UNIVERSITI PUTRA MALAYSIA

THE DEVELOPMENT OF UNINTERRUPTIBLE POWER SUPPLY FOR PERSONAL COMPUTERS

ALI MILAD JARUSHI

THE DEVELOPMENT OF UNINTERRUPTIBLE POWER SUPPLY FOR PERSONAL COMPUTERS

By

ALI MILAD JARUSHI

Thesis Submitted in Fulfilment of Requirements for the Degree of Master of Science in the Faculty of Engineering Universiti Putra Malaysia

October 2000

Dedicated to

My Parents,

Wife

and son Anas

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

THE DEVELOPMENT OF UNINTERRUPTIBLE POWER SUPPLY FOR PERSONAL COMPUTERS

By

ALI MILAD JARUSHI

October 2000

Chairman: Dr. Ishak Bin Aris

Faculty: Engineering

Computer systems have become very important all over the world They are capable of doing complicated works When the main power fails, the computer system cannot support its normal operation and it will shut down immediately Consequently, all working data will be lost if they are not saved previously Therefore, an uninterruptible power supply (UPS) should be designed to protect data loss and to prevent any output interruption during a power failure

The objective of this project is to design, construct, and test UPS for personal computers The proposed UPS is cheaper and its size is smaller than that of the conventional UPS available in the market

The proposed UPS consists of rectifiers, a battery charger, an automatic controller, a sealed lead acid battery, regulators and a boost DC-to-DC converter

The proposed UPS is capable of supporting the normal operation of the PC for 20 minutes during power failure. This 20-minute time is enough for the user to save the current work on the PC and switch off the PC properly. The detailed analysis of the design, experimental works and simulation are discussed in this report.

Results of the experimental and simulation work showed that there was a good agreement between the hardware and software. This indicated that UPS was successfully developed.

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

PEMBINAAN BEKALAN KUASA TIDAK BOLEH GANGGU (UPS) UNTUK KOMPUTER PERIBADI

Oleh

ALI MILAD JARUSHI

October 2000

Pengerusi : Ishak Aris, Ph. D.

Fakulti: Kejuruteraan

Sistem komputer adalah penting di seluruh dunia. Ia mempunyai kemampuan melakukan kerja yang kompleks. Apabila kuasa utama gagal, sistem komputer tidak dapat beroperasi dengan normal dan ia akan terpadam serta-merta. Akibatnya semua data yang sedang dibuat akan hilang jika sebelumnya tidak disimpan. Oleh itu, sebuah bekalan kuasa tidak boleh ganggu (Uninterruptible Power Supply, UPS) direkabentuk untuk melindungi kehilangan data dan mengelakkan daripada terjadinya gangguan keluaran semasa kegagalan kuasa.

Objektif projek ini ialah untuk merekabentuk, membina dan menguji sebuah bekalan kuasa tidak boleh ganggu untuk komputer peribadi. Sistem yang dicadangkan adalah lebih murah dan saiz litarnya lebih kecil berbanding sistem biasa yang terdapat di pasaran.

Umumnya, struktur yang dicadangkan adalah terdiri daripada penerus, sebuah pengecas bateri, sebuah pengawal automatik, sebuah bateri asid berplumbum, pengatur, dan sebuah pelonjak penukar arus terus ke arus terus.

Sistem yang dicadangkan berkemampuan menyokong komputer peribadi untuk beroperasi secara normal selama 20 minit selepas kegagalan kuasa. Masa 20 minit ini adalah mencukupi untuk pengguna menyimpan data kerja yang sedang dibuat ke atas komputer peribadi. Kemudian pengguna boleh menutup suis komputer peribadi dengan lebih selamat. Analisa terperinci tentang rekabentuk, kerja ujikaji dan simulasi akan dibincang dan dikemukakan di dalam laporan ini.

Keputusan dari ujikaji dan simulasi menunjukkan terdapat persetujuan yang baik di antara perkakasan dan perisian. Ini menunjukkan UPS tersebut telah berjaya di hasilkan.

ACKNOWLEDGEMENTS

I thanks Allah (S W T), the most gracious and merciful, who has given me the ability to finish this project successfully

I gratefully acknowledge the guidance, advice, support and encouragement received from my supervisor, Dr Ishak Aris, who has been advising and commenting on this project until it turns to a real success

I also thank my co-supervisor Dr Norman Mariun, for his advice, remarks, and encouragement from the beginning to the completion of this work

High appreciation is expressed to my supervisory committee member, Pn Ratna Kalos Zakiah Sahbudin, for her advice and encouragement

Great thanks to my family members, who have not stopped encouraging and supporting me to achieve this success

Appreciation is also extended to the Faculty of Engineering for providing the facilities and the components required for undertaking this project

Finally, I would like to thank everyone, who has given me help, comments and suggestions

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATIONS

AC	Alternate Current
Ah	Ampere hour
c	Capacity of the Battery
C	Capacitor
C_i	Input Filter Capacitor
C_O	Output Capacitor
CPU	Central Processor Unit
D	Diode
D_1	Duty Ratio
DC	Direct Current
En	Energy
GND	Ground
h	Hour
Hz	Hertz
I_c	Capacitor Current
I_D	Drive Current
I_{in}	Input Current
I_L	Inductor Current
$I_{MAX.}$	Maximum Current
I_{OC}	Over Charge Current

I_{OCT}	Over charge Transition Current
I_P	Peak to Peak Current
IC	Integrated Circuit
k	Constant
kVA	Kilo Volt Ampere
K	Duty Cycle
L	Inductor
$L_{crı}$	Critical Inductor Value
L1	First Static Logic Latch
L2	Second Static Logic Latch
LED	Light Emitting Diode
mA	Millie Ampere
ms	Millie Second
MG	Motor-Generator set
MOV	Metal Oxide Varistor
PC	Personal Computer
PCB	Printed Circuit Board
PQ	Power Quality
P_{bar}	Status Indicator Switch of the Primary Supply
R	Resistor
RG1	Regulator 1
RG2	Regulator 2

S	Switch
S1	Switch 1
S2	Switch 2
S_{bar}	Status Indicator Switch of the Battery
SCR	Silicon-Controlled Rectifier
t_o	On time of the switch
t_1	Time of the Close Switch State
t_2	Time of the Open Switch State
T	Thyristor
UPS	Uninterruptible Power Supply
V_{12}	Transition Voltage
V_a	Average Voltage
V_B	Battery Voltage
V_{dc}	DC Voltage
V_f	Float Voltage
V_l	Inductor Voltage
$V_{Max.}$	Maximum Voltage
$V_{Min.}$	Minimum Voltage
V_o	Output Voltage
V_{OC}	Over Charge Voltage
V_P	Primary Voltage

V_{REC}	Output Voltage of Rectifier
V_T	Threshold Voltage
V_s	Input Voltage
μs	Micro second

CHAPTER I

INTRODUCTION

The term *power quality* (PQ) has become one of the most prolific buzzwords in the power industry since the late 1980s. This issue has a sharp attention because of the increase in the number of loads sensitive to power disturbances and has become tougher as the loads become important causes of degradation of quality.

Modern electronic circuits, such as computers, data processors, and communication equipment, require extremely reliable power sources. While commercial power is normally utilised as the basic source for these circuits, many power problems may occur to this power source and affect the operation of computer circuits and the like.

To operate this sensitive equipment in a safe operation, a source of continuous, regulated power having very stable characteristics is needed. This need is met generally by one of the power conditional devices according to the type of the power problem.

Unintrruptible Power Supply (UPS) can be used overcome any kind of power problems. Even during the outage power, UPS can be switched on to maintain the operation of the system by compensating the total loss of power from the battery.

Importance of the Project

Computer systems have become important all over the world due to its capability of doing complicated work such as: calculation of mathematics, word processing, and PC based industry automation. The continuity of power supply for computer systems is very important for some applications. When there is a power failure, the computer system cannot support its normal operation and it will shut down immediately. Consequently, all working data will be lost if they are not saved previously. Therefore, an UPS system is designed to protect data loss and prevent any output interruption after the main power input fails suddenly.

According to many studies reported in the computer world, power disturbances have disastrous effects on computers such as: hardware or CPU damages, hard-disk crashes, short-term memory loss, and permanent memory loss.

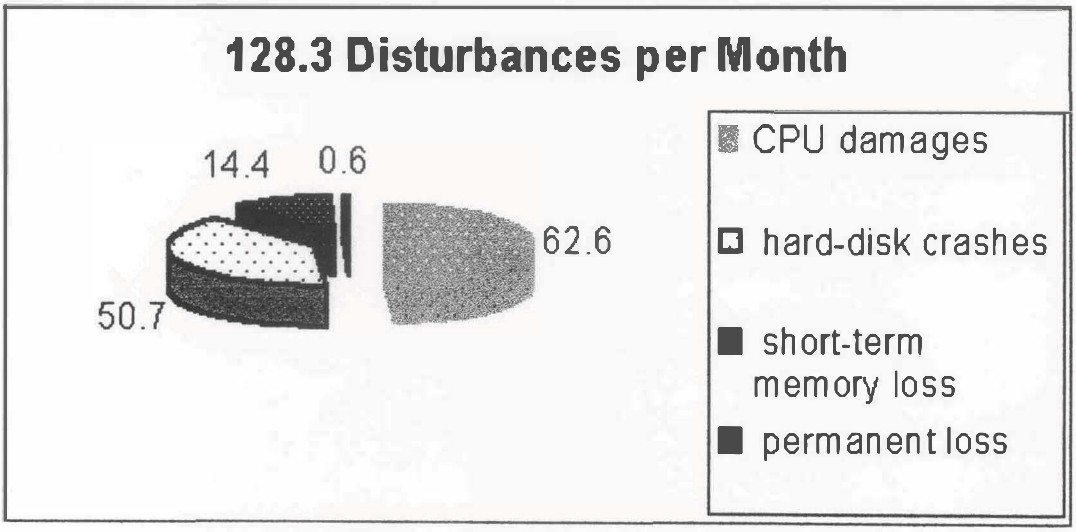

Figure 1: IBM Study Result (Aykul, 1995)

One of the studies conducted by IBM shown in Figure 1 revealed that on average, a computer can expect to encounter 128.3 power disturbances per month; these can be disruptive to its proper operation and cause increased computer service costs (Aykul, 1995).

An interesting finding of another national study by AT&T is that lightning causes damaging sags and outages in addition to spikes. The reason is that impulse suppression equipment in the AC distribution system shortly disconnects the power line when lightning strikes the system (Aykul, 1995).

In another study reported in the computer world as shown in Figure 2, it indicates that power disturbances have disastrous effects on computers such as: hardware or CPU damages (22.1%), hard disk crashes (24.6%), short-term memory loss (61.8%) and permanent memory loss (13.6%) (Aykul, 1995).

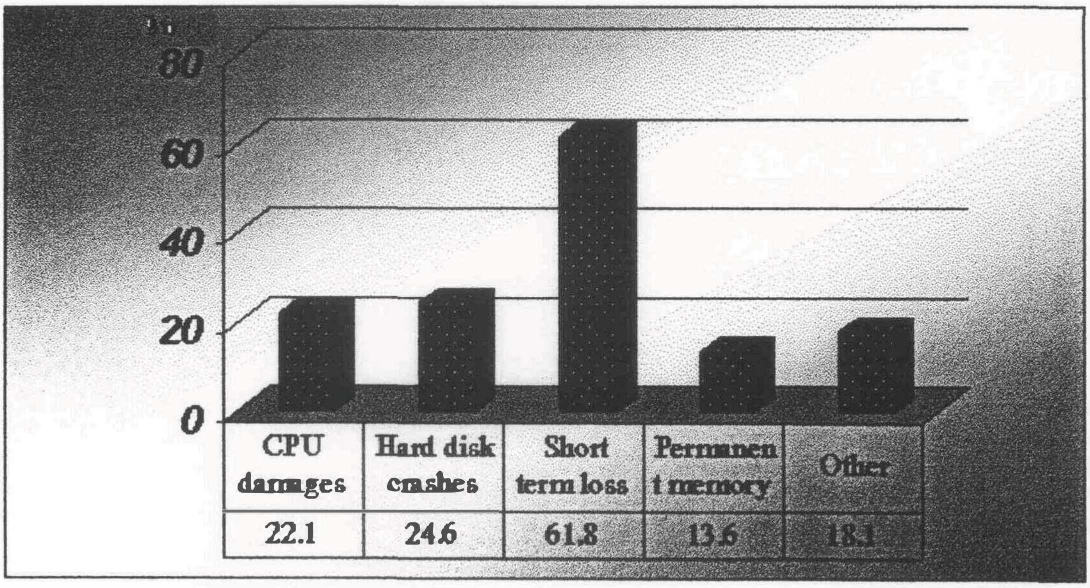

Figure 2: Effects of Power Disturbances (Aykul, 1995)

As a conclusion, the line power should not be fed to the computers, telecommunication equipment, or other sensitive and critical electronic gear It causes lost data, downtime, increased service costs and reduces equipment life

The following are examples of applications of computers, which require continuous power supply

1- Life support systems such as monitoring systems

2- Hospital information systems patient history files, treatment schedules

3- Paramedics and fire departments

4- Public utilities electric power, gas, water and sewage

5- Air traffic control

6- Financial institutions banks, stock markets and commodities

Problem Statement

The current protection scheme used by PCs for the power failure problem is depicted in Figure 3 The conventional UPS is used to provide power supply to a group of PCs during power failure The disadvantage of this scheme is that it is expensive and bulky Furthermore, ıt has a high maintenance cost Consequently, not many people manage to buy this system to protect their PCs from power failure In order to solve this problem, a low cost and small size UPS is needed