UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF 6kW VARIABLE POWER SUPPLY LEADING TO KNOWLEDGE EXTRACTION FOR POWER ELECTRONIC DESIGN AID SYSTEM DATABASE

YOUSIF ABBAKER ADAM

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By

YOUSIF ABBAKER ADAM

Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of Science in the Faculty of Engineering
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Dedicated to

My

Parents, Wife, Sisters and Son

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the Degree of Master of Science.

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Faculty : Engineering

Expert systems are starting to play an important role in this era of knowledge. As we are moving from information age to knowledge age; management and organisation of human expertise will have a great impact in all aspect of life in terms of time saving and money. This project is targeted to feed the expert system with the knowledge that is extracted during the process of design and development of a power supply. The design of the power supply is the major part of the work while the extraction of knowledge comes after.

The power supply circuit is composed of three major stages; the input power AC to DC conversion circuit, the Buck converter power circuit that is controlled by PWM signal, and the control circuit which includes the logic, isolation and driving circuits.

Switching technique is employed based on duty cycle control by which the different outputs is obtained. Insulated Gate Bipolar Transistor (IGBT) is used as a power switch protected by snubber circuit. A negative feedback is employed to maintain constant output. The power supply design is simulated using PSpice and the hardware circuit is then built and tested.

The complete design of the power supply is achieved and as the expected results are obtained leading to the knowledge extraction process during the power supply development, by which this work contributes to the Power Electronic Design Aid System database (PEDAS).

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains.

PEMBANGUNAN PEMBEKAL KUASA BOLEHUBAH 6kW KEARAH MEMPEROLEHI PENGETAHUAN BAGI PANGKALAN DATA SISTEM REKABENTUK LITAR ELEKTRONIK KUASA

Oleh

YOUSIF ABBAKER ADAM

November 1999

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Sistem Pakar memainkan peranan penting dalam era pengetahuan masa kini. Perubahan kepakaran manusia daripada era maklumat kepada pengurusan pengetahuan dan organisasi akan memberikan kesan yang baik dalam semua aspek kehidupan dalam ertikata menjimatkan masa dan wang. Projek ini disasarkan untuk memberi Sistem Pakar dengan pengetahuan yang diperolehi semasa proses rekabentuk dan membangunkan bekalan kuasa. Rekabentuk bekalan kuasa merupakan bahagian utama projek ini yang mana pengtahuan akan datang kemudian.

Litar bekalan kuasa terdiri daripada tiga peringkat utama; kuasa masukkan AC kepada litar penukar DC, litar kuasa penukar 'Buck' yang dikawal oleh isyarat PWM, dan litar kawalan termasuk logik, pemisahan dan litar pemacu.

Penggunaan teknik pensuisan berasaskan kepada litar kawalan kerja dengan keluaran berbeza diperolehi. ‘Transistor Dwikutub Get Tertebat (IGBT)'

digunakan sebagai suis kuasa yang dilindungi oleh litar 'Snubber'. Tindakbalas negatif diambil untuk menetapkan keluaran kekal. Rekabentuk bekalan kuasa disimulasikan dengan menggunakan perisian 'Pspice' dan kemudian dari itu litar perkakasan dibina serta diuji.

Rekabentuk bekalan kuasa yang lengkap dicapai dan hasil/keputusan yang dijangka diperolehi yang membdehkan proses pengambilan pengetahuan semasa pembangunan bekalan kuasa, dengan itu projek ini menyumbang pembangunan pengkalan Data Sistem Rekabentuk Elektronik Kuasa (PEDAS).

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Verily those who say, " Our Lord is Allah," And remain firm (On that Path)- On them shall be no fear, Nor shall they grieve.

First and foremost my thanks to Allah S.W.T who gave me power and help to complete this work which I hope will contribute to the welfare of our nation.

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LIST OF ABBREVIATIONS

BJT	Bipolar Junction Transistor
C	Collector
D	Duty Cycle
E	Emitter
f	Frequency
f_c	Corner Frequency
f_s	Switching Frequency
FM	Frequency Modulation
G	Gate
GTO	Gate turn-off thyristor
IGBT	Insulated Gate Bipolar Transistor
J	Junction Area
J_c	Dissipated Conduction Energy
L	General Inductance Symbol
MCT	MOS Controlled Thyristor
MOSFET	Metal-Oxide Silicon Field Effect Transistor
P_c	Conduction Power Loss (W)
P_s	Switching Power Loss (W)
P_t	Total Power Dissipation (W)
PWM	Pulse Width Modulation

Q	Charge (Coulomb)
R	General Symbol for Electrical Resistance (OHMS)
$R_{c\text{-}a}$	Case to Ambient Thermal Resistance
$R_{h\text{-}a}$	Heatsink to Ambient Thermal Resistance
$R_{J\text{-}a}$	Junction to Ambient Thermal Resistance
R_{θ}	Thermal Resistance (^{o} C/W)
R_{CS}	Thermal Resistance (^{o} C/W)
R_{JC}	Thermal Resistance from Junction to Case (^{o} C/W)
R_{SA}	Thermal Resistance from Heatsink to Ambient (^{o} C/W)
S	Heatsink
SDR	Sequential Discharge Rectification
SMPS	Switch Mode Power Supplies
T	General Symbol for the Temperature (^{o} C/W)
T_A	Ambient temperature (^{o} C)
T_C	Case Temperature (^{o} C)
T_J	Junction Temperature (^{o} C)
V	General Symbol for the Voltage Measured in (Volts)
VAR	Volt-Ampere Reactive
ZCS	Zero Current Switching
ZVS	Zero Voltage Switching
τ	Time Constant
Ω	Ohm Symbol
ξ	Damping Factor

CHAPTER I

INTRODUCTION

Electronic Power Supplies Development

Electronic power supplies are most often charged with the task of altering, controlling or regulating electrical power. All electronic and electrical devices need a power supply in order to operate. Usually a dc supply voltage is delivered to the device and a dc current was drawn which depends on the absorbed power.

Switch mode regulators are the most popular due to their fairly high efficiency and compact size and a switch mode regulator is used in place of a linear voltage regulator at relatively high output. Switch-mode regulators overcome the drawbacks of linear regulators. They are more efficient and tend to have an efficiency of 80% or more. As well they can be packaged in a fraction of the size of linear regulators (Danel, W. *et al.,* 1995).

Switch-mode power supplies can step-up or step-down the input voltage. In this design step down power supply is needed. The design of the power supply was governed by the certain specifications to be met. The power supply required in this work is used for sludge treatment system.

In this power supply, six output voltages were required therefore; buck converter topology was chosen.

Knowledge Base Expert System Development

Expert systems are the most practical application of AI today. An expert system is a computer program that emulates the behaviour of a human expert in a well-specified, narrowly defined domain of knowledge (Medsker, *et al.*, 1994). The aim of an expert system is to reproduce the behaviour of a human expert, thus performing an intellectual task in a specific field (Gondran, 1986).

Expert systems have three major components. The dialog structure is the user interface that allows the user to interact with the expert system to obtain results and query the system. The inference engine houses the control strategies for generating hypotheses to arrive at a solution. The knowledge base is a set of facts and heuristics for the task at hand used to describe expert system.

Present problem areas where expert systems have been successfully built were: Interpretation, prediction, diagnosis, fault isolation, design, planning, monitoring, debugging, repair, scheduling, instruction, control, analysis, maintenance, configuration and targeting (i.e., Resource allocation).

Objective of Thesis

This thesis has two objectives to be achieved at the end of the project which are:

- The first objective of this project is to design 6kW power supply that can provide the load with variable output voltage varies from 10 to 60V with a maximum current of 100A.
- The second objective of this thesis is to contribute with knowledge and experience that is acquired during the power supply development and feed it to the Power Electronic Design Aid System (PEDAS), developed by the department research group.

The Importance of the Work for Knowledge Base Expert System (KBES)

The successful production of an expert system depends, ultimately, on two individuals or group of individuals; the expert in the field and the knowledge engineer who translates the expert's knowledge into computer software. The knowledge facts and experience gained during the development of power supply was extracted and managed by a knowledge engineer that translates it into computer software. The importance of this work comes in providing the Power Electronics Design Aid System (PEDAS) with the knowledge acquired during power supply developments. The contribution will be on the circuit database of PEDAS system.

Thesis Layout

This thesis consists of five chapters. Chapter I gives a brief introduction to power supply concept and expert systems. Chapter II is devoted to literature and what others have done in this area. Chapter III describes the methodology and materials and the detailed design calculations used in the design. In Chapter IV the results of the simulation and the hardware is shown and discussed, as well as the knowledge extracted from the work. Finally, Chapter V concludes the thesis and recommends future work that can be carried out.

CHAPTER II

LITERATURE REVIEW

Power Supply System

All electronic devices need a power supply in order to operate. Usually a dc supply voltage is delivered to the device and a dc current is taken by it, which depends on the absorbed power. There are only two possible power sources the energy can be taken from: dc batteries and the 50Hz (60Hz) mains. The energy sources of such a nature that electrical perturbation and faults can occur at the delivery point (transient over-voltages, lightening and so on), while the electronic equipment is so delicate that no supply voltage perturbations can be withstood. Moreover, some electronic loads (that is, any electronic equipment supplied by the power supply) themselves cause perturbations (e.g. electric motors and their electronic drives). So power sources need to be protected against them in-order to prevent noise and disturbances to nearby equipment and systems. Hence the power supply must be able to perform the following basic tasks:

- To deliver suitable dc voltages to electronic equipment and systems (loads).
- To decouple the load from the line (or vice versa) in order to prevent any electrical interaction between them.