"I hereby declare that I have read this project report and in my opinion this project report is sufficient in terms of scope and quality for the award of Bachelor Degree in Electrical Engineering (Industry Power)"

Signature : ……………………………………..

Supervisor's name : MR. AZZIDDIN BIN MOHAMAD RAZALI

Date : ………4/5/06……………………………...

ANALYSIS AND CONSTRUCTION OF PUSH PULL CONVERTER

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This Project Report Is Submitted In Partial Fulfilment of Requirements for the Degree of Bachelor in Electrical Engineering (Industry Power)

Faculty of Electrical Engineering
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May 2006

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

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Name : NOOR RULMUNA BINTI MOHD SARMIN

Date : ......4 May 2006..................

DEDICATION

To my parents Mohd Sarmin Bin Seros and Habibah Binti Saring, my brothers Mohd Fuad, Mohd Hafiz, Khairun Nizam and Khairul Anuar, my sisters Siti Zuraidah, Noor Rasyidah and Nurul 'Izzah, and my families for all their support and unconditional love throughout my college studies. To Muhammad Mokhzaini Bin Azizan, my inspiration that encourages and motivate me to study harder into achieving my goals.

ACKNOWLEDGEMENT

السلام عليكم ورحمة الله وبركاته

Alhamdulillah, I am very grateful to Allah S.W.T for all His wisdom and guidance, allowing me to conclude the report for final year project 2006. Projek Sarjana Muda (PSM) is a two semester syllabus required by Kolej Universiti Teknikal Kebangsaan Malaysia (KUTKM) in order to enable student to graduate. PSM is a crucial tool in maturing and widening students' knowledge in facing the real time career. It also serves as a yardstick to measure the competent and competitive level of students in acquiring what market needs nowdays.

I would like to extent my endless thanks Mr Azziddin Bin Mohamad Razali, my supervisor for his attention and relentless help in assisting me toward completing this final year project. Being a supervisor, he had instilled good values in me and make me a better person altogether.

I also must thank all the laboratory assistants and the faculty for allowing me to use the laboratory and equipments in completing this project. I always thankful for their help; whether it is major or minor; and only Allah can give back to what they had given to me.

I am also indebted to all my lecturers who had taught me since the first year until this final semester. Their teachings had only benefited me, not only in educational aspect, but also my life had turn better all the time.

Finally, I must thank my parents and family as well as my friends for standing strongly beside me all the time. You always wake me up when I must have been dreaming; you carry on supporting me when I'm limping to the stairs of success. I'm very grateful to Allah for blessing me with these exceptional individuals who always love me and make me feel loved all the time. Thank you very much.

Wassalam.

ABSTRACT

The purpose of this project is to develop a converter that convert a value of direct current to another value of direct current that can produce 360V output voltage from 12V input voltage. Some of the components that use in this project is a high frequency transformer, integrate circuit SG 3525A and full bridge rectifier. The hardware implementation also use two MOSFET as a switching device due to its high power rating and high switching speed. Consequently, the design circuit will deliver accurate output value with low power losses and small output ripple because this converter have its own filter.

ABSTRAK

Tujuan projek ini adalah untuk membina satu penukar untuk satu nilai arus terus ke satu nilai arus terus yang lain yang boleh menghasilkan voltan keluaran tinggi sebanyak 360V dari voltan masukan 12V. Antara komponen penting yang digunakan ialah pengubah berfrekuensi tinggi, litar bersepadu SG 3525A dan litar penerus. Projek ini juga menggunakan dua MOSFET sebagai alat pensuisan kerana ia mempunyai kadar kuasa yang tinggi dan tempoh pensuisan yang cepat. Penukar yang direka ini akan menghasilkan voltan keluaran dengan kehilangan kuasa minimum dan riak pada voltan keluaran adalah kecil kerana ia mempunyai penuras sendiri.

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CHAPTER 1

INTRODUCTION

1.1 DC – DC CONVERTER

A dc – dc converters are widely used in regulated switch – mode dc power supplies and in dc motor drive applications. Often the input to the converters is an unregulated dc voltage, which is obtained by rectifying the line voltage, and therefore it will fluctuate due to changes in the line voltage magnitude.

Switch mode dc – dc converters are used to convert the unregulated dc input into a controlled dc output at a desired voltage level. Converters are very often used with an electrical isolation transformer in the switch – mode dc power supplies and almost always without an isolation transformer in case of dc motor drives.

The aim of this project is to design and to analysis the push pull converter. Push pull type dc - dc converter is suitable to boost up the voltage from low to high voltage. This converter may be used in conjunction with a high frequency transformer to boost the output voltage with the advantage of providing isolation between the input and output stage.

This project will use a push pull converter topology, which will step up a 12Vdc voltage supply to 360Vdc output voltage. A 12V power supply will be used as the input supply. ORCAD P - SPICE software is used to analyze the output of center tap transformer. Output of the hardware implementation is analyzed using the oscilloscope and multimeter.

1.2 OBJECTIVE

The main objective of this project is to design a push pull converter, which can gain output 360V dc from 12V dc input. This project also try to implement P - SPICE simulation of push pull converter with a center tap high frequency transformer.

1.3 PROJECT SCOPE

The scope of this project is using push pull converter that convert 12Vdc input voltage to 360Vdc as the output voltage. The design consist of parallel connected MOSFET, full bridge rectifier, SG 3525A control chip for feedback control, high frequency transformer, coupled inductor and bulk capacitor. The circuit is constructed on the PCB board.

CHAPTER 2

LITERATURE REVIEW

2. 1 INTRODUCTION TO PUSH PULL TRANSFORMER

Push pull converter is one of dc -dc converter that has transformer isolation. As with the forward converter, the transformer magnetizing inductance is not a design parameter. The transformer is assumed to be equal for this analysis. The push pull transformer configuration is widely used in converting direct current (d.c.) voltage into another value of dc voltage, and in inverters. Inverters convert direct current into alternating current (a.c.). The push pull transformer is usually the preferred choice in high power switching transformer applications exceeding one kilowatt. It is usually used in a circuit known as a forward converter circuit.

The core in a push pull transformer has bipolar operation. Both "B" and "H" cross zero value and reverse polarity. Bipolar operation is depicted graphically in Figure 2.1. Note that the "dB" value (change in B) in Figure 2.1 for the bipolar push pull transformer can be more than twice the "dB" value for the unipolar forward converter (assuming the same core material). Push pull transformer (bipolar) operation permits one to handle the same amount of power in a smaller package than for that of a unipolar operation. The push pull transformer operation requires more switching elements and its control circuitry is more complicated.

Consequently a push pull transformer application is more expensive. The voltage pulses must be adequately controlled to avoid phenomena known as saturation walk. Center tapped push pull transformers have winding capacitance issues at higher frequencies. Winding imbalances can contribute to saturation walk. Power ratings for push pull transformer can vary from a fraction of a Watt to Kilowatt.

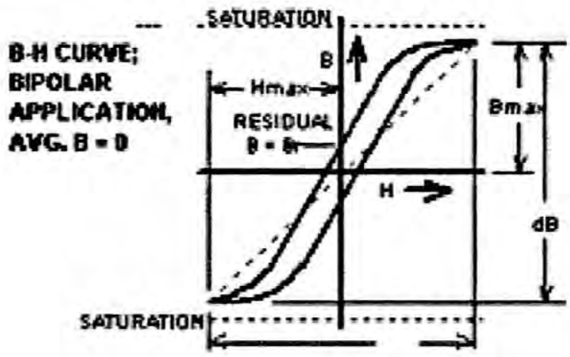

Figure 2.1 : Bipolar operation

2.1.1 Push pull schematic diagram

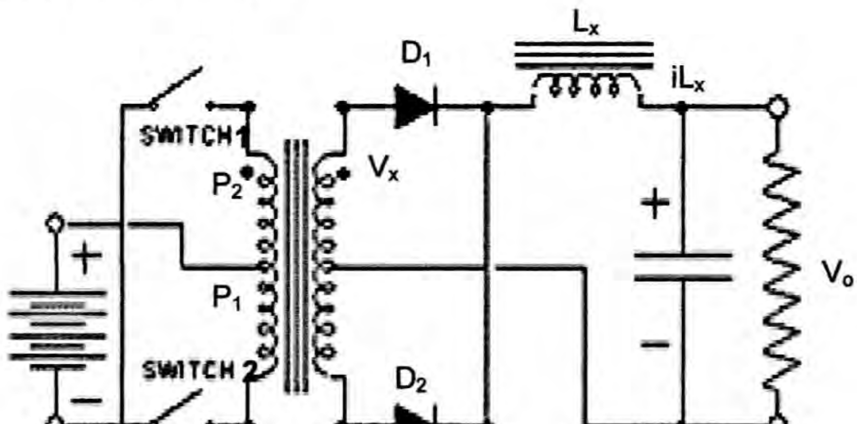

Figure 2.2 : Push pull converter diagram

2.1.2 **Push Pull analysis**

i) Switch Sw_1 closed

The voltage across primary winding P_1 at :

$$vp_1 = Vs \tag{2.1}$$

Diode D_1 is forward biased, D_2 is reversed biased. Assuming a constant output voltage V_o, the voltage across L_x is a constant, resulting in a linear increasing current in L_x. In the interval when Sw_1 is closed, The change in current L_x is :

$$(\Delta iLx)closed = \frac{Vs(Ns/Np) - Vo}{Lx}[DT] \tag{2.2}$$

ii) Switch Sw_2 closed

Closing Sw_2 establishes the voltage across primary winding P_2 at :

$$vp_1 = -Vs \tag{2.3}$$

Diode D_2 is forward biased, D_1 is reversed biased. The current Lx increases linearly while Sw_2 is closed and current L_x is :

$$(\Delta iLx)closed = \frac{Vs(Ns/Np) - Vo}{Lx}[DT] \tag{2.4}$$

iii) Both switches open

The current in each of the primary winding is zero. The current in the filter inductor L_x maintain continuity, resulting both D_1 and D_2 becoming forward biased. Inductor current divides evenly between the transformer secondary windings. The voltage across each secondary windings is zero.

$$v_x = 0 \tag{2.4}$$

$$vL_x = v_x - V_o \tag{2.5}$$

2.1.3 Theoretical push pull converter waveform

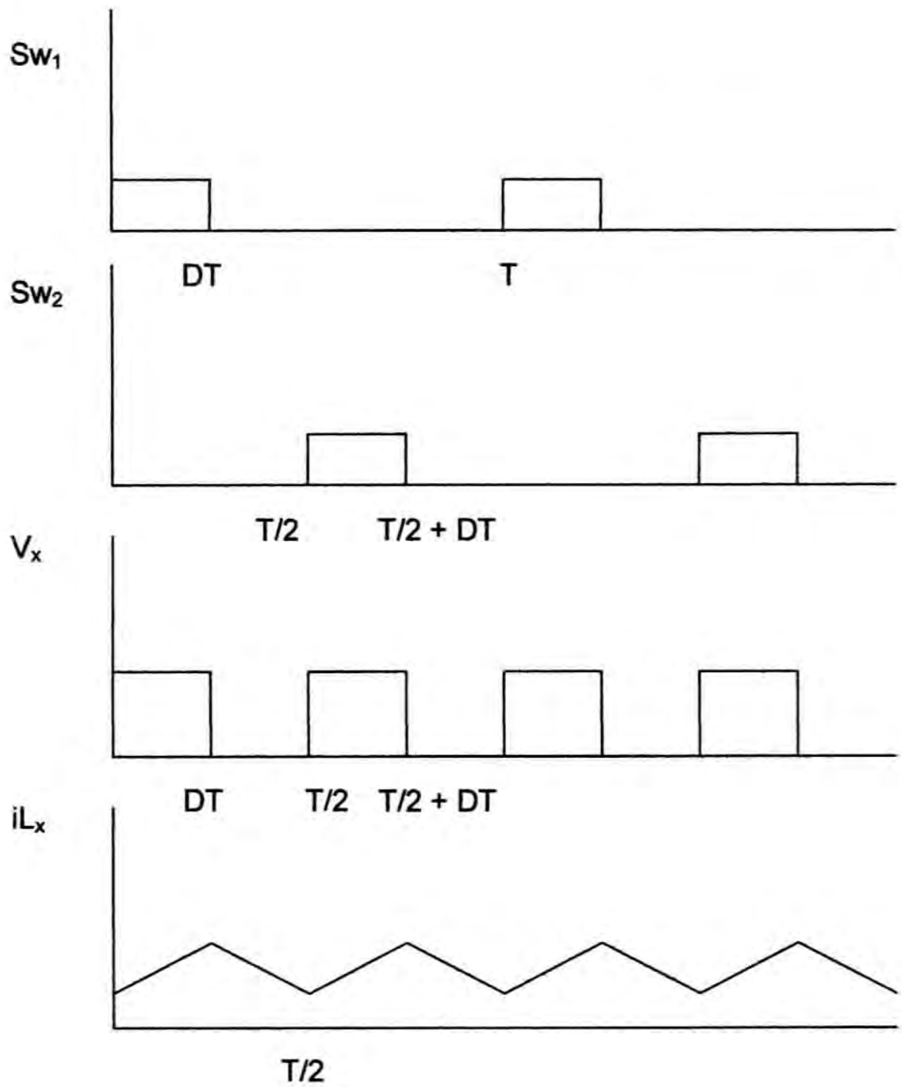

Figure 2.3 : Output waveform

2.2 CONTROL OF DC – DC CONVERTER

In dc – dc converters, the average dc output voltage must be controlled to equal a desired level, though the input voltage and the output load may fluctuate. Switch – mode dc - dc converters utilize one or more switches to transform dc from one level to another. In a dc- dc converter with a given input voltage, the average output voltage is controlled by controlling the switch on and off durations (t_{on} and t_{off}) . To illustrate the switch – mode conversion concept, consider a basic dc – dc converter shown in Figure 2.4.

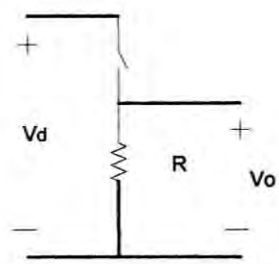

Figure 2.4 : Switch mode dc – dc conversion

The average value of V_0 of the output voltage employs switching at a constant (hence, a constant switching time period $T_S = t_{on} + t_{off}$) and adjusting the on duration of the switch to control the average output voltage. In this method, called pulse width modulation (PWM) switching,the switch duty ratio D , which is defined as the ratio of the on duration to the switching time period, is varied.

In the PWM switching at a constant switching frequency, the switch control signal,which control voltage $v_{control}$ with a repetitive waveform as shown in Figure 2.5. The control voltage generally is obtained by amplifying the error, or the difference between the actual output voltage and its desired value.

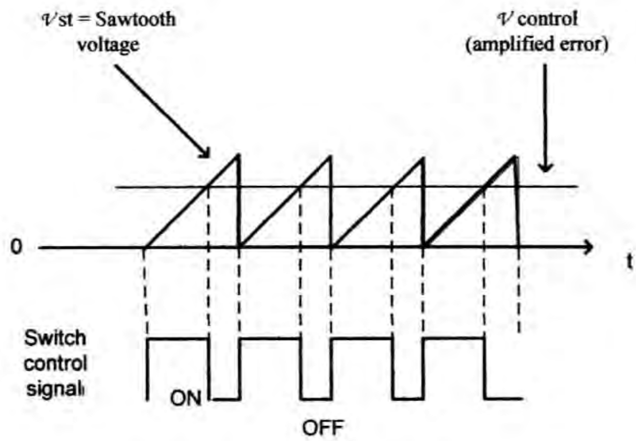

Figure 2.5 : Pulse width modulator comparator signal

2.3 FAST RECOVERY DIODES

The fast recovery diodes have low recovery time, normally less than 5μs. They are used in dc – dc and dc – ac converter circuits, where the speed of recovery is often critical importance. These diodes cover current ratings of voltage from 50V to around 3kV, and from less than 1A to hundreds of amperes.

For voltage rating above 400V, fast recovery diodes are generally made by diffusion and the recovery time is controlled by platinum or gold diffusion. For voltage ratings below 400V, epitaxial diodes provide faster switching speeds than those of diffused diodes. The epitaxial diodes have a narrow base width, resulting in a fast recovery time of as low as 50ns.

2.4 SCHOTTKY DIODES

The charge storage problem of a pn – junction can be eliminated (or minimized) in a Schottky diodes. It is accomplished by setting up a " barrier potential " with a contact between a metal and a semiconductor. A layer of metal is deposited on a thin epitaxial layer of n – type silicon. The potential barrier simulates the behavior of a pn – junction. The rectifying action depends on the majority carriers only, and as result there are no excess minority carriers to recombine. The recovery effect is due solely to the self-capacitance of the semiconductor junction.

The recovered charge of a Schottky diode is much less than that of an equivalent pn- junction diode. It is due to the junction capacitance, it is largely independent of the reverse di / dt . A Schottky diode has relatively low conduction voltage drop.

The leakage current of a Schottky diode is higher than that of pn – junction diode. A schottky diode with relatively low conduction voltage has relatively high leakage current, and vice versa. As a result, the maximum allowable voltage of this diode is generally limited to 100V.

The current ratings of Schottky diodes vary from 1 to 400 A. The Schottky diodes are ideal for high current and low voltage dc power supplies. However, these diodes are also used in low current power supplies for efficiency.

2.5 CONTROL CIRCUIT

Varying the duty cycle , D can control the output voltage of a converter. There are commercially available PWM integrate circuit (IC) controllers that have all the features to build a PWM switching power supply using a minimum number of components.

A PWM controller consists of four main functional components : an adjustable clock for setting the switching frequency , an output voltage error amplifier, a sawtooth generator for providing a sawtooth signal that is synchronized to the clock, and a comparator that compares the output error signal with the sawtooth signal. The output of the comparator is the signal that drives the power switch. Either voltage – mode control or current – mode control is normally applied.

2.6 PULSE WIDTH MODULATION

Pulse-width modulation control works by switching the power supplied to the switch on and off very rapidly. The DC voltage is converted to a square-wave signal, alternating between fully on (nearly 12v) and zero, giving the motor a series of power.

If the switching frequency is high enough, the switch runs at a steady speed due to its fly-wheel momentum. By adjusting the duty cycle of the signal (modulating the width of the pulse, hence the PWM) i.e. the time fraction it is on, the average power can be varied, and hence the motor speed.

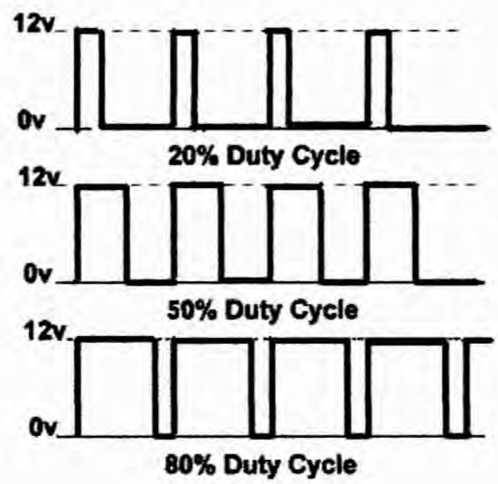

Figure 2.6 : Pulse width modulator duty cycle

Advantages of pulse width modulator are:

1. The output transistor is either on or off, not partly on as with normal regulation, so less power is wasted as heat and smaller heat-sinks can be used.
2. With a suitable circuit there is little voltage loss across the output transistor, so the top end of the control range gets nearer to the supply voltage than linear regulator circuits.