VARIABLE DC POWER SUPPLY

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2007

"I/We hereby declare that I have read this project report and in my/opinion this project report is sufficient in term of scope and quality for the award of Degree of Electrical Engineering (Power Electronic and Drive)"

Signature : ....

Name of Supervisor : MR. ZULKIFLI BIN RAMLI

Date : 8 MAY 2007.

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This Project Report Is Submitted In Partial Fulfillment of the
Degree of Bachelor in Electrical Engineering (Power Electronic and Drive)

Faculty of Electrical Engineering
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May 2007

"I hereby declare that this project report is the result of my own work and all sources of reference have been clearly acknowledged."

Signature : ……………………………
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Date : 3 MAY 2007

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ABSTRACT

This report is to explain about AC-DC converter project. This is because to fulfill a "Projek Sarjana Muda" for Bachelor of Electrical Engineering (Power Electronic and Drive). This AC/DC converter project can step down AC input voltage to variable DC output. AC voltage of 240V is converted to DC voltage by using push-pull transformer concept. UC3526 microcontroller is used to control the output voltage that make the output can be adjusted from 0V to 30V. To get the smallest and light appliance, the transformer with 100kHz frequency is selected. So that the transformer size and it filter used is in smaller size. The prototaip has been developed and it can give an output as stated in the objective.

ABSTRAK

Laporan ini menegenai rekabentuk penukar AC kepada DC boleh laras untuk projek Sarjana Muda . Ia merupakan perkakasan yang dapat menurunkan voltan arus ulang alik, 240Vac kepada voltan keluaran Dc boleh laras. Voltan AC 240V ditukarkankan kepada DC dan diturunkan kepada 80V menggunakan push-pull transformer. Chip UC3526 kemudian digunakan sebagai pengawal untuk membolehkan voltan keluaran boleh dilaras dari 0 hingga 30V. Bagi mendapatkan rekabentuk yang ringan dan kecil, frekuenci tinggi 100kHz dipilih dengan cara ini saiz transformer dan penapis yang digunakan adalah kecil. Sebuah prototaip penukar ini dibina dan ia dapat menghasilkan voltan keluaran seperti yang dikehendaki.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter is discusses about a main point of this project, problem statement, scope and project objectives. Beside that, it also explains about a power supply background.

Power supply, which are used extensively in industrial applications, are often to meet all or most of the following specification:

1. Isolation between the source and load
2. High-power for reduction of size and weight
3. Controlled direction of power flow
4. High conversation efficiency
5. Input and output waveforms with a low total harmonic distortion for small filters.
6. Controlled power factor in the source is an ac voltage.

The power supply can be categorized into two types:

1. Dc power supply
2. Ac power supply

Linear and switch-mode types are under isolated DC-DC group. The advantages of switch mode over linear power supply are the efficient is between 70% to 95% and the weight and size can be reduction. The advantages of switched mode over linear power are the design is complex and it has the EMI problems.

However above certain rating, Switch Mode Power Supply or SMPS is the only feasible choice. The types of SMPS are fly back converter, push-pull converter, forward converter, half-bridge converter and full-bridge converter.

The switching mode supplies have high efficiency and can supply a high-load current at low voltage. The output of the inverter, which is varied by a PWM technique, is converted to a dc voltage by a diode rectifier. Because the inverter can operate at a very high frequency, the ripples on the dc output voltage can easily be filtered out with small filter.

1.2 PROJECT OBJECTIVES

This project has four objectives which it's be a guide line in process to develop this project. The objectives are:

1. To reduce the AC current 240Vac to the output voltage variable DC
2. To produce the variable output voltage in range 0-30V, 5A
3. To develop a small and light equipment
4. To estimate the equipment cost to the minimum

1.3 SCOPE OF PROJECT

The scope of the project is in the AC-DC converter, DC-DC converter which consist 2 type of circuit; drive circuit and the control circuit. The output is variable and can be adjusted. The development of this equipment also should produce the small and light.

1.4 PROBLEM STATEMENT

Mostly the available power supply is in a big size and heavy. So, this project will produce the small and light power supply. The DC power supply that available now is in a big size, so that it gives a high price.

For the equipment that been develop from this project, it use the switch- mode method in which a small and light transformer is being replaced for the power supply. By using the small and light transformer and the minimum quantity of the electronics components, the cost is reduced and the marketing price can be estimate to the minimum price which not expensive as the available one in the current market.

As the normal power supply gives the fix voltage output, this project develops the flexible equipment which can supply variable voltage output.

1.5 PROJECT METHODOLOGY

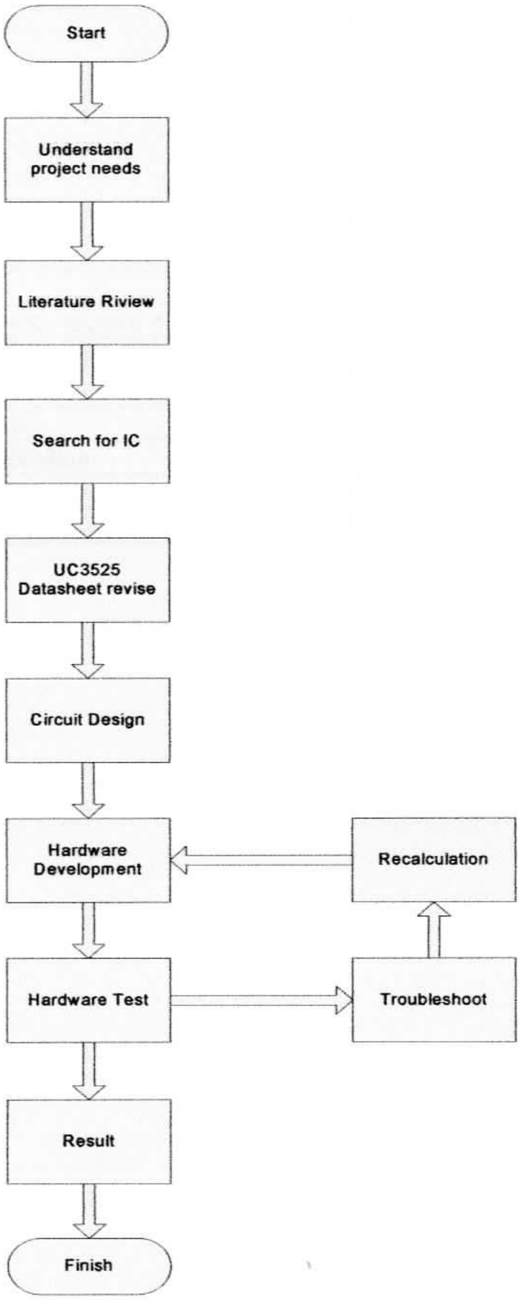

Figure 1: Project Methodology

1.6 PROJECT PLANNING GANTT CHART

Project Activities	July	August	September	October	November	December	January	February	March	April
Project understanding	■	■								
Literature review	■	■	■	■	■					
Search for the IC that can receive high voltege	■	■								
Revise the UC3526A divice datasheet	■	■	■	■	■	■				
Circuit design		■	■	■	■					
Hardware development				■	■	■	■	■		
Hardware test and evaluation					■	■	■	■		
PSM1 presentation				■						
PSM2 presentation									■	

Table 1: Project Planning

CHAPTER 2

LITERATURE RIVIEW

DC converter can be used as switching-mode regulators to convert a dc voltage, normally unregulated to a regulated dc output voltage. The regulation is normally achieved by PWM at a fixed frequency and the switching device is normally BJT, MOSFET or IGBT [1]. There are many topologies available for the DC/DC converter. There are designs for higher and lower output voltages along with inverting voltage polarity. There are:

2.1 Fly-back Converter

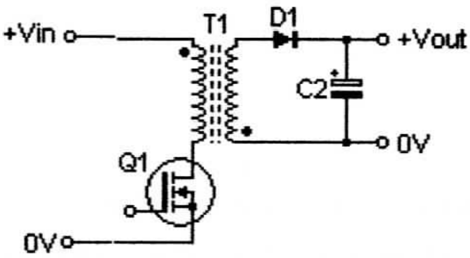

Figure 2.1: Flyback converter schematic

The advantage of fly-back for this design is that it allows a varying output voltage 0V-30V. However, the fly-back converter uses one switch, which will result in high heat loss. Besides, this topology is mainly used for a low power applications between 1-10W, therefore is unsuitable for this project.

2.2 Boost Converter

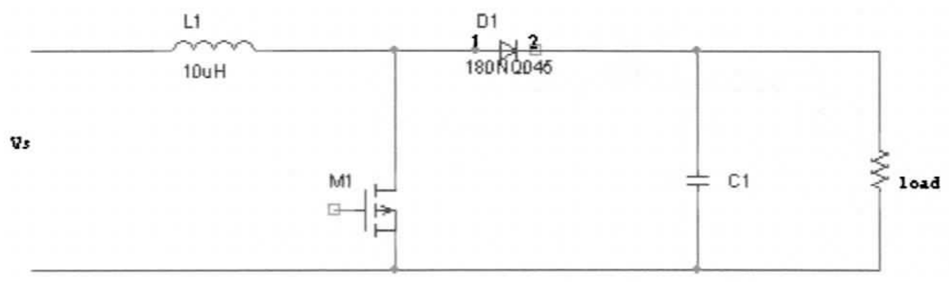

Figure 2.2: Boost converter schematic

Another design is the Boost converter. This converter is cable of providing the 0V-30V DC output required for the DC/DC converter however it doesn't have a security protection which is isolation transformer. The output relationship is

$$Vo = \frac{Vs}{1-D} \tag{2.1}$$

2.3 C'uk Converter

The C'uk converter is capable of meeting the demands of supplying 0V-30V Dc at the output. This converter has similar problem as the Boost converter because the duty ratio is large. The duty ratio can be calculated using the following equation:

$$\frac{Vo}{Vs} = \left(\frac{D}{1-D}\right) \tag{2.2}$$

This topology is ideal for a lower power application only and will produce a high switching power loss.

2.3.1 Half-Bridge Converter

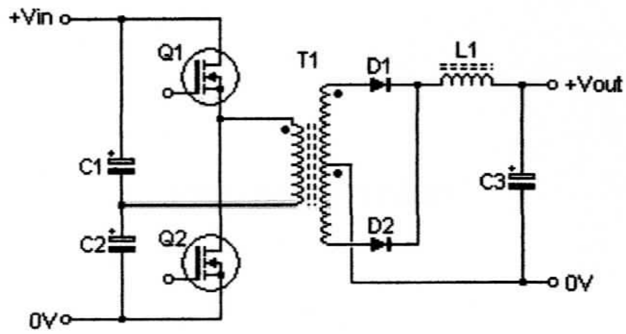

Figure 2.3: Half-Bridge Converter Schematic

Another configuration is the Half-Bridge Converter. It has a higher efficiency and a simpler structure with only two switches. Furthermore, the voltage of the Half-Bridge converter Bridge converter is half that of the Push-Pull Converter.

The main disadvantage with this design is the sensitivity to the load variations. This converter will need a more complex control design to accommodate the rapid change of the voltage ratio. The regulated output voltage would be very difficult to control within desired constraints. Other than that it required a complex gate drive circuit. The equation for the output voltage is shown below.

$$Vout = Vin\left(\frac{Ns}{Np}\right)D \tag{2.3}$$

CHAPTER 3

PROJECT THEORY

3.1 Switch Mode Power Supply – Push Pull Converter

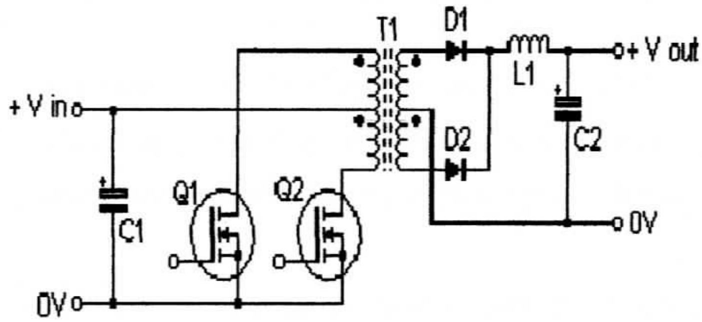

Figure 3.1: Half-bridge push-pull converter schematic

A push-pull converter is a type of DC to DC converter that uses a transformer to step the voltage of DC power supply. It has a configuration similar to the Full-Bridge but has two switches instead of four to cause a low switching loss.

With reference to the diagram above, when Q1 switches on, current flows through the 'upper' half of T1's primary and the magnetic field in T1 expands. The expanding magnetic field in T1 induces a voltage across T1 secondary, the polarity is such that D2 is forward biased and D1 reverse biased. D2 conducts and charges the output capacitor C2 via L1. L1 and C2 form an LC filter network.

When Q1 turns off, the magnetic field in T1 collapses and after a period of dead time, Q2 conduct, current flows through the 'lower' half of T1's primary and the magnetic field in T1 expands. Now the direction of the magnetic flux is opposite to that produced when Q1 conducted. The expanding magnetic field induces a voltage across T1 secondary, the polarity is such that D1 is forward biased and D2 reverse biased. D1 conducts and charges the output capacitor C2 via L1. After a period of dead time, Q1 conducts and the cycle repeats.

There are two important considerations with the push pull converter:

1. Both transistors must not conduct together, as this would effectively short circuit the supply. Which means that the conduction time of each transistor must not exceed half of the total period for one complete cycle, otherwise conduction will overlap.
2. The magnetic behavior of the circuit must be uniform, otherwise the transformer may saturate, and this would cause destruction of Q1 and Q2. This requires that the individual conduction times of Q1 and Q2 be exactly equal and the two halves of the centre-tapped transformer primary be magnetically identical.

When T1 is on, T2 off: $(\Delta iLx) = \left[\frac{Vin}{2}\left(\frac{N2}{N1}\right) - Vo\right] * \left(DT/_{Lx}\right)$ (3.10)

When T2 is on, T1 off: $(\Delta iLx) = \left[\frac{Vin}{2}\left(\frac{N2}{N1}\right) - Vo\right] * \frac{DT}{Lx}$ (3.11)

When both switch open: $(\Delta iLx) = -\frac{Vo}{Lx}\left(\frac{1}{2} - 2\right)T$ (3.12)

The output voltage: $Vo = Vin\left(\frac{N2}{N1}\right)D$ (3.13)

The output ripple: $r = \frac{\Delta Vo}{Vo} = \frac{1-2D}{32LxCf^2}$ (3.14)

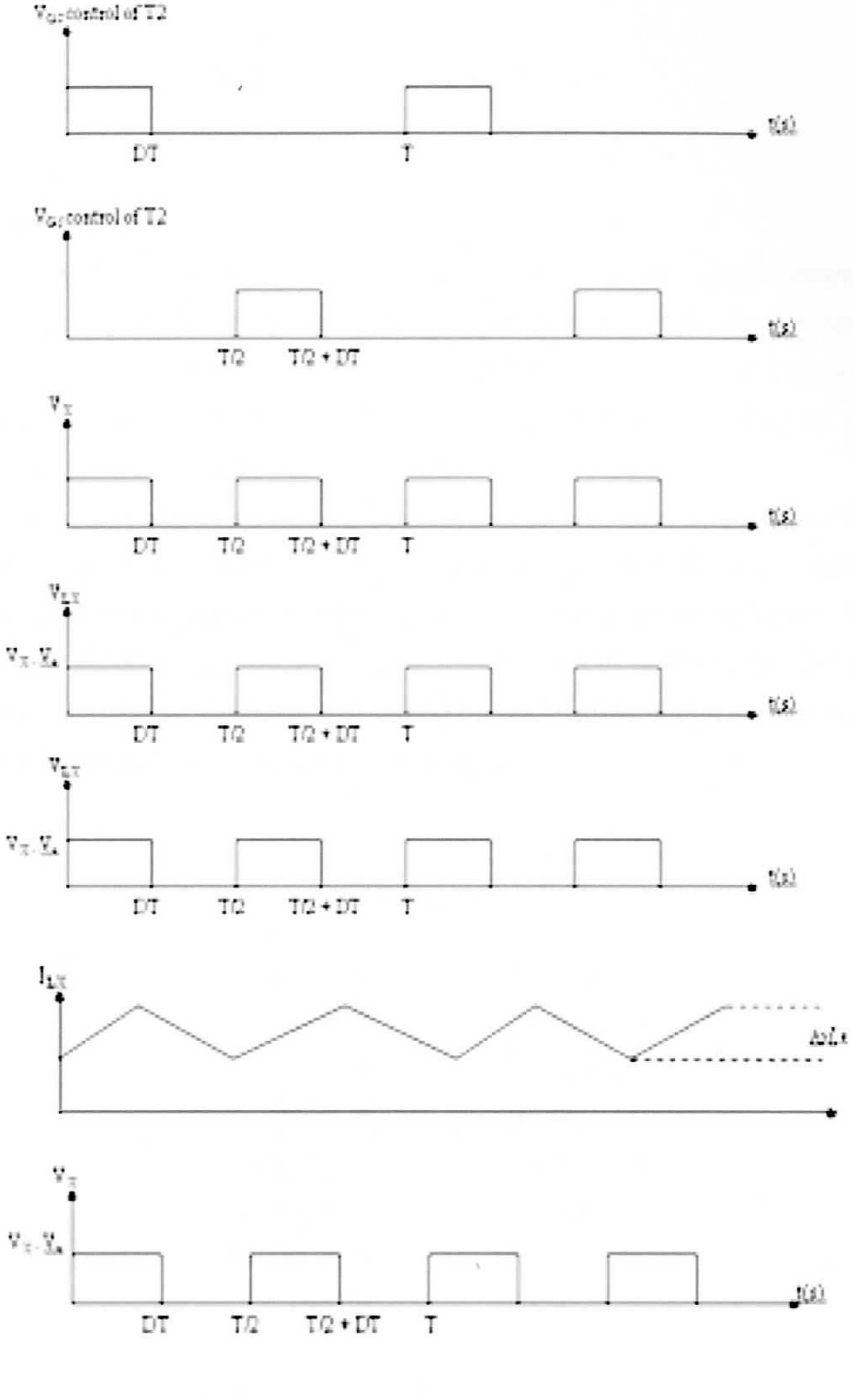

Figure 3.2: Half-bridge push-pull converter waveform