by using conventional converter circuit, use higher step-up transformer for fewer stage DC supply and another methods which is Pulse Width Modulation and Cockroft-Walton voltage multiplier circuit techniques. But, these methods have their own advantages and disadvantages as well. To produce high DC voltage using conventional converter circuit, the conventional converter circuit must cascade many stages to get a high DC output voltage. Besides, the higher set-up transformer can be used to produce high DC voltage. The advantage of these methods is it uses the simple circuit but it looks bulky and the higher step-up transformer is costly.

The new method that can be used to produce the high DC voltage is by use Cockroft-Walton voltage multiplier circuit and PWM techniques. The advantages of this method it is cheaper and smaller size. But the disadvantage is it is use more complex signal.

1.4 SCOPE OF PROJECT

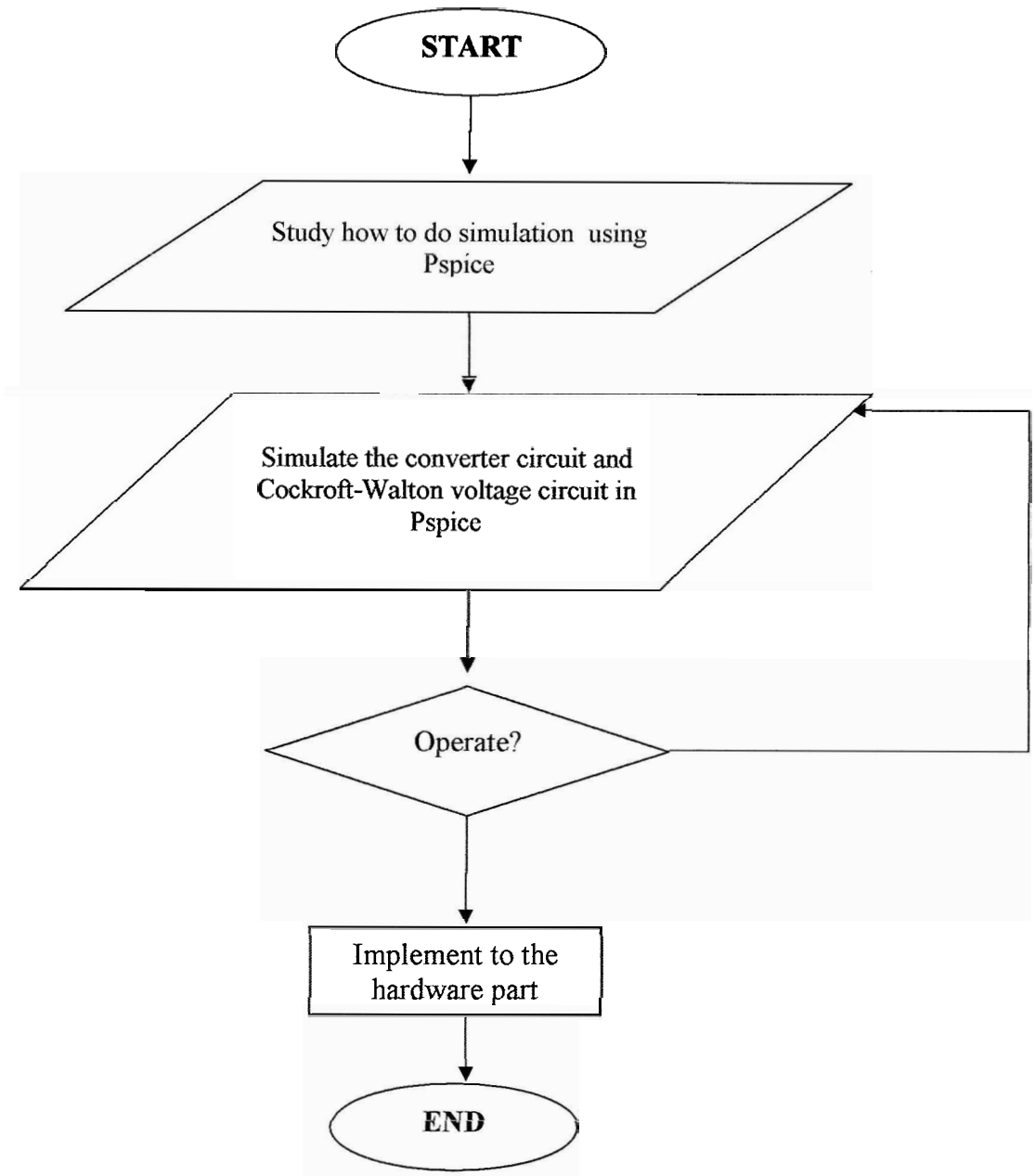
The scope of this project is specified below:

a. Understanding the topology of Cockcroft-Walton voltage multiplier circuit and the pulse width modulation (PWM) technique that employed to boost voltage.
b. Simulation by using Pspice simulation software to simulate the circuit prior to the implementation.
c. Construct the circuit stage by stage. Prototype circuit will be built in bread board.
d. PWM module using operational amplifier, comparator and AND gate ic will be use in order to produce PWM switching signal.
e. Check component datasheet to ensure the right part is used.

1.5 METHODOLOGY

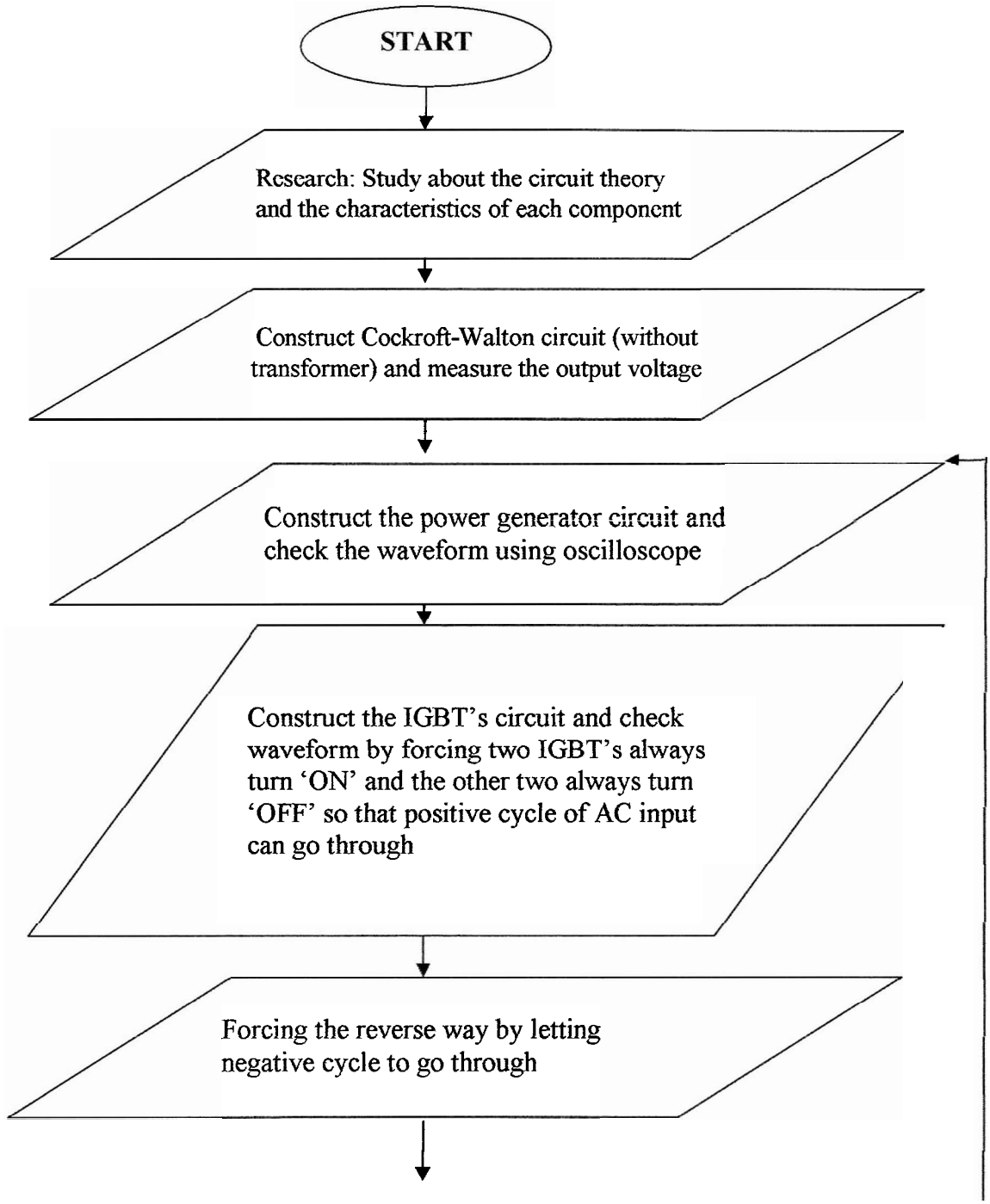
This part shows the project flows for this project for the simulation and hardware part.

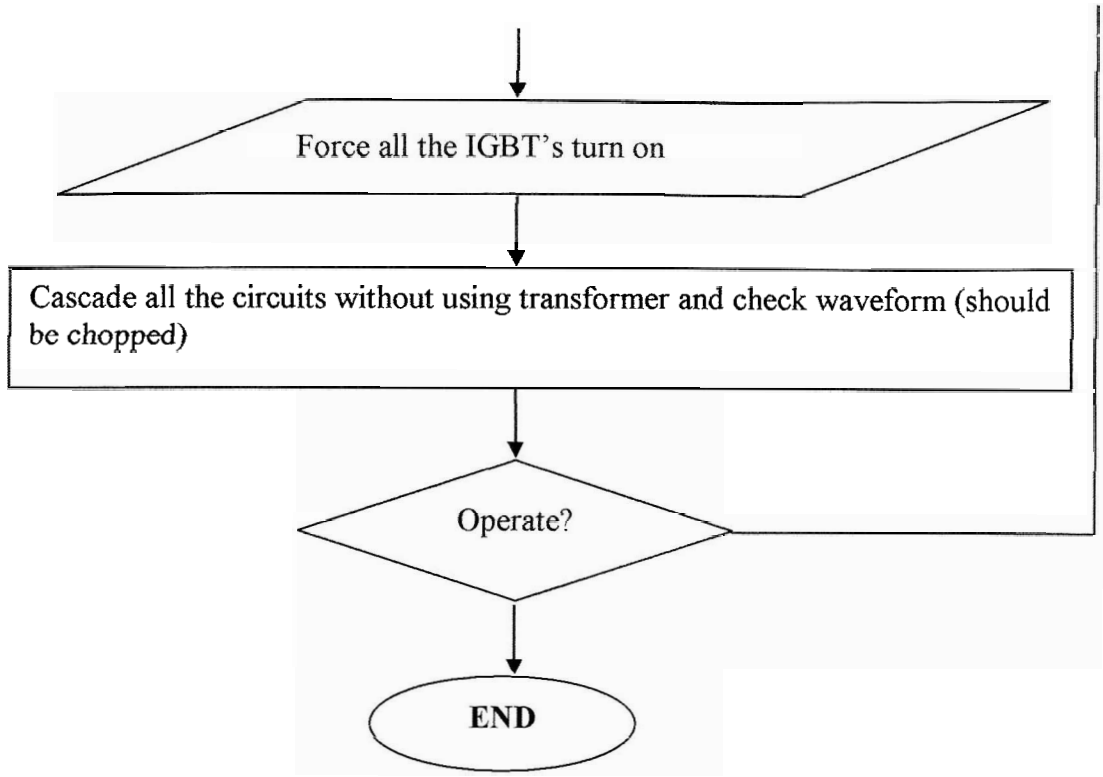
1.5.1 SIMULATION METHODOLOGY



Flowchart 1: Simulation methodology process flow

1.5.2 HARDWARE METHODOLOGY





Flowchart 2: Hardware methodology process flow

CHAPTER II

PROJECT BACKGROUND

2.1 INTRODUCTION

This chapter will focus on my research that had been done by the past project. This will help in explained about the perspective and methods that have been used in the past project to implement in my own project.

2.2 LITERATURE REVIEW

A fundamental knowledge about generators and circuits which are in use for the generation of high voltages belongs to the background of work on high voltage technology. Generally commercially available high voltage generators are applied in routine testing laboratories; they are used for testing equipment such as transformers, bushings, cables, capacitors, switchgear, etc. The tests should confirm the efficiency and reliability of the products and therefore the high voltage testing equipment is required to study the insulation behavior under all conditions which the apparatus is likely to encounter. The amplitudes and types of the test voltages, which are always higher than