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FINAL REPORT

DESIGN SWITCH MODE POWER SUPPLY (SMPS)
USING FLYBACK TOPOLOGY

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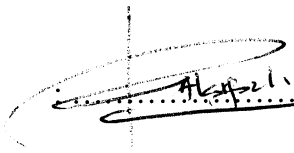
Bachelor of Electrical Engineering (Power Electronic and Drive)
May 2009

"I hereby declared that I have read through this report entitled Design Switch Mode Power supply (SMPS) Using Flyback Topology and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Power Electronic and Drive)"

Signature 

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DESIGN SWITCH MODE POWER SUPPLY (SMPS) USING FLYBACK TOPOLOGY

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This Report Is Submitted In Partial Fulfillment Of Requirements For The Degree of Bachelor In Electrical Engineering (Power Electronic and Drive)

Faculty of Electrical Engineering
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MAY 2009

I declare that this report entitle "*Design Switch Mode Power Supply Using Flyback Topology*" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

SIGNATURE :

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DATE : **13 MAY 2009**

"special dedicated to my dearest parent, sisters, brothers, lecterurs and friends....."

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Alhamdulillah, praise be to Allah, the Cherisher and Sustainer of world, most Gracious, most Merciful Lord.

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ABSTRACT

The purpose of this project is to design a Switch Mode Power Supply (SMPS) using a flyback topology. A switched-mode power supply can be defined as an electronic power supply unit (PSU) that incorporates a switching regulator, which is an internal control circuit that switches power transistors (such as BJTs, MOSFETs, IGBTs and etc) rapidly on and off in order to stabilize the output voltage or current. Switching regulators are used as replacements for the linear regulators when higher efficiency, smaller size or lighter weights are required. The selection of type of the switching regulator is depends on the applications and loads, but in this project a flyback converter topology is used. The Flyback converter can be developed as an extension of the Buck-Boost converter that replaces the inductor by a transformer. This project has been elaborated in detail about all the designing process of SMPS using flyback converter topology, starting from determination of parameter of PSU until the developing of designed SMPS hardware. P-Spice software is used to simulate and analyze all the designing processes. Hardware of the SMPS has been built based on the designed circuit and simulation result. The output of the built hardware is expected approximately match with the simulation result.

ABSTRAK

Projek ini adalah bertujuan untuk merekabentuk pembekal kuasa *'Switch Mode Power Supply '* atau SMPS menggunakan topologi *Flyback*. SMPS didefiniskan sebagai sebuah pembekal kuasa elektronik yang terdiri daripada satu switching regulator, iaitu sebuah litar kawalan dalaman yang mengaktifkan suis kuasa (seperti *BJTs, MOSFETs, IGBTs* dan sebagainya), dengan pantas untuk menstabilkan voltan atau arus keluaran. Switching regulators telah digunakan sebagai pengganti kepada linear regulator kerana ia mempunyai kecekapan tinggi, size kecil dan ringan berbanding *linear regulator*. Pemilihan jenis Switching regulator adalah bergantung kepada aplikasi penggunaan dan jenis beban. Dalam projek ini, *Flyback Converter Topology* digunakan untuk membangun dan merekabentuk pembekal kuasa. *Flyback Converter* boleh dibangunkan dari binaan *Buck Boost Converter* dengan menggantikan inductor dalam *Buck Boost Converter* dengan *transformer*. Dalam Projek ini telah dihuraikan dengan lebih terperinci berkaitan proses merekabentuk SMPS yang menggunakan *Flyback Converter topology*. Ia bermula dengan proses menentukan parameter PSU sehingga lah proses membangunkan perkakasan bagi SMPS ini. Perisian *P-Spice* dan *Proteus* telah digunakan untuk membuat simulasi dan membuat analisis bagi semua proses merekabentuk SMPS ini.. Hardware bagi SMPS ini telah di bina berdasarkan rekabentuk litar dan hasil simulasi. Dijangkakan voltan dan arus keluaran bagi perkakasan akan hampir sama dengan hasil voltan dan arus keluaran bagi simulasi.

LIST OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

AC	-	Alternating Current
DC	-	Direct Current
ADC	-	Analog to Digital Converter
DAC	-	Digital to Analog Converter
SCR	-	Silicon-Controlled Rectifier
CMOS	-	Complementary Metal–Oxide–Semiconductor
RAM	-	Random Access Memory
CPU	-	Central Processing Unit
ISP	-	In-System Programming
UART	-	Universal Asynchronous Receiver / Transmitter
VCC	-	Supply Voltage
GND	-	Ground
TTL	-	Transistor–transistor logic
DTE	-	Data Transmission Equipment
DCE	-	Data Communications Equipment
LED	-	Light Emitting Diode
HEX	-	Hexadecimal
USB	-	Universal Serial Bus
LCD	-	Liquid Crystal Display
PWM	-	Pulse Width Modulation
SMPS	-	Switch Mode Power Supply
PIC	-	Peripheral Interface Controller
IO	-	Input Output
BJT	-	Bipolar Junction Transistor

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

A DC-to-DC converter is a device that accepts a DC input voltage and produces a DC output voltage. In many industrial applications, it is required to convert a fixed voltage dc source into variable voltage dc source. Typically the output produced is at a different voltage level than the input. [1]

In any type of DC-DC Converter circuit, the selection of power device for a particular application not only the required voltage and current levels but also its switching characteristic. The key parameters to look for in the transistor are the switching time and current rating. These two parameters greatly affect the maximum switching frequency of the converter, and also how much current the converter can be designed for. Because switching speed and associated power losses are very important in the power electronics circuits. For the example, the BJT transistor is minority-carrier device, whereas the MOSFET is a majority-carrier device that does not have minority-carrier storage delays, giving the MOSFET advantage in switching speeds. BJT transistor switching time may be a magnitude longer than for the MOSFET. Therefore, the MOSFET generally has lower switching losses. A DC-DC Converter is normally chosen because of its high efficiency in converting the input power to output power. [3]

1.2 PROJECT OBJECTIVES

The objectives of this undertaken project are:

i. Design a SMPS using Flyback Converter Topology.
ii. Design and build a SMPS which have variable Ouput Voltage.
iii. Use a high frequency transformer to reduce the size and weight of the Flyback Converter
iv. Design and simulate the designed circuit stage by stage using Proteus Lite and P-spice software.
v. Study and analysis the Flyback Converter performance and characteristics.
vi. Build the Flyback Converter as simple as possible with the reasonable circuit protection.

1.4 PROBLEM STATEMENT

In many DC-DC applications, multiple outputs are required and output isolation may need to be implemented depending on the application. In addition, input to output isolation may be required to meet safety standards and / or provide impedance matching. The electrical isolation is switching DC power supplies are providing by high frequency isolation transformer [5]. So, the purpose of designing SMPS using Flyback converter topology is to solve that problem stated above. An open loop SMPS using flyback converter topology is a simple designed circuit. Although it is simple, an open loop SMPS it difficult to build it hardware. It is because it involved the switching and high frequency component.

1.5 PROJECT SCOPES

The scopes for this project are:

i. Analysis for open loop circuit by doing simulation on flyback converter circuit.
ii. Design a flyback converter which consists of switching circuit, high frequency transformer, rectifier and filter circuit.
iii. Develop a hardware which consists of power stage, microcontroller circuit and converter circuit.
iv. Analyze and compare the experiment result with the simulation results.

CHAPTER 2

LITERATURE REVIEW

This section, will discuss about the SMPS, Flyback converter and Pulse Width Modulation.

2.1 BACKGROUND

All electronic circuits need a supply of power. For low power consumption units, it suffices use battery or solar cell. However, for most applications the power consumption is such that an electronic power supply must be used and for high power application, surely it will use power supply because the battery even solar cell cannot provide energy for long duration usage. Two types of electric energy waveforms are used to run the applications; alternating current and direct current. To supply electric energy to applications, there are four types of power supply are used that are AC to AC conversion, AC to DC conversion, DC to DC conversion and lastly DC to AC conversion power supply.

The switching Mode Power Supply using Flyback Converter Topology (SMPS) is designed to supply electric energy to DC applications from main domestic AC voltage that is $240V_{rms}$, 50Hz. Therefore, the AC to DC conversion circuit has been used for this project. There are two common types of AC to DC power supply which always find in market that are linear power supply and

switch-mode power supply (SMPS). In theory and research that made by power supply designer, the switch-mode power supply (SMPS) is better compare to linear power supply in efficiency, size and weight because the switch-mode power supply (SMPS) will regulate the voltage using pulse-width modulation (PWM) and the transistor that is used as switch in this power supply are always fully on and fully off. Thus, and "ideal" switch-mode power supply (SMPS) will be 100% ideal and the only heat generated is because ideal components do not exist. Compare to linear power supply, it regulate the voltage or current by wasting excess voltage or current as heat which is very inefficient.

In this project, the designed and developed hardware for switch-mode power supply (SMPS) will be used to supply electric energy to low voltage and high current applications. Besides that the developed hardware of switch-mode power supply (SMPS) also can be used to supply electric energy to various DC applications such as computer, handset charger, stepper motor, HiFi system, guitar speaker amplifier and many more because the output voltage can be regulate for multiple output voltage (0 to 30 V dc range). The electric energy usage for the developed switch-mode power supply (SMPS) can sustain limits to 120 Watt applications only.

The switching element for this switch-mode power supply (SMPS) has been connected to PIC microcontroller type because this microcontroller can be programmed to generate pulse-width modulation (PWM) where various duty cycles can be produced by setting the generation of pulse-width modulation (PWM) from PIC microcontroller. For this designed switch-mode power supply (SMPS), the desire DC output voltage can be produced follows to the duty cycle of transistor switching. If the duty cycle change, the output voltage also change.

2.2 SWITCH MODE POWER SUPPLY

Over the past 10 years, there have been significant changes in the design of power supplies. The most important of these has been the widespread change from linear power supplies to those which operate on a switching basis – so-called Switched Mode Power Supply (SMPS). The principal reason for the move to SMPS is their much greater efficiency – typically 80-90% as opposed to 30-40% for linear units. This greatly reduces the cooling requirements and allows a much higher power density.

Efficient conversion of electrical power is becoming a primary concern to companies and to society as a whole. Switching power supplies offer not only higher efficiency but also offer greater flexibility to the designer. Recent advances in semiconductor, magnetic and passive technologies make the switching power supply an ever more popular choice in the power conversion arena today.

The switched-mode power supply is an electronic power supply unit (PSU) that incorporates a switching regulator that is an internal control circuit that switches power transistor such as MOSFETs rapidly on and off in order to stabilize the output voltage or current. Switching regulators are used as replacements for the linear regulators when higher efficiency, smaller size and lighter weight are required.

Power supply is a device that transfers electric energy from the source to the load using electronic circuits, although power converter would be a more accurate term for such a device. For electronic equipment, a typical application of a power supply is to convert utility AC voltage into required regulated DC voltages. Nowadays in most power supplies providing more then a few watts the energy flow is controlled with power semiconductors that are continuously switching on and off with high frequency. Such devices are referred to as switch

mode power supplies or SMPS. In general, SMPS can be classified into four types according to the form of input and output voltages: AC to DC (off-line power supply or a rectifier); DC to DC (voltage converter); AC to AC (frequency changer or cycloconverter); DC to AC (inverter). In this project, type of SMPS being used is DC to DC converter.

2.3 DERIVATION OF THE FLYBACK CONVERTER

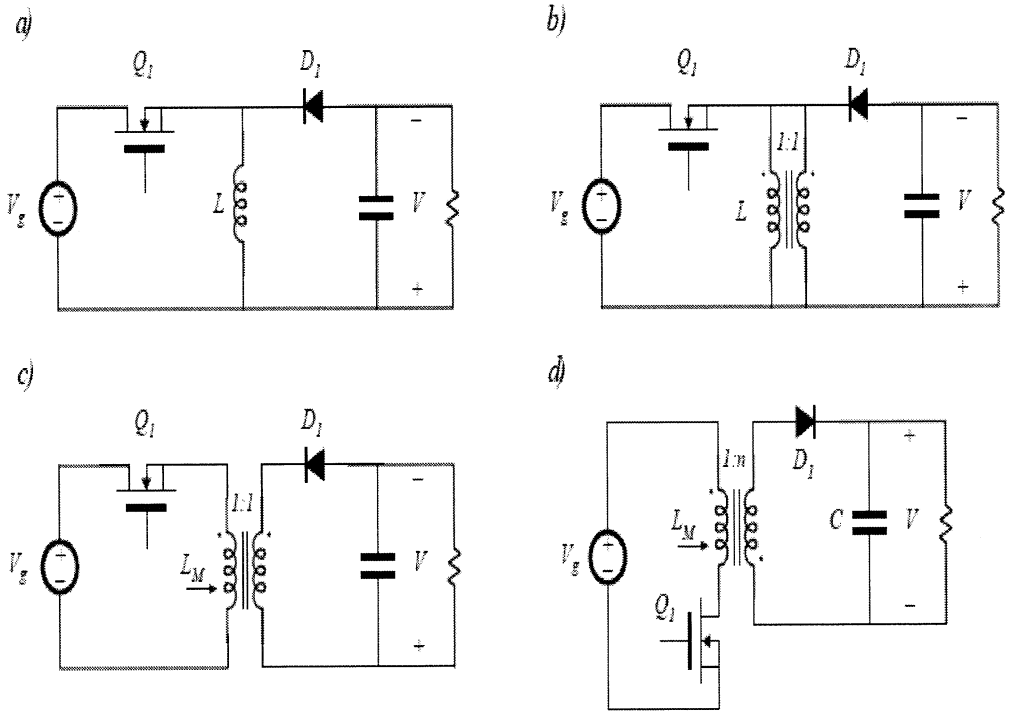

Figure 2.1: Derivation of the Flyback converter: (a) Buck-boost converter, (b) inductor L is wound with two parallel wires, (c) inductor windings are isolated, leading to the flyback converter, (d) with a $1{:}n$ turn ratio and positive output.