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Signature : .....

Supervisor's Name : JURIFA BT. MAT LAZI

Date : 03/05/06

# FLEXIBLE ELECTRIC POWER CONVERTER

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"I hereby declare that this report is a result of my own work except for the excerpts that have been cited clearly in the reference."

Signature : .....

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Date : 4 MEI 2006

*Especially dedicated to my family and friends ...*

## ACKNOWLEDGEMENTS

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## ABSTRACT

This project is called 'Flexible Electric Power Converter. This project describes a integration between 3 converter circuits which are AC to DC (rectifier), DC to AC (inverter), and DC to DC (chopper). All of them will be working in a single housing and able to do the power conversion simultaneously or separately. The voltage level and frequency level can be controlled at the circuit itself. There are a few switching methods that will be used prior to each circuit. Switching method that will be used for all converter is Pulse Width Modulator (PWM). Problems like output can be eliminated by using capacitor which is the simplest filteration method. The overall design including the housing is expected to be small and portable so it can be relocated anywhere without problem. This device is intended to be use for normal or home usage and not for industrial use.

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# ABSTRAK

Projek ini dikenali sebagai Penukar Kuasa Elektrik Bolehubah. Ia menerangkan gabungan antara 2 litar pengubah iaitu pengubah voltan ulang - alik kepada voltan terus dan pengubah voltan terus kepada voltan terus. Kedua - dua litar pengubah ini akan bekerja dalam satu perumah dan mampu menjalankan peranan untuk menjadi pengubah voltan secara serentak ataupun satu demi satu.(bukan pada masa yang sama). Magnitud voltan keluaran boleh dikawal pada litar pengubah itu sendiri. Tugas menjalankan projek ini adalah untuk merekabentuk litar yang paling sesuai di mana ianya akan menggunakan komponen yang betul untuk menjalankan fungsi tertentu, mampu bekerja secara berterusan dan mampu memberi bekalan kepada beban. Terdapat beberapa cara kawalan penukar yang akan digunakan untuk setiap litar. Masalah seperti riak gelombang pada gelombang keluaran boleh diatasi dengan mengunakan kapasitor. Rekaan keseluruhan termasuk perumah litar diharapkan kecil dan mudah alih supaya senang dibawa ke mana – mana oleh pengguna tanpa sebarang masalah. Sasaran kegunaan pengubah ini hanyalah untuk penggunaan biasa dan bukan untuk kegunaan industri. Keluaran untuk setiap litar difokuskan kepada saiz voltan yang biasa digunakan.

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction to the Project

This project with title "flexible electric power converter" is meant to ease human life in the aspect of using electrical appliances because the differences of the electrical source in terms of types of voltage that might be incompatible with the types of voltage needed by the electrical appliances itself. Even though it might not be suit with certain loads because of bigger power rating due to the transformer that is used is rated at smaller amps, it is hoped that it could match the objective of the converter.

## 1.2 Project Background

The difference of voltage types which alternating current (AC) and direct current (DC), voltage level which are root mean square (RMS) and dc (direct current) between the main supply or source (electricity) and the load could bring difficulties to connect both of them at each ends [1]. Normally this can be solved by using electric power converter which based on the voltage type at the input terminal and output terminal.

Nonetheless, it is needed to use a new method or replacement of this normal converter when the source and the load are not suitable anymore which each other and can lead to non-relevancy. So, the alternative solution for this to prevent the problem of non-compatibility between source and load is to use flexible converter.

This electric power converter is a merging result of switching method like full Pulse Width Modulator (PWM) trigger transistor and Metal Oxide Semiconductor Field-Effect Transistor (MOSFET). The electric power converter is going to facilitate two operating modes that are controlled through knob built on the electric power converter itself. The two operating modes are AC to DC (rectifier) and DC to DC (chopper). A proper circuit design of the flexible electric power converter is developed in this project, and a prototype of the flexible electric power converter will be build in order to test out the performance of the developed circuit design.

It is expected that both circuit will be integrated into one or perhaps will be separated, (depends on the complexity of the design) Socket design for input and output should be universal which supports almost all male socket design of the market today. The voltage will be controlled on the device itself

## 1.3 OBJECTIVES AND THE SCOPE OF PROJECT

This project only covers about converter circuit design for small applications like normal chopper, and rectifier. Normally for home and light usage which draws only low and moderate power. In conjunction with that, the input and output socket for both DC and AC will be designed to support normal electrical appliances. So, 2 pin input and output socket will be preferred. This project it's not expected to support any industrial purpose because of some limitations and constraints. For instance,

continuous and large power delivery won't be guaranteed because the limitation of budget.

For rectifier, the input voltage range is planned to be around 110 – 240Vac and output voltage range is around 5 – 12Vdc.

The scope of this project is to develop a multi purpose converter that will perform the following task:

1. The chopper input voltage is variable which would be 0 to 12Vdc and so does the output voltage.
2. The rectifier would be able to receive 240Vac from normal 3 pin electric socket at home and convert to 3 types of common Vdc output that is normally used:

    a) Variable Vdc output ranging from 0 – 24V
    b) Fixed 12Vdc output which consists of positive and negative voltage.
    c) Fixed 5Vdc output.

3. Able to feed small loads but the continuous supply power won't be guaranteed.

## 1.4 PROJECT BASIC REQUIREMENT

Multiple tools as below are needed to complete the schematic design and hardware for the converters.

1. Circuit design and simulation
   - Multisim 7 is a circuit simulation software that incorporates advanced schematic capture capabilities, integrated with full analog/digital SPICE simulation. It offers a single, easy-to-use graphical interface for all design and analysis needs.

   - Easily Applicable Graphical Layout Editor or EAGLE as its abbreviation. EAGLE is mainly used by me to transfer the schematic circuit to PCB layout

2. Breadboard and components for early phase of the project
   - The schematics circuitry will be applied to breadboard with all components that are needed.

   - For bigger schematics circuitry, etching based circuit method will be proceeded.

   - No protoboard will be used for all circuit because two times job will be too costly.

3. Multimeter and Oscilloscope for testing

   - For each increment or decrement for each input voltage, and the result of the output voltage. The value of each can be observed by using multimeter.

- To see the waveform for output AC voltage, oscilloscope will be used. The output waveform can show how smooth the output voltage will be.

## 1.5 Project Significant

This project could deliver a few benefits which are providing solution for Electric power conversion for almost electrical utility that covers domestic use. The power supply is restricted to single phase only. Other than that, it also provides an alternative to those expensive power converters that's available in the market today. Even though this is an amateur project, this might be considered as a starting point. Any mistakes or error can be reduced by repeating a few steps that will lead to improvement from time to time. The power converter is not promised to be as good as the one that is proven to be the best seller. Since it is not meant to be commercialized and will never be scrutinized by SIRIM or any related authority, the normal usage for consumer's load is not promised. This is because there are a lot of things that should be done to the design to ensure its reliability and stability. Due to time constraints, the detailed process for this project won't be settled. But at least it could be a more economical way for those who can't afford such expensive converter.

## 1.6 Expected Results

The final result is expected to be a flexible electric power converter which is able to support three operating modes which is AC to DC (rectifier) and DC to DC (chopper). Even electricity source and the load have difference in terms of voltage type, it is hoped that this device will connect both of it together.

Switching method that will be use for each converter is PWM in conjunction to trigger MOSFET or IGBT switch. It's understood that both of them do have advantages and disadvantages of their own. So smart choice should be done while designing and simulating which is the current step right now.

The target user for this device is only home application only. Continuous and non-fluctuated power delivery is the most important thing in this project.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

Literature review and project methodology are two crucial steps for the completion of this project. A literature review is an account of what has been published on a topic by accredited scholars and researchers. The purpose is to understand what knowledge and ideas have been established on a topic, and what their strengths and weaknesses are. The first step of doing literature review is focusing on problem formulation where a topic or field is being examined. Second step is literature search, where the aim is to find materials relevant to the subject being explored. Third step is data evaluation where one has to determine which literature makes a significant contribution to the understanding of the topic. Finally, analysis and interpretation where one has to discuss the findings and conclusions of pertinent literature.

The result later will be come in handy as a supportive reference for the project title. It is also a result of the compilation of a series of material from all kind of sources. The sources can be from all kinds of reading materials which include books, journals, technical reports, project/research papers and etc. For this project,

the materials have been used are reference books, thesis's, project/research papers, and technical reports from the library, internet and organizational journals such as of IEEE. The details of the literature study and the project methodology is under the two sections below. All the reference that been use are approved by international bodies.

## 2.2 Facts and Finding

After doing a few research and information seeking, there are a few literature review that been done by several engineers where their paperwork is quire useful to be treat as a guideline for this project.

### 2.2.1 PC-Based Integrated Power Converter

This paper was done by Ikis Rohadikisno and Martin Roekman from Fakultas Teknik Universitas Indonesia, as a part of their project. For this design, it is observed that they were using the integrated form of push pull inverter, full wave inverter and half wave rectifier to generate 4 operating modes of AC/DC, DC/DC, DC/AC or AC/AC. All three circuit are working together so all 4 modes can be used at the same time. In other words, each circuit is dependant to each other. To control voltage level and frequency, special software is developed and can be controlled through computer. There is a microcontroller in between computer and the converter circuit to achieve a connection between those two. So, there are 3 major section in this project which are electric circuitry, microcontroller design and software development.

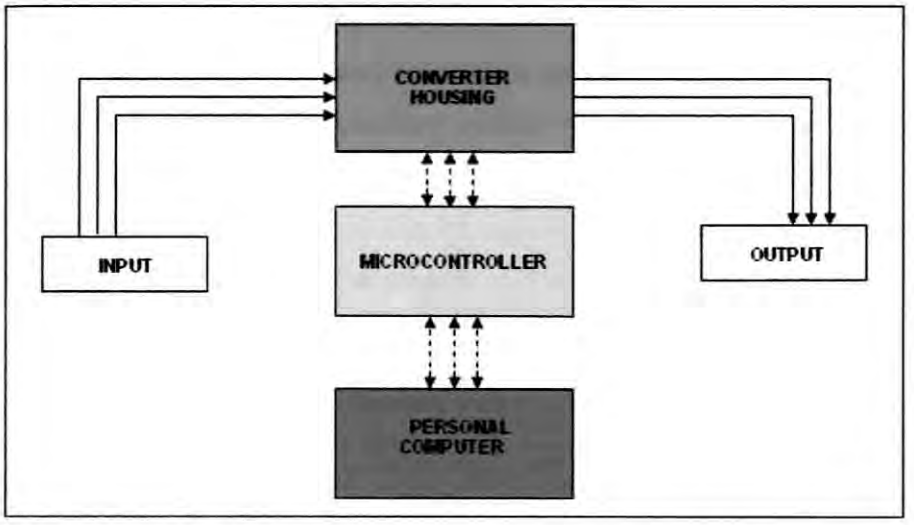


**Figure 2.1: PC based Integrated Power Converter**

This kind of project can be considered as fully computerized. The operation of this project is simplified in the block diagram shown above. All four converters are depends on the push pull inverter and the push pull inverter's operation is controlled by pulse that is generated by microcontroller. The basic operation of the microcontroller is 16-bit digital divider. It will process the received signals from personal computer to 3 digital counters respectively. The sequence of the counter is determined by the value of desired output whether AC output or DC output.

In conclusion, the aim of PC based Integrated Power Converter is to connect as much as possible between two different source and load even thought there are differences in matter of frequency or type of voltage. Integration of three type of converters in elementary will create a scheme where it will work it four different conversion mode at a time. The digital triggering control is defined by setting the value of alpha for firing angle method in switching scheme and controlling the frequency by using computer.

There are a few things obtained from this research paper where the idea of creating a flexible electric power converter by using 3 different circuits is done. These circuits are not meant to control specified mode of conversion but the manipulation of digital controller enable the circuits to do four function of conversion mode one at a time. So, from this paper, it generate an idea of using one type of switching mode that can be use for all conversion method where quite beneficial in the process of this project.

### 2.2.2 Dc Ripple Current Reduction Method On A Single Phase PWM Voltage Source Converter

This paperwork, which were proposed by Toshihisa Shimizu, Yasuhiro Fujioka, Gunji Kimura from Tokyo Metropolitan University introduces a single phase PWM voltage source converter and related control method that can produce not only a sinusoidal input current but also zero-ripple output current The main circuit of this converter is composed of a conventional single phase PWM voltage source converter and a ripple reduction circuit. The ripple reduction circuit is composed of an additional switching leg, an inductor, and a switching leg that is shared with the PWM converter.

The input current control is achieved by the conventional high-frequency PWM current control technique. On the other hand, DC ripple reduction control is associated with some difficulties because one of the switching legs in the ripple reducing portion is shared with the PWM converter portion. In order to reduce the DC ripple current, the inductor current at the ripple reducing portion must be maintained to the adequate value which is deeply influenced by the modulation factor on the PWM converter. The effectiveness of this circuit was confined by these researchers experimentally and by simulation. The converter is useful for DC power supplies, particularly in the case in which batteries are connected to the DC line.

The generation of harmonics and their subsequent propagation into utility lines is a topic of increasing concern for power supply authorities. To reduce harmonics in power lines, unity power factor PWM converters are used. However, single-phase PWM converters have serious defects including low frequency ripple current which appears on the DC output increases in proportion to the input current into the PWM converter, resulting in low frequency ripple voltage in the DC output Therefore, a very large capacitor or a passive L-C filter circuit is generally connected to the DC line in order to reduce low frequency ripple voltage.

This proposed scheme does not covers the whole aspect of a converter but the method that is used for reducing DC ripple current is quite important in the task of designing chopper circuit. Smooth output waveform from DC-DC converter ensures that the power output will be delivered constantly to match with the load needs. Even the ripple is not fully eliminated; it is reduced at quite satisfying level. The usage of this DC ripple reduction really helps PWM to maintain the DC output level.

### 2.2.3 A Single Stage Single Switch Power Factor Corrected AC/DC Converter

This title were proposed by M. Daniele, P. Jain*, and G. Joos from Department of Electrical and Computer Engineering, Concordia University, Canada. It describes a concept of single stage single switch isolated converter topology to achieve a regulated dc output voltage having no low frequency components and a high input power factor. The topology is derived from the basic forward converter, but incorporates an additional transformer winding, an inductor, and a few diodes. The proposed circuit by this trio inherently forces the input current to be discontinuous and ac modulated to achieve high input power factor. Both duty cycle and variable frequency controls are used to regulate the output voltage and to minimize dc capacitor voltage variations. Analysis of the converter is presented and performance characteristics are given. Further, design guidelines to select critical